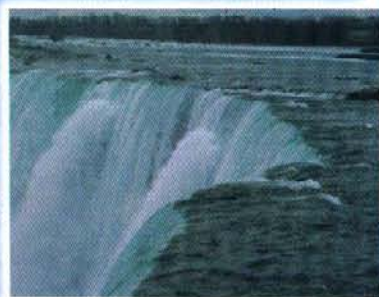


Water

Global Common and Global Problems



Editor
Velma I. Grover

WATER

Global Common and Global Problems

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PROGRAMME DES NATIONS UNIES POUR L'ENVIRONNEMENT · PROGRAMA DE LAS NACIONES UNIDAS PARA EL MEDIO AMBIENTE
ПРОГРАММА ОРГАНИЗАЦИИ ОБЪЕДИНЕННЫХ НАЦИЙ ПО ОКРУЖАЮЩЕЙ СРЕДЕ

Foreword

Fresh water is the life-blood of the environment. There is no life without water – nothing can survive without water including human beings. Although 70% of earth is water, the growing freshwater crisis has impact on billions of people on our planet. In no other case is the link between well-being of the people and the environment so clear. Water pollution renders water unusable by people and also makes people – often children – sick and kills millions every year. Excess withdrawal of water also reduces the water available and thus the productive benefits that it produces. Water is a key input to economic development and broader human well-being, and the current water crisis is a direct threat to human well-being in an increasing number of cases. The freshwater crisis must be solved if we are to achieve long-term sustainable development. Indeed, the lack of access to safe drinking water is perhaps the world's greatest social and developmental challenge. The failure to manage water effectively seriously hampers effort to alleviate poverty worldwide and threatens progress towards sustainable development.

To deal with the water crisis requires a clearer understanding of the extent of the problem, their causes and the solutions available and this publication admirably covers the issues and potential solutions. It also highlights that there are some difficult water problems with geo-political implications that are the subject of strong views as to causes and solutions. Without supporting either side involved in these contentious issues, I wish to emphasize that any proposed solution must treat the environment as part of the solution, not a competitor for scarce water resources. The book also highlights that water problems cannot be solved without a multidisciplinary and integrated approach, and opens avenues for a wider dialogue among water professionals, academicians and public at large.

I congratulate Velma Grover in taking the initiative to prepare this publication and I am sure that it will stimulate energetic debate that leads to concrete actions to fix what is arguably the most serious and urgent environmental and development crisis in the world today – the freshwater crisis.

Klaus Toepfer
Executive Director

Preface

Water is one of the important elements for the survival of living beings. *Silent Spring* by Rachel Carson in 1962 changed the public view on water concerns. This book is often cited as the beginning of the modern environmental movement in general and for water problems in particular. The book describes the story of a lovely rural town that suddenly suffers blight, sickness, and death because people had unwittingly poisoned themselves. Carson explains how the strongest bugs survive, making stronger pesticides necessary, and that DDT, though scarce in the water, becomes concentrated as it works its way up the food chain – from plankton to fish to birds and so on. Her message that humans cannot totally control nature, or eradicate species we do not like—at least not without harmful side effects came through clearly. She advocated integrated management: using a minimum of chemicals combined with biological and cultural controls. In *Silent Spring** (1962) she challenged the practices of agricultural scientists and the government, and called for a change in the way humankind viewed the natural world. It was later discovered how DDT (and other pesticides) travel from one end of the world (like India and Pakistan where it is used without discretion) to the tribal people in Northern Canada (where DDT has been banned since 1970s) causing negative health impacts.

Although, the UN Conference on Human Environment held in Stockholm in 1972 did mention the need for coordination of UN bodies and governments on water resource management, yet the next major milestone in water management was the UN sponsored conference on water at Mar del Plata, Argentina in 1977. This meeting focused on the principles for water management and planning. Significant advances have been made for the process of water management since then at the Dublin Conference and the Earth Summit in Rio in 1992. The next major stepping stone for the water problems was the 'United Nations Millennium Declaration' in September 2000. The UN General Assembly adopted Resolution No. 55/2 where the UN's members proclaimed *inter alia* that no effort would be spared to eradicate the "abject and dehumanizing conditions of extreme

<http://www.pbs.org/wgbh/aso/databank/entries/dt62si.html>

poverty, to which more than a billion [people] are currently subjected.” To give this declaration substance a set of targets was agreed for the year 2015, including the goal of reducing the proportion of people without access to safe drinking water by half by 2015.

However, like food, water availability is not matched by equal access for all regions or all people. Freshwater is unevenly distributed geographically and temporally, resulting in surpluses for some people and a threat of severe water insecurity for others. For example, Canada has 120,000 m³ per capita per year of renewable water resources compared with Jordan’s 300 m³. The importance of overcoming such constraints to water development and management in the world’s poorest nations has been increasingly recognized and proclaimed.

With the increase in demand for water and decreasing water quality and quantity, water has become one of the major issues and problems in the world today. As pointed out by Gleick and others, instead of continuing to adapt to increasing water demand it is time to adopt to the idea that water is a finite and vulnerable water resources and that excessive withdrawal from natural water bodies is exponentially costly and is likely to cause considerable harm to the ecosystems’ functioning and downstream areas.

Even though all the scientific and technical problems have not been fully understood water science, in general, is quite developed. On the other hand the social and economic sides are still evolving. This book deals with some of the scientific aspects and has a few chapters on governance and best management practices. The chapters show that good governance, policies for effective conservation and with public participation are important for water use. There are a lot of examples of Best Management Practices all over the world – for effective and efficient use of water, community-based programs in North America, Asia and Africa, some of the South African examples are quite innovative. Thailand has developed a concept of land-use plan associated with water usage. This book gives details of two case studies – one in India which is an example of community-based management and one in the United States. Although, each country needs a national plan and each region needs a local solution – lessons can be learnt in general from other case studies in the world.

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Introduction

1

General Overview

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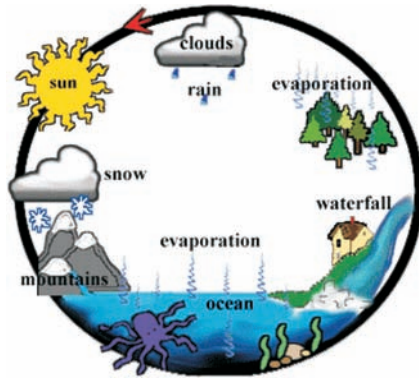
INTRODUCTION

Although, three-quarters of earth is covered with water, not all of it is available for human consumption. Ninety seven percent of water is in oceans and seas and only 3% is freshwater. Of this 3% of freshwater 77.6% is frozen polar ice, 21.8% is groundwater, part of which is too deep, only fraction of the water (0.6%) is available surface water (rivers, lakes representing 0.34% of the planets atmosphere) in atmosphere, soil or aquifers.

Water is distinct from all the other natural resources because of its unique physical properties (its ability to exist as solid, liquid and gas), cultural and religious significance, complex economic characteristics and last but not the least its essential role in supporting all the life on this planet earth. This means that developing effective water policies need to consider economic, ecological, environmental, cultural, legal and political issues.

SCIENCE

The movement of water between land, water bodies (oceans, lakes, rivers) and the atmosphere is called the hydrological cycle. This natural process is driven by energy from the sun which evaporates water from the earth and water comes back to earth in the form of precipitation (rain, hail, snow). This means that water is neither created nor destroyed but it just changes its form and location.



Source : www.wavcc.org

The book is organized in four sections dealing with different issues such as general science, impact of climate change, governance and policy issues, and human rights issues. The first section is a cluster of chapters on a general introduction to the book, water quality management in India, river basin management in Hungary and the Upper Danube River. These are followed by chapters on effluent treatment in Australia, impact of water contamination on health and challenges of climate change on water (and infrastructure) especially in Canada and Tanzania.

The task of ensuring adequate access to safe water for all people at all times is one of the greatest challenges facing development professionals in the 21st century, at least as hard as (possibly harder than) ensuring food security for all. Webb in *Household Water Security: The Next Great Challenge to Developing Countries*, provides an analysis of major issues in water security, with a focus on the household level and paying attention to the multifunctionality of water (the multiplicity of demands made on it). Water is not only a natural resource but also an economic commodity and a human entitlement. At a time when the privatization of water allocation responsibilities and the creation of water markets offer some gains in economic efficiency there is growing attention to other less price-driven dimensions of water usage. Can the demands of economic efficiency, ecosystem integrity, agricultural growth and household use be met simultaneously, especially where supplies for more than one of these demands have to be provided at one time? Webb proposes a conceptual framework to highlight the cross-sectoral approach needed for effective analysis of, and responses to, the problems of water insecurity.

In the next chapter *Fresh Water A Scarce Resource: Its Global Utilization and Sustainable Work Practices*, Hussainy and Kumar present an overview of availability of freshwater and consequences of human interaction on natural flows. The authors discuss the sources of freshwater and the consequences of human interferences; harvesting of freshwater from natural sources;

social impact on the local communities. This is followed by a discussion on impact of human activities on environment in Australia and some general remarks on water as a scarce global resource. Examples are cited from different parts of world with detailed discussion around the Australian situation with special emphasis on the city of Melbourne in the State of Victoria.

As in any other developing country – water quality in India is degrading at a very fast rate, partly due to fast urbanization and industrialization and partly due to over-exploitation of water resources. *Water Quality Management in India* by Trivedi describes that in the Indian context untreated domestic sewage is a much bigger problem than the industrial waste. Domestic sewage not only pollutes surface water where it is discharged, but also pollutes groundwater due to inadequate collection and transport of sewage resulting in stagnation and percolation. Industrial wastes, although smaller in quantity, have significant effects on aquatic environment due to their toxic and conservative nature. Although a number of initiatives are taken by the Government of India and state governments to protect the water resources, however, the efforts are not adequate to cope with the challenges of poverty, water scarcity, lack of awareness and lack of resources. The author feels that with the large number of regulations, increasing public awareness, involvement of judiciaries and involvement of many international agencies it is expected that the water quality will improve in the future.

Wijeyekoon in *Status of Freshwater in Sri Lanka: From a Precious Resource to a Commodity Wasted and Mismanaged* looks at the fresh water situation in Sri Lanka and also discusses the best management practices in Sri Lanka. The author also describes the laws and policies related to water in Sri Lanka. According to the author, although there are a number of legislations dealing with water resource management yet most of these are too old to meet present day water needs. He further talks about an initiative under Asian Development funding to strengthen National Policies and institutions.

This is followed by a case study in Brazil, where Marques, Rodrigues Da Silva and Hogland in *Strategic Impact Assessment and Root Causes of Pollution in a Transboundary Drainage Basin in Brazil* presents transboundary Paraíba do Sul river basin. The basin is shared by three Brazilian states and considered by the National Agency of Water as the first priority for strategic action planning. This chapter illustrates the application of the Causal Chain Analysis conceptual model developed for the UNEP/GEF project Global International Waters Assessment for seeking policy options. The immediate, sectoral and root causes related to different issues that cause the concern are identified, as well as the environmental and socio-economic impacts they cause. A strategic approach for the region is recommended by the authors for the region.

Briggs in *River Basin Management and EU Expansion: Hungary and the Upper Danube River*, addresses the issue of how scarce economic and political resources have been allocated to address pervasive problems of industrial, municipal and agricultural water pollution in Upper Danube River. With the introduction of new member states to the European Union (EU) in 2004, more efforts have been promoted to manage and sustain transboundary water resources.

This chapter examines freshwater resources in Hungary and the increased attempts for regional cooperation in regulating water quality standards and monitoring. Hungary presents an interesting case study for several reasons such as: problems with water policies in the region is not limited by the total amount of water, but rather by the quality, and ecological vulnerability of the water; 96% of surface water in Hungary originates in other countries; Hungary adds significantly to pollution pressures upon hydrologic resources to its downstream neighbors. In the last fifteen years Hungary has undergone two transitions, first from a Communist government in 1989-1990, and then into a full membership of the EU in May 2004. During this time the issue of water quality has been of prime importance, and in some ways was crucial to undermining the legitimacy of the former Communist government. The author concludes that a country like Hungary has a notable history of water pollution, and faces barriers to effective action in addressing effective freshwater resource management, but the more important point is that Hungary has committed itself to effective freshwater regulation long before such requirements were imposed by EU directors in Brussels.

The next chapter *Liquid Waste Management Strategies in Developing and Developed World and the Utilization of the Treated Effluent*, by Hussainy and Kumar reviews the liquid waste management current practices and their historical development in Melbourne, Australia. It also describes the utilization of the treated effluent and its implications on freshwater availability and supply in this city.

In *Chemical Contaminants of Water and Potential Impacts to Health*, Bhardwaj describes that both natural and anthropogenic elements, materials and chemicals found in surface, ground and drinking waters have the potential to harm human, animal and plant health. Drinking water quality and its chemical composition varies throughout the world suggesting that possible health risks associated with water consumption may also vary globally. For example, in some regions of the world, levels of certain trace elements such as arsenic, fluoride, nitrate is found to exceed the average range of 1µg/l to 1 mg/l. These elements possess unique influences on health. In other parts of the world high levels of pathogens are commonly found in drinking water sources. Yet in other areas constituents of drinking water more closely reflect average compositions and pose no health threat. It is

known that many elements in drinking water influence human health. Some inorganic components of water are essential to human health and metabolism. There have been a significant number of drinking water constituents identified and suspected to pose a risk to human health but human health risks has not yet been clearly established. The list of chemical substances is extensive and due to the significant numbers that have been identified the contaminants covered in this chapter are limited to trace elements such as arsenic, pharmaceuticals, pesticides and chlorination products and the focus is on the human health effects. Through this discussion the author anticipates a better understanding of the potential human health risks posed by drinking water contaminants, which is valuable knowledge for development and global application of better drinking water maintenance and management strategies.

The hydrological cycle alters with the change in climate because of varied precipitation as a result of metamorphosis in temperatures (in addition to the decrease in quantity of water because of increased consumption of water). The change in water distribution has a direct impact on the livelihood of poor people. The next couple of chapters deal with some of these issues in addition to health issues related to water contamination.

Changing Impact of Precipitation as a Consequence of Climate Change and Implications to the Infrastructure by McBean describes historical trends in precipitation and flows from the Great Lakes, which indicate apparent long term increases in response to climate change scenarios. These trends are used in support of additional historical monitoring trends quantified in terms of the intensity of precipitation events of alternative durations, to predict the changes in the intensity-duration-frequency (IDF) curves in response to climate change. IDF curves for 25 and 50 years in the future, based on projections of the monitored trends from historical precipitation intensities, are used to characterize potential design intensities for municipal infrastructure systems. The results indicate that climate change scenarios are going to significantly influence design storms for infrastructure design where, for example, a 5-year storm in 25 years corresponds to an equivalent 13-year storm in terms of current recurrence frequency, and a 5-year storm in 50 years corresponds to an equivalent 36-year storm in terms of current recurrence frequency. The implications to design of municipal infrastructure systems are examined in this chapter.

Paavola in *Water, Poverty and Climate Change: The Challenge in the Ruvu River Basin, Tanzania*, investigates the complex interactions between climate variability, water and poverty in the Morogoro region in the South-Eastern Tanzania. Intense conflicts take place between the farmers and pastoralists who have relocated to the region with their cattle from drought-stricken highlands. Farmers have responded to ongoing drought by switching

crops, expanding cultivations and engaging in charcoal production causing deforestation, reduced water retention and increased flooding. These environmental changes have many adverse local impacts and they also affect water availability for external users. The author then reviews climate change impacts that are likely to be experienced in Tanzania and in the Morogoro region in particular, followed by a discussion in greater detail on livelihood, developmental outcomes and patterns of vulnerability in the Morogoro region and people's response in the region to the past and present climate variability. The chapter concludes by discussing the implications of responses to climate variability for adapting to changing climate in the future.

GOVERNANCE, INSTITUTIONS, LAWS AND POLICIES

Thus far, it is believed that water is indestructible and is recycled through the hydrologic cycle. But recent experience has shown that water cannot be treated as a perfectly renewable resource. Withdrawals from our watersheds for drinking and industrial water and subsequent wastewater treatment processes, at today's scale, have large 'unpriced' external effects such as water quantity depletion, land use consequences and biological degradation. With expansions in water and wastewater capacity posing significant environmental problems in most major metropolitan areas, the need for conservation and planning is greater than ever.

Water is also considered as a 'public good'. A 'public good' is defined by two characteristics: (1) non-excludability (it is difficult to exclude some one from using the good) and (2) non-rivalness in consumption (one person's enjoyment does not affect another person's enjoyment, up to the point of congestion). The characteristics of public goods necessitate government responsibility and action. Although, many goods and services provided by government exhibit some 'publicness' (such as street lighting), there are few pure 'public goods' like air and water. Being a 'public good' and a necessity of life, water should be available to everyone free of cost. As discussed above the amount of water withdrawn from hydrological cycle is much more than it can replenish, so it cannot be considered infinite and renewable and used mindlessly and free. Today, the water allocation problem is more difficult than ever due to a number of forces: increased population, periodic drought, depletion of groundwater, degradation of water quality, land use concerns and competition among water users (agriculture, recreation, urban drinking water and industrial use). With the change in consumption and thinking of natural resources, water and sewage services which do possess some elements of public goods, they more closely approximate 'private goods', and thus, it is desirable to charge for

them. This brings in the responsibility of government and their policies on water conservation and allocation. Section 2 is devoted to the governance, institutions and policy issues and presents a mosaic collection on experiences in Europe, North America, Australia, Brazil and Turkey.

Based on the results from the European research project EUWARENESS, Bressers and Kuks in *Water Basin Regimes in Europe and Institutional Conditions for their Sustainability*, examine when, whether, under what conditions and in what form integrated water resource regimes are established which can successfully regulate all of the use demands and thus react to the growing scarcity of goods and services provided by a water resource or the depletion of its stocks. A historical screening of water resource regimes in different countries is used to examine whether the emergence of resource regimes corresponds to our theoretical phase model and whether the suggested transitions from complex to integrated regimes can be identified. This development of national regimes has been examined for a period extending over more than hundred years (from the early 19th century until the end of the 20th century). Authors have described the change from complex to integrated regimes, of the six countries involved (the Netherlands, Belgium, France, Spain, Italy and Switzerland), to get a better view of the specific conditions under which regime transitions towards integration appear. The case studies focus on the last three decades of the 20th century (1970-2000), in which all countries have attempted to achieve integrated water management. This is followed by some theoretical backgrounds of the study; description and comparison of the water management national regime changes in six European countries; and the result of the analysis of 24 attempts to gain more integral management in 12 water basins.

The next chapter in the section *European Water Framework Directive and Particularly the Way it Envisages a Process of Participatory River Basin Management Planning* by Huitema and van de Kerkhof describes two methods of involving citizens and stakeholders in water management: the focus group and the citizens' jury. Authors give a general description of these two methods and discuss their usefulness for water management on the basis of their experience in applying them in the Netherlands. According to the authors, the focus group method is a low cost method that appears useful in the early stages of the policy process – problem definition and policy preparation, while the citizens' jury is more costly and useful in the process of policy preparation as an addition to normal steps taken in that stage of the policy process. At the end of the chapter, authors reflect on the different purposes and usefulness of the two methods in different settings than the Netherlands and their applicability in transboundary water bodies.

Ecosystem management has growing support from practitioners, government officials, and researchers and has been utilized in a variety of

settings to address a wide range of resource management problems. A prominent application of the ecosystem-based approach is watershed management. Imperial in *On subject Intergovernmental Challenges Associated with Watershed Management*, draws upon the growing research on watershed management, intergovernmental management (IGM), interorganizational networks (IONs), and collaboration to identify strategies for improving watershed governance. The chapter begins with a discussion of IGM and how these strategies build, manage, and reconfigure governance networks, followed by some common IGM strategies such as: coping and adjusting arrangements; collaborating to get things done; interorganizational planning; developing shared policies or priorities; creating watershed management organizations (WMOs); capacity building and leveraging resources; and performance management systems. The final section of the chapter identifies factors that influence these strategies including: (1) how contextual factors influence watershed governance; (2) problems due to the human side of IGM; (3) the importance of minimizing transaction costs; and, (4) the challenge of maintaining accountability.

In the next chapter *Water Policy in the Western United States*, Davis points out that the current US policies focus on water as a commodity that should be used efficiently to promote a prosperous economy for current generations; the resource, however, has additional values. All non-marine species depend upon freshwater for basic survival. Water in healthy ecosystems provides food, water purification, flood mitigation, drought mitigation, wildlife habitat, soil fertility maintenance, nutrient delivery, beauty, recreation opportunities and biodiversity conservation. To explore what a sustainable water regime would require, this chapter defines the goals of water sustainability; utilizes Sabatier and Jenkins-Smith's Advocacy Coalition framework (ACF) to discuss water policy making, discusses the development of water policy over time, and evaluates water policy reform to promote stability.

In the next chapter *Governance in Abundance and Scarcity: The Development of Water Rights in the Great Lakes and Murray-Darling Basins* Heinmiller demonstrates the importance of abundance/scarcity to water governance through a brief comparison of water property rights in the Great Lakes Basin of North America and the Murray-Darling Basin of Australia. The chapter shows that, the relative abundance of water in the Great Lakes has resulted in a water rights regime that is very different from the water rights that have developed in the Murray-Darling, where water resources are much more scarce.

At one time big dams were a sign of development, and all the developing countries considered it as a status of growth and development. But dams (especially big dams) have become controversial these days because of their environmental impacts, displacement of population and loss of

biodiversity due to submergence of flora and fauna in the region. Although, it has some uses e.g. control of water flow, availability of water for irrigation and generation of electricity in some cases, yet the side effects are proving to be far more in some cases. Pool and Grover in *GAPs in the Dialogue of Governance: Conflicting Ideologies of Development in Turkey* discuss the importance of dams in Turkey and the government policies related to it. In the last 20 years, Turkey has built a network of 22 dams, 19 hydroelectric plants, and extensive irrigation systems on the Tigris and Euphrates Rivers, together called the Southeastern Anatolia Project (GAP). With the US \$30 billion price tag, these dams are supposed to provide increased agricultural production, industrialization and power output. The chapter will also discuss how the Turkish government is using GAP to strategically reformat the process of governance on a national level. The social effects of the development project are interpreted very differently by governmental, environmental, and minority interest groups, and the actual effects generally point to expanded government control rather than increased development. This chapter evaluates the conceptions and arguments of different actors engaged in decision-making vis-à-vis development projects. It focuses on the following questions regarding the social construction and governance of GAP in Turkey: How are development projects perceived, and what is the language used to describe them? How does this construction affect the structure of governance? How do historical trends augment socio-political relationships in the development process? These questions are designed to direct research towards the processes through which development is planned, accepted, and incorporated into certain ways of organizing and controlling society. Answers to these questions uncover changing knowledge systems as they are embedded within geographical, historical and social frameworks. The dialogue among interest groups is, in essence, a power struggle over ideological systems. It is manifested in different types of projects at different scales and with different moral arguments.

Conflict over water can be at the domestic level, water can cause or contribute to internal conflict, which generally manifests itself at the community level, between individual users and water-use sectors. Water related conflicts can be

- Between drinking water needs and other competing users such as agriculture use, industrial demands
- Between rural and urban needs
- Between different countries, states, communities or farms
- Between upstream and downstream communities
- Between dam builders and people displaced
- Between environmentalist and developers
- Building of dams on a shared river can cause conflict between countries on flow of water

Poor government water management schemes, the lack of social safety measures in times of crisis, can all produce conflict. Water conflicts can also be transboundary – among different states (provinces) or nations sharing the same water sources, such as, a river or lake. A proper response by governments to water resources management has the potential to eliminate conflicts both at the national and international levels. The challenge lies in the design and implementation of regulatory and institutional frameworks that respond to the multidisciplinary and limited natures of water, and operate in a democratic and participatory manner reflecting the needs of the current and future generations.

The Palestinian-Israeli case is the best example where water conflict is still prevalent. Daibes in *Management and Regulatory Frameworks for Fresh Water Resources in Palestine: National and International Perspectives*, describes that the imbalance in the power structures between the two parties, which appears to be in favor of Israel, continues to hinder the attaining of a fair and equitable binding arrangement concerning the shared water resources. On the one hand, the Palestinians—being the weak party—find no support to their demands for an equitable and reasonable utilization of the shared resources. This has consequently weakened their position and contributed to the continuation of status quo. On the other hand, Israel continues to ignore the alarming situation arising from the lack of cooperation and coordination concerning the utilization, development and protection of these resources. The current water situation and management practices by both parties are indeed threatening the sustainability of the water resources and the general welfare of both nations. The author recommends an innovative approach that draws lessons from international law and best state practice in order to systematically address the hydrological, legal and institutional challenges in a stepwise manner. This chapter attempts to present an important step forward in formulating a national and regional water policy based on cooperation for transboundary water management. It introduces in a nutshell the concept of 'Integrated Water Resources Management' (IWRM) and what policy decisions and structural changes are needed by the Palestinians and Israelis for the implementation of this concept at the national and regional levels.

The governance and policy issues lead to the discussion on should water be priced or not – this becomes all the more important because of increase in demand for water, decreasing quality, conflicts between different users such as residential use, industrial and agricultural use. The economics of water is based on the allocation of the resources among different users based on its value. The value of water is determined by demand (utility to human beings and willingness to pay) and supply (cost of providing water in a certain quantity and quality). With the increasing population and demand for limited quantity of water, food security and peace issues

are upcoming problems. The next chapter on the Middle East Water Scarcity and Peace by Kubursi deals with these issues and recommends an economic solution to the problem in the Middle East.

Throughout the Middle East, water shortages, asymmetries in political-military power and water control, consumption and demand interplay form a complex hydro political web. In this chapter, the author discusses the issues related to water in the Middle East, frequently drawing on his previous work, to focus on the region's hydrological conflicts recognizing that water is a particularly critical, as well as an emotional point of dispute for all parties in these water disputes. There is, however, no alternative to an honest and forthright discussion of the water issues to expose the current unsustainable and unstable reality. Finding a common understanding of water issues in the Middle East would go far to enhance the possibilities of achieving stability in the region. It is only then that neighbors can negotiate long term regional arrangements. Agreements concluded under duress cannot be expected to last.

BEST MANAGEMENT PRACTICES

Access to safe drinking water is a serious concern in developing countries, where 1.1 billion people lack access to it. But access to water is also inadequate in many urban areas of industrial countries, especially during periods of drought. The situation may worsen in industrial urban areas due to: increased water demand for economic development and population growth; impacts of changes in both global and regional climate on water supply systems; and reduced percolation due to high levels of impervious surfaces resulting from urbanization of basins.

On a global level, annual freshwater availability per person decreased from 16,800 m³ to 6,800 m³ per year between 1950 and 2000. When drought conditions persist, urban centers in many industrialized regions are prone to experience a severe freshwater supply-demand gap. A traditional method of attempting to resolve this gap is to increase supply vis-à-vis, large reservoirs, desalination plants and inter-basin transfers. While such techniques can provide a definite source to offset water demand, costs and environmental impacts are major concerns. However, through demand-side management, the gap can be closed without large construction costs and negative environmental consequences. Community-based water conservation methods can also be used for effective and efficient water management. The next section on 'Best Practices Management' has chapters on demand-side management and community-based management. The first chapter in this section *Common People Rallying for a Common Resource: Conserving Freshwater Through a Community-based Program in India* by Joshi

et al. argues that amongst all approaches, integrated watershed management has emerged as an effective strategy of addressing the problem of natural resource degradation that includes land, water and forests. In fact, the watershed approach has become the sole approach for all the rural development programmes funded by the Indian Government having a component of natural resource management. The chapter gives the evolution of the watershed concept over a period of time with a focus on the case study of Rajiv Gandhi Mission for Watershed Management. The authors discuss how the Indian Government, in the early 50's and 60's, addressed the issue of water scarcity and how over a period of time the watershed concept was embraced. The chapter also describes the Rajiv Gandhi Mission for Watershed Management and finally, enlists the main achievements of the programme. Short caselets and stories of watershed driven local successes that dot the landscape of Madhya Pradesh, are presented in the chapter.

The next chapter in the section by Byrne et al. *Freshwater Management in Industrialized Urban Areas: Water Conservation Practices during Droughts*, explores how demand-side management can be applied to help close the expanding freshwater supply gap in industrialized urban centers, especially in drought conditions. The authors provide a US case study that serves as a model for mitigating drought in such settings in which demand-side options are cost effective, environmentally benign, less energy intensive, and often more socially equitable when compared to supply options.

Water and Human Rights Issues

Historically water has been considered as a common heritage. According to Alphonse X's Code, 'The Seven Resolutions', a compilation of laws enacted between 1256 and 1265 considered water as a public utility, *res communis*, not susceptible to private appropriation. The Code declared that rivers were public property whether they were navigable or not. In the same sense, Common Water Rights prevalent in Europe prescribed that surface waters be maintained uninterrupted and free flowing as they have been since ancient times. Even the Old English Common Law recognized a public right to common resources (public good), which was considered to belong to each and every member of the community. The resources were kept under the custody of the Sovereign who exercised control in order to preserve this public right, 'uninterrupted and inalienable', to the same. Water as a human right and how to finance water for all would be discussed in this section of the book.

The United Nations Committee on Economic, Social and Cultural Rights stated in 2002: "Water is a limited natural resource and a public good fundamental for life and health. The human right to water is indispensable

for leading a life in human dignity." *Water: A Human Right*, by Rosemann outlines how the definition of a sustainable access to water as a human right can help to challenge the global lack of safe, clean and affordable water. In order to explain this role, the author focuses on two predominant levels and scopes of action: the normative provisions of the United Nations with respect to the Millennium Development Goal and the demand to consider water supply and wastewater disposal a human right.

In the last chapter in this section, *Financing the Human Rights to Water as an MDG*, Rosemann discusses that the human right to water aims at guaranteeing the right to non-discriminatory and fair access to safe, sufficient and affordable drinking water to all the people in order to satisfy their personal needs (such as the preparation of food, the use of water for sanitary facilities and for domestic consumption). Safe drinking water means that the water quality must not risk people's health. Affordable water means that the expenditure for water must not jeopardize the fulfilment of other basic needs that are guaranteed by human rights – such as the right to education and food. But these normative objectives are far from being attained. One billion people still lack access to a sufficient water supply and some 2.4 billion people lack access to adequate sanitation. The problem of not having access to safe water and sanitation is mainly a problem of developing countries. Within these countries, rural and disadvantaged urban areas are the most concerned ones due to a low number of water accesses and bad or no sanitation services. Given these figures it is obvious that the implementation of the human right to water and the fulfilment of internationally agreed targets aiming at the improvement of drinking water and wastewater infrastructures require considerable funds.

With a growing world population and the already existing lack of access to water and sanitation services to everyone on the one side and ever shrinking public budgets on the other, there is a need for alternative solutions in how to cover the required investment. This chapter addresses among others the questions, if privatization, public-private-partnership and foreign direct investment in the water sector can deliver the solution? Or does the Human Right to Water run the risk of being commercialized in a way that it becomes a luxury product, affordable just to those who can pay for an adequate water and sanitation service? Beside explaining the risks within a pure commercial perspective this chapter also focuses on other solutions like cross subsidizing.

The IWRM concept is not a new concept. As discussed in a couple of chapters in the book, it has evolved from sectoral to ecological to integrated approach. In the integrated approach a bigger picture is seen rather than an isolated problem and the solution sought is also integrated in nature. This involves looking at the problem from a scientific as well as sociological

and economic perspective and involving community and introducing the concept of good governance in reaching at the best solution. Some of the upcoming issues related to better water management are good governance, gender involvement, community involvement, impact of climate change on water and waste water infrastructure, virtual economics, water conflicts (increase in water demand and decreasing water quality and quantity) or use of water as a source for co-operation, scarcity of water etc. This book does not deal with all the issues especially related to community participation it does address community participation issues in some case studies presented and gender participation – it does not suggest that these are not important issues but its the limitation of the book on how much it can cover.

2

Water and Food Insecurity in Developing Countries: Major Challenges for the 21st Century

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INTRODUCTION

The world's population is projected to reach almost 8 billion people around the year 2025 (UN 1999). This expected increase has raised considerable debate about the world's ability to meet future food needs (Rosegrant et al. 2001a; Scanes and Miranowski 2004). However, food is only one serious concern. The implications of a parallel, but related, growth in demand for water are profound and far-reaching. Already more than 1 billion people live without access to clean water, many of whom inhabit developing countries classified as 'water scarce'ⁱ. Yet the number of 'water-scarce' countries is expected to rise to 30 by the year 2025, of which 21 will be low-income food-deficit countries home to 1.8 billion people (IWMI 2000). The task of ensuring adequate access to water will therefore be one of the most difficult challenges facing development professionals in the 21st century; at least as hard as ensuring food security.

ⁱ Countries with renewable supplies of less than 1000 m³ per person per year, a minimum benchmark for being able to meet food, industrial, and household water needs while maintaining a healthy aquatic environment. Using a different but related measure—the *criticality ratio*, which measures the ratio of water withdrawals for human use to renewable flows (a ratio >40 percent defines 'water stress')—it is estimated that close to 4 billion people, more than 50 percent of the world's population, will live in water stressed countries by 2025.

This chapter explores key issues in household water security focusing on the multiple links between food and water concerns, and resultant policy implications for the 21st century. Water scarcity is a problem that is closely linked to income and food scarcity, since it hinges on issues of inequitable resource distribution. Many of the most severe constraints to overall socioeconomic development, such as malnutrition, disease and low productivity, are closely linked to a lack of water. But simply making more water available (through more efficient supply management) is not enough. The importance of water is not only related to growing more food to feed more people, nor even simply about universal access to piped water and sanitation; it is about the distribution of rights at a local level, even among the poorest people, to decide on, and control water uses in the face of competing demands—something that dams, privatized utilities or water markets alone cannot guarantee.

GLOBAL VERSUS LOCAL WATER SECURITY

As with food, the world has sufficient water at an aggregate level to meet everyone's minimum needs. Against estimated annual renewable freshwater supplies of between 9 and 14 trillion m³, global usage stood at around 4 trillion m³ in the year 2000 (Rijsberman 2004). Although global withdrawals have tripled since 1950 and are expected to increase by a further 50% by 2025, there should still be adequate supplies to meet growth in demand for the foreseeable future, if supplies are evenly distributed in space and time (Rosegrant et al. 2002).

However, like food, water availability is not matched by equal access for all regions or all people. Freshwater is unevenly distributed geographically and temporally, resulting in surpluses for some people and a threat of severe water insecurity for others. For example, Canada has 120,000 m³ per capita per year of renewable water resources compared with Jordan's 300 m³. Similarly, while India has a national average of 2,500 m³ per capita, some states, like Rajasthan, have only 550 m³.

Unfortunately, as with most aspects of economic development, the scarcities tend to be most severe where capacities to overcome them are the weakest. Sub-Saharan Africa has a dozen water-scarce countries already, and it is this continent which has the lowest share of population with access to clean water (for domestic consumption)—only 57% in 2000, but falling in rural areas to only 44% (UNDP 2003). This compares with an average coverage for all least developed countries of 62% (and 55% among rural populations).

Also, it is in the poorest countries, and the environmentally marginal regions of Africa and Asia that investments aimed at improving water

access are lowest. Not only is less invested in Africa (annual global investments in the water sector stand at roughly US \$80 billion per year but the bulk of that is spent in rich industrialized nations such as the United States, Australia and Israel), but costs are so much higher in Africa due to a lack of other supportive infrastructure—resulting in lower returns to investment and hence lower investment itself (Rijsberman 2004).ⁱⁱ

The importance of overcoming such constraints to water development and management in the world's poorest nations has been increasingly recognized and proclaimed. For example, in September 2000, the UN General Assembly adopted Resolution No. 55/2 (UN 2000). In this 'United Nations Millennium Declaration' the UN's members proclaimed *inter alia* that no effort would be spared to eradicate the "abject and dehumanizing conditions of extreme poverty, to which more than a billion [people] are currently subjected." To give this declaration substance a set of targets was agreed for the year 2015, including the goal of reducing the proportion of people without access to safe drinking water by half by 2015.ⁱⁱⁱ

Similarly, the Copenhagen Consensus meeting of 2004 brought together eight of the world's leading (mostly Nobel Prize-winning) economists to review 38 options, put forward by leading experts, for addressing the world's most serious problems. The panel concluded that improving water productivity in agriculture represented one of the nine best opportunities available to address the world's greatest challenges. Indeed it was estimated that total net benefits of making significant progress towards the 'water MDG' (halving the proportion of people without access to clean water by 2015) would be in the order of US \$300 to US \$400 billion (Rijsberman 2004). These are truly huge potential gains. So why are they so difficult to realize?

It needs to be mentioned that important gains were made during the 1980s (the International Drinking Water Supply and Sanitation Decade), when 1.6 billion people were provided with safe water and about 750 million with adequate excreta-disposal facilities at an estimated cost in excess of US \$134 billion for the decade (WHO 1996). However, much of the success was located in the so-called 'tiger economies' of South America and South East Asia. Once again the poorest countries have not seen much improvement—the share of Africa's rural population with access to clean water barely changed in the 1990s, while the share of Africa's urban

ⁱⁱ The average investment cost of large-scale irrigation with full water control is around US \$8,000 per hectare, but this rises to over US \$18,000 in sub-Saharan Africa (Rosegrant et al. 2001b).

ⁱⁱⁱ There is considerable overlap across the various MDG targets since many people without clean water also lack sufficient food; additionally they are over-represented among household facing high child mortality and maternal morbidity (two other MDG targets). Thus, improvements in water access among these households would have positive impacts far beyond an increased use of water per se.

population with such access actually fell during the period 1990 to 2000 (UNDP 2003).

Simply making more irrigation infrastructure or piped water supply available at a national level is by itself no guarantee that those households most seriously affected by water scarcity will benefit at all. Since water-scarce regions of water-stressed countries already suffer most from undernourishment and poverty these are areas most needing to be served and still least served. In other words, the problem is not simply one of water resource supply—it is equally about accessibility to supplies, appropriate usage once accessed, and the management of hazards that may impinge on all three.

‘More Water’ is Not Enough

If household water security is defined as ‘access by all individuals at all times to sufficient, safe water for a healthy and productive life and sustainable livelihood’, then the concept incorporates elements relating not only to water supply but also access, water quality (minimum thresholds of purity or absence of contaminants/pollutants), and the minimization of water-related risks to health and livelihoods. These elements can be grouped under three main headings: *Availability*, *Access*, and *Usage*.

For example, *water availability* is a function of supply, largely dependent on ecological factors, some of which can be degraded or enhanced by human action, and distribution (the mechanisms by which water is made useful to human (and ecosystem) activities). *Water access* refers to household control of a commodity. This is partly determined by modes of distribution (national policies and investment priorities play important roles here), and partly by effective demand; that is, how much a household can actually ‘take home’ (to kitchen, farm or trough). The latter depends on income, location (in relation to distribution channels), and sometimes on status. *Water usage* relates to individual entitlements, i.e. water as a public and private good.

Physiological absorption depends on quantity of water consumed, its quality (safety), perceived entitlements, environmental constraints (non-water-borne diseases), opportunity costs, and knowledge (human capital formation in relation to hygiene, sanitation, consumption, and disease control).

The framework also allows for two cross-cutting notions: namely, ‘risk’—that is, the reality that individuals may not be able to secure water when and where they need it—and ‘multi-tasking’, that is, that unlike food the same water can be used for more than one purpose. The risk of availability failure can be driven from the supply side through prolonged drought. Access failure can be caused on the income side by an economic shock that

sharply alters prices, thereby making poor urban dwellers reduce water consumption rather than pay more. Access failure may also result from the sickness or death of women in a household (perhaps through HIV/AIDS), thereby increasing the opportunity costs of fetching water for remaining adults. Usage failure may be a result of a lack of information on best practice or health constraints that reduce the potential benefits of adequate water access.

The problem is that until recently, most research on water was framed in a uni-disciplinary or uni-sectoral context. For example, research exists on the modeling of renewable aquatic resources at a global level—work conducted mainly by environmental specialists concerned with world ecosystem requirements (WRI 1996; Revenga et al. 1998). There is also considerable work on technical issues relating to irrigation-management efficiencies (Hillel 1996). Furthermore, a valuable body of literature has emerged during the 1990s on water-market efficiency, water rights and water-pricing models (Meinzen-Dick 1996; Easter et al. 1998).

However, far less attention has been focused on cross-sectoral relationships in water use and competition, on the realities of household-level competition for community-based water resources, or on alternative policy and institutional options to address equity concerns. As noted by Bhatia and Falkenmark (1993), “Economic policy-makers tend to confront policy issues one at a time, stating policy objectives in single dimensional terms. This approach presents difficulties because a policy aimed at achieving a single objective usually has unintended and unrecognized consequences. Water managers and policy-makers need to assess the entire range of government interventions to understand fully the economic, social and environmental impacts on a given sector, region or group of people.”

In other words, public action (government policies, donor or NGO interventions) may have a positive or negative impact on water supply, access, utilization or risks. A country’s development strategy and use of macroeconomic policies — including fiscal, monetary and trade policies — can directly and indirectly affect demand and investment in water-related activities (such as irrigation, flood control or dams). Even macroeconomic and sectoral policies not focused on water can have a strategic impact on resource allocation and aggregate demand in the economy. In the short-term, income transfer or equity-focused projects (such as irrigation investments targeted at women farmers), also have ‘upstream’ and ‘downstream’ linkages that must be considered in assessing the net impact of a single intervention.

The following sections consider major concerns in each of these domains relating to water security; namely, availability, access, usage and risks.

1. MANAGING LIQUID ASSETS: ISSUES OF WATER AVAILABILITY

Globally, roughly 10% of water withdrawals are used for domestic consumption, 20% for industrial uses, with the remaining 70% dedicated to agriculture.

The domestic sector, the largest user of water for non-irrigation purposes, is expected to rise some 75% by 2025 (over 1995 levels). Demand from the livestock side of the agricultural sector is also expected to rise by over 70% in that period, reflecting rising demand for meat and dairy products worldwide as a result of the process of dietary transition linked with progressive poverty reduction (Rosegrant et al. 2001b).

By contrast, irrigation will increase its consumption by less than 5% by 2025—a small figure which can be explained by the fact that irrigation is already by far the largest user of water withdrawals. Irrigated farming covers roughly 20% of the world's cropped area, and yet contributes roughly 60% of total grain production (Seckler and Amarasinghe 2004). It is estimated that given the current population growth projections (and linked growth in food demand), the world will need to produce almost 50% more food by 2025—up to 80% of which will have to come from irrigation (FAO 2003). This represents a large commitment of a scarce resource.^{iv}

Such increases in per capita withdrawals will rise more strongly in some regions than in others. For example, China and India are expected to increase water consumption almost three-fold by 2020 as a result of continued expansion and intensification of irrigation combined with macroeconomic and industrial growth (which together provide the resources for investment in further irrigation while also underpinning the increased food demand). Most of sub-Saharan Africa, by contrast, faces very low gains in water consumption. Importantly, this does not mean that Africa has lower *needs*, merely that it cannot increase consumption due to low effective demand (because of deep and even growing poverty), and the lack of resources to bring about effective supply. Indeed, it has been calculated that simply to meet the expected food needs of Africa's growing population by 2025 it should expand its water consumption more than three-fold, compared with Asia with 'only' needs to double its water off-take in the same period (Falkenmark and Rockstroem 2004).

^{iv} As a rule of thumb, it takes 1 m³ of water to produce 1 kilogram of wheat, 1.2 m³ to produce 1 kg of rice, and as much as 13 m³ to derive 1 kg of beef, due to the volume of grain fed to beef cattle, alongside large amounts of drinking water (Rijsberman 2004). A cow yielding 10 liters of milk per day under semi-arid conditions needs around 100 liters of water, but to raise that milk yield by one third requires a more than one third increase in the volume of water available to the animal (McDonald et al. 1990).

The question is how? It is paradoxical that when additional *food* needs are defined the conventional response is to seek to increase food supply; that is, analysts and policymakers immediately look for the most efficient and cost-effective investments needed to raise agricultural productivity—boost the supply. Where water is concerned this is not so easy. When *water* insecurity looms, calls are usually made not for more supply but for more rational (more optimal) usage, and ideally reduced demand.

In terms of linking optimal water usage with food production a lot of attention has been paid to irrigation efficiency, as well as water management in rainfed farming. The problem is that water use efficiency in irrigation in most developing countries is as low as 25 to 40%. That is, 60 to 75% of the water diverted or pumped for irrigation is 'lost' from the system via evaporation, leakage of canals, seepage or inefficient management (Rosegrant et al. 1997). Seepage can also cause water-logging and salinity. It is calculated that around 25% of all irrigated land in developing countries suffers from varying degrees of salinization (Bhatia and Falkenmark 1993). Moreover, stagnant water and poor irrigation drainage can escalate the incidence of water-related diseases, resulting in human suffering and increased health costs.

More efficient irrigation technologies, including 'directed drip' systems, canal lining, targeted sprinklers, and better irrigation timing and volume control, *could* lead to savings and contribute to enhanced water availability (Oodit and Simonis 1990).^v Recently there has been a proliferation (production and adoption) of smaller-scale, low cost water technologies for small-holder farmers without access to conventional irrigated lands, including electric pumps, treadle pumps (for lifting water located near ground surface), low-cost bucket and drip lines (for example, the popular Pepsee system in India which is a 'disposable' micro-irrigation kit made of low-grade plastic tubes), rainwater harvesting systems (including tanks, bunds and vegetative approaches to soil-fixing, already widely adopted across West Africa), and even groundwater recharge technologies (Falkenmark and Rockstroem 2004). According to Rijsberman (2004), the potential 'market' for such small-scale water technologies in Africa and Asia is more than 100 million households for whom direct net benefits would amount to around US \$100 per year.

Beyond agriculture there are other domains in which technological efficiency can make inroads in conserving water supply. Innovations that allow use of alternative sources or multiple reuse of existing water hold some promise, but mainly for situations where water-stresses are already high. For example, the cheapest desalination technologies (producing drinkable water at US \$0.5 to US \$1 per cubic meter) are still too costly to

^v According to Radwan (1998), the savings linked to widespread adoption of such efficiency measures for Egypt's delta region could be on the order of 30 %.

be contemplated outside wealthy countries with relatively low population densities. In 2002, there were almost 13,000 desalination plants in operation in 120 countries (two thirds of those in the Arabian peninsula), producing 14 million cubic meters of water per day—roughly 1% of global usage (Rijsberman 2004). However, energy costs are extremely high at 6 kW per cubic meter of water desalinated through reverse osmosis. Thus, where large volumes of water are needed at low cost on a regular basis, affordable technology remains unavailable.

Pumping from deep groundwater sources is common, thanks to lessons from the oil industry, but such reserves are finite and there are environmental externalities attached, and costs of pumping water are high. For example, in Amman, Jordan, the average incremental cost of groundwater is US \$0.41 per cubic meter, but since demands are so high, water is being pumped up from a depth of 1.2 km (40 km away from the city) at a cost of US \$1.33 per m³ (Rosegrant 2001b).

Recycling offers potential gains. Closing the cycle of water-coolant systems for some industries would help since water would be used multiple times. The problem is that required system changes can be costly and manufacturing industries in developed countries have little incentive to make such investments since they pay only a fraction of the actual cost of water (Oodit and Simonis 1990).^{vi} Multiple usage of water does already occur since ecosystems make use of upstream water flow prior to human extraction. The extracted water may be used in an urban setting before later being diverted again for hydroelectricity generation or for agricultural use, as in Egypt where urban waste water is rechanneled to desert-based irrigation schemes. Indeed, roughly 20 million hectares of irrigated agriculture is fed directly or indirectly by wastewater in 50 countries. For example, in Pakistan one third of wastewater produced in the country is reused through irrigation (Ensink et al. 2004).

Gains are also possible in many municipal supply systems where leaking affect urban water utilities and recycling is not yet institutionalized. In Manila, the Philippines, over 50% of treated water distributed through public systems is unaccounted for, compared with only 8% in Singapore (Bhatia and Falkenmark 1993). Water losses in Latin America during the 1980s cost more than US \$1 billion in forgone revenue each year (Schmid 1987). Some loss is due to 'theft' through unregistered taps, but a lot results from inadequate metering, poor control systems or pipe breakages.

^{vi} To dilute and transport (flush out) a volume of 450 m³ of waste water entering the world's rivers after 'first usage' already requires 6,000 km³ of unpolluted water (WRI 1996). As urban and industrial areas grow so will the quantity of waste water produced, thereby raising demand for more 'clean' water for the flushing process. Without substantial investments in waste-water treatment, and more effective quality regulation, much more water will need to be diverted to the flushing process in future.

Yet technical efficiency which improves supply management is only one aspect of the solution. In addition, attention has to be paid to enhancing the efficiency of distribution, and hence the accessibility of water, to all consumers but particularly those who need it most.

2. WHO TURNS THE TAPS?: ISSUES IN WATER ACCESS

While considerable attention has been paid by the scientific community to demand management where such demand is already high, much less attention has been paid to problems associated with increasing effective demand for water where current usage is sub-optimal. Countries like Ethiopia, Sudan and Uganda share one of the world's most important rivers (the Nile), but each provides less than 50% of its inhabitants with access to safe water (UNDP 2003). One reason for this is that despite what limited public investments have gone into water development (in what are very poor countries), most have been directed more into dam-building for large-scale irrigation, urban supply/sanitation and/or hydro-electricity generation than towards rural community-level provision of clean water.

In theory, public sector investments should have the potential to benefit all citizens, but concerns for economic and technical efficiency often override such a concept. For example, a recent review of 192 World Bank-supported irrigation projects (implemented between 1950 and the mid-1990s) found that more than two-thirds performed satisfactorily, with an average rate of return of 15% (Lipton et al. 2003). However, most of these were large schemes benefiting larger land-owners (as in northern India). There were, of course, secondary benefits to the less wealthy, through increased employment and the potential for reduced food prices, however these potential gains (including the potentially lower food prices) do not always spread much beyond the immediate hinterland of irrigation schemes because of market constraints, price controls, or simply transport infrastructure deficiencies.

Even in regions benefiting from increased irrigation productivity and reduced poverty the distribution of gains (or lack thereof) can lead to social friction. For example, Kaosa-ard and Rerkasem (2000) argue that long-run equity concerns in the distribution of water in Southeast Asia are leading to a danger of social conflict and violence over the use of remaining resources that could compromise the social fabric of some Asian societies. Similarly, El Kady (2004) suggests that in many Middle Eastern countries, "there is a relationship between injustice and water scarcity" that is mediated through government inability to manage water resources efficiently or to ensure that the poor not only have access to water and are protected from pollutants delivered to them (from the upstream rich) via industrial and

agricultural waste. There are also reports that as much as 30% of the world's irrigated area is now affected by salinization and waterlogging (largely due to poor water management over many decades), leading not only to reduced productivity but also to reduced labor demand—which further reduces the potential indirect benefits of irrigation to the poor (Hansen and Bhatia 2004).

It is therefore in countries facing severe water stress, weak institutional capacity (in regulatory terms and in relation to protecting the interests of the poor), that water markets have been proposed as a means of improving both efficiency and equity.

Commodity Markets: A Solution for the Poor?

The arguments commonly given in support of removing water policy and management from the public sector are two-fold. On one hand, government control of water distribution has typically involved public subsidies with a view to 'making water affordable'. For example, subsidies paid in Mexico until recently to operate and maintain water systems (excluding capital investment costs) amounted to 0.5% of GDP (Rosegrant 2001b). In India, about 30% of all public investment has gone into establishing irrigation systems, for which water was then supplied almost without cost to the users (Bhatia and Falkenmark 1993). Yet, subsidies have rarely benefited the poor simply because they tend to be physically removed from piped services or irrigation perimeters. Shifting control of water management and distribution to the private sector is seen as a way of both increasing efficiency and reducing political distortions in the benefits of water access.

On the other hand, it has also been documented that poor households already pay relatively more for water than wealthier households, and would be willing to pay even more for a good service. For example, urban slum dwellers, who depend on street water vendors may pay up to 100 times more for their water than if they had access to conventional public utilities. In Parana state, southern Brazil, many households are not willing to pay for public taps, but would pay 2% of their household income for yard taps (World Bank 1993). In Imbaba (a community near Cairo), some households spend 8.5% of their income on water (Cestti 1995). In Onitsha, Nigeria, poor households spend 18% of their income on water during the dry season versus 2 to 3% spent by upper-income households (Whittington et al. 1991). And studies in Pakistan and Indonesia also found that households were willing to pay as much as 40% and 30%, respectively, more per month for a *reliable* service than for the existing (unreliable) service (Altaf et al. 1993; Cestti 1993).

The apparent willingness to pay for water among the poor, coupled with the rigors of macroeconomic reform during the 1980s and 1990s, brought many developing countries to reassess their role in water provision. For example, countries like Chile and Mexico replaced large-scale water

subsidy programs with various systems of tradable water rights, privatized infrastructure, and cost-recovery (Hearne and Easter 1995). Chile's 1981 water law granted users (farmers, industrial firms, power utilities) property rights to water without charge. In addition, the state auctioned new water rights. Subject to public regulations these rights can be sold for any purpose at freely negotiated prices. Mexico also established water property rights in the 1990s, although restrictions were initially put on inter-sectoral trading. And Peru's 1993 constitution accords equal status to land and water resources and permits tradable rights to both (Thobani 1995).

Early evaluations of such experiences lend qualified support to the argument that economic benefits can outweigh the potential political fallout. There is evidence of water savings and economic gains in many areas (Easter et al. 1998). However, there are two caveats. First, most of the 'positive' evidence has so far come from countries which already had high levels of infrastructure development, foreign direct investment, and large (irrigated crop) export capabilities (Brehm and Castro 1995; Bauer 1997). Indeed, UNDP (2003) concludes that "success in privatizing water services largely depends on government regulation, investor interest and the initial state of the enterprise. Countries with decent services before privatization often continue to do well after." This does not include most water-stressed countries in which private countries are not interested (or even able) to expand water services to the remote rural poor since it is essentially unprofitable to do so.

The second caveat is that even where economic efficiencies are documented it remains unclear what the equity outcomes have been. Chile, Mexico and Colombia are countries with fairly well-developed factor markets and institutions and yet even in these countries benefits of the shift to water markets are not seen to benefit the poor anymore than the rich (Gomez-Lobo and Contreras 2003). Well-functioning private markets are not cost-free. Strong public regulatory oversight, trusted legal (contractual) systems, a core infrastructure network, and transparent management appear to be prerequisites for successful hand-over of public responsibility to private entities (Gleick et al. 2002). What is more, according to UNDP (2003), "sustained service provision is best achieved through the efforts of local communities and firms...and building this is an important role for government." This requires attention to vital social and cultural dimensions that also relate to 'equity'.

Indigenous Institutions

At a time when the privatization of water allocation responsibilities and the creation of markets in water rights are offering gains in economic efficiency, there is increasing attention to the non-market dimensions of water. Indeed, the concept of water as a tradable economic good has recently become the focal point of much contention in the debate on how

to achieve greater efficiency and distributional equity in water services. Some religions (such as Islam) prohibit water allocation by market forces, and others treat water as a sacred good, a symbol of natural wealth that should be protected from the commercial rationality of the marketplace. As Gleick et al. (2002) argue, “water has vital social, cultural, and ecological roles to play that cannot be protected by purely market forces.”^{vii}

It is often argued therefore that the pursuit of equity in development requires that more attention be paid to indigenous water institutions that play a role well beyond water or even agriculture per se. Elaborate indigenous institutions have existed for centuries in many water-scarce environments. Such institutions are embedded in cultural and societal structures that at times operate differently from trade mechanisms based on price. According to Radwan (1998), water systems must be understood in terms of the cultural setting within which they operate: “the formal and informal power structures which govern social behavior... interact to create the functioning village.” There is a growing professional acknowledgement that non-state institutions (indigenous, traditional, informal) can exert a huge influence on the success or failure of development interventions in general, and water interventions in particular (Miller et al. 1996; Saywell 1998).

As Radwan (1998) notes for Egypt, “formal structures created to replace informal traditional structures have been less successful than envisaged and are themselves the sources of many... problems.” This is not to suggest that all indigenous institutions always protect the needs of the poor. Poor, water-insecure households are often marginalized by informal, culture-bound norms that may protect the interests of the community, but also benefit the interests of an influential elite. For example, water rights among the Sonjo people of northern Tanzania are regulated by an institutionalized group of elders (the Wenamiji) who have long controlled the management of water for hill-furrow irrigation (Potkanski 1987). Failure to cooperate in communal duties of irrigation maintenance or the ‘theft’ of water can result in the Wenamiji’s imposing fines or expulsion of the culprit from the community (Adams et al. 1994). It is hard for individual Sonjo households to operate outside of the institutional norms of the locality.

The challenge is therefore to inter-relate technical and economic concerns with the realities of social control in new ways that can be more directly beneficial to the poor—which is not as straightforward as it may seem. Asthana (2003) points out that the benefits in India of decentralization of authority for water distribution/regulation “are not as obvious as the

^{vii} In 2002, the United Nations adopted a General Comment on the right to water as part of the U.N. Covenant on Economic, Social and Cultural Rights (CESCR). This was the first time that water was explicitly and separately recognized as a human right. As of mid-2004, 145 member states of the U.N. had ratified the Covenant.

standard theory of fiscal federalism predicts.” While UNDP (2003) cautions that “the private sector’s reluctance to fund less profitable investment in poor rural areas hurts users”, and this cannot easily be rectified without stronger empowerment of local, accountable institutions to regulate costs and coverage. Even close government regulation of privatized systems in Chile aimed at ensuring that no household spends more than 5% of its income on water results in “unnecessarily high fiscal costs” (which reduces the resources available for extending and improving distribution systems) due to large targeting errors that continue to benefit already wealthy households.

In other words, access to clean water for the world’s billion poorest people will not be enhanced simply through privatization of existing delivery systems or enhanced management of supply. Strong government oversight of private markets has to be matched by strong involvement and oversight of local institutions, which in many cases will have legitimate social/cultural concerns that outweigh economic efficiency as a priority. What is more, ensuring that equity concerns are addressed requires much more attention to quality, not just quantity.

3. NOT ALL’S WELL THAT ENDS IN WELLS: HOUSEHOLD WATER USE

It is estimated that 1.2 billion people do not have safe (clean) drinking water and almost 3 billion lack adequate excreta disposal facilities (Rijsberman 2004). Without access to a minimum of 15 to 20 liters of safe water per person per day, a household faces serious risks. Unsafe water, sanitation and hygiene together represent the 6th highest risk factor in relation to the global burden of disease—but in developing countries with high mortality rates water problems jump to 3rd in the list of risks to health (WHO 2002). Thus, while not having enough water on a daily basis is a major problem for millions of people, often *having* water but of compromised quality is just as much a concern.

For example, some water is actually poisonous. Many Bangladeshis were seriously affected in the late 1990s by water containing high concentrations of arsenic, derived from wells sited over geologic deposits of arsenic (Nickson et al. 1998). India provides another case where deep boreholes sunk in the state of Madhya Pradesh during the 1980s were inappropriately sited. Some boreholes were tested and found to be free of harmful bacteria, but the water was never tested for naturally occurring chemicals. In that case, high concentrations of fluoride resulted in cases of fluorosis for at least 60 million people, of which 6 million were children (Pearce 1998). Drilling deep wells to get below contaminated or saline

water courses may seem logical, but it may instead be a much more expensive and potentially dangerous solution.

Other sources of water are merely harmful. There are five main categories of diseases related to water: i) water-borne diseases (typhoid, cholera, dysentery, gastro-enteritis and infectious hepatitis); ii) water-washed infections of the skin and eyes (trachoma, scabies, yaws, leprosy, conjunctivitis and ulcers); iii) water-based diseases (schistosomiasis and guinea-worm); iv) diseases from water-related insect vectors such as mosquitoes and blackflies; and v) infections caused by defective sanitation (hookworm).

A recent study of water-disease interactions in relation to the global burden of disease (calculated in Disability Adjusted Life Years (DALYs)) concluded that diarrhea remains the world's biggest water-related health risk with roughly 4 billion cases per year resulting in between 1 and 2 million deaths per year and as much as 76 million DALYs lost (Pruess et al. 2002). Africa is the worst-affected, with an average diarrhea-related mortality rate of 17 per 1,000 (Sharma 1996). Adding the impacts of these other main water-related diseases listed above results in a total impact of 2.2 million deaths and more than 82 million DALYs per year (Pruess et al. 2002).

The positive effects on health and nutrition appear to derive from multiple interactions among improvements in household sanitation and hygiene practice, improvements in water quality, and increasing the quantity of water consumed. In countries as diverse as Kenya, Pakistan, Guatemala and Sudan it has been shown that access to clean water (from pipes or private wells) is strongly correlated with household food insecurity, which itself is strongly correlated with poor nutritional outcomes among preschool children (Haddad et al. 1996; Merchant et al. 2003). However, improvement in only one of these areas is unlikely to lead to a sustained decline in morbidity. In some cases water quantity matters more than quality in terms of health and nutritional outcomes since many diseases are mediated through a lack of sanitation and hygiene rather than unclean water for direct consumption (Hoddinott 1997). This issue is closely linked to the proximity of poor households to water points and to the time available for poor women, in particular, to gain access to those points.

Gendered Opportunity Costs of Time

As in most other aspects of development gender is an issue in water, particularly in relation to their opportunity costs (time). Problems arise mainly in time constraints for women responsible for water hauling, carrying and domestic water chores, and in terms of access rights to water for productive use, particularly irrigation and home gardening.

Women in water-stressed environments spend a lot of time fetching water, which limits how much water is used. Village-based stand-pipes or

pumps can increase water usage four-fold simply by reducing the time required to obtain water (Cairncross 1987). Some women in Burkina Faso have to travel such long distances that they optimize time by choosing water sources lying in the same direction as their farms, where they can stop and work for an hour or two before completing the fetching and carrying (Zwarteveen 1997a). In southern Ethiopia, women spend 12% of their waking time collecting water to meet household needs (Coppock 1994). Their source is usually a well or spring that lies an average of 14 km from home.

However, water for agricultural production is an equally important concern. For example, a project aimed at reducing the time required for fetching water among Boran pastoralists of Ethiopia installed cement cisterns to capture rain and run-off. The siting of cisterns near encampments cut the time required for a round-trip from 3 h to 15 min (Coppock 1994). The result was a 74% increase in water consumption, 90% of which came from the new cisterns. Yet, there were two unexpected side-effects. On the one hand, women's time spent fetching water changed little; although their trips were shorter they went more often, making an average of 10 trips per week versus 5 trips per week previously. The net effect on women's time was neutral. On the other hand, although total household consumption rose the increase in water used for drinking, personal hygiene and washing clothes was minimal. The bulk of increased water use was accounted for by a more than three-fold increase in consumption by their livestock. In other words, the women decided to use the water gains to invest further in their capital stock. Their time constraints were not reduced by the intervention, but they did gain in productivity.

Productivity concerns also loom large in the context of women's participation in the management of irrigation. On one hand, women are often sidelined by the introduction of new technologies or techniques (including the establishment of tradable water rights or new irrigation schemes), and so distribution and equity concerns need to have a high priority in the assessment of perceived water needs (Webb 1989). On the other hand, net productivity gains from system changes are greater if women are involved as partners in the design and introduction of technologies and/or at least given access to water and land in their own right (Zwarteveen 1997b). For example, numerous studies of the Chhattis Mauja irrigation scheme in Nepal underline the 'success' of a project for which infrastructure was built by the users and "all users are involved in the irrigation organization" (Yoder 1994). The project was productive, appearing to support the case for management by users' associations.

However, there is a large group of users involved neither in the management of the scheme nor in its maintenance; namely, women farmers,

who are not consulted because they do not belong to the users' associations, and they help themselves to the water which is needed and avoid participation in infrastructure maintenance. Since they are not members, the users' association cannot easily enforce its rules on the women, who in effect have become free-riders by default (Zwarteveen and Neupane 1996). While the women were not unduly disadvantaged in economic terms this arrangement creates performance weaknesses in the scheme because of a lack of control over water withdrawal and a lack of labor mobilization at the 'head end' of the canal system.

Such examples not only suggest that women should be part of users' associations and be producers in their own right, but also that women's time in agriculture, like men's time, is more valuable where water management is improved. Finding ways to enhance the productivity of women's time through water projects is one of the challenges facing food and water policymakers.

4. SURPLUSES AND DEFICIENCIES: WATER-RELATED RISKS

Flooding and drought remain the two biggest 'natural' threats to life, as well as to food security and water security worldwide. During the decade of the 1990s over 665,000 people died in the context of natural disasters, of which 90% were water-related crises—97% of whom were inhabitants of developing countries (UNWWDR 2003). What is more, roughly 1.5 billion people were affected by floods during the 1990s (WMO 2004). The number affected is always much higher than the number killed, but when 60% of an entire country like Bangladesh disappears under water (as it did during 2004) then huge numbers of people have their livelihoods compromised.^{viii} Furthermore, poor country governments are also seriously affected by floods. For example, the commissioner of disaster preparedness in the Office of the Prime Minister of Uganda recently stated that "in Uganda climate-related disasters such as drought and floods...contribute over 70% of natural disasters and destroy an annual acreage of 800,000 hectares of crops, making economic losses in excess of sh120 bn [roughly US \$69 million]" (Epaija 2004).

Similarly, between the mid 1960s and mid 1990s, there were 284 major droughts (water deficits) resulting in the death of over 885,000 people and seriously affecting the livelihoods of a cumulative total of 2.4 billion people worldwide (USAID 1995). Most of these droughts occurred in semi-arid regions of developing countries, including (but not restricted to) China, India, Pakistan, north-east Brazil, the land-locked Sahel, the eastern African

^{viii} Over 30 million Bangladeshis were left homeless by the floods of 2004 and 20 million people required food assistance for 6 months or more because of lost income streams.

Rift Valley, and southern Africa. However, the greatest impact has been in Asia. Every year since the early 1980s over 400 million people on an average have been directly exposed to a flood. Between 1987 and 1997, 44% of all flood disasters worldwide affected Asia claiming 228,000 lives (93% of flood-related deaths worldwide). Economic losses for Asia in that time period totaled US \$136 billion (UNU 2004).

According to a recent United Nations University study (2004) the number of people threatened by floods is going to increase from 1 billion per annum today to more than 2 billion by 2050; similar numbers relate to the threat of drought. The causes related to climate change, deforestation, rising sea levels and, importantly, increased concentrations of poor people in either flood-prone or environmentally marginal, often semi-arid lands. The cost of constructing flood-resistant buildings or developing relatively drought-resistant crops and livestock is small compared with losses actually incurred in recent years. Meanwhile forecasting and warning systems commonly show a cost-benefit ratio of 10 or 15 to 1. While little can be done to prevent large-scale floods or droughts, increased planning for extreme events and improved medium-term food policy-planning are all required in the short run if only to protect against erosion of past gains. Indeed, shifting policymakers' attention to the need for investments in preparedness and effective warning systems aimed at minimizing non-insured losses and productivity foregone is a priority in humanitarian terms, but also one that is central to the issue of water management.

CONCLUSIONS

Water and food are two of the necessities of life, and they are inextricably linked. Just as food security cannot be achieved for all simply by making more food available (even today adequate global food supplies coexist with over 800 million chronically undernourished people), enhancing the supply of water to under-served countries will not suffice where household water security is concerned. On the one hand, targeting the needs of *least served* households is essential since these hundreds of millions of people bear the brunt of the economic, nutritional, and health deprivations that go along with low water consumption. This is a developmental priority of the highest order that involves enhancing access to clean water but also enhancing access to water for smallholder agriculture (rainfed and ground-water management as well as smaller-scale irrigation). On the other hand, ensuring water quality matters not only to reducing the terrible global burden of water-related diseases, but also in maintaining ecological integrity of fragile, as well as presently highly-productive ecosystems.

In other words, progress towards household water security for all requires a fuller understanding of the multiple characteristics and functions of

water—as a natural resource to be managed, but also an economic commodity to be optimized *and* a human entitlement to be fulfilled. Policy makers cannot lightly dismiss the relevance of entitlement or cultural concerns, and social research must also integrate the long-term inter-generational relevance of ecological integrity. Equally important is an understanding of how alternative policy instruments influence water security across competing economic sectors (agriculture, industry, domestic consumption, environmental management), and across different scales of activity. The search for solutions to competing demands continues to be based too heavily on analysis of each function separately: market solutions for competition for a commodity, technical solutions for problems of supply, policy and regulation solutions for competing societal entitlements. Potential solutions can only be adequately assessed if attention is focused on net effects.

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Section 1
**Freshwater—
Groundwater, Surface Water**

3

Freshwater—A Scarce Resource: Its Global Utilization and Sustainable Work Practices in Melbourne, Australia

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INTRODUCTION

Freshwater, we drink it, we wash with it, we cook with it, we use it for recreation, agriculture and industry. The abundance of water or its scarcity often decides where we live and our prosperity also depends on the quantity and quality of water in that region. In spite of its importance for the survival and welfare of all living beings, water is often misused, rather abused both at the industrial and domestic fronts. Earth water resources consist of freshwaters from lakes, streams, rivers; saline waters from the oceans and the seas, the ice and snow of the polar region, mountain glaciers, and the water contained in the soil and underground strata. Freshwater is less than 3% including freshwater-ice located mainly in the polar region and the remaining 97% is saline water and sea ice. For human use, availability is a meagre 0.003% of total freshwater, the rest is often too expensive before it can be made available for human use. For all practical purposes it can be assumed that the water of the hydrosphere was of natural quality until the Industrial Revolution in Europe and North America.

At present the entire hydrosphere is contaminated due to human activities except polar ice, which was formed before the industrial revolution and human activities were not been able to tamper with it. Although the majority of freshwater resources have been polluted, yet this water remains suitable for diversified legitimate human activities. This kind of situation is fairly common worldwide in urban as well as in rural societies. It is also reasonable to assume that the demand for freshwater for domestic, industrial and agricultural purposes is on the increase leading to a decline in the water quality in the ambient environment. In many parts of the world, low rainfall coupled with excessive abstraction of groundwater has led to drying out or reduction in many inland streams.

In section 2 the sources of freshwater and the consequences of human interferences have been discussed. Section 3 deals with the harvesting of freshwater from natural sources. Social impact on the local communities has been presented in section 4. Melbourne's freshwater situation has been presented in section 5. Environmental impact of human activities in Australia has been discussed in section 6. In section 7 we have made some general remarks on water as a scarce global resource and finally in section 8 some concluding remarks have been presented.

SOURCES OF FRESHWATER, ITS UTILIZATION AND CONSEQUENCES OF HUMAN INTERFERENCE

There are many sources of freshwaters and these vary from country to country and within a country from city to city. In many countries, by and large, surface water is the primary source. However, in some places water from other sources is also drawn e.g. artesian water and saline water from the sea is made potable after adequate treatment. Agricultural practices have raised the water table and consequently bringing salt to the surface. This is particularly likely if there are no deep-rooted trees to lower the water. In addition irrigation water may also contain some salts. Its continued evaporation can leave a deposit of those salts on the land.

About 18% of world's cropland is irrigated and this area produces about 33% of world's food because irrigated land is usually more productive than rain-dependent land. However, irrigation can also, over time, lead to a rise of groundwater and thus salination of the area. Salination is a problem in many parts of the world including Australia. Each year there is an increase in the area going out of productivity due to salination. In Australia alone 20,000 farms or two million hectares of agriculture land shows signs of salinity and 800,000 hectares of land is unusable for agricultural production. Among various states, Western Australia is most affected by salinity with 7000 farms and 2 million hectares showing saline

signs. Non-irrigated farms make up 1.8 million hectares or 93% of the land showing signs of salinity. Eighty-two per cent of the farms showing salinity were used for beef cattle and sheep grazing. Agricultural practices and deforestation can increase soil erosion into lakes and rivers and create torrents and floods. The greatest impact of deforestation on water flow comes if and when trees are removed from a slope. During heavy rainfall, as a consequence of deforestation of a hillside, the water will run down the bare slope quickly, forming a torrent at the lower reaches of the river. This situation is well illustrated in a densely populated country like Bangladesh. Almost every year monsoon results in heavy rainfall for a few weeks on Northern India and the surrounding regions including Bangladesh. When the foothills of the Himalayas were covered with trees, Bangladesh suffered a major flood about twice in a century. Now it endures one about every four years on an average. Currently floods are more intensified because rivers are carrying much more water sediments, which spread out over the country in massive runoff flooding the deltaic plains of Bangladesh. During 2004, two thirds of the country was flooded and according to official sources more than 20 million people were affected.

HARVESTING OF FRESHWATER AND IS POTENTIAL IMPACT ON RIVER DOWN STREAMS

Construction of barrages, dams and canals to take water to arid parts of a country is not a new idea; it has been practised over thousands of years. The Indians built barrages and maintained a network of cuttings and canals to take water from the Indus River and distribute it across thousands of square kilometres. The Australian aboriginal people built large stone constructions on the Darling River and at other places to catch fish. At present rivers are dammed for various purposes; these include flood control, source of potable water, irrigation, generate hydroelectric power, etc. This process continues at an estimated rate of about 700 new dams each year. Globally on an average about 60–70% of the world consumption of freshwater is for irrigation, only 8% is for domestic purposes. The potential impact of damming on a river's down stream causes restricted flow patterns of sediment transport and release of cold water from the bottom of reservoir. All these can have an impact on biotic diversity of down stream. Large rivers like the Nile, the Brahmaputra and the Ganges naturally transport sediments and deposit them either on the flood plain or at the delta. In these regions the build-up of naturally rich sediments have created fertile land or has helped to fertilize the land for the next generation of crops.

Some of the problems caused by the dam built in 1960 on the River Nile creating Lake Nasser are shown well by the Aswan High dam in Southern

Egypt. Prior to the construction of the dam, the annual flood restricted the use of the land until water receded and the floodwater left a cover on the ground with dark wet silt. Although farmers are able to grow those crops, which were produced prior to the construction of the dam, they are deprived of the natural fertilizer. Other people such as brick manufacturers lost the sediments and clay, which was their raw material for their product – brick. Floods also removed salt from the soil, which now gets accumulated. The sediments normally carried by the river remain in Lake Nasser. As a consequence, the fertile land within the delta is no longer rebuilt by fresh sediment deposition. This has also led to erosion of the existing islands and intrusion of seawater in the low lying areas.

SOCIAL IMPACT OF DAMMING ON LOCAL COMMUNITIES

Large dams force local residents to move away to create space for dam water to spread out, forming artificial lakes. In the case of the Yangtze River in China, millions of living beings have had to migrate away from their natural homes. In Northern India when Narmada River was dammed several towns and villages were blessed with a watery grave. In olden days planning of such large projects concentrated mainly on the scientific, engineering and economic aspects but due consideration was not given to environmental and social issues. Quite often social costs may outweigh the economic benefits, but it is too late to do any thing. This situation is clearly illustrated in the case of one of the world's greatest rivers the Mekong in Asia. The river has been reduced to a trickle in many places by a series of giant dams in China and thus threatening livelihood of up to 100 million people in South East Asia. The flow in the river at the end of the 4830 km journey that it takes from the Tibetan plateau through China, Myanmar, Thailand, Laos, Cambodia and Vietnam is severely affected. The down stream countries that are dependent for food, freshwater and transport fear that China's plan for a further six major dams could be disastrous for them. Only 20 years ago, the Mekong, one of the most untouched rivers, has become one of the most dammed rivers in the world with more than 100 major dams. About 80% of the rice produced in the lower Mekong basin depends on the water, silt and nutrients provided by the flood of the river. More dams means less flood and this translates into less agricultural benefits in terms of silts and nutrients.

Taking freshwater out of the river for irrigation also causes problems in the area that they drain into. A good example is provided by the Aral Sea, an inland lake bordering on Kazakistan and Uzbekistan. Overutilization of water from the rivers that drain into it has caused the water level to drop by several meters, large parts of the lake that were inundated have now

been exposed and are covered with salt deposits. Fishermen are failing largely due to the loss of the fish breeding habitat and the doubling of the salinity in the lake. The rivers have been exploited for irrigation and their levels have dropped so much that the saline water from the lake has started to flow in reverse into the river making them more saline and less suitable for irrigation.

Another example of the salt water flowing in the reverse direction is seen in the sea of Azov, between Russia and the Ukraine. The lake is connected to the Black Sea. The constant inflow of freshwater from the Azov Sea maintained its salinity lower than the sea. As a result of various diversions from the river, the water inflow into the lake is reduced and has led to an increase of salinity in the sea of Azov. Similar examples of environmental deterioration due to overexploitation of freshwater resources are well known in Australia. One such example is the Murray Darling River System, which experienced this phenomenon early in 1990 affecting the quality of life of the people in that area.

Australia is the second driest continent on the Earth. It is also the driest inhabited continent. It currently supports a healthy population of about 19 million, which is spread over mainly the coastal areas where supply of freshwater is unrestricted during the years of average rainfall. Many rivers have been dammed and catchment protected to ensure a reliable and safe water supply for industrial and domestic purposes. Since the European settlement about 200 years ago, extensive areas of native bush and grass land have been cleaned to establish a viable primary industry, such as sheep and cattle grazing, growing crops including cereals, oil seeds, fruits and vegetables, cut flowers etc. Many of these primary produces are export-oriented. The water usage figures show that irrigation farmers remain by far the biggest users of Australia's water resources. For example, water consumption accounting figures indicate that in 2000-01, two-thirds of all water consumed was by farmers. The Australian Bureau of Statistics (ABS) estimates that of almost 25,000 giga litres of water was consumed in 2000-01, of that 16,700 giga litres was used to irrigate pastures, cotton fields, rice fields, sugar cane, grapevines, fruits and vegetables. The consumption of water by various industries during 2000-01 is as shown in Table 3.1.

The domestic consumption shows an increase in the use of water in 2000-01, compared to seven years earlier. An average per capita domestic consumption during 2000-01 was 115,000 litres compared to 95,000 litres seven years earlier. Due to drought conditions prevailing in Victoria, the Victorians were restricted of water use, even then a typical Victorian used 102,000 liters, which is 10% more compared to 1993-94 figures. On an average each Australian used 51,000 litres of water in their garden or into their swimming pools. Another 23,000 litres used on bathing 17,000 litres

Table 3.1. Water consumption by various industries

2000-01 Consumption	Giga litres	%
Agriculture	16,660	4.2
-Dairy	2,834	7.2
-other Producers	5,568	1.4
-Cotton	2,908	7.4
-Rice	1,951	5.0
-Fruits/vegetables	1,358	3.5
-Sugar	1,311	3.3
-Grapes	729	1.9
Households	2,181	5.5
Supply/sewerage	1,794	4.6
Electricity/gas	1,688	4.3
Manufacturing	866	2.2
Environment	459	1.2
Mining	401	1.0
Total	39,397	100.0

in the toilet, 15,000 litres in the laundry, and 9,000 litres in the kitchen. This consumption is not significant, if we look at the consumption of water in agriculture. For example, in New South Wales rice growers alone used almost 2000 giga litres, which for comparison is sufficient for 7.3 million Australian households put together to produce rice worth just US \$350 million. Thus the bulk of freshwater (irrigation water) was utilized for farming activities producing relatively small returns per mega litre used. Irrigated dairy and beef pastures, wheat and rice fields, and sugar cane plantations between them used 70% of irrigation water, whereas high-return products such as fruits, vegetables, grapes for wine, cotton and cut-flowers used only 30% of the irrigation water. The ABS found that the area under irrigation had expanded by 450,000 hectares or 22% in past four years despite concerns of the overuse of freshwater resources especially in the Murray-Darling system.

The damming and harvesting of rivers in Eastern Australia has stressed the rivers, specially, during drought years to a level that have started to show adverse ecological conditions. The inflow during the warmer months is too low to sustain a biodynamic equilibrium. The breeding habitat of freshwater and fresh food organisms is either destroyed or badly affected. Examples of such exploitation are found all over the country. To name a few:

1. In Tasmania, during 1960, the ancient Lake Peddar and its catchment was drowned by damming to create Gordon dam to produce hydroelectricity. The Government of the day did not see the value in preserving Lake Peddar and the fauna and flower in its natural form.

Many of the endemic species inhabiting interstitial water of the sandy beach areas drowned forever.

2. In Victoria, many of the rivers have been dammed for the generation of the hydroelectricity or as a source of public water supply. Currently Victoria is experiencing a severe drought since 1996. Most of the storages are below 50% and water restrictions in major cities and towns. The catchment of various water storage reservoirs for Melbourne and the Metropolitan area are protected according to the Victorian Government's 2003 'Water Green Paper', rivers with less than 70% of natural flow are likely to be stressed (Hodge 2003). The general public is not allowed in the area, fishing and any other kind of recreational activities are not allowed in the reservoir.

THE CITY OF MELBOURNE, ITS CURRENT WATER SITUATION AND COMPARISON WITH OTHER AUSTRALIAN STATES

Melbourne is one of the few cities in the world that draws most of its water from protected forested catchments. The uninhabited catchments on the Yarra Ranges, close to the public for over 100 years, are the source of most of Melbourne's drinking water. Forests act as a natural spring, holding and slowly releasing rainwater in the streams and reservoirs (Melbourne Water 2004). The capacity of various reservoirs and the quantity of water in mega litres currently held is as follows (Melbourne Water 2004) is shown in Table 3.2.

Melbourne is the capital of the state of Victoria. Melbourne and the metropolitan area support a population of nearly 3.5 million. The demand

Table 3.2. Melbourne Water Storage Systems 2004

Reservoir	Capacity	Quantity held
Cardinia	287,000	186,206
Green Vale	27,000	16,304
Maroondah	22,000	9,312
O'Shannasy	3,000	785
Silvan	40,000	35,406
Sugarloaf	96,000	72,327
Thompson	1086,000	414,489
Upper Yarra	200,000	92,696
Yara Glan	30,000	18,368
Total	1773,000	848,297

for freshwater is for both domestic and industrial needs. The various industries include abattoirs, food processing, car manufacturing, breweries, paper manufacturing, pigment manufacturing, herbicide and pesticide manufacturing, and tourism and hospitality. A comparison of the per capita water consumption in the Australian capital cities with some of the states in USA is given in Table 3.3.

Table 3.3. A comparison of water consumption in Australian cities and US states

Australian capital cities	Population in 000s	Litres/head/day Total/residential	US States	Population in 000s	Litres/head/day Total residential
Adelaide	1052	471/282	Arizona	3920	780/507
Brisbane	835	546/351	California	30,5000	700/462
Canberra	325	522/295	Florida	12,200	640/390
Darwin	96	1078/421	Hawaii	1120	723/443
Melbourne	3456	393/224	Nevada	1290	1230/806
Perth	1375	469/322	Texas	17,600	712/530
Average		440/256	Average		805/522

Thus on an average the per capita consumption of freshwater in Australia and the USA is about 440 litres and 805 litres respectively, compared to 165 litres in the city of Mumbai, India.

It is obvious that Melbournians, although keen gardeners, are very conscious of water as a sacre resource and how to conserve it. It is also possible that a low total hardness of 34 mg/L as CaCO_3 assist in using less water during washing and bathing. The potable water quality in Adelaide, Perth, Brisbane clearly show that water is reasonably hard (total hardness > 100 mg/L CaCO_3) It is also seen that cat ions such as sodium and calcium are also in these waters (Table 3.4, taken from Hodge 2003).

ENVIRONMENTAL IMPACT OF HUMAN ACTIVITIES IN AUSTRALIA

Although the deterioration of the environment is less obvious in the Victorian riverine system, the Murray-Darling river system in New South Wales and South Australia and the Peel River in Western Australia provides clear evidence of environmental deterioration, overutilization and eutrophication due to intense agricultural runoff in these regions. An over-exploitation of water from these rivers combined with below average rainfall over many successive years during early 1990 led to low flow during summer. The condition in the river is exacerbated by the high summer temperatures and longer interaction of the water with the sediments

Table 3.4. Comparison of potable water in capital cities in Australia

	pH	Turbidity (FTU)	Total dissolved solids (mg/L)	Hardness (mg/L CaCO ₃)	Calcium (mg/L)	Sodium (mg/L)
Canberra	7.75	0.25	217	50	15	8.4
Sydney	8.04	0.15	279	60	12	13
Melbourne	7.53	1.0	244	34	6.5	9.9
Perth	7.97	0.1	823	110	30	110
Adelaide	7.39	0.15	612	120	24	66
Brisbane	7.82	0.2	833	100	22	34
Hobart	8.16	0.25	103	36	11	4.1
Darwin	8.1	0.35	88	36	6.3	2.7

underneath led to the infestation of the river system for a stretch of over 100 km of toxic cyanobacteria (blue-green algae) *Anabaena circinalis*. There were thick odorous scums all along the river and the water was unsuitable for human or animal consumption. The consumers all along the river could not use the river water and had to resort to rain water collected in tanks from the roof or water delivered to householders through tankers. The Federal Government of Australia had to enforce emergency measures and utilized the services of the armed forces to install temporary water treatment plants to purify river water for potable purposes.

The Peel River in Western Australia had similar toxic cyanobacterial problems. Several reactive control measures were tried but were proved to be of no avail. The bloom persisted in these rivers until the water conditions changed followed by heavy downpours. The increased river flow and cooler conditions were helpful in combating the blooms.

The construction of large dams and overutilization of the riverine ecosystem has been on the increase as discussed earlier. To add to this problem the quality of the Earth's freshwater is decreasing in many areas and in those areas the problem is more serious than the quantity. The Murray-Darling system in Eastern Australia and the Peel River Estuary in Western Australia testifies to the situation. The United Nations Environmental Programme reports that 10% of the 344 water-monitoring stations surveyed in 59 countries are polluted. In many developing countries the main cause is domestic sewerage contamination and the scarcity of financial resources to provide toilet facilities to the homeless and the slum dwellers and /or provide adequate treatment for their domestic wastewater. Municipal wastewater without adequate treatment may be discharged to the rivers and urban waterways, which incidentally may also be popular

places for the slum dwellers to bathe and wash their clothes. A few kilometres down stream the same waterways may be used as a source of potable water for the neighbouring towns without any adequate treatment. Further these waterways may suffer from eutrophication and thus support blooms of the toxic algae during the period of high temperature and low flow such as the ones experienced in the Murray-Darling River in 1992. Waste water contaminations could also contribute to the spread of entire diseases in the community, specially young children and the old are particularly at risk from these diseases.

In the developed countries, apart from the municipal wastewater, the stormwater contributes to the pollution of the freshwater streams and waterways. The major pollutants include nitrogen and phosphorus from fertilizers and from animal excret. It is estimated that in Melbourne after a storm event several tons of dog faeces is carried with the stormwater into the Yarra River.

WATER: A GLOBAL SCARCE RESOURCE

Freshwater is a scarce commodity and its shortage affects virtually every nation, especially, where the population is increasing without any appreciable increase in the availability of freshwater without any deleterious effect on the environment. In rural Australia, as in many parts of the world, rainwater from the rooftops is collected and stored in tanks to meet domestic needs. Water shortages are frequent, especially, during drought years. In such periods water is carted from distant places to meet daily needs. According to the World Health Organization, three out of every five people in the developing countries do not have access to clean-disease free freshwater. Additionally 80% of all the enteric diseases in those countries result from contaminated water.

Although the quantity of freshwater is the same as it was when civilization began and enough water falls as rain each year to flood the land to a depth of 86 centimetres providing sufficient quantity to meet our needs (Chiras 1994). However, water shortages in many countries can be assigned to any one or more of the following reasons:

1. Uneven distribution of rainfall across the Earth. Tropical rainforest experiences heavy rainfall whereas the desert areas receive scanty rainfall (< 25 cm/year);
2. The demand for the water by the industries and people exceeds the supply at sustainable levels especially due to urbanization;
3. In most cities and towns the cost of providing freshwater is so low that the community does not value the water as a scarce resource and as a consequence abuse the system.

The global consumption of freshwater is about 9% of the potentially available freshwater each year. Of this 90% is utilized for crops and livestock production. Industrial use account for 7% and domestic use makes up the rest (Chiras 1994). However, these averages vary from country to country based on the population, industry and the agricultural practices. As a general rule, it is economically feasible for most nations to withdraw up to 20% of the stream runoff, although some rich countries harvest up to 30%. Sometimes the water harvested is so high that a combination of local dry climate together with siphoning of water will be beyond their capability to sustain the river ecology and thus they virtually run dry and become biological deserts. Drought also contributes to water shortages. A drought exists when the rainfall is less than 70% below average for a period of 21 days or longer. A severe drought results in a decrease in stream flow, a drop in the water table, a loss in agricultural yield, a loss in aquatic biota, a drop in the water level in lakes, streams and waterways. This condition is presently experienced in most parts of Australia.

The world's human population has exceeded 6 billion. With a further increase in population, the demand on irrigated land worldwide is expected to grow to meet the demand of agricultural produce. Similarly the demand for industrial and domestic use is also expected to grow, thus freshwater demand is expected to exceed freshwater supply in many industrial countries. In some industrialized countries this situation already exist.

CONCLUDING REMARKS

Rivers, aquifers and lakes do not respect state and international boundaries. They pass through various states and countries. The bureaucrats/technocrats cannot be parochial in making decisions on the rights and usage of water. Conservation of scarce resources should be the main aim in their programming. Before contemplating on harvesting water resources, it is imperative that the scientific community should advise the authorities, based on sound environmental data as to how much water is required to maintain the health of the riverine system. This should then be taken as a guide on the amount of water available for harvesting from the river. This quantity of available water should be a guide to decide the crop under local conditions. An appropriate design of irrigation system would also assist in the reduction of loss of water during transmission due to evaporation, leakage and seepage. Not all crops require the same quantity of water, similarly not all industries require the same quantity and quality of water.

Overutilization of potable water at the domestic front would also need to be curtailed, currently customers are being charged the real cost of water supply.

Where possible, attempts must be made for recycling the effluents after adequate treatment for functions such as gardening and flushing toilets. In most instances, recycling after adequate treatment can be done at the place of origin.

Societies in many developed countries, like Australia, are complacent and take water for granted. The consumers have to change their habits, conserve water and maintain the habitat that provides the scarce resource.

Fines and incentives must be included in the master plan to make the community think and react as how the cost of water hits their hip pocket reserve. Currently the state of Victoria, Australia is leading the change on water policy. The proposed reform includes the imposition of 5% environment levy on most water users, a three-tier system of pricing that will favour those who conserve water, no new dams for Melbourne and no discharge of wastewater back into the natural water system. These policies will also be incentives to encourage better use of water by irrigators and to open channels.

Currently most parts of Victoria has some restrictions on the use of water e.g. washing of cars, hosing of driveways and pavements etc. Victorians have shown over the past two years that they can make some significant savings with minimal interruptions to normal life. Seldom do Governments devise a package of reform on a matter of such vital importance that may have support from across the community. The Victorian Government may have managed just that with its water reform.

A fundamental challenge for present and future generations of Melbournians is to continue to live within the water means. The city's population will continue to grow, increasing demand for water reserves. Future cities must be water sustainable cities. Above all, they must be the cities that meet the future social and economic needs of Australians within the unique context of the Australian landscape. There are several components for a sustainable city. The standing committee on environment and heritage appointed by the House of Representatives suggests the following as necessary objectives, (House of Representatives 2005)

1. Establish an integrated sustainable water and stormwater management system addressing capture, consumption, treatment and reuse opportunities.
2. Manage and minimize domestic and industrial waters.
3. Ensure equitable and efficient use of energy, including renewable energy sources.
4. Develop sustainable transport network and logistics.

With the urban spread and the expansion of low density housing at city outskirts, cities of the future will undoubtedly exceed the existing capacity of surrounding water supplies. The characteristic approach of many large

cities to water and stormwater is that management cannot be efficiently maintained as the consumption and geographical size of the city expands. A change in water management methods alongside settlement patterns are needed to achieve the desired outcome. A sustainable city must fully embrace the ethos of product stewardship with supplies and purchases recognizing a responsibility for the waste generated from production process, packages and consumption. A sustainable city must unite the community, industry and government to push for and implement sustainability within the sphere of influence.

Australia is currently one of the highest consuming societies in the world – a reversal of this trend is fundamental to the development of sustainable cities in Australia. It must increase efficiency, reduce usage of water and manage more appropriately that water through treatment and recycling.

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State of Water Quality and its Management in India

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WATER RESOURCES OF INDIA

As per the observations taken by the Indian Meteorological Department at more than 3000 rainfall-recording stations for a period of 50 years (1901-1950) the average rainfall is 105 centimeters. It is the largest in the world for a country of comparable size. From precipitation alone India receives 4000 Km³, including snowfall. Of this 3/4th occurs only during the monsoon. A good part of it is lost through the process of evaporation and plant transpiration, leaving only half of it on the land for use. After allowing for evapotranspiration losses the country's surface flow is estimated as 1880 Km³ (CWC 2000). Due to topographical, hydrological and other constraints, it is assessed that only about 700 Km³ of surface water can be put to any beneficial use by conventional methods of development. The annual replenishable groundwater resources are assessed to be about 600 Km³ of which the annual usable resources are estimated at 420 Km³ (CWC 2000). Since Independence, the country has been planning to utilize this water by prolonging its stay on land by using engineering innovations such as dams and barrages.

The distribution of water resources potential in the country shows that as against the national per capita annual availability of water of 1905 m³, the average availability in the Brahmaputra and Barak is as high as 16589 m³, while it is as low as 360 m³ in the Sabarmati basin. The Brahmaputra and Barak basin with 7.3% of geographical area and 4.2% of population of the country has 31% of the annual water resources. Per capita annual

availability for rest of the country excluding the Brahmaputra and Barak basin works out to about 1583 m³. Any situation of availability of less than 1000 m³ per capita is considered by international agencies as a scarcity condition. The Cauvery, Pennar, Sabarmati, east-flowing rivers and west-flowing rivers are some of the basins that fall into this category.

Water Bodies

Inland water resources of the country are classified as rivers and canals; reservoirs; tanks and ponds; beels, oxbow lakes, derelict water and brackish water. Other than rivers and canals, total water bodies cover an area of about 7 million hectares. Uttar Pradesh occupies the first place with the total length of rivers and canals as 31.2 thousand km. that is about 17% of the total length of rivers and canals in the country.

Other states followed by Uttar Pradesh are Jammu and Kashmir and Madhya Pradesh. Among the remaining forms of the inland water resources tanks and ponds have a maximum area of 2.9 million hectares followed by reservoirs (2.1 million hectares). Most of the area under tanks and ponds lies in Southern States of Andhra Pradesh, Karnataka and Tamil Nadu. These states, along with West Bengal, Rajasthan and Uttar Pradesh account for 62 % of the total area under tanks and ponds in the country. As far as reservoirs are concerned, major states like Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Rajasthan and Uttar Pradesh account for a larger portion of area under reservoirs. More than 77% of the area under beels, oxbow lakes and derelict water lies in the states of Orissa, Uttar Pradesh and Assam. Orissa ranks first in the total area of brackish water and is followed by Gujarat, Kerala and West Bengal. The total area of inland water resources is, thus, unevenly distributed over five states namely Orissa, Andhra Pradesh, Gujarat, Karnataka and West Bengal accounting for more than half of the country's inland water bodies.

Rivers

India is blessed with many river basins. As many as 13 of them are classified as major rivers which have a total catchment area of 252.8 million hectares (m.ha). The Ganga-Brahmaputra-Meghna system is the biggest with a catchment area of about 110 m.ha which is more than 43% of the catchment area of all the major rivers in the country. The other major rivers with catchment area of more than 10 m.ha are the Indus (32.1 m.ha), Godavari (31.3 m. ha), Krishna (25.9 m.ha) and Mahanadi (14.2 m.ha). The catchment area of medium rivers is about 25 m.ha. Among the medium rivers, Subernarekha is the largest with a catchment area of about 1.9 m.ha. The other rivers with catchment areas of more than 1 m.ha are the Palar (including tributary Cheyyar), Ponnaiyar, Baitarni and Vamshadhra.

Almost the entire country is covered by rivers. There are 13 major river basins in the country which occupy 82.4% of the total drainage basins, contribute 85% of the total surface flow and house 80% of the country's population. They are the Brahmaputra, Ganga, Indus, Godavari, Krishna, Mahanadi, Narmada, Cauvery, Brahmini, Tapi, Mahi, Pennar and Sabarmati. Three major divisions based on drainage basins are accepted for Indian rivers as shown in Table 4.1.

Table 4.1. Classification of River Basins of India

Category	Basin area (Km ²)	Number of basins	Percentage of total drainage area
Major	More than 20,000	13	82.4
Medium	Between 2000 and 20,000	48	8
Minor and Desert	Less than 2000	52	9.6

There are few desert rivers, which flow for some distance and get lost in deserts.

There are complete arid areas where evaporation equals rainfall and hence there is no surface-flow. The medium and minor river basins are coastal rivers. On the east coast and part of Kerala, the width of land between the mountains and the sea is about 100 km, and hence the riverine length is also about 100 km. Whereas, the rivers in the rest of the west coast are much shorter as the width of the land between the sea and mountains is less than 10 to 40 km.

A look into the river basins map of India reveals some interesting features. The Brahmaputra, Ganga, Indus basins along with that of Godavari cover more than half of the country. The entire of the west coast stretching 1500 km between Surat in Gujarat and Cape Comorin in Tamil Nadu are fed by 14 medium and 18 minor river basins leaving important cities like Bombay, Panaji, Cochin, Trivandrum out of the major river basins. On the east coast of Peninsular India there are three pockets, which are out of any major river basins. These three pockets are: the area south of River Cauvery starting from Madurai to Cape Comorin; the area between Pennar and Cauvery basin wherein Chennai and Pondicherry are located; and the area between Mahanadi and Godavari basins in Orissa coast.

There is a tremendous variation both in the quantity of discharge from a major basin to minor one and also in the quality of discharge from region to region. With a few exceptions, all the medium and minor river basins originate in the coastal mountains, and thus exhibit common features of fast flowing and monsoon-fed in the hilly regions and by the time they reach the plains they become tidal. Industries or communities are located

in the plains. The treated or untreated discharges from such sources can find a situation where pollutants once discharged into the rivers continue to oscillate like a pendulum because the river is not receiving any flow from the mountain in dry weather. During the monsoon when rain water flows down the river the discharged pollutants get flushed out by upland flow. As the discharge location moves downstream, the flushing out time for pollutants decrease exponentially.

All the major river basins are not perennial. Only four of the thirteen major basins possess areas of high rainfall, i.e. the Brahmaputra, Ganga, Mahanadi and Brahmini having annual average discharge of a minimum of 0.47 million cubic metre per km², and they are perennial. Six basins (the Krishna, Indus, Godavari, Narmada, Tapi and Subernarekha) occupy the area of medium rainfall and have an annual average discharge of a minimum of 0.26 million cubic metre per Km², and the remaining four (the Cauvery, Mahi, Sabarmati and Pennar) occupy the area of low rainfall and have an annual average discharge between of 0.06 and 0.24 million cubic meter per Km². Thus, many of the major river basins also dry up during summer leaving no available water for dilution of waste water discharged in them.

Groundwater

The total replenishable groundwater potential of the country has been estimated by the Ministry of Water Resources as 431 Km³ per year. After making provision for drinking, industrial and other purposes (other than irrigation), which is about 16% of the total potential, the potential available for irrigation is 360 Km³ per year. The figure for net draft of groundwater considering the present utilization indicates that substantial portion of the total potential (about 68%) still remains untapped (CWC 2000).

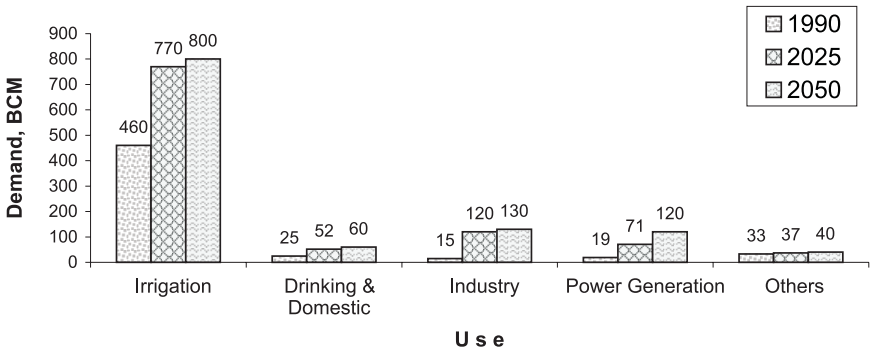
Analysis of basin-wise potential of groundwater by the Ministry of Water Resources indicates that the Ganga basin has the maximum potential for use, which is 171 Km³ (CWC 2000). Other basins are far behind the Ganga that accounts for more than 39% of the total potential in the country. As a consequence of its prime place regarding availability, the quantities of groundwater potential in the basin apportioned for different uses are very high vis-a-vis other rivers. Net draft is highest in the Ganga, yet the groundwater development is highest in the Indus basin, where it is 78.9%. The other basins which have exploited more than 50% of their groundwater resources are : (a) The Cauvery (b) Madras and South Tamil Nadu composite and (c) The Kutch and Saurashtra composite. Groundwater development is the lowest in the Brahmaputra (3.37%), followed by Meghna (3.94%), Mahanadi (6.95%), Brahmani with Baitarni (8.45%), Subarnarekha (9.57%), North East Composite (17.20%) and Godavari (19.53%). Exploitation in the

basins of the northern part of the country like the Indus and Ganga is comparatively far better than those in others (CWC 2000).

Among the states, the highest potential of groundwater is in Uttar Pradesh which mainly lies in the Ganga basin. The potential for Uttar Pradesh is about 84 Km³ per year. Goa with 0.22 Km³/year is at the bottom among the states. Development of groundwater in Punjab is highest where about 94% of the resources appear to have been tapped. The neighbouring state of Haryana with 84% development occupies the second place. The other states where the development is more than 50% are Tamil Nadu (60%) and Rajasthan (51%). Percentages of development in the states of Jammu and Kashmir, Assam, Goa and Orissa are very low.

Water Use

The water use in India is divided into two categories: abstractive uses and in-stream uses. A brief description of these uses is given as follows. Water demand for different uses and future needs is shown in Figure 4.1.



Source: Ministry of Water Resources, Govt. of India 2002

Fig. 4.1. Water demand for different uses

Abstractive Uses

The different abstractive uses are:

a) Domestic water supply

The cities located along the water bodies use the water for drinking and other domestic purpose after conventional treatment.

In India nearly 85% of the population depends on groundwater as a source of water for domestic use. Some of the urban and rural population also uses surface water after conventional treatment for domestic purposes.

According to an estimation done during 2003-04 by the Central Pollution Control Board (CPCB) nearly 35,000 million litres of water per day is supplied to Class-I Cities and Class-II towns of the country. According to the Ministry of Water Resources nearly 25 billion cubic meter (BCM) of water was used for domestic purpose in 1990 in India.

b) Irrigation

Irrigation is the most important use of water in India. Nearly 84% of the water is used only for irrigation. The total water used for irrigation is estimated as 460 BCM per annum.

c) Industrial use

A large amount of water is used for industrial purpose. As per the estimation of CPCB about 10 BCM per annum of water is used in the industries as process water, whereas about 30 BCM per annum is used as cooling water in power plants.

In-stream Use

The in-stream uses of water are as follows:

a) Hydro-power

The total potential for hydropower development in India has been estimated at 84,000 MW at 60% load factor. So far a potential of about 13,400 MW has already been created and three schemes with a total power potential of about 5,420 MW are under construction (CWC 2000).

b) Fisheries

Indian water resources are extensively utilized for fish production in many parts of our country. India has the distinction of being the seventh largest producer of fish in the world and second largest producer of inland fish after China.

As per the information from the Ministry of Agriculture (CWC, 2000) the inland fish production increased quite substantially from 2 lakh tonnes in 1950-51 to about 24 lakh tonnes during 1997-98. The state-wise inland fish production during 1990-98 shows that West Bengal continues to occupy the foremost position among fish producing states, accounting for about one third of the country's total fish production during 1997-98, apparently facilitated by the prevalence of extensive fish pond culture in the state unlike other states which are heavily dependent on rivers/reservoirs for their fish catch. Bihar, Andhra Pradesh, Assam and Uttar Pradesh are the other major fish producing states and major producers of inland fish.

c) Navigation

At present the river systems are not fully utilized for navigation, but there are plans to use the several stretches of the river system for navigation.

Inland waterways in the public sector is managed by government owned Central Inland Water Transport Corporation (CIWTC). In addition, the private sector companies operate a major chunk of Inland Waterways Traffic (IWT). The Inland Waterways Traffic constitutes only a very small part of total transport network in the country which is dominated by rail and road transport. Apart from suffering due to the problem of spatial dimensions and inadequate drafts in many waterways for bigger vessels to operate, the performance of IWT traffic is likely to be adversely affected by withdrawal of water for other priority consumption such as domestic use, irrigation, industry, etc.

d) Community Bathing and Washing

Most of the surface water sources are being used for bathing and washing. On particular religious and cultural occasions, millions of people take a holy dip in several stretches of riverine system lake system. At some auspicious places it is more intensive.

e) Cattle Bathing and Watering

Most of the towns and villages along the surface water sources use surface water for cattle bathing and watering.

Groundwater Use

Due to often contaminated surface water resources, groundwater plays an important role in India, particularly as a drinking water source. Groundwater has a number of unique features that render it particularly suitable as a water supply source. The unique features are:

- 1) Generally uncontaminated and thus can be consumed directly without any treatment;
- 2) It is generally available in close proximity to the place where it is required, as it is widely distributed;
- 3) It is dependable and relatively less affected by drought;
- 4) Large storage, treatment and distribution can be avoided;
- 5) Less expensive because it does not require transportation from distant places.

For the reasons mentioned above, nearly 85% of India's population today is dependent on groundwater for their domestic demand. Groundwater is particularly important as a source of drinking in rural areas. Groundwater also plays an important role in agriculture, for both irrigation and cattle. As mentioned above, 140 billion cubic meters of groundwater is abstracted annually for use in irrigation.

Industrial demands for groundwater are also high, as many prefer to use groundwater for the unique features mentioned above.

Water Quality Requirement for Different Uses

Water is a multiple use resource. With industrialization and increasing populations, the range of requirements for water have increased. The main uses of water are public water supply, outdoor bathing and recreation, fisheries and wildlife propagation, irrigation and other agricultural uses, cooling in power plants, navigation and disposal of wastes. Most of the aquatic resources have conflicting multiple uses.

To ensure any water body to function adequately to fulfill any one of the above-mentioned uses, it must have a corresponding degree of purity/quality. Such as, drinking water needs the highest purity of water, whereas disposal of wastes can be done in any quality of water. Since water scarcity is already a big issue in India, the concept that management of the quality of water is quite as important and obligatory.

Water quality has broad spectrum of meaning. The user interprete the quality in terms of protection of his use of water. The term quality, therefore, must be considered relative to the proposed use of water. Thus user defines water quality as "those physical, chemical or biological characteristics of water by which the user evaluates the acceptability of water". For example for human consumption water should be pure, wholesome and potable. Similarly, for agriculture, the water quality should match the sensitivity of different crops to dissolved minerals and other toxic materials. Industries have their specific need of water quality.

Agricultural Use

Agriculture is the largest user of water in India (about 84% of total water used). Thus, consideration of water quality for agricultural purposes is quite important, not only from the quality point of view but from the potential adverse effects on irrigated land. Irrigation water quality is of particular importance in arid and semiarid regions because of potential adverse effects on the soil. The WHO (1993) recommends faecal coliform concentrations below 1000/100 ml, in order to avoid hazards from pathogenic microorganisms from use or consumption of raw crops irrigated with such waters. In addition recommendations are also given for trace elements that are toxic in nature. The Bureau of Indian Standards and CPCB also prescribe water quality required for irrigation with respect to limited number of physico-chemical parameters.

The main adverse effects are due to water lost by evaporation from agriculture that has no salt content, therefore, soluble salts present in water will be retained by soil. Thus, gradual building of salt in soil leads to soil salinity and becomes infertile. It is obvious that salt content of irrigation water is of primary importance.

Ecological Water Requirements

Maintaining ecological quality often requires significant amount of water to flow in a river. Each river has developed a well-established ecosystem in its course having different habitats and seasonality. All the biological processes are highly timed and spaced. Water quantity has ecological impact in a number of ways. Flood flows flush out spawning areas, leaving clean new gravels, sand washed out of the hills. Controlling flows by dams prevents both cleaning and renewal. High flow rates sweep debris from river channels and wash down new gravels and sand needed for spawning of many fish. In the past and even now, dilution was considered to be an acceptable 'solution to pollution' and self-purifying capacity of a stream. This has been included in most of the effluent standards (Minimum National Standards, MINAS) notified under Environment (Protection) Act, 1986 by Government of India. It is assumed that at least 10 times dilution is available in a stream where the effluent is going to be discharged. As all deleterious material is not removed in wastewater treatment, the role of dilution is very significant in protecting the health of a river. In India, the need for fresh water is growing at a fast rate. Thus, the focus is laid on utilization of every drop of water. This has resulted in drastic reduction in flow conditions of many rivers in the country. Reduced flow followed by increased waste load rendered many rivers almost ecologically dead. Thus, special attention is required in water resource planning. Several efforts are made to conserve water in order to reduce the abstractions. Under the National Water Policy (MOWR 2002) Government of India has focussed on ecological water requirement. A National Water Quality Assessment Authority was created under Environment Protection Act, 1986. One of the function of this Authority is to ensure minimum flow in the rivers of India.

Major Water Quality Issues in India

The major water quality issues in the Indian context can be summarized as follows:

a) Water Scarcity

- Due to uneven distribution of rainfall in time and space and the ever-increasing demand of water for agricultural, industrial and domestic activities, the water resources are over-exploited. This is resulting in shrinking or even drying up of many water bodies for considerable periods in a year. Maintaining targeted water quality in such water bodies is very difficult. If objectives of Water Act, 1974 or EPA, 1986, are to be fulfilled maintaining minimum level of water needs to be specified. For example, restriction on water abstraction from different water bodies (rivers, lakes or groundwater). The Central Ground

Water Authority (CGWA) formed under Environment Protection Act, 1986 has already taken such initiatives. The restrictions need to be extended to the rivers and lakes also.

- Targets for conservation: reducing demands by optimum use, minimization of wastage, efforts to reduce the percolation and evaporation losses, conservation efforts in domestic uses, GW recharging, rain water harvesting, afforestation, recycling and reuse.

b) Eutrophication

The discharge of domestic wastewater, agricultural return water or run-off water and many industrial effluents contribute nutrients like phosphates and nitrates. These nutrients promote excess growth of algae in water bodies leading to a state called eutrophication. Eutrophication leads to many problems related to water quality like filling of water body decomposition of dead algal matter and large diurnal variation in dissolved oxygen.

c) Pathogenic Pollution

- One of the major water quality issues is 'water-borne diseases'. This is mainly due to inadequate arrangements for transport and treatment of wastewaters — a major portion of the wastewater generated from human settlements is not properly transported and treated before discharging into natural waters. This results in contamination of both surface and groundwaters. Moreover, contribution of pathogens through diffuse sources is also quite significant. Thus, most of the surface water bodies and many groundwater sources are contaminated. Many people especially children are affected by diarrhea, dysentery, cholera, typhoid, polio and many other enteric diseases, which are water borne in nature. In many areas, the presence of natural contaminants like arsenic (in West Bengal), fluoride (in about 200 districts of 19 states of India) are also important health problems.
- A large population of the country still uses water directly for drinking or contact use without any treatment, thus, exposed to water-borne diseases. This is the single major cause for mortality due to water pollution. India has about 72% population living in rural areas. Most of the rural people use groundwater from open dug wells for drinking and other domestic uses. They also use surface water like rivers, lakes or village ponds for bathing, washing and cleaning. Many rural people also use lake/river/pond water directly for drinking and domestic use without treatment. However in urban areas, the water supply is by municipal authorities through piped supply. Due to water scarcity, the municipal supply many times is not adequate and thus people have their own arrangements through underground sources, which is used without treatment.

d) Oxygen Depletion

- As indicated above a large portion of wastewater is discharged into watercourses without any treatment. A major portion of it is originated from domestic sources. Such wastewater contains high amount of organic matter. The industries also discharge effluents containing high organic matter e.g. agro-based industries. This organic matter when oxidized in water through microbial activities, consumed dissolved oxygen. Since water has a limited availability of oxygen, if consumption exceeds the availability, then the result is oxygen depletion and survival of aquatic life becomes difficult.
- In many water bodies massive input of organic matter sets off a progressive series of chemical and biological events in the downstream water. The stretch is characterized by high bacterial population, cloudy appearance high BOD and strong disagreeable odour — all indicating general depletion of oxygen. Masses of gaseous sludge rising from the bottom are often noticed floating near the surface of the water. During the monsoon due to floods, the sludge deposited in such stretches is flushed and stays in suspension, causing rise in oxygen uptake in the downstream. Due to such sudden oxygen depletion, heavy fish mortality occurs every year during the first flushing after the onset of monsoon in many rivers of India.
- As per the CPCB's monitoring results nearly 14% of the riverine length of the country is facing problem of oxygen depletion. The riverine stretches are identified as polluted water bodies. Government of India has been implementing National River Action Plan to restore these rivers by intercepting diverting and treating the wastewaters being discharged. This has been explained in the last section of this chapter.

e) Salinity

- Salinity is increasing in many water bodies especially groundwater due to leaching of salt build-up in agricultural areas under intense irrigation.
- A number of industrial activities discharge wastewater with high dissolved solids, causing an increase in salinity of water.

f) Toxicity

- Due to discharge of toxic effluents from many industries and increased use of chemicals in agriculture and their subsequent contribution to the water bodies, many water bodies in the country are polluted due to the presence of toxic substances.
- Presence of toxic substances impairs the water quality by making it unfit for human consumption, aquatic life and irrigation.

g) Ecological Health

- A large number of areas in our aquatic environment support rare species and are ecologically very sensitive. They need special protection.
- Since the Water Act, 1974 provides for maintenance and restoration of 'wholesomeness' of aquatic resources, which is directly related to the ecological health of the water bodies, it is important that the ecological health of the water bodies is given first priority in the water quality goal. In India, such efforts are reflected in the policy planning and legal framework for water quality protection, which are explained later in this chapter.

Main Causes of Water Quality Degradation

Pollution due to Urbanization

Urbanization has encouraged the migration of people from villages to the urban areas. This has given rise to a number of environmental problems such as water supply, wastewater generation and its collection, treatment and disposal. In urban areas, water is tapped for domestic and industrial use from rivers, streams, wells and lakes. Approximately 80% of the water supplied for domestic use passes out as wastewater. In most of the cases, wastewater is let out untreated and it either percolates into the ground and in turn contaminates the groundwater or is discharged into the natural drainage system causing pollution in downstream areas.

The total wastewater generated by the 299 class I cities is 16,662.5 mld approximately 81% of the water supplied. The state of Maharashtra alone contributes about 23%, while the Ganga river basin contributes about 31% of the waste generated.

As per the latest estimate out of 22900 mld of waste water generated, only about 5900 mld (26%) is treated before letting out, the rest i.e., 17000 mld is disposed of untreated. Twenty-seven cities have only primary treatment facilities and forty-nine have primary and secondary treatment facilities. The level of treatment available in cities with existing treatment plant varies from 2.5 to 89% of the sewage generated.

The comparison of water supply, wastewater generation, collection and treatment during 1978-79, 1989-90 and 1994-95 is given in Table 4.2. As revealed from this Table the water supply has increased from 143 lpcd in 1978-79 to 183 lpcd in 1994-95, while the wastewater generation is more than double during the same period. However, the treatment capacity has increased from 2755.94 mld in 1978-79 to 4037.20 mld in 1994-95, which is only 39% and 24% of the wastewater generated respectively. A

Table 4.2. Decadal trend of water supply and sanitation status in class-I cities and class-II towns

S.No.	Parameters	Class-I cities			Class-II towns		
		1978-79	1988-89	1994-95	1978-79	1988-89	1994-95
1.	Number	142	212	299	190	241	345
2.	Population (millions)	60	102	128	12.8	20.7	23.6
3.	Distribution of class-I cities according to catchment area						
	a) Major river basins	112	170	233	135	168	262
	b) Coastal	17	23	29	13	20	16
	c) Non-basin, non-coastal	13	19	37	42	53	67
4.	Population distribution of class-I cities according to catchment area (millions)						
	a) Major river basins	42.7 (71%)	74.4 (80.19%)	97.4 (76%)	9.2 (72.07%)	14.7 (71.03%)	17.2 (72.84%)
	b) Coastal	12.8 (21.3%)	20.6 (10.85%)	23.2 (18%)	0.81 (6.38%)	1.69 (8.14%)	2.23 (9.45%)
	c) Non-basin, non-coastal	4.66 (7.7%)	7.85 (8.96%)	7.43 (6%)	2.75 (21.55%)	4.30 (20.83%)	4.19 (17.71%)
5.	Water supply (mld)	8,638	15,191	20,607	1533	1622	1936
	Groundwater (mld)	784 (9%)	3,528 (23.2%)	1,542 (7.5%)	449 (29.29%)	700 (43.15%)	838 (43.27%)
	Surface water (mld)	5,261 (61%)	11,132 (73.3%)	8,136 (39.50%)	1018 (66.41%)	814 (50.21%)	307 (15.87%)
	Combined ground and surface water source (mld)	2,582 (30%)	531 (3.5%)	10,929 (53.0%)	66 (4.30%)	108 (6.64%)	791 (40.86%)
6.	Per capita water supply (lpcd)	143	147	183	125	78	103
7.	Wastewater generated (mld)	7,007	12,145	16,662	1226	1280	1650
8.	Wastewater treated (mld)	2,756 (39%)	2,485 (20.5%)	4,037 (24%)	67 (5.44%)	27 (2.12%)	62 (3.73%)
9.	Wastewater untreated/ disposed (mld)	4,251 (61%)	9,660 (79.5%)	12,625 (76%)	1160 (94.56%)	1252 (97.88%)	1588 (96.27%)

comparison of status in class I cities and class II town is presented in Figure 4.2.

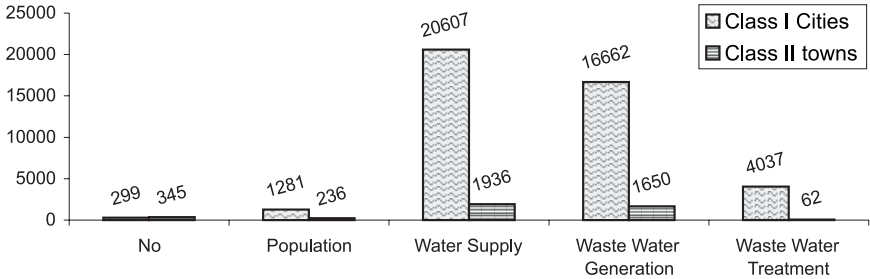


Fig. 4.2. Comparison of water supply and wastewater generation from class-I cities and class-II towns of India (1996)

Treated or partly treated or untreated wastewater is disposed into natural drains joining rivers or lakes or used on land for irrigation/fodder cultivation or to the sea or a combination of them by the municipalities. The mode of disposal in 118 cities is indirectly into the rivers/lakes/ponds/creeks; in 63 cities to the agriculture land; in 41 cities directly into rivers and in 44 cities, it is discharged both into rivers and on agriculture land.

Major Causes of Groundwater Quality Degradation

The supply of groundwater is not unlimited, nor it is always available in good quality. In many cases, the abstraction of excessive quantities of groundwater has resulted in the lowering of groundwater table, drying up of wells, salt-water intrusion and drying up of rivers that receives their flows in the dry seasons from groundwater. Groundwater quality is being increasingly threatened by agricultural, urban and industrial wastes, which leach or are injected into underlying aquifers. Once pollution has entered the subsurface environment, it may remain concealed for many years, becoming dispersed over wide areas and rendering groundwater supplies unsuitable for human uses.

A vast majority of groundwater quality problems are caused by contamination, over-exploitation, or a combination of the two. Most groundwater quality problems are difficult to detect (since the problem may be concealed below the surface) and hard to monitor and resolve since the solutions are usually very expensive, time consuming and not always effective. An alarming picture is beginning to emerge in many parts of the country. Groundwater quality is slowly but surely declining everywhere.

Many times the contamination is not detected until noxious substances actually appear in the water used, by which time the pollution has often dispersed over a large area.

Essentially all activities carried out on land have the potential to contaminate the groundwater, whether associated with urban, industrial or agricultural activities. Large scale concentrated sources of pollution, such as industrial discharges, landfills and subsurface injection of chemicals and hazardous wastes are an obvious source of groundwater pollution. These concentrated sources can be easily detected and regulated but the more difficult problem is associated with diffuse sources of pollution like leaching of agrochemicals and animal wastes, subsurface discharges from latrines and septic tanks and infiltration of polluted urban run-off and sewage where sewerage does not exist or is defunct. Diffuse sources can affect entire aquifers, which is difficult to control and treat. The only solution to diffuse sources of pollution is to integrate land use with water management. Table 4.3 presents land-use activities and their potential threat to groundwater quality.

Table 4.3. Land-use activities and their potential threat to groundwater quality

Land use	Activities potential to groundwater pollution
Residential	<ul style="list-style-type: none"> • Unsewered sanitation • Land and stream discharge of sewage • Sewage oxidation ponds • Sewer leakage, solid waste disposal and landfill • Road and urban run-off, aerial fall out
Industrial and commercial	<ul style="list-style-type: none"> • Process water, effluent lagoon • Land and stream discharge of effluent • Tank and pipeline leakage and accidental spills • Well disposal of effluent • Aerial fall out • Landfill disposal and solid wastes and hazardous wastes • Poor housekeeping • Spillage and leakages during handling of material
Mining	<ul style="list-style-type: none"> • Mine drainage discharge • Process water, sludge lagoons • Solid mine tailings • Oilfield spillage at group gathering stations
Rural	<ul style="list-style-type: none"> • Cultivation with agrochemicals • Irrigation with wastewater • Soil salinization • Livestock rearing
Coastal areas	<ul style="list-style-type: none"> • Salt water intrusion

Common Groundwater Contaminants

- 1) *Nitrates*: Dissolved nitrate is the most common contaminant in groundwater. High levels can cause blue baby disease (Metha-moglobinamia) in children, may form carcinogens and can accelerate eutrophication in surface waters. Sources of nitrates include sewage, fertilizers, air pollution, landfills and industries.
- 2) *Pathogens*: bacteria and viruses that cause water-borne diseases such as typhoid, cholera, dysentery, polio and hepatitis. The sources include sewage, landfills, septic tanks and livestock.
- 3) *Trace metals*: include lead, mercury, cadmium, copper, chromium and nickel. These metals can be toxic and carcinogenic. Sources include industrial and mine discharges, fly ash from thermal power plants either due to fall out or disposal in ash ponds.
- 4) *Organic compounds*: include volatile and semi-volatile organic compounds like petroleum derivatives, PCBs pesticides. Sources include agricultural activities, street drainages, sewage landfills, industrial discharges, spills, vehicular emissions fall out etc.

Government Initiatives for Control of Water Pollution

Realizing the consequences of water quality degradation, the Government of India has taken several measures to restore the water quality in the country. The important legal and institutional provisions are described below:

Water (Prevention and Control of Pollution) Act, 1974

The Water (Prevention and Control of Pollution) Act, 1974 is comprehensive in its coverage, applying to streams, inland waters, subterranean waters and sea or tidal waters. Standards for the discharge of effluent or the quality of the receiving waters are not specified in the Act, but it enables the pollution control boards created under this Act, to prescribe these standards.

The Act provides for a permit system or 'Consent' procedure to prevent and control water pollution. The Act generally prohibits disposal of polluting matter in streams, wells and sewers or on land in excess of the standards established by the state boards. A person must obtain consent from the state board before establishing any industrial operation or process, any treatment and disposal system or any extension or addition to such a system which might result in the discharge of sewage or trade effluent into a stream well or sewer or onto land. The state board may condition its consent by orders that specify the location, constructions and use of the outlet as well as the nature and composition of new discharges. The Act

empowers a state board, upon 30 days' notice to a polluter, to execute any work required under consent order which has not been executed. The board may recover the expenses for such work from the polluter. The Act gives the state boards the power of entry and inspection to carry out their functions. Moreover, a state board may take certain emergency measures if it determines that an accident or other unforeseen events have polluted a stream or well. These measures include removing the pollutants, mitigating the damage and assuming orders to the polluter prohibiting effluent discharges.

Pollution Control Boards

The Water Act establishes a Central and State Pollution Control Boards. The Central Board may advise the Central Government on water pollution issues, coordinate the activities of state pollution control boards, sponsor research relating to water pollution, and develop a comprehensive plan for the prevention and control of water pollution. The Central Board also performed the functions of a state board for the Union Territories till 1991. During 1991 these functions were transferred to the local administration of respective Union Territories. In conflicts between a state board and the Central Board, the Central Board prevails. Since 1982 the Central Board has been attached to the Department of Environment, Government of India, which was converted to full fledged Ministry of Environment in 1985.

The state boards were established by the State Government under the provision of the Act to perform functions specified in the Act. The state boards may plan a comprehensive pollution abatement programme and advise the State Government on water pollution issues. They also collaborate with the Central Board, inspect sewage or trade effluent, grant consent for the discharge of the effluent, lay down and modify the standards, evolve economic methods of treatment and disposal of sewage and trade effluent, advise the State Government on location of industries, collect and disseminate the data in relation to pollution status in the State and prosecute the offenders under the provisions of the Act.

Penal Provisions

The Act employs a system of criminal sanction to discourage the polluters from polluting the water courses. The penal provisions can be categorized into four classes:

- Penal provision for not providing information as required under the provision of the Act, is punishable with imprisonment up to three months or a fine of up to Rs. 10,000 or both.

- Penal provision for disposal of polluting matters in water bodies more than the prescribed limit in the consent order or providing new outlets without obtaining consent of the state pollution control board is punishable with a minimum imprisonment of one and a half years which may be extended up to six years. For repeating the above offence the penalties are enhanced.
- The penalty for continuing contravention of provisions of the Act is punishable with a fine of Rs. 5000 every day till polluter complies with the provisions of the Act.
- There is a provision of publishing the name of the offender in the newspaper at the offenders' cost.

The 1988 Amendment Act introduced a new Section 33A which empowers state boards to issue directions to any person, officer or authority, including orders to close, prohibit or regulate any industry, operation or process and to stop or regulate the supply of water, electricity or any other service. The state boards can also apply to courts for injunction to prevent water pollution under Section 33 of the Act. Under Section 41 the penalty for failure to comply with a court order under Section 33 or a direction from the board under Section 33A is punishable by fines and imprisonment. The Amendment also increased the power of the Central Board relative to the state boards. Under Section 18 of the Act, the Central Government may determine that a State Board has failed to comply with Central Board directions and that because of this failure an emergency has arisen. The Central Government may then direct the Central Board to perform the function of the State Board.

Approach to Water Quality Management

As mentioned above the basic objective of the Water Act is to maintain and/or restore the 'wholesomeness' of aquatic resources. The 'wholesomeness' is not defined in the Act. Central Pollution Control Board (CPCB), tried to define this in terms of protection of human uses of water and accordingly it has been classified on the basis of uses of the waters in the country. For management of water quality of a water body, one has to define the water quality requirements or water quality objectives for that water body. Since, each water use has a specific water quality need, for setting water quality objectives of a water body, it is essential to identify the uses of water in that water body. In India, the CPCB, an apex body in the field of water quality management, has developed a concept of 'designated best use'. According to which, out of several uses a particular water body is put to, the use which demands the highest quality of water is called its 'designated best use', and accordingly the water body is designated. The CPCB, in collaboration with the concerned State Pollution Control Boards, has classified all the water

bodies including coastal waters in the country into five 'designated best uses'. All those water bodies, which are used for drinking without any treatment except disinfection (chlorination), are termed as 'A' Class Water, those which are used for outdoor bathing are termed as 'B' Class Water, those which are used for drinking after conventional treatment are termed as 'C' Class Water, those which are used for propagation of wildlife and fisheries are termed as 'D' Class Water and those which are used for irrigation, cooling and controlled waste disposal are termed as 'E' Class Water. For each of these five 'designated best uses', the CPCB has identified water quality requirements in terms of a few chemical characteristics, known as primary water quality criteria.

The 'designated best uses' along with respective water quality criteria are given in Table 4.4.

Table 4.4. Use based classification of surface water in India

Designated-Best-Use	Class of Water	Criteria
Drinking water source without conventional treatment, but after disinfection	A	<ol style="list-style-type: none"> 1. Total Coliforms Organism MPN/ 100 ml shall be 50 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 6 mg/1 or more 4. Biochemical Oxygen Demand 5 days 20°C 2 mg/1 or less
Outdoor bathing (organized)	B	<ol style="list-style-type: none"> 1. Total Coliforms Organism MPN/ 100 ml shall be 500 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 5 mg/1 or more 4. Biochemical Oxygen Demand 5 days 20°C 3 mg/1 or less
Drinking water source after conventional treatment and disinfection	C	<ol style="list-style-type: none"> 1. Total Coliforms Organism MPN/ 100 ml shall be 5000 or less 2. pH between 6 to 9. 3. Dissolved Oxygen 4 mg/1 or more 4. Biochemical Oxygen Demand 5 days 20°C 3 mg/1 or less
Propagation of wildlife and fisheries	D	<ol style="list-style-type: none"> 1. pH between 6.5 to 8.5 2. Dissolved Oxygen 4 mg/1 or more 3. Free Ammonia (as N) 1.2 mg/1 or less
Irrigation, industrial cooling, controlled waste disposal	E	<ol style="list-style-type: none"> 1. pH between 6.0 to 8.5 2. Electrical Conductivity at 25°C micro mhos/cm Max. 2250 3. Sodium absorption Ratio Max. 26 4. Boron Max. 2mg/1

This classification helps the water quality managers and planners to set water quality targets and identify needs and priority for water quality restoration programmes for various water bodies in the country. The famous Ganga Action Plan and subsequently the National River Action Plan are results of such an exercise.

A scientific rationale on which a decision or judgement on the suitability of water quality to support a designated use is based, is called water quality criteria. Water quality criteria specify concentrations of water constituents which, if not exceeded, are expected to be suitable for the designated use.

Water quality criteria may not have regulatory impact but form basis to prescribe standards which are regulatory.

To provide the water resource protection for which they are designed, quality criteria should apply to virtually all the country's waters with modifications for local conditions as needed. To violate quality criteria for any substantial length of time or in any substantial portion of a waterway may result in an adverse effect on aquatic life and perhaps a hazard to man or other consumers of aquatic life.

THE WATER (PREVENTION AND CONTROL OF POLLUTION) CESS ACT, 1977

Objectives and Legal Provisions

To strengthen the pollution control boards by providing money for equipment and technical personnel and to promote water conservation by recycling, the Parliament adopted the Water (Prevention and Control of Pollution) Cess Act, 1977. The Act empowers the Central Government to impose a cess on water consumed by industries listed in schedule I of the Act. Specified industries and local authorities are subject to the cess if they use water for purposes listed in schedule II of the Act.

Standards for Regulation of Pollution

The simplest administrative approach to regulate industrial pollution would be to promulgate permissible limits for various pollutional parameters on a general basis, make them binding on all discharges and prosecute and punish any offenders. Control of pollution at sources is the immediate short-term objective adopted by all the state pollution control boards. To control pollution at source, the industries must know the extent up to which their effluent or emission must be treated/controlled so that they can discharge the treated effluent to receiving environment without any significant effect. The cost of treatment should be such that the industry is able to take the burden. The Central Pollution Control Board has initiated

evolving industry specific Minimum National Standards (MINAS) as early as in 1977-78. Today it has developed standards for all the important polluting industries in India. The state boards use these guidelines for necessary follow-up action. No State Board is permitted to relax the MINAS, if the situation so demands, the state boards may make them more stringent. These standards have been notified under Environment (Protection) Act, 1986, by the Government of India.

The Environment (Protection) Act, 1986

In the wake of the Bhopal gas tragedy, the Government of India enacted Environment (Protection) Act, 1986 under Article 253 of the constitution. The purpose of the Act is to implement the decisions of the United Nations conference on the Human Environment of 1972, insofar as they relate to the protection and improvement of the human environment and the prevention of hazards to human beings, other living creatures, plants and property. The Act is an 'Umbrella' legislation designed to provide a framework for Central Government coordination of the activities of various central and state authorities established under previous laws such as Water Act and Air Act.

The potential scope of the Act is broad with 'environment' which include water, air and land and interrelationship which exist among water, air, land, human beings, other creatures, plants, micro-organisms and property. Section 3(1) of the Act empowers the Centre to take all such measures as it deems necessary or expedient for the purpose of protecting and improving the quality of the environment and preventing, controlling and abating environmental pollution. The Central Government is authorized to set new national standards for ambient quality of the environment and standards for controlling emissions and effluent discharges; to regulate industrial locations; to prescribe procedures for managing hazardous substances; to establish safeguards for preventing accidents; and to collect and disseminate information regarding environmental pollution.

The Environment (Protection) Act (EPA) was the first environmental statute to give the Central Government authority to issue direct written orders including orders to close, prohibit or regulate any industry operation or process or to stop or regulate the supply of electricity, water or any other services (Section 5). Other powers granted to the Central Government to ensure compliance with the Act include the power of entry for examination, testing of equipment and other purpose (Section 10) and power to take samples of air, water, soil or any other substance from any place for analysis (Section 11). The Act explicitly prohibits discharge of pollutants in excess of prescribed standards (Section 7). There is also a specific prohibition against handling hazardous substances except in compliance with regulatory procedures and discharges (Section 8). Persons responsible for discharges

of pollutants in excess of prescribed standards must prevent or mitigate the pollution and must report the discharge to the government authorities (Section 9.1).

The Act provides for severe penalties. Any person who fails to comply with or contravenes any of the provisions of the Act, or the rules or directions issued under the Act shall be punished for each failure or contravention, with a prison term of up to 5 years or a fine up to Rs.0.1 million or both. The Act imposes an additional Rs.5 up to Rs.5000 for everyday of continuing violation (Section 15 (1)). If a failure or contravention occurs for more than one year after the date of conviction an offender may be punished with a prison term which may extend to seven years (Section 15 (2)).

The Act empowers the Central Government to establish standards for the quality of the environment in its various aspects, including maximum allowable concentration of various environmental pollutants (including noise) for different areas. These standards could be based on ambient levels of pollutants sufficiently low to protect public health and welfare. Emission or discharge standards for particular industries could be adjusted to ensure that such ambient levels are achieved. The Environment (Protection) Rules, 1986 allow the state or central authorities to establish more stringent standards based on a recipient system.

The EPA includes a citizen's suit provision (Section 19.6) and a provision authorizing the Central Government to issue direct orders to protect the environment (Section 5). The Central Government may delegate specified duties and powers under the EPA to any officer, state government or other authority (Section 23).

Framework for Enforcement of Provisions

The Department of Environment, Forests and Wildlife of the Central Ministry of Environment and Forests is responsible for making rules to implement the EPA. The Department has also delegated the powers to carry out enforcement to the Central and State Pollution Control Boards in the country.

Rules and Regulations Enforced

The Ministry of Environment and Forests has so far enforced several rules and regulations. It has adopted industry-specific standards for effluent discharge and emissions for all important categories of industries respectively. The Department has also designated certain state and central officials to carry out specified duties under the Act and has designated specific laboratories for testing the samples of air, water and soil obtained under the Act.

Hazardous Wastes and Hazardous Substances Management

The Hazardous Waste (Management and Handling) Rules issued under the Act of July 1989 have introduced a permit system administered by the State Pollution Control Boards to regulate the handling and disposal of hazardous wastes. The regulatory quantity of hazardous wastes is also notified under the Rules. These Rules fix the responsibility for proper handling, storage and disposal of such wastes. No person without the Board's authorization may collect, receive, treat, transport, store or dispose of hazardous wastes. Moreover, the rules provide for the packaging, labelling and transport of hazardous wastes and require state governments to compile and publish an inventory of hazardous waste disposal sites. Significantly, the import of hazardous wastes into India for dumping and disposal is prohibited under the Rules.

The Manufacture, Storage and Import of Hazardous Chemicals Rules of November 1989 gives responsibilities of those handling hazardous substances (other than hazardous wastes). Under these Rules the hazardous industry is required to identify major accidents, hazards, take adequate preventive measures and submit safety report to the designated authority. An importer of hazardous chemicals must furnish complete product safety information to the competent authority and must transport the imported chemicals in accordance with the Central Motor Vehicle Rules, 1989. A set of rules on the transportation of hazardous chemicals by road have also been notified under the Motor Vehicle Rules, 1989 by the Ministry of Surface Transport. A few amendments clearly indicating the responsibilities of the occupiers, transporters, drivers are being included in the rules. The State Government has identified hazardous installations and operations in their states and implemented the notified rules. Rule 3 prescribes the duties of various governmental authorities, for example, the Central and State Pollution Control Boards are required to enforce governmental directives and procedures pertaining to the isolated storage of hazardous chemicals, and the district collectors or other designated authorities are required to prepare off-site emergency plans to contain major chemical accidents. Under Rule 4 an occupier must identify the major hazards posed by his industry, take steps to prevent and limit the consequences of an accident and train workers in operational safety.

Under Rule 18 an importer of hazardous chemicals into India must disclose complete product safety information. Where the imported chemical is likely to cause a major accident, the designated governmental authorities are empowered to issue directions, including an order to stop the import. The importer must also ensure that the transport of the chemicals from the port of entry is in accordance with the Central Motor Vehicle Rules, 1989.

Rules to regulate the manufacture, use, import, export and storage of hazardous micro-organisms and genetically engineered cells were issued under the Environment Act in December 1989. These rules cover industries, hospitals, research institutions and other establishments that handle micro-organisms or are engaged in genetic engineering. Committees of experts established, under Rule 4f play a pivotal role in administering regulations.

Besides the rules issued under Environment (Protection) Act, provisions touching on certain other aspects of storage, transportation and regulation of hazardous Substances are contained in the Central Motor Vehicle Rules, 1989, the Insecticides Act, 1968, the Explosive Substances Act, 1908, the Inflammable Substance Act, 1952 and the Atomic Energy Act, 1962. In addition, the 1987 Amendment to the Factories Act, 1948 introduced a new chapter on hazardous industrial activities. This chapter aims at increasing plant safety by such measures as increased worker participation in the monitoring of safety measures and stiff penalties against employees for non-compliance with safety norms.

Under Rule 5, Central Government may prohibit or restrict the location of any industry and the conduct of certain activities in notified areas. Any aggrieved person, including an affected industry, may file an objection against the prohibitions and restrictions.

Coastal Area and Tourism Management

For protecting the ecological, cultural and aesthetic values of coastal areas and to ensure that the use and activities in the coastal areas are consistent with the environmental conservation principles the Ministry of Environment and Forests has issued a notification under Environment (Protection) Act, 1986 to ban certain activities and to categories in the coastal areas into certain regulation zones. The notification identifies prohibited activities within the 500 m of the high-tide line and those that are to be permitted in accordance with the guidelines given in the notification.

Pollution Control in Major Polluting Industries

Compliance by the industries with the environmental standards has not been adequate inspite of the best efforts, including financial incentives made over the years by the Pollution Control Boards/State Govt./Central Govt.

The Central Pollution Control Board selected 17 categories of major polluting industries for priority action, and in February 1991, directed the state boards to ensure compliance of standards in these industries.

Accordingly, most of the state boards amended the consent order of all the industries in these categories so that no defaulting unit shall have consent of the board. Extensive discussions were held with the state boards in groups in a scheduled manner, to assess the problem and identify the defaulting units and initiation of suitable actions. It is observed that about 90% of the industries have adopted pollution control measures.

Incentives for Control of Pollution

For the initial years of pollution control, the expenditure on providing pollution control equipment were termed as non-productive expenditures and the regulatory authorities had to face a tough task in convincing the industry for providing and running of pollution control devices. Although a few industrialists understood the need of pollution control as a social obligation and were willing to discharge their responsibilities but the main constraint was non-availability of cheaper technologies and finance. It was felt if the expenditure on the prevention of pollution could either be made productive or compensated, most of the industry may come forward to provide the same to comply with pollution control regulation. Pollution control technologies which are self paying and sustainable were developed and publicized. The concept of recovery of energy and by-products received appreciation. At the same time the government showed its willingness to extend fiscal and financial incentives to encourage adoption of pollution control measures by the willing industries. A prime example of this is the exemption on fly ash bricks from excise duty. The concept of common treatment plant and providing financial assistance up to 50% of the cost of common effluent treatment plant will greatly benefit the small-scale industries located in clusters and having space, technological and financial constraint in controlling the pollution individually. Provision of rebate in water cess for these industries who comply with the prescribed effluent standards have also helped indirectly the industries who run the effluent treatment plant regularly and properly.

The industry must accept social obligation towards the society of which it is an integral part. The industry may not remain unaffected if the environment around the industry is affected. Large industries located in urban areas may adopt small areas in the cities for improving its environment and thereby the quality of life. In the process many industries may join hands to adopt bigger areas. The industry must take all necessary steps to keep the environment clean and to contain pollution. Only a few years back the attitude of the industries was antagonistic. The industries were not willing on the pretext of finance, space and technical constraints to provide Effluent Treatment Plants (ETPs). With the generation of mass-awareness, development of technology, offering of fiscal and financial

incentives, rigorous persuasion and stricter supportive legislation and involvement of judiciary, many of the industries have not only understood the necessity of pollution control but have also taken necessary steps to control pollution. Now a trend has been set where the industry is interacting with surrounding settlements. Many of industries have not only made sincere efforts to keep the surrounding environment clean but also provided service to the society by opening schools, parks, hospitals and other amenities as a compensation for their inconvenience.

Pollution Abatement Policy

In 1992 the Government of India published a policy document on pollution abatement. The policy document has the following main features.

To achieve pollution control a mixed instrument is required e.g. legislation, fiscal incentives, voluntary agreements, educational programmes and information campaigns.

It highlights the gravity of the pollution problem in India, and the future course of action including positive attitude, comprehensive approach, prevention of pollution by adopting the best available technology for manufacturing, imposing polluter pay principle, focussing on critically polluted areas and involving the public in decisions.

The policy also provides for mass-based standards, waste minimization, adoption of clean technology or 'no-waste', 'low-waste' technology of manufacturing, promotion of recycling and reuse of wastes and conservation of water, energy and other resources, financial assistance in common effluent treatment plants for small-scale industries.

The policy also focussed on integration of different departments/ ministries in the government (both Central and State) related to pollution.

It highlighted the environmental audit of all the industrial activities and involvement of the public through mass-awareness, public interest litigation and 'Ecomark'. The 'Ecomark' is a mark given to the products, which are produced in an eco-friendly manner. The people voluntarily buy such products in order to promote environmental friendly products in the market.

Public Interest Litigations

In the last one decade a large number of public interest litigations in the Supreme Court of India and various High Courts of the States have resulted in strict implementation of various regulations, which were not implemented due to several reasons.

SPECIAL INITIATIVES

The Ganga Action Plan and National River Action Plans

Apart from the legal and institutional provisions made by the government to regulate water quality, several other measures are also taken to improve water quality of the national aquatic resources. The most important of such measures is the execution of an ambitious plan to restore the Ganga river water quality called Ganga Action Plan in 1985. A separate authority was created to implement the plan called 'Central Ganga Authority' headed by Prime Minister of India. The most important activities in this plan are interception, diversion and treatment of major pollution outfalls into the Ganga river. Subsequently such measures were extended to other selected river stretches in the country which are critically polluted. The Central Ganga Authority is converted into the National River Conservation Directorate (NRCD) with more extended scope of work. Today the activities of river cleaning are being implemented at 157 cities/towns of the country located along different rivers.

CONCLUSION

Water quality in India is degrading at a very fast rate, partly due to rapid urbanization and industrialization and partly due to over-exploitation of water resources. Untreated domestic sewage is the major cause of pollution in India. The domestic sewage not only pollutes surface water where they are being discharged, but also pollutes the groundwater due to inadequate collection and transport of sewage resulting in stagnation and percolation. Industrial wastes although smaller in quantity, having a significant effect on the aquatic environment due to their toxic and conservative nature. A number of initiatives are taken by the Government of India and State Governments to protect the water resources. However, the efforts are not adequate to cope with the rapidly growing problem in the country. There are challenges like poverty, water scarcity, lack of awareness, lack of resources. However, with the large number of regulations, increasing public awareness, involvement of judiciaries and many international agencies it is expected that the water quality will improve in the future.

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5

Status of Freshwater in Sri Lanka: From a Precious Resource to a Commodity Wasted and Mismanaged

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*“Not a single drop of rain water should be allowed to escape into the sea
without being utilized for human benefit”*

—King Parakramabahu the Great (1153–1186 AD)

INTRODUCTION

The above quote from the ‘Mahawansa’; the historical bible of Sri Lanka and the startling statistic of approximately 79% of the run-off escaping into the ocean in the wet zone today, perhaps would partly justify the selection of the title for this chapter. In keeping with the above noble policy statement, the ancient rulers of the country constructed the large irrigation tanks that dot the landscape in the dry zone and the canal network connecting the tanks and agricultural lands to store rain water for irrigation during the dry season. However, most of the precipitation falls outside this catchment area and no major effort is planned to use the bulk of the rainwater during the dry season when water crises precipitate. Consequently the water resource for which every Sri Lankan is paying by way of indirect taxes is wasted through lack of foresight and misplaced priority. It is important that one looks at the freshwater issue in a holistic manner taking into consideration the country’s

population statistics, geography, climatic patterns, industrialization and agricultural practices.

Country Profile (Department of Census and Statistics, 2002)

Estimated Population ('000), 2002	18,990
Percentage of Population 18 Years and Over, 2001	66.5
Crude Birth Rate, 2000	17.3
Crude Death rate, 2000	5.7
Growth Rate of Population, 2000	1.2
Infant Mortality Rate, 1999	13.4
Total Fertility Rate, 2000	1.9
Life Expectancy – 1999	73
Literacy – 1999	91.4%

Sri Lanka is an island in the Indian Ocean located between the latitudes 5° 55' N and 9° 55' N; and longitudes 79° 42' E and 81° 52' E. The total land area of 65,621 km² has a rich biodiversity with cities in the central hills situated at elevations greater than 500 m above mean sea level. The tropical climatic island nation's 'tear drop' shape is 440 km long from north to south and a maximum of 226 km wide from east to west. Out of the total land area, approximately one-third has been utilized for plantations and agriculture holdings (Manchanayake and Madduma Bandara, 1999). The total forest cover has drastically reduced over the years from 44% in 1950 to 18% by year 2000. However Sri Lanka can boast of having the highest percentage of protected land area of 12%. As a nation with one of the highest population densities in the world (289 persons/km²), Sri Lanka faces severe environmental issues from water pollution, air pollution and solid waste disposal. With an increasing urban population (22% in 1995) and restrictions placed by man and nature on habitable land, the most populace district the western province has a population density of close to 1000 persons/km².

The island receives on average rainfall of 1800 mm from two monsoons, namely the South-West monsoon prevailing from April to September and the North-East monsoon from October to March. However, lately these two monsoons have been inconsistent with respect to the timing and rainfall. Global climatic changes and the country's diminishing forest reserve are contributory factors. The South-West and North-East monsoons provide an annual rainfall of 2400 mm on average to one quarter of the area of the land, commonly identified as the wet zone. Major commercial crops, the tea, rubber and coconut benefit from these bi-annual rainy periods and are the country's only source of freshwater. However the remaining three-fourths of the land receives only one significant monsoon (North-East) that has an annual average of 1450 mm.

Until the 1980's, Sri Lanka had an agricultural economy mainly dependent on the three export crops of tea, rubber and coconut. Paddy cultivation that requires large volumes of water was for domestic consumption and presently the country has achieved self-sufficiency in rice. However, with the implementation of the open economic policies beginning from the year 1977, the service sector has become the major contributor for the GDP. The industrial sector though showing signs of growth still contribute only 23% of the GDP. Sri Lanka has achieved a reputation as one of the major suppliers of textiles and garments in the world. The dyeing and washing operations require large amounts of water and are the major polluters of freshwater from discharge of industrial wastewater.

Industrialization and population increase has led to an annual demand for power at the rate of 8%. The country's installed power capacity that stood at 1526 MW in 1992 has risen to 2300 MW by 2001. The hydroelectric power (1135 MW) that contributed almost 80% of the installed capacity in the 1980's, thanks to the Accelerated Mahaweli Development Program, contribute less than 50% of the power requirement in 2003. Lack of sufficient rainfall, prolonged droughts and increasing demand for power has forced the country to turn to expensive diesel power generators to meet the power requirements.

1. Fresh Water

Precipitation is the only source of freshwater in Sri Lanka as dew, hail, frost and snow are not present under tropical climatic conditions. With the increasing population, rapid industrialization and change in climate patterns, Sri Lanka is heading for a severe shortage of freshwater. Although receiving a mean annual rainfall of approximately 1800 mm, the spatial (Fig. 5.1) and seasonal variations have shown large districts in the dry zone being below the threshold per capita water supply of 1700 m³. The arid regions of the country receive a rainfall of approximately 900 mm and certain parts of the central hills receive in excess of 5000 mm. The North-East monsoon rainfall brings in a fall of 800 mm to 3000 mm whereas the South-East monsoon varies from 150 mm to 3000 mm. The 'dry zone' and the 'wet zone' are demarcated by the 2000 mm annual average rainfall isohyet. In the dry zone (two-thirds of the total land area), over 50% of the total run-off is utilized whereas in the wet zone (average rainfall of 2500 mm) nearly 79% of the run-off escapes into the ocean. Such is the level of utilization of precious freshwater received in a country that is increasingly facing a severe water crisis. The primary reason for the large disparity in the run-off between the two zones is the geology and the topography of the land. The major portion of the valuable land for agricultural purposes lies

in the dry zone where most of the paddy cultivation exists. This then was contributory for the construction of a large number of storage reservoirs during the hydraulic civilization period. Together with the fact that the major landmass in the dry zone is located away from the surrounding sea with low altitude gives rise to the higher capture rate of the precipitation. The wet zone catchment area is comparatively smaller totaling only up to 19% of all catchment areas of Sri Lanka. Although small in area, the rivers flowing through the wet zone account for 49% of the total mean annual yield of all rivers. This calls for trans-basin diversion, as in the Mahaweli Diversion Project, and construction of multitude of storage reservoirs to meet the water needs of the country.

Although small in area, Sri Lanka has 103 river basins spread across the length and breadth of the country (Fig. 5.1). Most of these rivers originate from the central hills and flow through the low altitude coastal areas to the sea. However, a large proportion of these rivers are small in size and more appropriately identified as streams that would go dry during the dry season. Table 5.1 lists the major river basins with catchment areas greater than 1000 km². The largest among the rivers is the river Mahaweli that is 335 km long and drains an area of 10,448 km². The flowing waters support many activities such as irrigation for agriculture, hydro power both large and mini hydro schemes, small and large scale industries, water supply and sanitation for human settlements, inland fishing, inland transportation, water sports and other leisure activities, hospitality industry etc. Unfortunately these very same rivers are being used for nefarious activities like effluent and sewage discharge from industry and households, garbage disposal, sand mining and even illicit brewing to avoid land detection. Such activities have severely restricted the beneficial use of these waters and contributed to causing health impacts and environmental nuisance. Although 6.4% of the total land area is occupied by streams, large and small reservoirs (Somasekaram et al., 1997); Sri Lanka frequently experiences severe droughts when some of these reservoirs go dry affecting large segments of its population.

Large-scale water resources in Sri Lanka are state-owned and the National Water Supply and Drainage Board (NWS & DB), which is under the Central Government, is the main provider of pipe-borne water to the nation. There are 277 major, minor and small water supply schemes in operation under the NWS & DB's purview. Out of this 29 schemes cover major cities and 248 schemes cover townships and villages. It has a customer base of 7,32,935 connections and produces approximately 350×10^6 m³ per annum. In addition to NWS & DB, local authorities and community-based organizations are managing a number of water supply schemes. As of the year 2002, 26.5% of the total population is served by pipe-borne water supply and 11.7% of population are served with tube wells. The pipe-

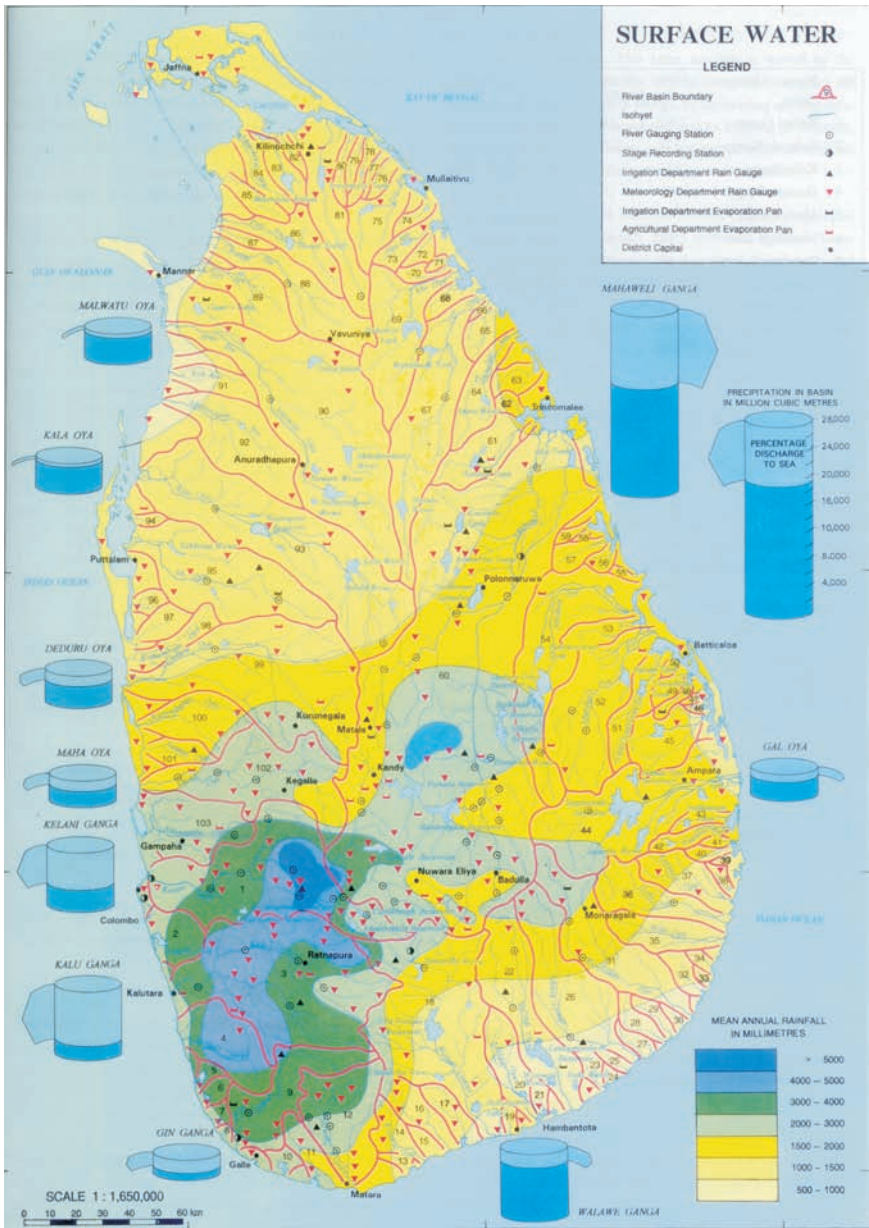


Fig. 5.1. The map of Sri Lanka showing the 103 river basins numbered anti-clockwise beginning from Kelani river and the spatial distribution of average rainfall (Source: Somasekaram et al., 1997)

Table 5.1. Major river basins of Sri Lanka

Name of basins	Catchment area (km ²)	Mean annual precipitation volume (mem)	Mean annual discharge volume to sea (mem)	Annual discharge as a % of precipitation
Kelani River	2292	8660	5579	64.4
Kalu River	2720	11302	8183	72.4
Walawe River	2471	4577	2200	48.1
Kirindi stream	1178	1774	428	24.1
Menik River	1287	2098	484	23.1
Kubukkan stream	1233	1938	428	22.1
Gal stream	1873	3640	1079	29.6
Mundeni aru	1295	2609	781	29.9
Maduru stream	1559	2816	777	27.6
Mahaweli River	10448	26368	8141	30.9
Yan stream	1538	2476	482	19.5
Ma stream	1036	1500	300	20.0
Malwatu stream	3284	4573	566	12.4
Kala stream	2805	3974	855	21.5
Mi stream	1533	1925	199	10.3
Deduru stream	2647	4589	1129	24.6
Maha stream	1528	4218	1485	35.2

borne water is obtained from surface water sources while the tube wells draw groundwater in areas that are sparsely populated without a central water supply scheme. A staggering 50% of the supply is unaccounted for due to leakages, unauthorized connections and free stand-post supply to low-income groups. Increasing use of water by industries, for power generation and sanitation has polluted most of the existing surface and groundwater supplies thereby restricting its use. The average water quality at the Ambatale water intake over a period of three months is given in Table 5.2. Heavy metals are not among the parameters regularly tested although many industries discharge wastewater to the Kelani River. Over 90% of surface water is used for irrigation and the irrigation efficiency for the country is as low as 20%. Table 5.3 summarizes the capacities of the water treatment plants in the Greater Colombo Area managed by the country's main water distributor.

Groundwater is the main source of water for the population that is not served by pipe-borne water. Among the different types of aquifers, the karst limestone aquifers are regarded as the richest sources of groundwater

Table 5.2. Kelani River Ambatale intake average raw water quality during the period March-June 2004 (Nanayakkara, 2004)

Parameter	Average	Normal range
pH	6.7	6.6 – 6.8
Turbidity (NTU)	12	6 – 200
Colour (Hazen Units)	10	5 – 70
Conductivity ($\mu\text{s}/\text{cm}$ at 25°C)	30	20 – 50
Total Solids (mg/l)	35	20 – 150
Total Alkalinity (mg/l)	10	4 – 25
Total Hardness (mg/l)	8	4 – 20
Calcium (mg/l)	4	2 – 15
Chlorides (mg/l)	6	4 – 12
Total Iron (mg/l)	0.4	0.2 – 1.0
Free Ammonia (mg/l)	0.02	0.01– 0.04
Albuminoid Ammonia (mg/l)	0.02	0.01– 0.08
Biochemical Oxygen Demand (mg/l)	1.3	0.3 – 3.3
Chemical Oxygen Demand (mg/l)	16.8	7.8 – 50.0

Table 5.3. Water treatment plants managed by NWS&DB for Greater Colombo area

Plant data	Ambatale	Labugama	Kalatuwawa
Date of commissioning	1966 (old plant) 1994 (new plant)	1882	1960
Raw water source	Kelani River	Labugama reservoir	Kalatuwawa reservoir
Intake	Two pumping stations	Gravity flow to treatment plant	Gravity flow to treatment plant
Sedimentation tank	61,300 m ³ — 05 Nos. 45,000 m ³ — 04 Nos.	02 Nos.	02 Nos.
Rapid sand filters	26	15	10
Daily production (m ³)	470,000	38,000	68,000
Maximum capacity/day (m ³)	500,000	53,000	90,000
Chemicals used	Alum, lime and chlorine gas	Alum, lime and chlorine gas	Alum, lime and chlorine gas

in Sri Lanka (Manchanayake and Madduma Bandara 1999). The high porosity of the limestone allows the water to seep through and retain between the bedrock and the limestone layer. The most studied aquifers in the country are the Vanathavillu, Murunkan and Mulangavil basins. In the confined Vanathavillu basin that spreads over some 40 km², the estimates

of groundwater resources available vary from 5,000–20,400 million l/annum (Wijesinghe 1975; Foster et al. 1976). In the high yielding Murunkan basin situated to the north of Vanathavillu, pumping rates of 19–25 l/s are reported (Wijesinghe 1985). The next major aquifer system located in the Mulankavil basin lies between the water courses of two rivers and has an area of 180 km². Comparable pumping rates to that of Murunkan basin are reported.

There are a few commercial scale groundwater exploitations at present (bottled water plants) and under current laws and regulations for water, any one is free to use this resource at zero cost. Individual households have their 'own' wells in the backyard that are used either by pumping (where electricity is available) or manually drawn water through a bucket-pulley combination. Where the water table is deep, tube wells (hand pump wells) are common. In rural areas, it is common for the local government to install a common tube well where a community can draw water to meet its individual needs. Many industries use 'treated' groundwater for industrial processes either due to lack of municipal supplies or to avoid the high cost of water.

In a socio-economic impact survey conducted among 600 households east and south of Colombo by the Third World Center for Water Management; it has been revealed that 30% of the households are still using well water for drinking purposes (Daily News 2002). Some 55% of the households considered piped water to be good and only 2% considered it to be bad with the rest holding neutral views. In the same study, it was reported that well water is seriously contaminated in those households that perceive it to be of better quality than piped water. In contrast the piped water was of good quality.

2. Science

The water balance for the entire country can be conceptually shown as in Fig. 5.2. Approximately 65% of rainwater received is retained in the soil and the groundwater body and the balance is estimated to flow into rivers and streams. This is then carried on to the ocean or finds its way into lakes and reservoirs. It is also estimated that 45% of the water that seeps to the ground is lost through evapotranspiration. There is no estimate to indicate the quantity of groundwater extracted for irrigation, hydropower and water supply. These figures vary widely depending upon the climatic zones of the country. For example in the dry zone, approximately 50% of the surface water is utilized, whereas close to 79% is run-off in the wet zone.

Groundwater quality is closely dependent on the geology of the area. Due to the dissolution of cations, it is common for the groundwater to be

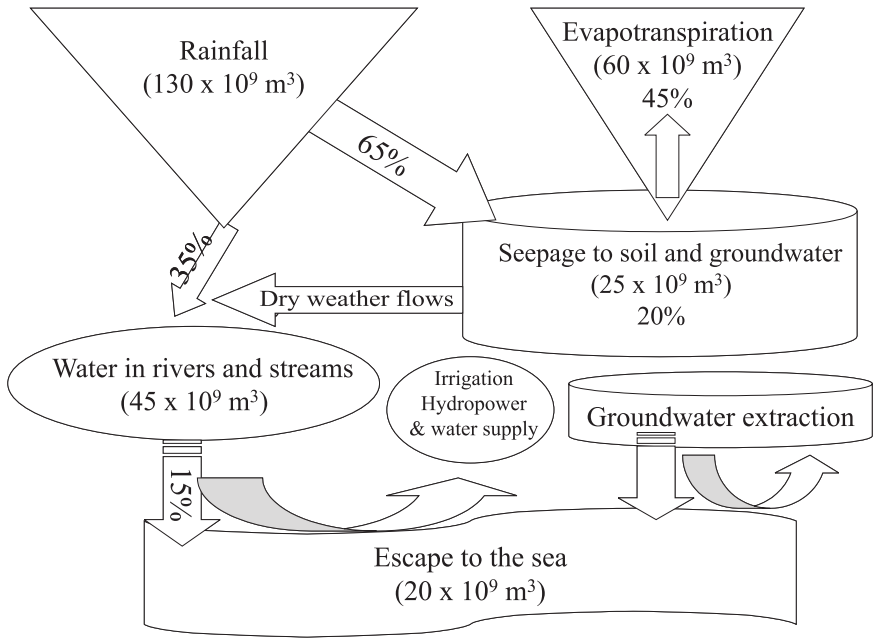


Fig. 5.2. Schematic representation of water balance for Sri Lanka (Adapted from IWMI, 2003)

‘hard’. In areas containing ferrite soils, the groundwater contains a high level of iron. Excess fluoride and nitrate are found in deep well water in the districts of Anuradhapura, Polonnaruwa, Kurunegala, Monaragala and Nuwara Eliya, Badulla areas respectively. Table 5.4 gives an indication of water quality found in limestone aquifers. In highly urbanized areas, sewage contamination from soakage pits is common and many wells are abandoned in such instances. A minimum distance of 20 m is recommended between a septic tank and a well. However, rainwater infiltration results in many septic tanks to discharge contaminated water into nearby groundwater wells.

Table 5.4. Water quality in limestone aquifers (Basnayake 1985)

Chemical parameter	Minimum value (ppm)	Maximum value (ppm)	Usual range (ppm)
Bicarbonate	327	547	400 – 500
Chloride	133	1040	250 – 700
Nitrate	0.05	1.5	01 – 05
Sulphate	5	240	50 – 150
EC (at 25° C) mhos	910	4200	1500 – 3000

3. Laws and Policies

The Ministry of Environment and Natural Resources in its 'National Environmental Policy' document carries the following policy statements on managing the water resources in Sri Lanka. "The quality and quantity of surface water, groundwater, coastal waters will be managed to balance the current and future needs of ecological systems, communities, agriculture, fisheries, industry and hydro-electric generation." To accomplish this the Government of Sri Lanka (GOSL) will:

- (i) Manage the risks to water supply and quality through the integration of land-use and natural resource management within critical catchment zones using community catchment groups
- (ii) Adequate protection of all major watersheds will be provided with the services of community catchment groups
- (iii) Ensure that surface freshwater quality is suitable for community needs including drinking, swimming, fishing
- (iv) Ensure that coastal waters are of such quality to enable the sustained use of fishery resources for human consumption
- (v) Prevent degradation of the quality and flow of waters considered to be of national importance
- (vi) Ensure that the in-stream value of water relating to ecological functionality and aquatic biodiversity is protected through gazettement of such waterways and activities that place them at risk
- (vii) Protect groundwater aquifers through the control of land-use and waste disposal within recharge zones
- (viii) Reduce water wastage through the provision of incentives for the maintenance of water distribution systems for urban, industrial and irrigation systems including the recycling of wastewater wherever possible
- (ix) Promotion of small-scale water harvesting methods to be encouraged
- (x) Classification of waterways according to their quality and the implementation of information systems that notify the public of the water quality, contamination sources, and the regulation of pollution levels
- (xi) Integration of river basin management plans into a broader management program, which includes coastal zone, wherever appropriate

In recognition of the fact that water is a scarce resource essential to life, the state exercises full authority over water resources, its use, priorities and distribution. In Sri Lanka, there are a number of laws dealing with the utilization of water. Some of these legislations are administered by the government departments (Irrigation ordinance, No. 32 of 1946, as amended

in 1968; Factories ordinance No. 45 of 1924 and No. 22 of 1946, Fisheries ordinance, No. 24 of 1940 etc.); some by public corporations (river valleys development board, Act No. 6 of 1956; Water resources board act No. 29 of 1964; Mahaweli development board act No. 14 of 1970, 3 of 1976 and 38 of 1983 etc.) and others by local bodies (Urban councils ordinance No. 61 of 1939, Town council ordinance No. 3 of 1946; Municipal council ordinance No. 29 of 1947 etc.). Although the number of legislation on water resource management are numerous, the archaic nature of these regulations enacted under then prevailing economic conditions possess several shortcomings when looked at from present day water needs. Multi-sectoral demand for freshwater has necessitated the adoption of new policies for prioritization and conservation of water resources and inaction of new regulations to meet policy objectives.

Under the financial assistance of Asian Development Bank (ADB), a project was launched for comprehensive water resource management and institutional strengthening. A Water Resources Council and a Water Resources Secretariat was created to develop a national water policy, draft a national water act and amend other water related legislation, establish data and information systems to meet the needs of water management, policy and planning, facilitate maximum public awareness, participation in water management strategies and establish appropriate systems and procedures for comprehensive planning based on management of river basins. Subsequently an Interim National Water Resources Authority was created and a National Water Resources Policy (NWP) was formulated.

However the policy has run into difficulty with many controversial aspects being contested by both government Ministries handling different uses of water and Non Governmental Organizations (NGOs) and the general public. The most controversial issue has been the 'fear' of privatization of water resources that can lead to unequal distribution of water resources based on the ability to pay principle and levying of 'taxes' on water used for agricultural purposes. The environmentalists express doubts about ownership, entitlement, full cost recovery, pricing, the rights of the bulk water users, the control of river basin management committees in the proposed policy which they allege make water a tradable commodity. Under the full cost recovery policy, it is argued that the poor will be deprived of access to safe drinking water. With the proposed introduction of water permits (entitlements) the permit holder can sell, transfer and sell the permit for a higher price and as such the agriculture water entitlements can be transferred to industrial water. It is also alleged that all the garden well-holders will be taxed to the tune of Rs.500 per annum which at the moment is a free resource.

Many of the objections to the policy are a result of funding obtained for the formulation of the policy from an institution such as ADB which clearly

envisions that water is an economic commodity. Many fear that under the proposed policy, water would become a commodity with a potential commercial value. "This problem has to be reviewed with the General Agreement in Trade on Services (GATS) of the World Trade Organization (WTO) which may pave the way for privatization of both drinking and irrigation water" opined an analyst.

However such fears are dismissed by the Water Secretariat who assures the public that no water resources would be privatized. The financier of the policy responding to the criticism have also assured the nation that privatization is not the objective of the proposed policy, but the aim was to introduce proper water management policy to conserve water resources. Given the huge lack of trust between the protagonist and the stakeholders, the nation may not see a clear policy coming out in the immediate future!

4. Contamination of Water

River waters are increasingly subjected to pollution from point and non-point sources that have threaten not only the aquatic ecosystems but also the human population living close to and using such waters for daily activities. Sri Lanka's pipe-borne water supply is fully dependent on surface waters from the main rivers and reservoirs in the catchment areas. Illegal settlements on riverbanks discharge untreated sewage to the rivers that are tapped for freshwater. Industrial effluents containing heavy metals are also discharged to the capital city's main water source the 'Kelani River'. The NWS&DB monitors the quality of river water at locations upstream of the Ambatale water intake. Samples are taken from Rukgahawatta Ela (to which treated wastewater from the Biyagama Free Trade Zone is discharged), at the 11th mile post located in between Rukgahawatta Ela and the water intake, close to Ocean Lanka (a private company with its own wastewater treatment facility) effluent discharge point to the river and the intake well to Ambatale plant. Water quality monitoring at strategic points along the Kelani River revealed that the Biyagama Free Trade Zone wastewater treatment plant that is operated by the NWS&DB does not meet the discharge standard for BOD₅ 41% of the time (Nanayakkara 2004) with concentrations exceeding 100 mg/l frequently. However, average water quality (15 readings over a period of 3 months) at the Ambatale intake does not reflect the level of pollution due to the effects of dilution and natural attenuation (Table 5.2). Heavy metals are not frequently monitored and it will be interesting to see how the country's major water source fare with regard to this important parameter.

River sand is the country's sole source of sand for the construction industry. Unsustainable mining has led to serious environmental issues such as erosion of river banks due to higher flow rates from deepening

rivers and salt water intrusion due to over exploitation of groundwater and seawater infiltration. As a critical example, the capital city's water supply was disrupted for two days during high tide owing to seawater intrusion into the country's major water purification plant at Ambatale in March, 2004 which is located 15 km away from the river mouth.

Although the authorities do act on specific complains to 'check' deterioration of water quality, no strict enforcement of effluent discharged regulations is practised for the elimination of unauthorized effluent discharges to the country's main water sources. However, as part of the awareness program conducted by the Ministry of Environment and Natural Resources, a program named 'Pawithra Ganga Program' (Clean River Program) was launched in the year 2003 to educate the masses on river water quality. Weekly readings of important water quality parameters are displayed along the main rivers with explanations provided for interpretations of the results.

Surface and groundwater pollution due to discharge of untreated industrial, municipal and agricultural non-point sources is a serious and wide spread problem in Sri Lanka. Although regulations were enacted under the National Environmental Act (NEA) in 1980 with effluent discharge standards for the discharge of wastewaters to surface, marine coastal waters and land for irrigation, these standards are not enforced due to multitude of economic, social, managerial and technical reasons. The effluent discharge standards itself need further review considering the environmental issues of the present day. The discharge standards are concentration based and assuming a dilution factor of eight for discharge into surface water bodies, has stipulated levels for different pollutants. The general effluent discharge standards applicable are given in Table 5.5. In addition there are different sets of regulation for identifying high pollution industries such as tanning, textile, rubber and latex for which the concentration levels are less stringent than the general standards.

Only 24 categories of pollutants are regulated and many of the pollutants of photographic and lithographic waste are unregulated. Phosphorous is not regulated and this has led to many of the country's lakes (Beira, Bolgoda, Kandy and Gregory lakes) becoming eutrophic. The ammoniacal nitrogen standard is set at a very high 50 mg/l level which is not at all suitable for controlling eutrophication. However only a few of the effluent treatment plants are designed to control ammoniacal nitrogen and almost none for the removal of phosphorous. Frequently addition of uncontrolled levels of nutrients to biological wastewater treatment plants give rise to eutrophication in receiving water bodies. The concentration based effluent standards does not promote water-frugal methods and infact encourage water-intensive practices for dilution purposes. Approximately 60% of the small and medium scale enterprises (SME) that are responsible for industrial

Table 5.5. General standards for discharge of effluents into inland surface waters

No.	Determinant	Tolerance limit
1.	Total Suspended solids, mg/l, max	50
2.	Particle size of total suspended solids	shall pass sieve of aperture size 850 micro m.
3.	pH value at ambient temperature	6.0 to 8.5
4.	BOD ₅ at 20°C, mg/l, max	30
5.	Temperature of discharge	shall not exceed 40 C within 15 m down stream from the effluent outlet
6.	Oils and greases, mg/l max	30
7.	Phenolic compounds (phenolic OH) mg/l, max	1.0
8.	Cyanides as (CN) mg/l, max	0.2
9.	Sulfides, mg/l, max	2.0
10.	Fluorides, mg/l, max	2.0
11.	Total residual chlorine mg/l, max	1.0
12.	Arsenic, mg/l, max	0.2
13.	Cadmium total, mg/l, max	0.1
14.	Chromium total, mg/l, max	0.1
15.	Copper total, mg/l, max	3.0
16.	Lead total, mg/l, max	0.1
17.	Mercury total, mg/l, max	0.0005
18.	Nickel total, mg/l, max	3.0
19.	Selenium total, mg/l, max	0.05
20.	Zinc total, mg/l, max	5.0
21.	Ammoniacal nitrogen, mg/l, max	50.0
22.	Pesticides	Undetectable
23.	Radioactive material	
	(a) Alpha emitters micro curie/ml	10 ⁻⁷
	(b) Beta-emitters micro curie/ml	10 ⁻⁸
24.	Chemical Oxygen Demand (COD), mg/l, max	250

Notes

1. All efforts should be made to remove color and unpleasant odor as far as practicable
2. These values are based on dilution of effluents by at least eight volumes of clean receiving water. If the dilution is below eight times, the permissible limits are multiplied by 1/8th of the actual dilution
3. The above-mentioned General Standards shall cease to apply with regard to a particular industry when industry specific standards are notified for that industry

pollution are located in the western province due to the proximity to the commercial capital and the availability of better infrastructure facilities. This has resulted in surface water bodies in this province being exposed to

high pollution loads. For example the Kelani River from which 130 million gallons per day is withdrawn for the supply of pipe-borne water to the populace of the western province receives wastewater from tire, textile, metal plating, battery manufacturing industries, many small cafes and restaurants, leachate from garbage disposal and domestic sewage from unauthorized constructions that do not have latrine facilities. Even if all these sources comply with the effluent discharge standards, the river water will still have high amounts of pollutants from load discharges. However increasing public concern has resulted in some of the industries being prosecuted, others being denied a mandatory environmental protection license (EPL) and the sensitive river basin being declared a protective area.

Groundwater contamination due to untreated industrial wastewater has become a serious environmental and health issue. Most of the industries tend to discharge untreated and partially treated effluent into the nearby drains or streams resulting in groundwater pollution. The country still has only one sanitary landfill and the indiscriminate disposal of garbage and industrial solid waste pose a serious threat to groundwater. Even though the processes such as sorption to soil and natural attenuation by micro-organisms results in natural purification of the wastewaters, persistent release of large volumes make these processes ineffective and cause contamination of the groundwater resource. Specifically the contamination of groundwater by heavy metals pose a problem of phenomenal proportion due to their resistivity to biological degradation, toxicity to ecosystems, property of bio accumulation, persistence in environment and inability to be removed from conventional water treatment methods. Some of the health and environmental concerns of heavy metals in water are tabulated in Table 5.6.

Table 5.6. Health and environmental concerns of heavy metals in water

Metal	Health and environmental concerns
Iron	Adds color and taste, affect aesthetics, stains laundry, causes hemorrhagic necrosis, sloughing of mucosa in stomach, genetic disorders
Manganese	Lethargy, increased muscle tone
Silver	Discoloration of skin, hair and fingernails
Nickel	Toxic at high concentrations
Aluminum	Causes Alzheimer’s disease, kidney dialysis
Chromium	Highly toxic specially the hexavalent form
Copper	Unpleasant, astringent taste, staining of laundry and plumbing fixtures
Lead	Cumulative general poison in infants, teratogen, affects the central nervous system, reduces IQ in children
Cadmium	Suspected carcinogen, causes anemia, anosmia, osteomalacia and cardiovascular diseases

Two of the areas in the western province that have had serious industrial pollution problems are the Ekala-Ja-ela and Moratuwa-Ratmalana cities located towards the north and south of the capital city of Colombo respectively. Problems have arisen due to unplanned siting of industries in residential areas that has resulted in serious pollution of water, air and land due to effluents and emissions from these industries. Absence of common sewerage facilities has resulted in the industrial effluents being released into uncovered and unsealed drains, nearby marshy lands and other water bodies (Figs. 5.3 and 5.4). The majority of the drinking water wells in the neighborhood of these industries have been abandoned due to contamination (Fig. 5.5). Due to the built-up nature of the cities, there is lack of space for adoption of environmental control measures. A study was undertaken in the year 2002 to gauge the extent of heavy metal contamination of groundwater in the Moratuwa-Ratmalana area (Gunawardhana 2002, 2004).



Fig. 5.3. Untreated textile industry wastewater in common sewers leading to the Lunawa lagoon in the Moratuwa-Ratmalana area

The coastal cities of Moratuwa-Ratmalana are located approximately 15 km south of Colombo, the capital of Sri Lanka. Geologically the area has silty-sand with some pockets of organic clay. The water table is very shallow (approximately 1–2 m) and the groundwater is replenished mainly



Fig. 5.4. Discharge of colored wastewater into an inland surface water body



Fig. 5.5. An abandoned drinking water well in the Moratuwa-Ratmalana area polluted by textile industry effluents

by precipitation. There exist almost 125 industries in the study area: prominent among them are textile and garment, chemical, metal finishing, food, pharmaceutical and asbestos manufacturing plants. Residential development amidst these industries has taken place particularly as single units, although pockets of higher density multi-family developments are also present. Low-income settlements occur throughout the area, in particular, along canal banks and lake/lagoon shorelines.

A total of 79 groundwater wells and 36 industrial effluents were sampled for heavy metal analysis. Biased sampling based on historical information, knowledge on the behavior of the contaminants and knowledge on the type of near-by industries were carried out. A discrete sample was taken at once and at a particular point in the sample matrix. From these selected sample locations, samples were collected using a depth sampler at a distance of 0.25–0.5 m from the water surface. The samples were preserved at the site with nitric acid and were stored at 2°C until analysis. Autoclaved and digested samples, to convert particulates to free metal form and reduce interference from organic matter, were analyzed using flame atomic absorption spectrophotometry.

Results revealed the presence of iron in well water far in excess (1.1 mg/l on average) of WHO stipulated standards for drinking water (Table 5.7). High iron concentrations were detected in 55 of the 79 wells tested that also contributed to discoloration and complaints about the palatability of such water. Analysis of industrial effluents showed the existence of high iron levels in 18 out of 36 industrial effluents tested that confirmed the source of pollution to industrial wastewater. The effluent discharged by the machinery and metal product category showed the highest average concentration of 314 mg/l of iron.

Table 5.7. Heavy metal concentrations in well water from the Moratuwa-Ratmalana area

Metal	Maximum concentration in groundwater	Average \pm s.d. in groundwater	WHO standard for drinking water	No. of wells that exceed WHO standard
Fe	9.27	1.10 \pm 1.607	0.3	55
Mn	0.92	0.09 \pm 0.130	0.1	24
Ag	0.58	0.05 \pm 0.065	-	15
Ni	0.21	0.10 \pm 0.047	0.02	78
Al	5.62	0.37 \pm 0.756	0.2	31
Cr	0.13	0.03 \pm 0.21	0.05	03
Cu	0.03	0.01 \pm 0.004	1.0	-
Pb	0.04	0.01 \pm 0.012	0.05	-
Cd	0.00	0.00 \pm 0.00	0.005	-
Co	0.02	0.01 \pm 0.007	-	-

The concentration of Mn and Ag though low in value yet exceeded the drinking water standards stipulated by WHO. Their presence in industrial effluents did not exceed 2 mg/l, however water in 15 wells exceeded the threshold value for Ag of 0.05 mg/l. No industrial effluent violated the effluent discharge standard of 3.0 mg/l of Ni, although 78 out of 79 wells had high Ni levels than the drinking water limits (Table 5.8). High Al concentration was detected in a wastewater stream close to an automobile maintenance shop. Correspondingly 31 wells were found to contain Al levels in excess of the WHO standard of 0.2 mg/l of Al. The investigation found that Cr, Cu, Pb and Co did not exceed the WHO drinking water standard values in any of the wells tested though found in elevated levels in some industrial wastewaters. This shows that certain heavy metals are bound in soil and therefore do not affect the groundwater quality at the low levels observed in industrial effluents.

Table 5.8. Heavy metal concentrations in Moratuwa-Ratmalana industrial effluents

Metal	Maximum concentration in industrial effluent (mg/l)	Average \pm s.d. in industrial effluents (mg/l)	Maximum tolerance limit (mg/l)	Number of industries that exceed the tolerance limit
Fe	314.19	44.97 \pm 88.15	-	-
Mn	1.67	0.30 \pm 0.40	-	-
Ag	0.45	0.04 \pm 0.08	-	-
Ni	0.61	0.12 \pm 0.15	3.0	0
Al	75.42	12.06 \pm 18.60	-	-
Cr	1.27	0.22 \pm 0.31	0.1	10
Cu	25.81	2.02 \pm 5.90	3.0	4
Pb	54.91	2.81 \pm 9.12	0.1	21
Cd	0.29	0.03 \pm 0.07	0.1	2
Co	0.44	0.07 \pm 0.10	-	-

5. Water Treatment

The level of water treatment required depends on the source and hence the quality of water and the purpose to which the water is put to use. Depending on the scale of treatment plants they can be categorized in to large, medium and small where the operations are carried out from continuous mode to batch operation. The level of sophistication varies from innovative yet primitive in rural water supply and sanitation schemes to advanced treatment for industrial use.

The major water supply schemes operated by the NWS&DB use either river or reservoir water as the source. This surface water is subjected to

quality fluctuation with climatic conditions. Conventional raw water clarification methods are employed by the water board which consists of aeration, pH adjustment using lime, alum coagulation, flocculation, sedimentation, rapid sand filtration, chlorine disinfection and post lime pH adjustment.

The Greater Colombo Water Supply Scheme claims the major share of water production through three production centers at Ambatale, Labugama and Kalatuwawa which amounts to 62% of the total water production by NWS&DB. The treatment plant details are given in Table 5.3. The monthly treated water production is approximately 17×10^6 m³ and the cost of production is nearly 45 million Sri Lankan rupees (1US \$ = 104.00 SLR). This water when distributed serves approximately 1.3 million consumers in the Greater Colombo area. The treated water quality is monitored to verify its compliance with the country's drinking water standards (Table 5.9).

Table 5.9. Drinking water standards in Sri Lanka

Quality	Maximum desirable level/permissible level
pH	7.0 - 8.5 / 6.5 - 9.0
Electrical Conductivity	750/3,500 μ s/cm
Chlorides	200/1200
Free Residual Chlorine	0.2
Total Alkalinity (as CaCO ₃)	200/400
Free Ammonia	0.06
Albuminoid Ammonia	0.15
Nitrate	10
Nitrite	0.01
Fluoride	0.6/1.5
Total Phosphate	2.0
Total Residue	500/2000
Total Hardness	250/600
Total Iron	0.3/1.0
Sulphate	200/400
Color (Hazen Units)	5/30
Turbidity (N.T.U.)	2/8

Although conventional treatment has served well in meeting water quality standards and keeping treatment costs reasonably low, the use of advanced treatment methods such as ultra filtration and alternative disinfection methods need to be explored to meet the increasing quality

demands of pipe water. Even though no published reports exist on disinfection byproducts, the trihalomethanes in the chlorinated water, such concerns in other countries justify selection of physical methods of disinfection. Ultra-violet disinfection is widely used by the bottled-water industry and also by the NWS&DB who operate the Seethawaka Industrial Estate wastewater treatment plant at Avissawella that discharge the treated water into the Kelani River after UV treatment. The country's electronic and print media frequently warn the general public to boil their drinking water to prevent the spread of water-borne diseases. There is clearly regrowth occurring in the long-water distribution network due to diminishing chlorine residual levels with time. Furthermore it is common for Sri Lankan households to possess overhead water storage tanks due to the unreliability of the supply. Biological contamination frequently results in such tanks that require boiling the water prior to drinking. Intrusion of salinity, possible presence of heavy metals, pesticide residues, viruses etc. require that Sri Lanka needs to be prepared to accept advanced treatment techniques to meet the increasing quality demands of its populace.

Rural water supply schemes that rely on tube wells have faced problems due to high iron levels in water. The source of iron has been either from corroded metal parts beneath the surface or geological origin in certain areas. The problem of iron due to corrosion has been largely solved by changing the below-ground components of the hand pumps with new non-corrosive parts (Attanayake and Padmasiri 1994). Various configurations of iron removal plants have been developed and introduced with financial assistance of donor agencies that frequently fund rural water supply schemes. Therefore these units are identified by the funding agency name such as FINNIDA dual unit type, FINNIDA circular type, UNICEF type etc. One of the appropriate technological inventions to suite the hand pump wells named FINNIDA square type was developed by Attanayake and Padmasiri. The unit is based on the principal of biological oxidation of iron and has an up flow hopper with granite chips for bacterial attachment. The water from the hand pump wells enter a 700 mm long and 75 mm diameter PVC pipe where the aeration take place due to turbulence caused as a result of vanes provided. The overflowing water, fall onto the adjacent sand filter where polishing of the water takes place. The success of this unit is reported to be its easy maintenance by washing off the bacterial flocs by raking the granite chips after filling the hopper and draining the water and provision of commercially available non-woven fabric where the filtered material can be taken out. This has increased the filter run length and also decreased the ripening period for the 'schmutzdecke' after the cleaning process. A similar development is seen for the removal of fluoride from groundwater in areas such as Anuradhapura and Kurunegala. Locally made bricks have proved to be

effective for the removal of fluoride. Simple domestic fluoride filters have been developed and distributed among rural households to treat their own water by allowing the water to percolate through the brick filter. It is thought that the presence of iron and aluminum in clay that is used to manufacture the bricks have an affinity to fluoride and investigations are under way to manufacture special type of bricks for this purpose by adding bentonite and kaolinite to increase the iron exchange capability of the bricks.

6. Best Practices Management

The ancient 'hydraulic civilization' in Sri Lanka revolved around the temple, village and the tank. Water was central to the agricultural economy at that time and great strides were made in harvesting, storage and distribution of water. The large number of tanks that dot the landscape of the dry zone bare witness to the efforts of ancient kings in water management. These tanks are connected by an intricate network of canals that feed the down stream tanks during the rainy season. The famous Giant Canal has marveled the irrigation engineers of recent time due to its meager slope of 1 inch per mile. The Giant Canal runs through an area rich with phosphate deposit (Eppawala Rock Phosphate) and it is believed that the canal was deliberately designed to run through the deposit. The slightly soluble phosphorous in water was thought to be sufficient to meet the needs for agricultural purposes and therefore alleviate the need for phosphate fertilizer to irrigated lands. Today most of these tanks are silted and go dry during the dry season, canals are non-existent or broken and the supplied water insufficient to cultivate in both the seasons. Currently (2004) there is a major rehabilitation scheme to resuscitate 1000 tanks to revive the agricultural economy in the dry zone.

Rainwater harvesting is the collection and storage of water that runs off the natural or man-made catchment surface. At the household level, the catchment is often the rooftops made of asbestos, GI sheets or clay tiles, directed through a gutter to a storage tank. The volume harvested depends on the amount of rainfall, the area of catchment and the run-off coefficient. The size of the storage tank can vary depending on many social, environmental and financial factors. The tanks are made of either bricks or ferrocement and can be partially buried or mounted above the ground surface. The quality of the water collected depends on the following:

- Roof material
- The tree coverage above and in the vicinity of the roof
- Nesting of birds, rats etc. beneath the roof that litter on the roof surface

- Installation of a first flush device
- The exclusion of light from the storage tank
- Flushing pipe at the base of the tank
- Availability of a hand pump or gravity tap for drawing of water from the tank

The quality of the rainwater so harvested has met most of the drinking water quality standards stipulated by the World Health Organization (WHO). The pH in ferrocement tanks was found to be high initially due to cement dissolution but improved after flushing of the newly built tanks (Lanka Rainwater Harvesting Forum). The standards for conductivity, turbidity and total hardness have been consistently met in the sampled tanks (6 nos) although *Escherichia coli* has been found in three out of six tanks tested. Dirty gutters and poor tank design are attributed to the above.

Rainwater harvesting was evident in the ancient civilization of Sri Lanka. The 5th century BC rock fortress 'Sigiriya' has a number of rainwater-fed ponds, swimming pools, artificial streams and fountains. However, with the introduction of pipe-borne water supply in the last century, many rainwater-harvesting techniques have been abandoned. With increasing water scarcity, prolonged droughts and increasing cost of water, rainwater is receiving a lot of attention as a source from the authorities in government and non-governmental organizations. There is appreciation at the policy level of making rainwater harvesting important if not mandatory at government organizations and institutions and providing incentives for others to tap this precious source of freshwater. The benefits of a better water supply begins with convenience of having water in the premises, saved time, less effort and enable the women to make choices, since women are the primary caregivers in Sri Lankan households. Traditionally women are responsible for assuring the supply of water for domestic purposes.

Rainwater can be used as a stand-by resource to complement the existing main water supply or for the entire use for domestic and agricultural purposes. It is not uncommon to find utilization of number of water sources for different activities by a single family in Sri Lanka. Well waters used for drinking purposes are protected and sparingly used in remote villages that do not have access to pipe-borne water. Nearby rivers and streams are used for bathing, washing of clothes and livestock, and rainwater is used for toilets, household cleaning and even gardening. This is a reflection of awareness of scarcity of water and cascading use, based on the quality and quantity of water by these poorly educated people in the remote villages.

Although there are no concerted efforts at harvesting rainwater from the urban areas as yet, the feasibility and benefits gained from projects in

rural areas can serve to popularize this mode of collection and utilization in other areas as well. Further improving technologies can provide an additional water source for domestic and non-domestic purposes for urban communities, reduce the cost and use of chemicals for treating water, reduce flooding problems in urban cities and enhance the groundwater table by limiting the number of users of groundwater.

Agriculture is the largest water-consuming sector in Sri Lanka and there is a greater need to adopt better practices for efficient use of water in this sector. Water is conveyed to land for irrigation purposes by several methods. In flood irrigation, water is supplied to flood the land and cover the entire area to a depth of few centimeters. This mode of irrigation is applied in paddy cultivation and large quantities of water are required for sustaining the extensive paddy fields situated in the dry zone. Water-intensive crops like paddy is a sensitive subject in Sri Lanka as rice is the staple diet of its population. Self sufficiency in rice production was achieved after making great strides in agricultural practices and development of new varieties that give higher yields and resist pest attacks. Donor agencies discourage the cultivation of water intensive crops and do not provide financial assistance for irrigation projects that support such crops. However the solution is not abandoning such crops that are indispensable to local people but adopting and practicing better management measures that increase the efficiency of freshwater utilization.

Efficient water use or management is not only concerned with application of water but also includes the timing of application, method of application, consideration of soil structure, crop selection, climatic conditions, agricultural practices and social issues. Integration of these issues can lead to optimum utilization of precious water resource for efficient irrigation of agricultural land. Current wasteful flood irrigation practices for control of weeds and aeration by continuously flowing water columns should be done away with to conserve water. These are best achieved by other means than use of flood irrigation.

Furrow irrigation is practised when the soil is sufficiently sandy for water to permeate and reach the crop roots. Here the water is supplied to the furrows between the rows of plants and is expected to recharge the soil moisture by filtering through the soil. Furrow irrigation is characterized by relatively higher labor cost for maintenance and operation than flood irrigation and it requires intensive land preparation (Manchanayake and Madduma Bandara 1999). However furrow irrigation when applied methodically is a more efficient method of irrigation water-supply method than flood irrigation. Ability to control water flow rate, determine timing based on weather patterns and crop age and the possibility of controlling water volume to different areas of the land based on spacing, slope and width of furrows make it better suited for management of irrigated water.

Sprinkler irrigation system as practised in Maduru Oya project where the water is discharged from above the ground level or crop through sprinkler nozzles. Sprinkler irrigation can be applied to terrain that is not suitable for most other irrigation methods. Land in hills or slopes and with irregular topography can be irrigated by properly designed sprinkler systems. Among the advantage of this method of irrigation are; uniform application of water over the area, minimization of soil compaction and loss of porosity due to sprinkling of water, conservation of water through controlled use, better distribution of water in high intake sandy soils and avoidance of loss of water from seepage etc. during water distribution. However the incursion of some capital expenditure at the beginning has discouraged the wide spread application of this method of irrigation by farmers.

Another piped water supply system gaining popularity in Sri Lanka is drip irrigation where the water is allowed to drip close to the roots of the crop being irrigated. Agricultural research institutes are investigating its efficacy and advising farmers on its merits although it is an expensive method of irrigation. However in areas where there is severe water scarcity, this method of irrigation can be justified as the heavy capital investments are outweighed by the long-term benefits gained through larger areas of cultivation with smaller quantities of water.

Apart from adopting better methods of irrigation, there is considerable potential to conserve agricultural water use in areas of water collection and storage, distribution, institutional mechanisms, farmer education and in agronomy. As stated before, approximately 79% of precipitation in the wet zone flows directly to the ocean without being used for beneficial purposes. Most of the rain received in the wet zone is not diverted to areas that lack water. Through the Mahaweli project such concerns were addressed by diverting the waters of the country's longest river to the dry zone. This mega project has cascading uses for the diverted water by way of hydropower generation, agricultural irrigation and sanitation. Yet, change of climatic conditions lately with prolonged droughts has stymied the expected benefits from this project. Prioritizing hydropower generation over agricultural use for economic reasons has led to irregular supply of water for irrigation which in many instances have not had the desired effect due to crop failures. Although adequate capacity exists for storage of water during the rainy season, lack of coordination among ministries responsible for different water use and absence of policy/proper direction has led to sub optimal utilization of water. Considerable losses occur during storage and distribution through canal network. Leaking dams, seepage in constructed reservoirs and canals, evaporation losses exist although no quantitative estimates are available. The Samanalaweva reservoir is one of the better known examples of heavy seepage loss due to a grave technical blunder committed during geological investigations at

the planning stage of this project. Considerable expenditure was incurred for wet blanketing to mitigate seepage losses. Unlined distribution canals are another source of water loss. Canal lining is very costly and therefore proper irrigation management methods should be followed to minimize conveyance losses. Among institutional mechanisms that can lead to better utilization of water are planning, coordination, training and use of modern technology such as Geographical Information Systems (GIS) and Remote Sensing (RS). An integrated approach incorporating water supply, distribution, methods of irrigation, period of irrigation, crop selection, soil management, climatic condition, social and cultural factors need to be developed for better water management for irrigational purposes. Farmer education on modern agricultural practices, crop selection, crop rotation, integrated pest control are central to improving utilization of water.

No accurate statistic is available for industrial water use although it is believed that this sector is the smallest consumer among the main sectors of agriculture, domestic and industry. Such a conclusion is based on the fact that the industrial sector is quite small contributing a mere 23% of GDP and most of the industries use groundwater and therefore water consumption data is not available to account for it. The current policy of free groundwater exploitation for industries is a disincentive for water conservation and management. Absence of effluent discharge taxation based on flow rates is another factor that has discouraged efficient water utilization practices. However increasing energy costs, scarcity of freshwater, gradual enforcement of effluent discharge standards and increasing wastewater treatment costs have forced the industries to adopt cleaner production practices. Technological changes that minimize water for processes, for utilities and housekeeping can help conserve water. Changing from 'once-through' cooling systems to recirculation systems, use of counter current rinsing systems, condensate recovery, dry methods of cleaning, high pressure low volume cleaning hoses, promptly repairing leaks and preventing spills, proper monitoring and measuring of water use, process control are few of the measures that can be adopted for water conservation in industry. Cascading use of water, recycling, reuse can effectively reduce water consumption. Larger industries currently do practice cleaner production and use partially treated wastewater for toilet flushing, gardening, vehicle washing, and as fire hydrants.

Domestic consumers are the largest segment of treated water users. In 1991, 60% of the water produced by NWS&DB was sold to domestic consumers. The per capita daily water consumption for Colombo city in 1995 was estimated to be 200 liters. However, with the introduction of new water tariff system based on pro rata billing procedure and increasing cost of water, the per capita daily water consumption for Colombo city has been brought down to 140 liters in 2003 (NWS&DB news report). The new

Table 5.10. Water tariff rates of National Water Supply and Drainage Board effective from 1st June 2002

Category	Block (units)	Rate per unit (Sri Lankan Rupees)
Domestic	1 – 10	1.25
Govt. Quarters	11 – 15	2.50
	16 – 20	6.50
	21 – 25	20.00
	In excess of 25 units	45.00
Govt. Schools and Govt. Assisted Schools		4.00
Religious and Charitable Institutions	1 – 50	4.00
	In excess of 50 units	12.00
Stand Posts		7.00
Commercial Institutions		42.00
Industrial/Construction Purposes		42.00
Export Processing Zones of Board of Investment		26.00
Tourist Hotels/Guest Houses		42.00
Shipping		140.00
Other Commercial and Private Institutions		42.00
Govt. Institutions		42.00
Bulk Supplies of Water to All Local Authorities		9.00
Bulk Supplies of Water to All Rural Water Supply Schemes Maintained by Community Based Organizations		7.00

water tariff structure is shown in Table 5.10. In consideration of the low-income groups and the realization of importance of water for consumption and sanitation purposes, the water board has adopted a policy of providing water at a highly subsidized rate for the domestic category up to a maximum of 20 m³/month. This is based on a daily per capita water consumption of 170 liters for a medium size family of 4 persons. Consumption above 20 units (m³) per month is charged at more than 3 times the subsidized rate and more than 25 units are charged almost 7 times the subsidized rate. Such a tariff system clearly encourages water conservation though it is not based on the number of householders within the premises.

In addition to the use of tariff measures on water consumption to encourage or force the general public to adopt and practice water conservation measures and prevent wastage, the government can use still other economic instruments such as provision of tax incentives for the importation of, and provision of incentives for the development of water thrift equipment used in households and commercial organizations. Such ‘eco-designs’ are increasingly available in the market today. Dual flush

toilet cisterns that use 6 and 3 liters per flush are improvements from systems that utilized almost 8–10 liters per flush in earlier designs. Such cisterns are gaining in popularity in the leisure industry and even in households and apartments. Front loading washing machines consume less water per kg of clothes washed than top loading machines. Improved designs of bathroom showers with narrow, focused sprinkling nozzles reduce wastage and shower periods. Installation of pressure reducing devices have considerably reduced water flow rates and hence wastage during use. Development of garden hoses with sprinkler nozzles is effective in reducing run-on when not in use. The leisure industry has benefited from a number of water-conserving devices. The use of heat or movement sensors for water flush activation in common toilets, press-on pressure taps that prevent continuous run-on from basin taps, improved hot water systems that reach desired temperatures rapidly have reduced water consumption and are justifying additional costs in an increasingly water scarce environment.

Public awareness created through both print and electronic media on the importance of water conservation is a positive measure that leads to a water-conscious society. Social organizations do carry out campaigns on water conservation among school children and rural folk by way of poster competitions and photographic exhibitions. The NWS&DB also forewarn the general public on water availability especially during drought periods and solicit cooperation to manage the crisis situations. However, Sri Lanka is still to enact legislation to prevent piped-water use for gardening, vehicle washing etc. during water shortage periods. Such measures although less enforceable, will show government commitment that can rally people around and supplement voluntary good practices.

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6

Strategic Impact Assessment and Root Causes of Pollution in a Transboundary Drainage Basin in Brazil

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INTRODUCTION

Current multiple uses of water and its associated living resources are unsustainable in most of the drainage basins, all over the world. There are clear evidences of deterioration of the freshwater quality, which in many regions leads to freshwater shortage, decline in fish stocks and destruction of aquatic ecosystems (Marques, 2002; Marques et al. 2002). Most actions taken to mitigate these problems have focused on removing the symptoms, rather than identifying and removing the societal causes of environmental degradation. The participation of different socio-economic driving forces and the root causes responsible for the environmental and socio-economic impacts related to pollution of water resources is seldom addressed (Marques 2002). Limited financial resources are not sufficient to face the increasing demand for investments. Therefore, it is necessary to agree upon funding priorities, particularly in developing countries.

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The first step in promoting a sustainable response to complex environmental problems is to understand the linkages between perceived problems and their societal root causes. Once the main root causes for a given environmental problem in a drainage basin are properly identified, the policy options can focus on the most cost-effective levels for intervention (Marques et al. 2004).

In this chapter, the concern *Pollution* in a transboundary basin Paraíba do Sul River basin – shared by three Brazilian states and considered by the National Agency of Water (ANA) as the first priority for strategic action planning – is here presented, illustrating the application of the Causal Chain Analysis conceptual model developed for the UNEP/GEF project Global International Waters Assessment (GIWA, 2000). The immediate, sectoral and root causes related to different issues that cause the concern are identified, as well as the environmental and socio-economic impacts they create. A strategic approach based on the CCA model for seeking policy options is suggested.

CAUSAL CHAIN ANALYSIS (CCA)

CCA Conceptual Model — A Causal Chain is a series of statements linking the causes of a given environmental problem with its effects (GIWA 2000). Systematic investigation of root causes of natural resources degradation has been carried out with different purposes, such as seeking for the causes of biodiversity loss (Woo et al. 2000; Stedman-Edwards 1998).

The chain is built by successively answering the question “*Why?*” or “*What is the cause?*”. The Causal Chain Analysis (CCA) as a management tool provides: (i) an insight into the nature of the problem and the main causative connections; (ii) a diagnosis of the transboundary effects and consequences of unarticulated upstream-downstream policies; (iii) links between physical and societal causes; (iv) identification of barriers to be removed in order to minimize or eliminate the impacts.

Examples of Immediate, Sectoral and Root Causes related to Pollution of aquatic ecosystems are presented respectively in Tables 6.1, 6.2 and 6.3. Examples of pollution issues (or particular types of pollution) and the environmental and socio-economic impacts caused by them are presented later on in the case study PSRB illustrating the CCA conceptual model.

The CCA conceptual model constructed to a selected environmental concern (e.g. pollution) and its issues includes the components shown in Figure 6.1, being the cause-effect flow from the right towards the left.

Table 6.1. Issues under the concern pollution and their most common immediate causes

<i>Issues</i>	Immediate Causes (physical world) generating the issue
<i>Microbiological</i>	Discharge of municipal wastewater; runoff from agriculture areas-animal wastes; discharge of solid waste; change in circulation (flushing of rivers, lakes and coastal systems).
<i>Eutrophication</i>	Enhanced discharge of nutrients due to: agriculture runoff; discharge of industrial and municipal wastewater; solid waste landfills; trapping of nutrients in lentic water bodies (river impoundments, lakes, lagoons, estuaries, bays, reservoirs); discharge of solids.
<i>Chemical Pollution</i>	Discharge of industrial effluents; discharge of leachate from industrial and municipal landfills; runoff and stormwater; atmospheric fallout of pollutants from combustion and other activities; disease/vectors control; chemicals release (e.g. aquiculture); emissions from fossil-fuel combustion; remobilization of suspended solids and pollutants in the bottom.
<i>Suspended Solids</i>	Enhanced sediment erosion, remobilization and leaching; alteration in river and stream flow; dredging and dredge spoil activities; mining releases; discharge of industrial effluents; stormwater runoff; drilling mud and particulate additives; prospecting activities for oil and gas exploitation.
<i>Solid Waste</i>	Solid waste discards at beaches, river banks and sea; releases from ships and offshore platforms; sewage related debris; in platforms; municipal, industrial and construction/demolition waste; releases from land development; tar balls; disposal of sludge from wastewater treatment in open dumps, rivers and sea.
<i>Thermal Pollution</i>	Discharge of cooling water; increasing of temperature in water body due to removal of riparian belts, exposing the water to direct sunlight; increasing concentration of suspended solids due to erosion, raising temperature.
<i>Radionuclides</i>	Incidents and spills from treatment facilities; discharge/emissions from nuclear power plants; discharge/emissions from nuclear fuel reprocessing plants; accidents involving nuclear-powered vessels; fallout from nuclear weapons tests.
<i>Spills</i>	Inputs from shipwreck or collision; operational accidents; breaching of waste containment dams and ponds; small and frequent accidental spills; force majeure.

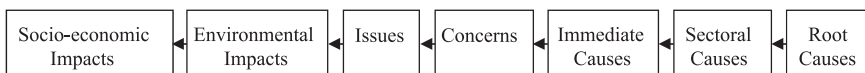


Fig. 6.1. Components of a Causal Chain Analysis from the root causes towards the socio-economic impacts caused by an environmental concern, as, for instance, pollution

Table 6.2. Examples of sectoral causes associated to different pollution issues

<i>Economic sector</i>	Sectoral causes generating the immediate causes of pollution
<i>Urbanization</i>	Housing construction with no proper sanitation infrastructure (no proper collection, transportation, treatment and final disposal of wastewater, sludge, leachate from landfills, municipal/demolition waste and stormwater runoff).
<i>Agriculture</i>	Cattle raising areas with no proper collection and treatment of wastewater; excessive use of fertilizers and pesticides, deforestation and agriculture activities in slopes enhancing erosion processes.
<i>Industry</i>	Untreated or insufficiently treated industrial wastewater, leachate from industrial landfills and stormwater runoff from industrial areas; uncontrolled emissions from fossil fuel combustion in factories and atmospheric fallout; generation of heated water.
<i>Energy</i>	Construction of dams and reservoirs causing alteration in river/stream flow and sediments/nutrients; prospecting activities for oil and gas exploitation; releases from nuclear power plants.
<i>Mining</i>	Enhanced sediment erosion, remobilization and leaching; mining releases and chemicals used during mining.
<i>Transport</i>	Atmospheric fallout of pollutant emissions from fossil-fuel combustion; releases from ships and offshore platforms; dredging activities; inputs from shipwreck or collision; operational accidents; breaching of waste containment dams and ponds; small and frequent accidental spills.
<i>Tourism</i>	Solid waste discards at beaches, river banks and sea; increase wastewater and solid waste generation during high seasons.
<i>Fisheries</i>	Use of chemicals for fishing that pollutes the water body and destructive fishing practices re-suspending sediments and pollutants.
<i>Aquiculture</i>	Pollutants resulting from development of aquiculture in tanks and at mangrove areas.
<i>Health</i>	Chemicals for disease and vectors control; generation of medical waste.
<i>Land development</i>	Land development associated to many different economic sectors, creating flushing of rivers, lakes and coastal systems; remobilization of suspended solids and pollutants; trapping nutrients in lentic water bodies such as reservoirs, river impoundments, lakes, lagoons and bays.

CCA APPLIED TO POLLUTION IN PARAÍBA DO SUL RIVER BASIN

Physical and Geographical Aspects of the Basin

The Paraíba do Sul River Basin (PSRB) is located in the southern sector of the East Atlantic Basin of Brazil and is part of one of the most important urbanized and industrialized regions of Latin America (Figure 6.2). Paraíba do Sul River (PSR) is 1,145 km long and drains an area of 55,400 km². The drainage basin is located between Latitude 20°26' and 23°38'S and Longitude 41°00' and 46°30'W. The source of Paraíba do Sul River lies in

Table 6.3. Examples of root causes of pollution classified in different sub-groups

Group	Root causes
Demographic	Population growth, urbanization trends, migration.
Technological	Access to technology; technological trends.
Economic	Prices; income distribution; poverty; economic growth; economic structure; market structure; taxes and subsidies.
Legal	Laws; regulations; property rights.
Knowledge	Information; training; education.
Political	Power structure; capacity of affected groups to oppose/promote policy changes.
Environmental	Natural phenomena in the root of another issue, such as El Niño.
Socio-cultural	Traditions; religion; non-formal rules; lifestyles; beliefs.
Governance ⁱ	Ability to reach social agreements; legitimacy; stakeholder participation; credibility; capacity to promote compliance and enforce agreements and policies such as adequate budgets; competent; sufficient and motivated staff; adequate legal and judicial framework; credible punishment; credible rewards; bureaucratic competence including adequate budgets; policy integration such as capacity to incorporate environmental considerations and values in sectoral policies and corruption.

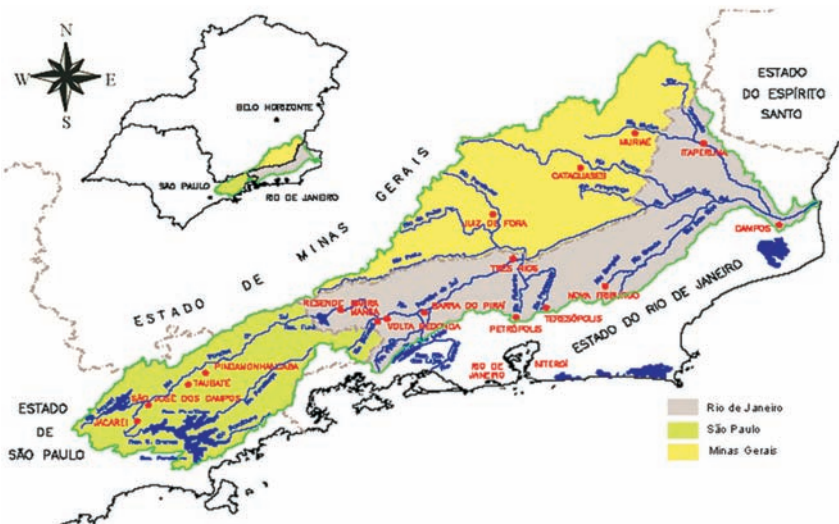


Fig. 6.2. Paraíba do Sul River Basin and its corresponding coverage in the State of São Paulo (green portion of the basin), Minas Gerais (yellow portion) and Rio de Janeiro (grey portion)

ⁱ Governance is a response term embracing regulations, laws, policies, projects and institutions. Governance factors are found associated to different levels of causes responsible for the environmental degradation. The absence of effective governance is usually not regarded as the cause of pressure on the environment but as a failure to deal with a pre-existing cause.

the State of São Paulo at approximately 1,800 m altitude (Marques et al. 2003). The estuary lies within a wide coastal plain in the north-eastern portion of the State of Rio de Janeiro.

The PSR estuary (21° 37' S, 41° 01' W) is backed by lowlands and the high relief Atlantic Serra do Mar mountain range, which proliferates more or less parallel to the coast. The river desembouches in the sea at Latitude 21° 37' S and Longitude 41° 01' W. The coast is characterized by high wave energy from the southeast and micro-tides with a maximum range of 1.3 m. Apart from wave energy and tidal range, sea-level history played a particular role in the formation of the PSRB coastal plain and other coastal regions of eastern and south-eastern Brazil. The coastal plain of PSRB is characterized by a sequence of sandy beach ridge terraces, established during the Late Quaternary (Marques et al. 2003).

In the region, sand barriers and coastal lagoons attained peak expansion during two major sea-level high stands. The first occurred at about 123 000 yr BP during the last Pleistocene interglacial stage with a relative sea-level at 8 ± 2 m above the present level (Marques 2002). The second occurred during the Holocene at about 5 100 yr BP, with a sea-level high stand at 4.8 ± 0.5 m. Thereafter, sea-level dropped with several oscillations towards today, but experienced several oscillations. Longshore transport of sediments under normal conditions with incidence of wave fronts from the Southeast occurs from south to north. Under El Niño conditions when the front is positioned below the basin, the direction of wave fronts is from the northeast and littoral sand transport reverses from north to south. In general, the coastal plain is characterized by Quaternary hydromorphic podzols and quartz.

The climate regime is governed by the Equatorial Continental air mass in summer and the Tropical Atlantic air mass in winter. The annual rainfall in the upper reaches ranges between 1,500 to 1,800 mm, in the middle between 1 100 and 1 500 mm, and at the coastal plain between 900 and 1,100 mm. River discharge follows a unimodal seasonal pattern similar to rainfall. The discharge attains its maximum in summer, with about $3\ 000\ \text{m}^3\ \text{s}^{-1}$, and a minimum in winter, with about $300\ \text{m}^3\ \text{s}^{-1}$. The average annual long term discharges of PSR, recorded at Campos city 32 km from the coast has been $886\ \text{m}^3\ \text{s}^{-1}$. However, comparisons between the average annual discharge of the period 1934 to 1943 and 1990 to 1999 revealed a decrease of about 30% in the rivers water input to the ocean (Marques 2002).

Socioeconomic Aspects of the Basin

The PSR fulfils manifold economic services to the inhabitants of the States of São Paulo, Minas Gerais and Rio de Janeiro, Brazil. Additionally to 5.4 million inhabitants living in the basin, approximately 8 million inhabitants

living outside the basin – in the Rio de Janeiro metropolitan region - are supplied with the water from Paraíba do Sul River through two important transposition systems (Marques 2002). The existing 27 hydropower plants, 8,000 industries, mining, pasture and agriculture activities exert great pressure over the natural resources in the basin. PSR receives industrial, agricultural and domestic effluents, furnishes potable water for most of the cities along its course, generates energy from hydroelectric power dams, and maintains a substantial local fishery in its coastal waters (Marques 2002). Due to the strategic importance of PSRB, it has been elected as the maximum priority by Brazilian National Agency of Waters (ANA).

Pollutant Loads Released by the Economic Activities in the Basin

The Paraíba do Sul is an example of a highly impacted aquatic system along its river course, however with a lack of information on the impact consequences upon its delta region. Most of the environmental studies in the PSRB focused on the mid- to upper reaches of the drainage basin, subject to greatest human impact. In comparison, the PSR estuary has been largely neglected. The construction of dams along PSR course has slightly dampened the seasonal flow amplitude and suspended matter discharge to the coast. Estimates of material loads and fluxes from RPS to the coast are scant. The average annual load estimated during an austral annual cycle in 1994/1995 was 0.6×10^6 t/yr for Total Suspended Solids (TSS), 0.08×10^6 t/yr for total carbon, 0.02×10^6 t/yr for total nitrogen and 0.001×10^6 t/yr for total phosphorous. The TSS yield was low with 11 t/km²/yr (Carneiro, 1998).

The strategic impact assessment carried out in PSRB as part of the Brazil Current region (Marques et al. 2003), included the analysis of eight issues under the concern pollution: microbiological pollution; eutrophication; chemical pollution; suspended solids; solid waste; thermal pollution; radionuclides and spills. Among them, microbiological, eutrophication, chemical pollution and suspended solids were considered of priority importance, according the assessment and therefore, are here investigated regarding their immediate, sectoral and root causes.

The state of the water quality is, wherever possible, classified in accordance to the Brazilian guidelines and legislation for environmental control, established by the National Council of the Environment (Resolution No. 020, CONAMA, 1986). According to CONAMA (1986) the water quality standards for freshwaters include four main Classes: Class I refers to the highest water quality standard, permitting its usage for domestic consumption without prior treatment and the preservation of the natural equilibrium of aquatic communities. In contrast, the other extreme, Class IV represents the worst water quality standard or it may be the most

impacted by all types of pollution. Apart from at industrial and domestic point sources, the state of the river waters generally oscillated between Classes II and III, implying that water usage is only permitted after treatment and limited to differential types of irrigation and animal consumption (CONAMA, 1986).

Environmental Impacts due to Pollution in PSRB

Table 6.4 presents some indicators used for addressing the environmental impacts in PSR due to selected priority issues under pollution concern.

The criteria for sizing the environmental impacts (slight, moderate or severe) are presented below.

- **Microbiological Pollution** – The impacts in PSR due to microbiological pollution was considered *severe*, due to the fact that there are clear evidences of microbiological pollution in the studied aquatic system where sewage collection and treatment covers only a small percentage of the population and fish diseases have been reported as one of the main causes of some species disappearance. According to the water quality modeling studies carried out in the basin (SIH/ANEEL, 1999), microbiological contamination was revealed to be the most critical pollution issue.
- **Eutrophication** – The impact due to eutrophication was considered severe in lentic portions of the river like reservoirs due to significant communities changes, increase of filamentous algae, average frequency (once a year) of hypoxia at large scale and fisheries mortality and toxic algae blooms. In PSRB, eutrophication is confined to specific areas, and has to be distinguished between its impact upon dam reservoirs and the river course itself. There are evidences of eutrophication and blooms of *Microcystis aeruginosa* and *Anabaena* spp. and *Lyngbya confervoides* and *Phormidium* spp. are also found in reservoirs. Eutrophication has caused significant economic impacts related to costs of maintenance and repair of turbines at Funil reservoir, for instance. Apart from the reservoirs, eutrophication is less severe along the rivers course, the trophic state generally oscillating between mesotrophic to eutrophic according to the concentrations of the total phosphorous index. The Chlorophyll a Index was a good indicator for trophic state allocation in the reservoirs, but its application to the rivers course was more biased by higher turbidity.
- **Chemical Pollution** - Refers to the adverse effects of chemical contaminants released to the water body as a result of human activities. Chemical contaminants are here defined as compounds that are toxic and/or persistent and/or bioaccumulation and do not include

Table 6.4. Environmental Impact Indicators for different Pollution Issues in PSRB: extension, frequency, source and justification

Environmental Impact Indicator	Extent of the area	Duration, frequency	Source	Explanation or justification how the indicator supports the conclusion made in the assessment
Untreated municipal sewage (m ³ /day)	All PSRB	1999	IBGE 2000; SNIU 2000	1940 405 m ³ /day of freshwater is supplied but only 94 440 m ³ /day of the wastewater is treated. About 29% of houses have no sanitary facilities.
Faecal coliforms (MPN/100 ml)	Upper and middle PSRB, MG state	1997	SIH/ ANEEL 1999	>4000 MPN/100 ml in 80% of the samples. According to the water quality criteria established by CONAMA (1986)3, these values surpass to the threshold of Class 2 defined for Paraiba do Sul River. Lower PSRB, Rio de Janeiro state 1997 High Public access; PSRB and Jaguari River, São Paulo state 1997 Medium Public access; Paraiba do Sul River basin 1974-1998 High Public access
Faecal coliforms (MPN/100 ml)	PSR estuary (2 000 km ²)	1996	FEMAR 1998	At sewage outlets: < 1000 MPN/100 ml. Coastal waters and beaches: 0 MPN/100 ml.
Standard trophic state indices from Rast et al. 1989 and Nixon et al. 1996	Estuary, coastal waters of PSR (2 000 km ²)	1995-1996	Carneiro 1998, Costa 1998	Discharges of untreated domestic sewage and organic matter from sugar cane processing. Mesotrophic estuary and Oligotrophic coastal waters. Many of the references cited for the individual sub-regions also embed some information on nutrient loading.
Industrial effluent load estimates, remaining after treatment (tonnes/day)	PSRB	1997	COPPE/UFRJ 2002	Total inputs: Organic matter: 177 tonnes/day; Total suspended solids: 215 tonnes day Total nitrogen: 1.1 tonnes/day; Total phosphorus: 2.2 tonnes/day.
Municipal wastewater, pollutant load that remains after applying	PSR	1997	COPPE/UFRJ 2002	Total inputs: Organic matter: 103 tonnes/day; Total suspended solids: 43 tonnes/day.

EUTROPHICATION

MICROBIOLOGICAL P

Table 6.4. (Contd.)

the standard reduction factor (tonnes/day)				Total Nitrogen: 16 tonnes/day; Total Phosphorus: 7 tonnes/day. The values represent approximately 36% of raw loads. These values were obtained by per capita indices and the application of reduction factors considering the percentage and type of sewage treatment.
Increase of organic matter loads expressed in BOD (tonnes/day).	Upper PSRB, São Paulo state	1978, 1988 and 1995	CBH-PSM 1995	From 1978 to 1995 an increase from 20 to 78 tonnes BOD5/day of untreated effluents is estimated.
Efficiency of wastewater treatment expressed in percentage of BOD5 (kg/day)	Upper PSRB, São Paulo state	1997	SIGRRH-SP 1999	Only 10% of the organic loads of collected wastewater remain.
Dissolved oxygen (mg/l)	PSRB	1974-1998	SIGRRH-SP 1999, SIH/ANEEL 1999	Except for some stretches along the middle Paraíba do Sul River basin and at effluent discharge point, the river is well oxygenated due to its physiographical and hydrological characteristics.
P-tot, dissolved inorganic phosphorus and ammonia (mg/l)	PSRB	1997 and 1974-1998	SIH/ANEEL 1999	Above permissible levels for water body Class 2 according to the water quality standards (CONAMA 1986). Regarding total phosphorous content: most of the river presents mesotrophic conditions and in some stretches, eutrophic conditions.
P-tot mass balance in Funil reservoir (percentage of P-tot input that remains in the reservoir)	Funil reservoir	1978-1979 and 1989-1990	SIH/ANEEL 1999	Significant accumulation of total phosphorus in Funil reservoir during 1978-1979 and during 1989-1990. About 64% of the total P input was deposited in the reservoir. In 1991 this value was reduced down to 45% of the previous value. The cause of this reduction could not be confirmed. It might be either due to a higher exportation of P, variability due to sampling procedure or variation in the hydraulic discharge.
Oxygen demand due to	Funil reservoir	1978-1979	SIH/ANEEL	The mass balance indicates that part of the oxygen

Table 6.4. (Contd.)

nitrification processes in the reservoir	1989-1990	1999	demand in the reservoir occurs due to nitrification processes, observed as reduction of ammonia, partially transformed in organic N and the increase in the amount of nitrate as output from the reservoir. Nitrite values were too low and not considered in the analysis. The global net budget of N-tot (organic + inorganic) does not indicate accumulation in the reservoir (output minus input of N).
Qualitative and quantitative changes in phytoplankton associated to eutrophication	Funil reservoir 1978-1979 1989-1990	SIH/ANEEL 1999	Significant changes in the species composition due to eutrophication in Funil reservoir during 1978-79: Low density and large diversity of phytoplankton species in Funil. Chlorophyceae prevailed in number of species and individuals (50% of the total) meanwhile Cyanophyceae (dominant forms in eutrophic environment) were 17%. In 1989: The Cyanophyceae became the dominant group during almost all year reaching levels higher than 90% during summer when the blooms are observed for <i>Microcystis flosaquae aeruginosa</i> , <i>Microcystis</i> sp., <i>Oscillatoria</i> sp. and <i>Anabaena</i> sp.
BOD5 (mg/l)	Middle/ Lower PSRB MG and RJ states 1997	SIH/ANEEL 1999	Above permissible levels for Class 2 according to the water quality standards (CONAMA 1986).
BOD5 (mg/l)	Upper PSR, (SP state) 1997	SIH/ANEEL 1999	Above permissible levels for Class 1; Some tributaries surpassing water quality standards for Class 2 (CONAMA 1986).
Heavy metals concentrations (mg/l)	Upper PSR (SP state) 1997	SIGH-SP 1999	Conc. higher than permissible levels for Cr, Cd, Ni and Hg. Abides to Class 2 of water quality (CONAMA 1986).

Table 6.4. (Contd.)

Heavy metals concentrations in water samples (mg/l)	Middle and Lower PSRB MG and RJ states	1999	ANEEL 1999, COPPE/UFRJ 2002	Conc. higher than permissible levels for Cu, Cd, Zn, As and Al in water samples. Water quality standard either Class 2 or 3 (CONAMA 1986), depending on presence of industrial point sources.
Heavy metals concentrations in suspended matter and sediments (mg/g)	Middle and Lower PSRB (only RJ)	1998-1999	CPRM 2001	Conc. higher than permissible levels for Cu, Cd, Zn, As and Al in sediments (192 samples) and suspended solids (200 samples).
Phenol concentrations	PSRB	1997	SIGRH-SP 1999, SIH/ANEEL 1999	Concentration of phenol higher than permissible levels for Class 2 (CONAMA 1986).
Contamination of existing water supply by sodium sulphate, calcium hypochlorite, heavy metals, lignine; change of pH from 7.6 up to 11 and death of animals and fishes	PSRB. Affected area: Several municipalities in Northern of RJ	April 2003	Portuguese FEEMA 2003a, FEEMA 2003b, O Globo 2003a, O Globo 2003b	In March 29, 2003 about 1.2 billion liters of waste-water entered into PSRB at Minas Gerais state, after an accident in the industry Cataguases Papéis Ltd (paper-pulp industry). 40 municipalities in Minas Gerais and Rio de Janeiro states were affected. Fisheries, agriculture and water human supplies were the most impacted sectors. Fisheries kills and intoxication of animals due to consumption of contaminated water (birds, cattle, horses).
Suspended solids load remaining in the wastewater discharged after treatment (tonnes/day)	PSRB	1997	SIH/ANEEL (1999)	Industrial effluents: suspended solids: 215 tonnes/day. Municipal effluents: suspended solids: 43 tonnes/day.
Estuary and coastal zone erosion: Loss of suspended solids (tonnes/year)	PSR estuary and coastal zone	1989-1999	Argento 1989, Carneiro 1998, Muehe and Neves 1995a, and 1995b	Reduction of suspended solids loads, associated to dams construction, resulting in coastal erosion and instability. The amount of sediment delivery is about 0.6-2.0 million tonnes/year. Loss of habitats and valuable properties.
Loss of seasonal inundation of floodplains	Lower PSRB (RJ state)	Since 1970s	SIH/ANEEL 1999	Construction of dams almost suppressed seasonal inundation of floodplains.

nutrients or readily degradable organic matter. The impacts in PSR due to chemical pollution were considered severe due to the observation that chemical contaminants in the water body/sediments are above threshold limits defined for the country or region and the known contamination of the environment or foodstuffs. Chemical pollution is due to the highly industrial as well as the mining and agriculture development. The industrial activity (e.g. steel, chemical industry, paper-pulp industry) associated to the insufficient wastewater treatment by the industries lead to the severe pollution of this basin. The mid and upper reaches of the PSR receives a variety of metallic pollutants from metallurgic industries and also urban wastes, particularly Zn, Pb, Cu and Cr. The mid and lower PSR sections have also been affected by considerable inputs of Hg (Lacerda 1993; Lacerda et al. 2001). Until 1980, mercury was widely introduced through usage of the now banned fungicides in sugar cane plantations and from the early 1980's onwards, from gold mining via the amalgamation process which separates gold particles from the river sediments. The latter, contributed approximately 150 kg of mercury per year to the river. Average annual concentrations for 1994-1995 of heavy metals in particulates (SPM = 35 ± 45 mg/l, n = 15) close to the river mouth were 75 ± 41 $\mu\text{g/g}$ for Cu, 81 ± 42 $\mu\text{g/g}$ for Cr, 297 ± 197 $\mu\text{g/g}$ for Zn, 2.386 ± 1.043 $\mu\text{g/g}$ for Mn and 69.4 ± 14.8 Mg/g for Fe (Carneiro, 1998). The slightly higher Fe and Mn values than the global average are due to the naturally enriched Fe and Mn topsoils governing the watershed. Polycyclic aromatic hydrocarbon PAH concentrations are low, within the range of 1 to 10 $\mu\text{g/l}$; the total load measured on 5 occasions close to the river mouth varied between 116 to 442 kg PAH/day.

- **Suspended Solids** – Refers to the adverse effects of modified rates released suspended particulate matter to water bodies resulting from human activities. Pollution by suspended solids was considered to cause a moderate to severe impact, particularly in reservoirs where they are accumulated and the criteria was: Markedly increased or reduced turbidity in small areas or streams or dams/reservoirs or receiving riverine or marine environments; extensive evidence of changes in erosion or sedimentation rates; or changes in benthic or pelagic biodiversity in some areas due sediment blanketing or increased turbidity. Only 11% of the original vegetation remains in the basin. Removals of riparian vegetation along PSR tributaries due to mining activities and deforestation of the hillsides contribute to the increased concentration of suspended solids particularly in reservoirs (Marques et al. 2004).

Meanwhile reservoirs in PSR present significant amounts of solid particles, the most important one, Funil reservoir, furthermore, significant reduction of suspended solids loads at the coast is seen as result of reservoirs construction and water transfer. Engineering works for transfer of water for supply purposes downstream Funil reservoir also means transfer of solid matter across catchment basins. In Sepetiba Bay (Rio de Janeiro littoral), for instance, diversion of the adjacent PSRB to supply the Rio Janeiro Metropolitan area, starting in the 1950s has resulted in a 10-fold increase in the freshwater discharge to that bay and increased sedimentation from about 60 mg/cm²/year in the early 1970 to >320 mg/cm²/year in the 1990s (Forte 1996, Barcellos and Lacerda 1994, Barcellos et al. 1997). On the other hand, at the mouth of the PSR, on the north coast of Rio de Janeiro state and about 300 km from Sepetiba Bay, extensive erosion of the coastline is destroying fringes of mangrove forests, dunes and small villages in the area, due to lack of sediment transport, which has been further reduced because of the construction of dams along the PSR (Marques et al. 2004). In other words, suspended solids transport/sedimentation dynamics that cause pollution problems in reservoirs of PSRB and in the Sepetiba Bay, indirectly cause habitat and community modification in PSR mouth. The amount of sediment currently delivery in PSR mouth is only 0.6-2.0 million tonnes/year.

Socioeconomic Impacts due to Pollution in PSRB

Table 6.5 presents some indicators of socio-economic impacts due to pollution in PSRB. The socio-economic impacts due to pollution in PSRB, received the following scores: economic impacts (severe); health impacts (moderate); and other social and community impacts (moderate). The socio-economic impacts identified in PSRB are in many cases related to the water supply electricity generation including:

- **Economic Impacts** – Increased costs of human health protection; increased costs of water treatment; costs of clean-up; loss of property values; costs of weed control; loss in fisheries; change in fisheries value; increased costs of fish surveillance in the case of toxin incidence; reduction in options of other uses of freshwater; loss of reservoir storage capacity; damage to equipment (e.g. particle impacts and eutrophication in Funil reservoir); costs of cleaning intakes; increased costs of animal protection (endangered species); displacement of species with economic value; costs of contingency measures; costs of litigation.
- **Human Health Impacts** – Increased risks to human health, particularly incidence of waterborne diseases due to microbiological pollution, intoxication due to consumption of contaminated seafood, etc.

Table 6.5. Socio-economic impact indicators for pollution in PSRB: extent, duration, frequency, source and justification

Socio-economic impact indicator	Extent of the area	Duration, frequency	Source	Explanation or justification how the indicator supports the conclusion made in the assessment
Economic losses due to the interruption of the hydropower generation plus maintenance costs	Fumil reservoir	1985-1990	COPPE/UFRJ 2002	Eutrophication in reservoir: In 1984, after 14 years of operation, 3 units of the Fumil hydropower plant needed maintenance. The disassembling of these units was carried out during 1976. The hydropower operation was interrupted during 1 176 days. The energy stopped being produced during this period, equivalent to 35.3 million USD or 28 USD/MWh. The maintenance costs were comparatively low: 2.2 million USD. The total economic impact was 37.5 million USD. The diagnosis was corrosion of several parts of the system, mostly due to the eutrophication and the sediments accumulated in the reservoir, coming from the upper portion in São Paulo.
Pollution mitigation costs	PSRB	2001	Freitas 2003	In 2001, the National Agency of Water ANA made available about 9 million USD for investments in the construction of municipal wastewater treatment plants.
Pollution mitigation costs	PSRB	1997	COPPE/UFRJ 2002	Investment for mitigation and contingency plan of sewage collection, solid waste disposal and urban drainage in the PSRB. Total cost: 900 million USD.
Infectious and parasitic diseases (%)	PSRB	1999	COPPE/UFRJ 2002, IBGE 2000	Infectious and parasitic are the main diseases among children less than 1 year old. Hospital records in several municipalities in the upper SP, middle MG and north-eastern RJ attain 15%, 33% and 48%, respectively. Hospitalization of the total population is less than 20%.

Contd.

Socio-economic impact indicator	Extent of the area	Duration, frequency	Source	Explanation or justification how the indicator supports the conclusion made in the assessment
Waterborne diseases (% total deaths)	Upper PSR (SP) 1995	1995	COPPE/UFRJ 2002 IBGE 2000	for the entire basin and 2.6 to 5% at urban centers. Waterborne diseases such as leptospirosis and schistosomiasis. Both are common among poor people who live in areas with no sewage collection and flooding events. Death among the total pop. varies from 0.3 to 2.0%.
Child mortality (deaths per 1000 births)	PSRB	1998	COPPE/UFRJ 2002, IBGE 2000	The rate of child-mortality shows a trend for increasing from the upper portion (20 deaths/1 000 inhab) to the Lower portion of the basin (30 deaths/1 000 inhab). The highest mortality rates are found in the coastal plains in RJ.
Per capita income: Proxy indicator of pollution related to low sanitation coverage	PSRB	1991 and 1999	COPPE/UFRJ 2002 IBGE 2000	The number of minimum wages per capita along the main river course decreased from the upper portion (São Paulo) down to the lower portion and coastal plain in Rio de Janeiro, from a range of 1-3 times the minimum wage to 0.76-1.5 times the minimum wage, respectively. In manifold systems characterized by rural activities, the minimum wage per capita is lower, particularly in the North-western Rio de Janeiro (0-0.75 times the minimum wage). Some municipalities of the middle and upper basin also abide to these conditions.
Differences of income per capita between industrialized and non-industrialized cities in the basin	PSRB	1991 and 1999	COPPE/ UFRJ 2002 IBGE 2000	The basin presents discrepancies regarding the per capita income between highly industrialized and non-industrialized urban centers. In 1999, industrialized cities of São José dos Campos (SP), Juiz de Fora (MG) and Volta Redonda (RJ) exhibited respectively an average income per capita of 4.9, 3.3 and 2.6 times the minimum wage.

Socio-economic impact indicator	Extent of the area	Duration, frequency	Source	Explanation or justification how the indicator supports the conclusion made in the assessment
Reduction of the income/capita	PSRB	1970-1980 1991-2000	IBGE 2000	In contrast, the non-industrialized smaller cities of Cunha (SP), Mare de Espanha (MG) and São João da Barra (RJ) exhibited an average income per capita of 1.4, 1.5 and 1.5 times the minimum wage.
Poverty status (% of poor population)	PSRB	1970-1991	IBGE 2000	Reduction of the family per capita income as a result of migration of rural population to urban areas, which increased the unemployment rate of the cities. This trend is more intense in the states of RJ and MG than in SP.
Interruption of water supply due discharge of industrial wastewater into the existing water supply system	Pombas River (PSRB tributary)	April 2003	FEEMA 2003a and 2003b, O Globo 2003a and 2003b	Increasing poverty in most of the municipalities of the basin occurred between 1970 and 1991. In 1991, the upper percentage the poor population varied from 1% to 50% at sector of the basin (SP). In the middle sector of the basin (MG and RJ) from 25% to 75%. In the lower portion of the basin (north-eastern RJ) from 50% to 75%. Transboundary conflict between Minas Gerais and Rio de Janeiro. About 1.2 billion litres of hazardous waste-water entered into Pomba River coming from the pulp-paper industry Cataguazes Papéis Ltd in Minas Gerais. This hazardous effluent was transported downstream to Rio de Janeiro, caused the death of animals and the interruption of the water supply for 8 municipalities in northern and north-western Rio de Janeiro, affecting 600 000 inhabitants. Irrigation, water supply, fisheries were the main economic sectors affected.

- **Social and Community Impacts** – Loss of tourism or recreational values; loss of aesthetic values; loss of wildlife sanctuaries; potential for interstates conflicts; avoidance of amenities and products due to perceptions of effects of contamination.

Due to the fact that PSR is responsible for the water supply of about 12 million people (among them, 8 million living in Rio de Janeiro Metropolitan area, outside the basin), the socio-economic impacts due to pollution cover all economic activities that depend on water supply and therefore, receive the highest priority.

Regarding human health impacts (and consequently, also economic impacts), the accentuated reduction of water quality during intensive rainfall events after a dry season is related to re-suspension of solid particles and attached pollutants from the bottom, as well as runoff from polluted surfaces and ponds. Toxins produced by toxic algae in reservoirs have been released to the distribution system after long dry seasons. The toxin produced by the algae *Microcistina* sp., for instance, is associated to liver cancer. The occurrence of waterborne diseases is part of the infections and parasitic diseases that affect the population, as shown in Figure 6.3.

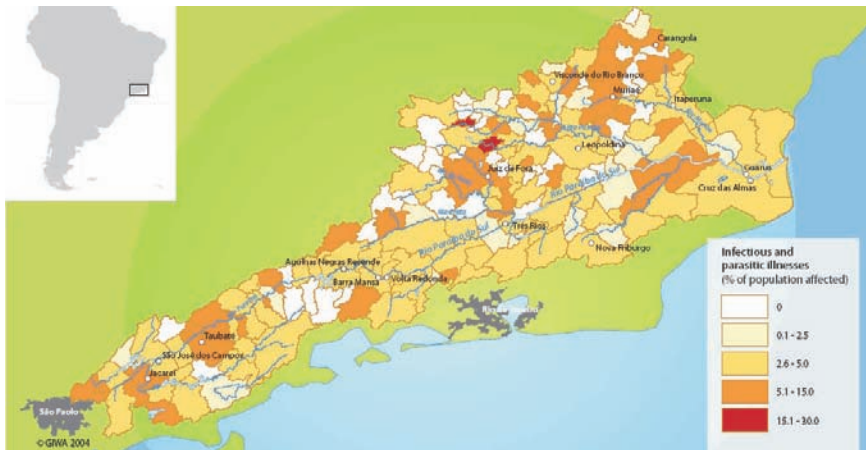


Fig. 6.3. Incidence of infections and parasitic diseases (% of population affected) in all municipalities of Paraíba do Sul River Basin (Minas Gerais, São Paulo and Rio de Janeiro states). (Source: Marques et al. 2004, based on data from IBGE 2001)

CCA for Pollution in PSRB

The Causal Chain Analysis (CCA) is here constructed for the Concern Pollution in PSRB having as a starting point four selected issues: microbiological pollution, eutrophication, chemical pollution and suspended solids. Moving forwards, it is found the environmental impacts

caused by these issues and the socio-economic impacts caused by the environmental impacts (Figure 6.4). At this stage, it is important to identify those impacts with the highest importance, so the causes of these shall be targeted when proposing policy actions for minimization or elimination of the problem. Moving from the issues point and backwards, the most relevant immediate cause that generated those issues are also identified. By immediate cause, one means events that belong to the physical world including physical, chemical and biological processes (Figure 6.4). Going a step backwards, sectoral causes that generated the immediate cause are identified. By sectoral causes one means activities associated to different economic sectors (Figure 6.4). Once more, moving from the sectoral causes backwards, one identifies the root causes.

CONCLUSIONS

Paraíba do Sul River Basin encompasses three of the most important states in terms of economic development in Brazil. This, combined with the fact that PSRB natural resources (particularly land and water resources) have been intensively and unsustainably exploited during different economic cycles in history, contribute to the severity of the water pollution. Currently, the economic sectors responsible for the highest anthropogenic pressures in the basin and consequently in the water resources are: urbanization, industry, agriculture, mining and energy. This means that investments to recover and preserve the water resources in this basin will certainly demand significant investments but also a very complex and well-integrated strategic plan including actions that – to a large extent – will affect for good or for bad, these economic sectors. In the second case, a strong reaction from the stakeholders involved in these sectors would occur jeopardizing the feasibility of the recovery plan. Therefore, in order to have positive results in a short/medium term perspective, one major challenge is to propose actions that can create a win-win scenario: economic development benefited from the environmental recovery and protection plan. This statement simply describes the challenge of developing the basin in a sustainable way. A one billion USD project for Pollution Control and Water Quality (PQA) has been proposed for PSRB. Such a large project includes structural and non-structural interventions and only 3.5% of the budget is designated for planning, management and monitoring (ANA, 2004). The project is based on the Law Ner 9.433/97 that establishes the National Water Resources Policy and defines the management model to be implemented in Brazilian transboundary basins (called federal basins) such as PSRB. All three states (São Paulo, Minas Gerais and Rio de Janeiro) shall participate in the PQA project where current as well as future priorities and demands are identified. The Causal Chain Analysis presented here presented emphasizes the relevance of prioritizing the integrated

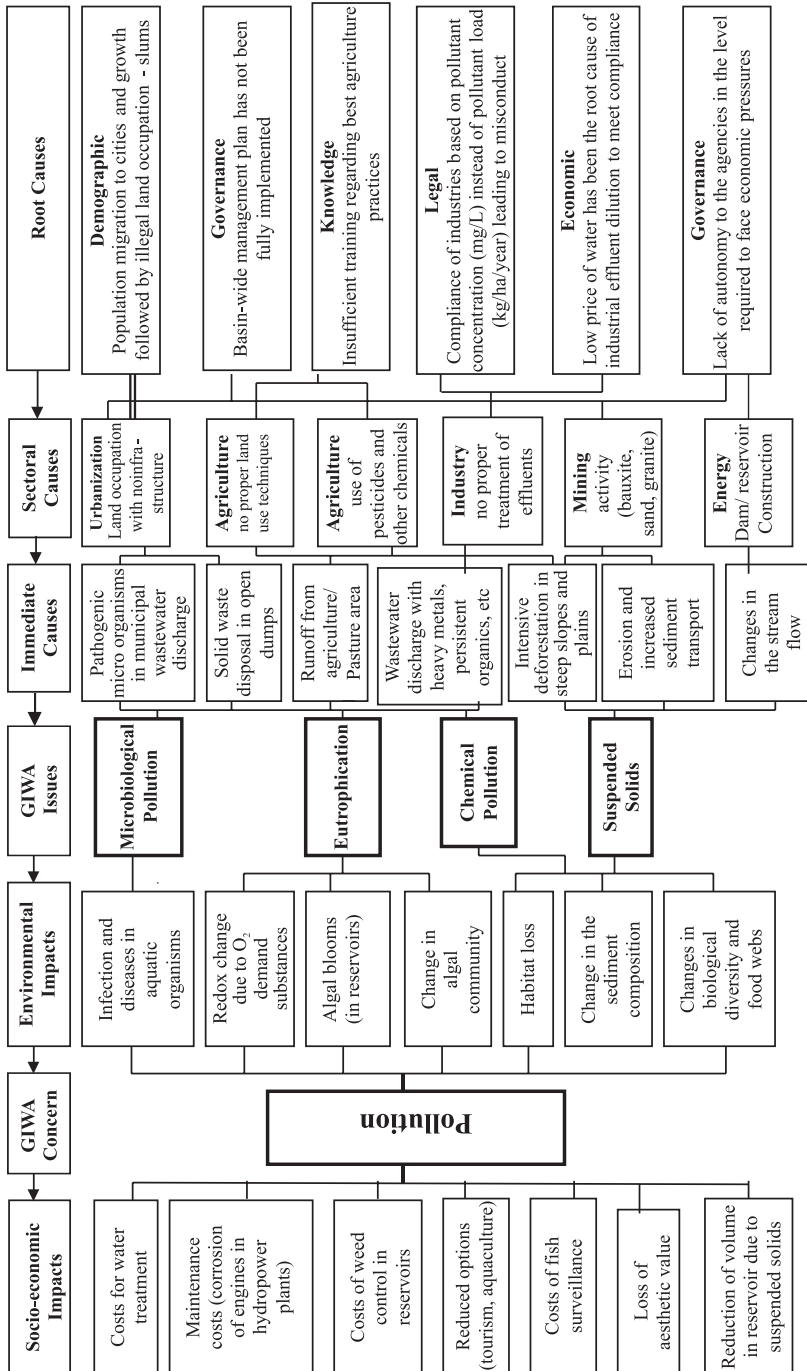


Fig. 6.4. CCA constructed for the concern Pollution in Paraiba do Sul River Basin (transboundary basin covering parts of the states of São Paulo, Minas Gerais and Rio de Janeiro in Brazil)

management plan and addressing the root causes of pollution in the most effective way. Any other approach, such as tackling the immediate causes of pollution by investing in structural measures (e.g. wastewater treatment plants) may temporarily solve the problem but will not be sustainable in a long run. This is probably one of the most common dilemmas faced by decision makers in drainage basins, particularly in the developing world.

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7

Water Regulation through Two Transitions: The Case of Hungary

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Like many places in Central and Eastern Europe, Hungary is characterized by a relatively ample supply of water, and most of its residents have easy access to drinking water from municipal sources. Several major rivers, most notably the Danube, flow across Hungary's borders, and this is appreciably supplemented by large groundwater reserves. The problem with water policies in the region is not limited by the total amount of water, but rather by the quality, sources and ecological vulnerability of the water. Ninety-six percent of the surface water in Hungary originates in other countries, which greatly limits Hungary's own ability to implement basin-wide approaches to pollution prevention and abatement. At the same time, Hungary adds significantly to pollution pressures upon hydrologic resources to its downstream neighbors. Despite widespread access to municipal (potable) water sources, Hungary and other countries have substantially lower rates of access to sewerage systems and wastewater treatment facilities. Until quite recently, only half of the Hungarian population was connected to public sewers (Nachtnebel 2000).

This chapter will examine the freshwater resources in Hungary and increased attempts for regional cooperation in regulating water quality standards and monitoring. The Hungarian case is notable for several reasons, the most obvious of which is the presence and importance of the Danube and its tributaries for Hungarian history and economics. In the last 15 years Hungary has undergone two transitions, first from a communist government in 1989-1990, and then into a full member of the



Fig. 7.1. Hungary (Source : CIA World Factbook)

European Union (EU) in May 2004. During this time the issue of water quality has been of prime importance, and in some ways was crucial to undermine the legitimacy of the former communist government.

Past Practices

The practice of polluting rivers and lakes in Hungary was not an issue of great importance to the communist regime, particularly as municipal drinking water was often drawn from underground sources. The reliance upon groundwater, often while ignoring the quality of such water, led to the widespread practice of releasing untreated waste into the Danube and other rivers in the basin (see Tables 7.2 and 7.3). Hungarian laws concerning sewage treatment plant design had been standardized and inflexible, resulting in high operating costs and poor operation. When combined with weak political will to invest in such operations, the result was widespread contamination of surface waters in the country. As of the mid-1990s, 84 million m³ of untreated industrial wastewater was leaked or dumped into lakes and rivers every year in Hungary. Agricultural operations were

Table 7.2. Wastewater legally requiring treatment (1000 m³)

	Agriculture	Mining/quarry	Manufacturing	Municipal waste	Totals
1995	20 488	15 080	165 562	496 203	827 503
1996	21 087	14 978	229 825	521 970	873 833
1997	14 132	12 361	220 970	515 344	800 290
1998	15 669	11 745	199 354	536 736	813 805
1999	15 031	12 354	205 085	549 615	832 215

Source: KSH 2003a, p. 64

Table 7.3. Wastewater treated as required (1000 m³)

	Agriculture	Mining/quarry	Manufacturing	Municipal waste	Totals
1995	n/a	10 374	74 081	91 820	224 871
1996	265	10 912	139 416	111 754	287 314
1997	340	10 942	160 831	131 276	309 917
1998	362	10 137	146 147	137 361	303 150
1999	376	10 520	149 717	200 566	369 898

Source: KSH 2003a, p. 64

producing nearly 50 million m³ of manure every year, while municipalities dumped 1.3 billion m³ of largely untreated sewage into rivers, mostly the Danube (Hinrichsen and Lang 1996).

Budapest alone contributed nearly one million m³ of sewage daily into the Danube, the same river from which it drew its supplemental water supply. Only 20-25% of the city's sewage was biologically treated, with the remainder providing only rudimentary, mechanical screening. Around Budapest, most of the water was pumped from the area around Csepel Island, an industrial area downstream from both the downtown area and release points of untreated sewage. It was not until the mid 1990s that the pumps were closed down, and only after it was discovered that iron and manganese levels far exceeded the World Health Organization potable water guidelines for those metals. Until that time, the use of water purification plants for drinking water had not even been seriously studied.

Water Management on the Danube

The heavy reliance upon groundwater has carried other problems, as well. Over-reliance upon underground sources has significantly depleted many wells, particularly those from karstic groundwater. Some water development projects, such as the Gabčíkovo (BGS)-Nagyymaros dam, have severely

affected groundwater levels in the Szigetköz region and downstream from Bratislava. In many ways the Gabčíkovo-Nagymaros project was a primary example of how former communist systems placed much more emphasis upon heavy industrial production than upon ecological considerations. The project decreased groundwater tables in the Szigetköz region, exacerbated pre-existing water quality issues near Bratislava, and in other ways heavily damaged the flora and fauna of the inland wetland areas of the Danube Bend (Balon and Holik 1999).

Gabčíkovo-Nagymaros was crucial to the state because it was a project largely imposed from the Soviet Union, with only lukewarm support from Hungarian politicians and with even less support from scientists and economists detailed to study the plan. What is most notable about the project was the way in which individuals and social movements were able to influence the process to a far greater degree than had been possible before, culminating in the first open protests against the government in 1988. Where other policy issues could be controlled by the state, water quality and regulation became the litmus test for legitimacy of the Hungarian government.

As conditions of water quality and quantity worsened, the government was less and less able to claim that it was acting in the best interests of the Hungarian people. By February 1989, 140,000 people had signed a petition calling for a referendum on the project, and the government at the time simply could not hold a referendum it risked losing. To do so would further undermine legitimacy of the government and its ability to dictate policies. With the project attracting increasing criticism from the public and reformist members of parliament, in 1989 Hungary decided to repudiate its 1977 treaty obligations to Czechoslovakia and abandoned the project (Fitzmaurice 1998). Although a variant of the dam project was completed by Slovakia in the 1990s, the issue had established the visible importance of water quality regulations in Hungary, as well as the measure of influence that could be held by non-governmental organizations (NGOs).

The Gabčíkovo-Nagymaros project also highlighted the need to re-examine regional planning and cooperation or water policies in the Danube region. The project was conceived earlier in the twentieth century and planned in the 1960s-1970s, at a time when older models of watershed management had priority over environmental concerns. With a focus purely on navigation, flood control and power generation, the Gabčíkovo-Nagymaros project effectively ruled out considerations of agricultural, fishery, municipal and health impacts, in addition to having dubious benefits relative to costs. With Europe divided by the Cold War, there was also little consideration of impacts from upstream development in Germany and Austria. Ironically, such cooperation with upstream riparian states might have helped to prevent the 1954 and 1965 floods that created the

final impetus to build Gabčíkovo-Nagymaros (Jansky et al. 2004). It was only after intense pressure from the public and scientific communities that the Hungarian government relented on its plans and admitted the possible negative consequences of construction.

The project exemplified the shortcomings of both the water management approaches and the control of scientific studies that were prevalent at the time. Not only was there little cooperation among riparian states regarding management projects, but the scientific studies so necessary for proper environmental protection were either restricted or entirely lacking. Environmental impact assessments, although first adopted by Hungary in 1985 legislation, were effectively controlled by the government. Only certain types of analyses were allowed, only certain conclusions could be made, and the Hungarian Academy of Sciences was told to change its conclusion regarding the Gabčíkovo-Nagymaros project several times. In addition, information was not shared between states, so that what might be a benefit to one upstream state, did not consider the negative impacts to the downstream state (Vargha 1981, 2000).

The Tisza River

In addition to the Gabčíkovo-Nagymaros project, another notable event in recent years was the cyanide poisoning of the Tisza River in Romania/Hungary, and into the Vojvodina region of Yugoslavia (Macklin et al. 2003). In January 2000, heavy rains and a poorly built holding pond at the Baia Mare gold mine in Romania resulted in the accidental release of high levels of cyanide to the Tisza River. Approximately 100,000 m³ of wastewater was released into the Lapus, Szamos and Tisza Rivers, resulting in downstream concentrations of cyanide of between 12-30 mg/l. The cyanide, which was used to separate out gold ore in the mining process, spread more than 800 km along the Szamos and Tisza Rivers before reaching the Danube and emptying into the Black Sea. According to sources, some 80% of flora and fauna along the rivers were destroyed (Ferguson 2000; Macklin et al. 2003).

The Baia Mare mine was owned by a multinational consortium (most notably Austria and Romania), and the incident in 2000 highlighted the fragmented nature of regulation and legal oversight that exists with respect to watershed management. An 80 kilometer length of the cyanide spill damage occurred in Romania, with most of the damage affecting areas within Hungary. Yet because of the location of the company's operations, its ownership and financial structure, and the nature of liability laws at the international level, neither the company itself nor its stakeholders were held financially accountable for the ecological damages incurred (Ferguson 2000). Planning for the project was not carried out with input from at-risk

populations in other countries, and such a criticism is not merely retrospective. A similar project by a Canadian company is currently in the planning stage in Rosia Montana in west-central Romania, despite strong objections by the Romanian Academy of Sciences and environmental groups (Budapest Sun 2002). The mine projects and their very real ecological impacts highlight the difficulty in relying upon watershed management models that have traditionally emphasized the importance of cooperative monitoring. Water quality monitoring and even legal liability reform cannot stand alone, for regulatory effectiveness relies upon strong prospective planning that helps to prevent harmful situations.

Further Concerns

The low investment in environmental infrastructure during the communist years was not simply evidenced by directed investment into large, so-called 'megaprojects,' nor was the environmental damage limited to visible areas or resources. Fortunately, heavy metal deposits and suspended solids were not particularly worrisome within the Austrian and Hungarian sections of the Danube, although some localized pollution was evident (Woitke et al. 2003). Surface waters have been more susceptible to pollution from organic compounds, such as nitrogen, phosphorous and nitrates leaching from agriculture or wastewater (Németh 1993). Of particular concern are total observed discharges of phosphorous into the Danube and its tributaries, which have significantly increased in recent years (see Table 7.4).

Further damage has been caused by non-point source runoff pollution in the form of oils and other persistent organic compounds, particularly from transportation sources. Such non-point sources have received relatively little research in recent years, but their collective impact is quickly being felt.

Table 7.4. Total phosphorous discharges (kg/year)

	Total industry	Municipal and residential	Total
1995	10,939.6	494,932.8	505,872.4
1996	14,384.0	489,567.0	503,951.0
1997	30,756.0	479,554.1	510,310.1
1998	89,551.0	552,946.0	642,497.0
1999	37,830.0	750,472.0	788,302.0
2000	149,029.5	739,684.3	888,713.8
2001	313,680.4	1,434,850.9	1,748,531.3

Needless to say, the Hungarian government and its people have many tasks ahead in order to meet EU standards for water quality and effluent emissions. The Hungarian government has committed itself to meeting the challenges, as it recognizes that meeting accession requirements is vital to economic and political stability in a more general sense.

Hungarian Political Responses

Hungary has historically possessed surprisingly good environmental laws, but until environmental issues became matters of legitimacy for the state around 1990, they were rarely recognized or enforced. This condition was slowly changed toward the end of the communist regime in the 1970s and 1980s, as social groups began to turn their interests toward environmental quality issues and the need for the state to address serious environmental and health issues (Savoia 2000; Fleischer and Vargha 1991). Water was one of the key areas of concern, particularly riparian surface resources. As a result, Hungary entered its democratic transition with a strong regulatory structure in place, overseen primarily by the Hungarian Environment and Water Ministry (Környezetvédelmi és Vízügy Minisztérium, or KSH).

Regulations were strongest with respect to groundwater, which have been regulated from a different office in KSH than surface waters. Groundwater extraction in Hungary is allowed only by permit, wells are metered, and thermal sources in particular are very difficult to obtain from new wells. It may be that the perceived importance, both cultural and otherwise, of the geothermal resources in Hungary has allowed groundwater extraction to be strictly controlled. Hungary also had the benefit of strong scientific resources and personnel, especially at the university level, and many of the people who had worked to have water issues recognized by government were now in senior government positions. As an example, one of the lead dissidents in the Hungarian environmental movement, Janós Vargha, by the late 1990s was a senior science and environment advisor to the prime minister.

One of the first reactions of the government after 1989 was to call for more accountability in areas of water quality, and to decentralize the process and devolve jurisdiction to the municipalities in 1991. National responsibility had been divided between several ministries, such as Energy, Environment and Transportation (Fleit et al. 2000). Such actions had real consequences for many communities, as Hungary has a unique governance structure wherein there are thousands of municipal units in government, yet most of the population of the country lives in a small number of them. For the rest of the municipalities, they contain a population far too small to support their own wastewater treatment facilities. Many municipalities were forced to sell their operations to private companies, although such companies have not always found the investments worthwhile.

Since 1996, it was decreed that all settlements with a population of more than 2000 had to have and maintain a sewage treatment plant by a 2015. By 2010, there will be 1365 plants in operation, with a daily total capacity of 2.9 million m³. Wastewater plants will generally use biological treatment processes, although tertiary treatment will be used in certain ecologically sensitive areas. The necessity for this is illustrated by the fact that inhabitants of large urban centers (slightly less than half the national population) daily create 1.8 million m³ of sewage waste. The amount of waste created by municipal sources has remained fairly steady, despite large decreases in overall water use within Hungary since the early 1990s (Vimola 2000).

Steps have been taken since the early 1990s to remediate the past damage, and new laws regarding water quality are rapidly being adopted to bring Hungary in line with EU regulations (Somlyódy et al. 1999). Many loans are being channeled through the EU to Hungary, via the European Bank for Redevelopment (EBRD), European Investment Bank (EIB) and even the World Bank. EIB spending alone for 2003 was expected to exceed EUR 1

Table 7.5. Consumption by total water demand (m³/s)

	Irrigation	Households	Industrial	Fishery	Total
1992	188.8	7.1	161.1	15.1	372.1
1994	167.6	6.9	166.3	15.6	356.4
1995	107.2	6.9	174.4	13.7	302.2
1996	135.8	3.4	162.7	14.1	316.0
1997	102.6	2.5	161.8	14.0	280.9
1998	97.9	2.3	166.3	16.9	283.4
1999	82.9	2.4	159.7	13.8	258.8
2000	82.5	2.4	133.4	11.6	229.9
2001	68.2	2.0	161.6	12.7	244.5

Source: KSH 2003a, p. 47

Table 7.6. Hungarian subsurface water production (thousand m³/day)

	Karstic	Stratum	Ground	Bank filtered	Total
1985	1239	1830	132	1157	4358
1990	950	1847	132	1142	4076
1995	508	1317	137	998	2960
2000	384	1277	123	864	2648

Source: KSH 2003, p. 48

billion. Many of these loans are given on the condition that water utilities are privatized, meaning that at least their operation be given over to private corporations (EBRD 1998). Although this raised questions concerning the accountability of private (usually French or German) corporations in legal and financial senses, KSH officials indicated that such concerns were secondary to meeting overall EU and international agreements for water quality.

Evolution of International Agreements

Many of the problems with water quality controls on the Danube stemmed from prioritization of policies for navigation on the river. Between 1856 and 1948, most Danube River agreements and compacts centered on issues of navigation, but after World War II the fractious political situation led to the Belgrade Agreement in 1948. This agreement allowed navigation concerns to be handled by each riparian country separately, rather than having to submit to a central Danube authority as has previously been the case. By resorting to country-by-country control of policies, it became even more difficult to conceive of regional policies to address other areas of cooperation, such as water quality concerns.

Recognition that water quality concerns were growing in importance, and that existing institutions could not cope with the issue on their own, in 1985 eight riparian states signed the Bucharest Declaration, formally known as the "Declaration of the Danube Countries to Cooperate on Questions Concerning the Water Management of the Danube". The Bucharest Convention reaffirmed the importance of regional cooperation, monitoring networks, and led to development of the later Strategic Action Plan under the 1994 Sofia Convention. The 1994 Sofia Convention (Convention on Cooperation for the Protection and Sustainable Use of the Danube River), formed the basis for many of the present policies of river basin cooperation and goal-setting, and provided a framework for action prior to membership in the European Union.

Since the Baia Marie incident Romania has been cooperating more with Hungary on environmental protection measures with respect to water management, such as the current efforts of the Tisza Water Forum, established by the signing of the Budapest Declaration in November 2001 by the five Tisza River riparian countries. The five countries will work together to develop a comprehensive water resources management plan for the Tisza River, which would then form a subset to the larger Danube River management plan due in 2009. Already Hungary and Romania have an agreement that extends cooperative management of watersheds 30 km beyond each respective border. The International Commission for Protection of the Danube River (ICPDR), based in Vienna, is further pressuring the EU

Director General for Environment to help coordinate action on Tisza River management.

The most overarching agreements are related to Hungary's new membership in the EU. As part of that accession process, Hungary must implement the procedures of the Water Framework Directive (WFD), first published in December 2000 with implementation procedures given to Hungary in 2003. The main emphases of the WFD, according to Article 1, are to:

- prevent further deterioration and protect and enhance the status of aquatic ecosystems and associated wetlands;
- promote sustainable water use based on long-term protection of available water resources;
- aim at enhanced protection and improvement of the aquatic environment;
- ensure the progressive reduction of pollution of groundwater and prevents its further pollution
- contribute to mitigating the effects of floods and droughts.

The transposition of the WFD to Hungary was completed and sent to Parliament for adoption in July 2004.

The agreements regarding freshwater regulation in the Danube basin have evolved over the years to focus more on environmental concerns. Previously the main emphases were placed upon flood control and navigation, as these were the problems most visible to the central governments, and also the ones most easily quantifiable by planners. Yet even prior to the end of the Cold War, environmental concerns grew in importance, and the holistic nature of river basin management became apparent. The transitions from communism and into the EU thus represented important points on a continuum, but they do not form a clear break from one era into the next.

Challenges Ahead

Despite such efforts, several troublesome aspects of the political situation prevented more effective action on the part of the Hungarian government, or pose possible problems in the future. In-depth analysis of such challenges to Eastern Europe and environmental policies in general can be found in Kramer (2004), but several key points should be made here. Those challenges that are most applicable to water issues and Hungary concern political structure, available political resources, administrative capacity, and a condition known as 'democratic deficit'.

The first such factor was that responsibility for water resources were often shared between KSH and other ministries (such as transportation),

and goals were not as clearly established as they may have been by parliament. As a result, prioritization of action to remediate past pollution was hampered, as the country was forced to deal with parallel issues of economic revitalization and attempts to attract foreign investment. To be fair, the overlapping jurisdictions were a holdover from the earlier government structure, and in many ways had contributed to policies such as the Gabčíkovo-Nagymaros project. Input from scientific and economic experts was at times adversarial, policy proposals did not always take into account the goals of related ministries, and the studies were often carried out that only examined areas within political boundaries, not ecological borders.

Problems in coordination have been made even worse by the relative lack of resources that the Hungarian government has had at its disposal in addressing water quality concerns. Lack of financial resources in Central-East European countries has been a severe issue in dealing with legacies of pollution, and Hungary has had to spend as much on wastewater treatment alone as many other European countries spend on their entire environmental policy and regulation budgets. Some estimates place this figure as high as one percent of gross domestic product (GDP). It would be misleading to characterize the lack of resources as stemming from an equal lack in political will, as the root problem is the sheer magnitude of environmental quality issues that faced Hungary after 1989 (Kerekes and Kiss 2000). Many years of under-investment in environmental infrastructure had led to poor surface water quality across the country, while groundwater resources were threatened with over-withdrawal, particularly from karstic sources. Some environmental concerns are natural in origin, such as the difficulty in attaining the EU 10 mg/l standard for arsenic in drinking water, due to the naturally high occurring levels of arsenic in some parts of eastern Hungary.

Even with political resources to address the problems of past pollution, there still exists a problem of administrative capacity for Hungarian environmental officials. Political resources and administrative capacity are related but distinct issues, as greater resources may increase capacity, they by no means guarantee it. Prior to the accession of Hungary to the EU in 2004, Hungarian officials were overwhelmed with directives from the EU offices in Brussels. Hungarian offices, at times only staffed by a few people, would be required to draft an official response with input from scientists and four other government ministries (including the Prime Minister's office) within a matter of hours. Many offices found that, rather than having a scarce supply of information available to them, now they were overwhelmed with new information and new requests. As in any political system, it has been difficult for the government agencies to accommodate to the new circumstances. In response, the Environment Ministry has created a new

office for development issues and another to deal with regional and watershed issues, and is extending its staff expertise to address new and future issues.

The pressures to accommodate change are not merely originating in EU offices, but ministries like KSH are now less insulated from public pressures as well. Hungary first adopted environmental impact assessment (EIA) legislation in 1985, but more recently it has come under pressure to integrate such analyses with decision-making and long range planning for water policies. Greater public participation has been enshrined in the Århus Convention of 1998. The Århus (Aarhus) Convention was signed by 29 countries and the EU, and calls for greater public participation in environmental policies through use of EIAs and non-governmental organizations (NGOs). Included as part of the convention is a requirement, modeled after the U.S. Freedom of Information Act (FOIA) to make publicly available environmental information (Bell et al. 2002; Botcheva 2001). A related agreement to Århus is the Kiev Protocol, a framework and agreement for use of Strategic Environmental Assessments (SEAs) in decision-making and long-term planning.

In both cases, the desire to accomplish more inclusive decision-making remains a laudable goal, yet one that is difficult to achieve in practice. If the U.S. case was at all instructive, it was many years after the passage of the National Environmental Policy Act in 1970 and the FOIA (passed in 1966, amended 1974) that decision-making at federal agencies changed to reflect the intentions of the original legislation. Even now, many problems still remain with openness to information in the U.S. For countries in Central Eastern Europe without as much recent history of democratic practice, it may well prove difficult to know how to implement more open decision-making procedures and information dissemination. The Kiev Protocol, for example, was supposed to be implemented in Hungary by July 2004, but it will yet be some time before suitable procedures are worked out by the bureaucracies. Even then, the ability to include NGOs and individuals in crucial activities such as monitoring and EIA review is limited, and made more difficult by the small nature of so many Hungarian municipalities.

CONCLUSION

Any summary of Hungarian approaches to water policies should not suggest to the reader that the aforementioned obstacles cannot be overcome, and that efforts to date may be largely symbolic in achieving EU membership. It is true that a country like Hungary has a notable history of water pollution, and faces barriers to effective action in addressing effective freshwater resource management. The more important point is that Hungary

has committed itself to effective freshwater regulation long before such requirements were imposed by EU directors in Brussels. The Hungarian transition from communism was marked by a symbolic conflict over a large water project, while other social groups mobilized around water quality concerns in lower reaches of the Danube. The transition to EU membership was therefore a mere acceleration of previously initiated policies, albeit a process assisted by outside funding and an influx of technical expertise from other countries. It is likely that, especially as more of Hungary's neighbors are granted membership into the EU, effective policies will emerge to address fully the concerns of environmental quality, in addition to the more traditional emphases on navigation and flood water management. With more open information, more recognition of the need to transcend state borders in studies, and perhaps an ability to integrate surface and groundwater protection, Hungary will more effectively utilize and protect its freshwater resources.

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8

Liquid Waste Management Practices and the Efficient Reuse Strategies with Reference to Melbourne, Australia

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1. INTRODUCTION

Liquid waste may be defined as the water produced from the domestic and industrial establishments in the form of a waste. It has also been referred to in literature as sewage and/or municipal wastes. It contains less than 1% solids and the rest is water, which serves as a carrier. The domestic waste component of liquid waste is mostly biodegradable, whereas the industrial one depends on the type of industry from which they originate. Industrial establishments such as food processing including canning, abattoirs, tanneries, etc. carry biodegradable wastes, whereas the chemical industries such as electroplating, paper pulp manufacturing, paints, motor vehicle manufacturers produce wastes that may contain non-biodegradable and even intractable wastes. Often these wastes are provided preliminary treatment on site before their discharge for future treatment at a centralized treatment facility. Other sources of liquid waste, which are discharged to sewerage include institutions such as hospitals, hostels, hotels, airports, recreational facilities and in some instances storm water.

With the growth of urbanization, there is an increase for demand in goods and services of which water is one. Often these increases in turn augment the production of liquid wastes. The wastewater amongst other things may contain one or more of the following:

- a. Pathogens
- b. Nutrients such as nitrogen and phosphorus
- c. High organic load containing carbohydrates, proteins and fats
- d. Toxicants such as pesticides, heavy metals and organichlorines
- e. Antibiotic and/or nuclear wastes

These wastes, if and when discarded to receiving waters, have the potential to:

- a. Deplete dissolved oxygen and affect the quality of life therein
- b. Produce malodorous gases
- c. The toxicants may enter the food chain and get biomagnified as they pass through the production chain

As water is becoming a scarce commodity, the community cannot afford to throw away the wastewater after having used it only once. After adequate purification, water can be reused for various purposes both for domestic and/or industry. The domestic utilization includes gardening and toilet flushing, whereas in industry recycled water can be used for cooling and agriculture. The ultimate treatment depends on the purpose for which it is targeted for reuse.

This chapter has been organized in five sections. In section 2, general objectives of liquid waste management have been discussed. Section 3 is devoted to methods of liquid waste management. In section 4, a historical perspective of wastewater management in Melbourne is presented. In section 5, a detailed discussion of liquid waste management system in Melbourne has been described.

2. GENERAL OBJECTIVES OF LIQUID WASTE MANAGEMENT

The level of treatment depends on the nature and strength of the constituents, their impact on the receiving water, and long-term effect on the environment. The objectives of a liquid waste management system are to:

- (i) Protect public health
- (ii) Protect the receiving environment from degradation
- (iii) Meet the legislative and/or licence requirements for their discharge to the environment
- (iv) Reduce the cost of treatment by the reuse of by products such as biogas and the treated effluent. The treatment methods that can be

used to remove or modify the constituents found in the wastewater is also important from the point of view of costs.

3. GENERAL METHODS OF LIQUID WASTE MANAGEMENT

Wastewater can be managed either through a decentralized system (on site) or through a centralized wastewater management system. A decentralized wastewater management process may be defined as the collection, treatment and reuse/disposal of wastewater from individual homes, cluster of homes, isolated communities, industries, institutional facilities as well as a portion of existing communities at or near the point of waste generation (Techobanoglous and Schroeder 1995). A centralized wastewater management system consists of a conventional or an alternative wastewater collection infrastructure that includes sewers, pumping station, centralized treatment plant and a reuse/disposal facility for the treated effluent; usually located faraway from the place of origin. The challenges for adequate treatment and the discharge are becoming increasingly demanding as we understand their effect on the environment. The challenge is to be able to provide the required level of treatment subject to serious economic constraints. The elements of wastewater management system are the same as far as the treatment process is concerned but the difference may be in the application of technology.

Wastewater contains a variety of solid materials varying from rags to fine colloidal materials. The solids may be either organic or inorganic. They may be in either suspended or in a filterable form. Information on the size of the biodegradable organic particles is important from a treatment point of view, as the biological conversion rate of these particles is dependent on size. The interrelationship of various solid fractions found in wastewater are shown in Figure 8.1 (Tchobanoglous and Crites 1998).

The liquid waste management systems in practice in various parts of world can be classified into two major categories. These are:

- (a) Conventional mode of treatment systems, which include:
 1. Septic tank
 2. Imhoff tank
 3. Activated sludge treatment plant
 4. Trickling filters.
- (b) Land-based mode of treatment systems include:
 1. Lagoons/ oxidation ponds/ maturation ponds
 2. Land filtrations system
 3. Grass filtrations otherwise known as overland flow systems

In the following section we discuss these systems with reference to Melbourne, Australia.

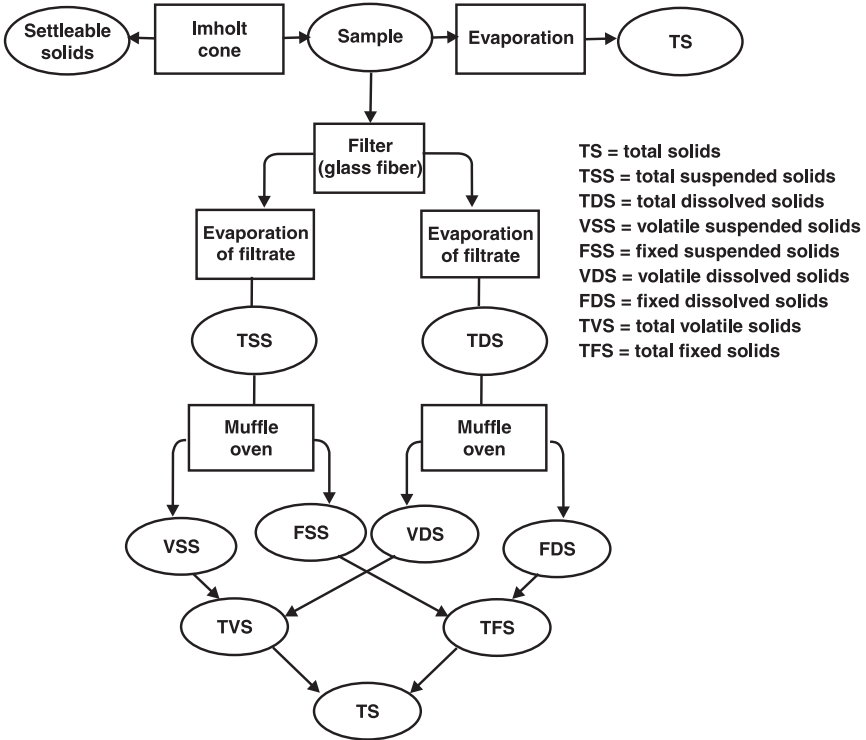


Fig. 8.1. Interrelationship of the various solid fractions found in wastewater

4. A HISTORICAL PERSPECTIVE OF WASTEWATER MANAGEMENT IN MELBOURNE

Melbourne and the Metropolitan Board of Works (The Board), a predecessor to Melbourne Water was created through an Act of Parliament in 1890. During the gold rush period of early 1800's, people were drawn to inland Victoria and as a consequence the demand for amenities increased. By the second half of the 1880's a worsening sanitary crises had drawn closer together and a Royal Commission was appointed to investigate the possibility of the management of both domestic as well as industrial wastes from places such as wool curing industries and abattoirs. During 1880's Melbourne had a population of almost two hundred thousand (Dingle and Rasmussen 1992). Melbourne was also a facilitator and a provider of all those services, which aided the flow of imports and export and it was a home to merchants, shippers, insurance companies, banks, warehouses and processors of both imported and specially exported commodities.

The quantity of wastewater produced increased and the Melbourne soil became water logged as it tried to absorb many times the amount of water, which fell as rain, especially, during the winter months. Drainage was more difficult because much of the land could no longer absorb water from impervious house-roofs and paved streets, thus water had to flow elsewhere. Along the drains flowed dirty water from the kitchen sinks, laundry troughs and bath, as well as the 'chamber slops' or the urine that had accumulated in the chamber pot during the night vigil beneath the bed. The water eventually flowed into street channels before reaching the river. The Yarra River received all of these and what ever would flow out of its tributaries. The Maribyrnong River with the greater concentration of its industries along its banks had been even more abused. The means by which human faeces were disposed off in Melbourne were both disgusting and dangerous. Each house had a closet, generally weatherboard. In each house was a 'midden stead' or framework on which the user sat and underneath was placed a galvanised iron pan or pail. The night man emptied the can, usually once a week via a small door at the back of the closet. This was the accepted method of excreta removal. Contractors were allowed only to empty pans under the cover of darkness in order to maintain the impact of smell from the operation. By 1880, the loads of human excreta were taken to the fringes of the metropolis, to be purchased by market gardeners and used as fertilizers. About 150 loads of 2.5 tons each were collected and carted to 15 miles (25 km) by men during the 16–18 hours working days.

By 1890, this system was collapsing. Suburban expansion pushed out the frontiers of settlement; consequently night-men from central areas had further to travel to find market gardeners willing to accept the cargo. Night-men sometime dropped their load illegally on vacant land or into the Yarra River, on roadsides or anywhere they could do so and remain undetected.

Melbourne stood ankle deep in its own waste. It had done so for many years, tolerance gave way to a growing repugnance and a desire to do something better. The metropolis was on the nose as visitors frequently complained (Dingle and Rasmussen 1992). During 1890, there were 400 deaths in Melbourne due to infectious diseases such as typhoid. This amounted to a death rate of almost 20 per 1000 people, more than double of what it has been in 1880's. Although it was not Melbourne's major killer, typhoid came to be seen as a special shame. After many years of apathy the public and politicians showed an increased willingness to listen to health professionals as the deaths soared. The Sanitary Commission linked typhoid and sewerage and concluded that typhoid was preventable and a sewerage system would prevent it. This was a powerful argument for building sewers.

James Mansergh, a water supply and sewerage engineer from the UK was chosen as an expert to design a proper sewerage system and to select a site

for the location of a centralized wastewater management system. Mansergh arrived on 18th October 1889 and planned a system which could cope with a population of 1.7 million in 1939. His plan included eight schemes. Most incorporated one or two sewerage farms at Mordiallac and Werribee (Penrose 2001). By 1891 Melbourne had decided on the sewerage system it would build. The main sewer would transport their cargo to the pumping station at Newport and then to the sewerage farm at Werribee.

Work on the pumping station began in 1894 and was completed in 1897. The main sewer was constructed by tunneling for most of the length. By the middle of 1899, more than 58 km of mains, sub mains or branch sewer and 380 km of reticulation sewer had been built. In August 1897, the first property in Port Melbourne was connected to the new sewer, and it was only five years earlier that the first sods was turned at Werribee. The sewerage of the city in carrying of the scourgings from the street and factories, instead of having that refuse shot into the Yarra, has done a great deal towards purifying the river with the result that the atmosphere of the whole city is much purer and the death rate much lower than it was earlier. By the year 1909–10, one hundred and five thousand nine hundred and ninety three (105,993) properties were sewerage for an estimated population of about half a million out of the metropolitan population of about 580,000 (Dingle and Rasmussen 1992). Water was supplied to 123,227 properties in the same year. This shows that less than 20,000 properties had reticulated water but no sewers. By 1900 the overall death rate in the sewerage suburbs had fallen more than in those where connections were yet to be made.

By mid 1950, because of the accumulated sewerage backlog septic tank was seen as an acceptable substitute to the 'Pan-System', at least as a temporary measure. The sewerage backlog continued to grow, by 1963 there were 117,000 unsewered properties in the metropolitan areas; 38,000 of them relied on septic tanks and could flush their toilet while the remainder used the Pan-System. Slowly but reluctantly, suburban families came to realize that it was the sillage and the seepage from the septic tanks of their own and their neighbours, which was polluting the areas and the bay beaches. A total of 80,500 septic tanks were in the suburbs. The social cost of un-sewered suburban growth was becoming painfully obvious. Thus the false promise of the septic tank, long regarded as the panacea to the solution of the sewerage backlog, was exposed no longer as a solution. Melbourne's clayey soil did not readily absorb septic tank effluent, allowing it to seep into the creeks, rivers and eventually the bay. The Board had done well during 1960's in connecting houses to the sewers. During 1970, with the assistance of the national sewer programme a peak backlog of 173,000 in 1973 were reduced to 104,000 by 1978. To meet the backlog in Altona area, a conventional treatment facility (trickling filter) was

established in 1960 for the treatment of domestic sewerage from the local catchment. Due to groundwater infiltration, the wastewater in this area is saline and it was considered unsuitable for purification at Werribee, as it was likely to damage the pastures in the land-based treatment areas. Initially the facility at Altona was considered as a temporary measure, but it still continues to operate and is essentially upgraded to meet the needs of the day. The effluent is discharged to Port Phillip Bay under the EPA licence requirements. The digested sludge is stored on site, and the digester gas, mainly methane, is utilized to heat the sludge digesters. The design and operation of the facility being a conventional one, further discussion on Altona facility is not desirable.

On an average the Melbourne Metropolitan area produces over 800 ML of wastewater per day. Of the about 480 to 500 ML is treated at Werribee, about 300 ML at south eastern purification plant at Carrum, and the rest at the Trickling Filter Plant at Altona and a few minor local treatment facilities.

In meeting with its environmental obligation and community expectation Melbourne Water and its predecessor MMBW has one of the objectives to contain all sewerage flows during a 1-in-5-year rainfall event and have no sewerage spills due to operational failures of Melbourne Water's Systems from either equipment breakdown or human error (Melbourne Water 2002/03).

5. LIQUID WASTE MANAGEMENT SYSTEMS IN MELBOURNE AND DETAILED DISCUSSION OF SOME PLANTS

Every day in the city of Melbourne, more than 3.5 million people use services provided by 'Melbourne Water', which is a statutory organization responsible for the collection, storage and supply of potable water to Melbournians. It is also responsible for the purification of the wastewater from the domestic and industrial establishment before their reuse/discharge to the environment. Currently, based on an average rate of about 500 litres/head/day, currently total volume of wastewater per day is about 800ML. This wastewater is treated at three major facilities and a few minor local treatment plants. The major facilities are:

1. The Altona treatment plant
2. The South-Eastern treatment plant at Carrum, and
3. The Western treatment plant at Werribee.

Details of some major plants are given in the following subsections.

5.1 The Altona Treatment Plant

The Altona treatment plant in brief is a centralized facility treating wastewater of domestic origin. It is a conventional trickling filter system,

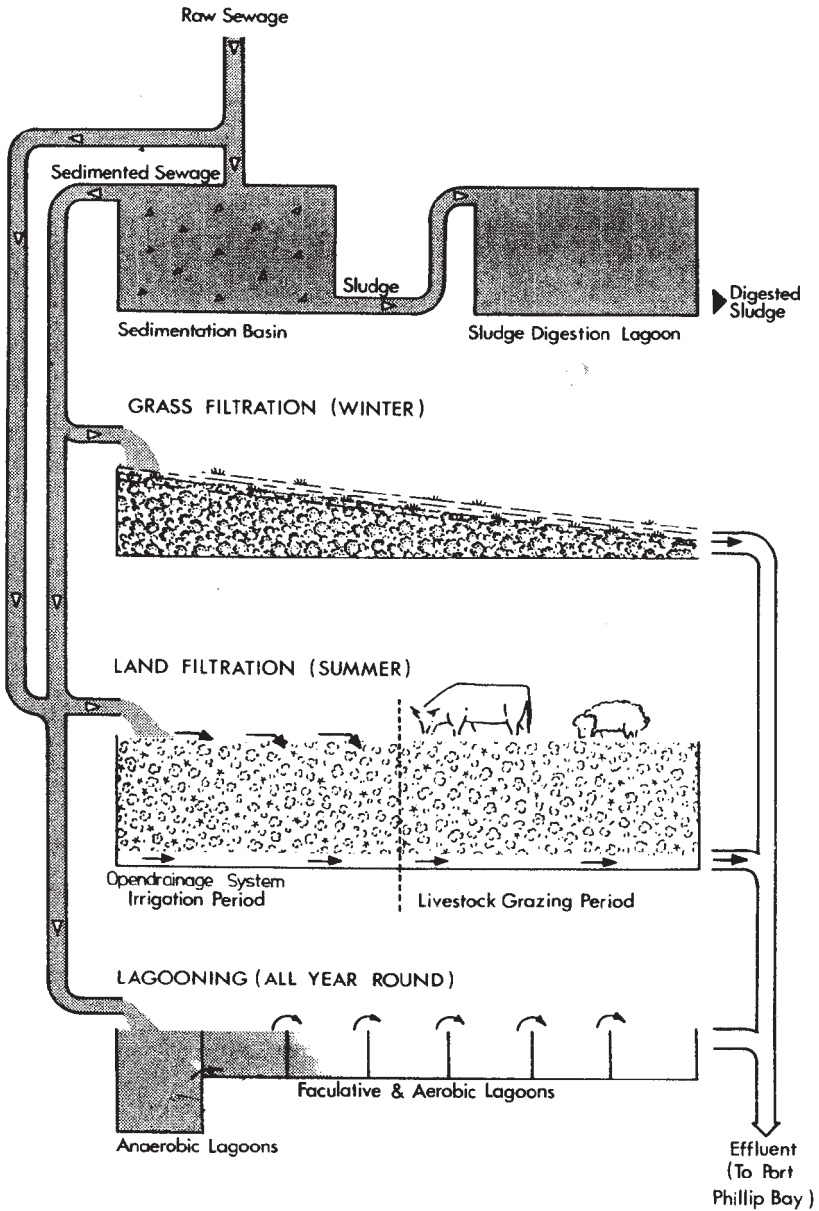


Fig. 8.2. Various treatment processes of the Western Treatment plant

wherein; the raw sewage is chlorinated to reduce the odour problem. It has a GNT chamber and primary clarifiers to remove all settleable material before its purification on to the tickling filters. The tickling filters purify

wastes aerobically and the affluent along with the biosolids is taken to the secondary clarifiers to remove the biosolids. The effluent from these clarifiers is discharged to the maturation ponds and then to the Bay. Biosolids digest to produce methane, which in turn is used to heat the digester.

5.2 The South-Eastern Treatment Plant

To augment the facilities at Werribee, during 1970's the MMBW designed and constructed another centralized conventional liquid waste management system (Eastern Treatment Plant) with its infrastructure in the South Eastern Region at Carrum. Its catchment, the eastern Plant of Melbourne and the Metropolitan area, was separated from the rest of the Melbourne area with two major pumping stations, one at Kew and the other at Ormond. It treats about 370 ML per day of municipal wastewater, mainly domestic. The quality of raw sewerage entering the Eastern Treatment Plant is shown in Table 8.1.

The South East Treatment Plant is a conventional system fully automated with human interference. The facility includes, pre-chlorination, coarse filters, grit chambers, primary sedimentation tanks, aeration tanks, secondary sedimentation tanks, mesophylic sludge digesters, digested sludge drying beds, secondary effluent chlorination, a facility to generate electricity from the digestive gas and effluent outfall 52 km long discharging the effluent to Bass Strait at Boags Rocks. The quality of the effluent before its discharge to Bass Strait at Boags Rocks are shown in Table 8.2.

The Eastern Treatment Plant has for some time sold class C recycled water for irrigation and spots facilities. In 1999 Melbourne Water intensified a potential demand of 8000 million litres of recycled water in a corridor from Carrum to Koo Wee Rup for horticultural requirements. The users of recycled water by the existing Eastern Treatment Plant customers, the product type and volume of the recycled water utilized are shown in Table 8.3.

The Eastern Treatment Plant uses recycled water on site for processes such as cleaning screens and toilet flushing. In 2002-03, the plant used 13,800 million litres for these purposes.

Many opportunities have been identified for recycling through sewer mining and for utilization of recycled water (see Melbourne Water 2002-03). It is good to note that Melbourne Water has continued to pilot and demonstrate recycling through sewer mining a potable water recycling plant used to irrigate Kings Domain gardens during last year and subsequently this was upgraded and installed at Albert Park. The recycled water was also utilized for park irrigation and for use in Albert Park Lake, to recharge depleted or degraded aquifers to store recycled water.

Table 8.1. Quality of raw sewerage entering treatment plant

Parameters (units)	Median	90 th percentile	Maximum
BOD (mg/L)	310	487	530
Suspended Solids (mg/L)	390	548	740
pH (pH units)	6.9	7.2	7.4
Ammonia as Nitrogen (mg/L)	35	39	42
Total Combined Nitrogen (mg/L)	66	86.8	95
Total Phosphorus (mg/L)	17	21	24
Anionic Surfactants MBAS (mg/L)	4.4	7.2	12
Cadmium (mg/L)	0.0008	0.00164	0.0028
Chromium (mg/L)	0.046	0.122	0.18
Copper (mg/L)	0.14	0.19	0.2
Lead (mg/L)	0.021	0.0444	0.063
Mercury (mg/L)	0.00009	0.00024	0.0004
Phenol	4	38.4	75
Toluene	2	4.8	6
Benzene	0.5	0.5	3
PAH total	4	4	4

Note that these results were less than the detection limit and were taken as half the given value i.e. $<2=1$.

Total PAHs were calculated using the sum of the PAHs: (acenaphthylene, anthracene, 1,2-benzanthracene, 3,4-benzofluoranthene, benzo (a,h) anthracene, fluorence and indeno (1.2.3-cd) pyrene. All results were less than the detection limit and were calculated at half the given value i.e. $<2=1$.

5.3 The Western Treatment Plant

A general layout of the Western Treatment Plant is shown in figure 8.2. Land based wastewater treatment processes have been in practice at the Western Treatment Plant at Werribee since 1893. The facility is located at 35 km South West of Melbourne on a land on the west of Werribee River occupying an area of 10,850 hectares. The historical events that led to the establishment of the facility have been described earlier. The area is bounded to the south by a frontage of 21 km to Port Phillip Bay, to the north by a national highway. The Werribee River adjoins the eastern boundary for 10 km, whilst to the west the boundary joins general farmland and the Avalon airport. Initially 3580 hectares on the west side of Werribee River was acquired from the Chirnside family in 1893 and successive additions were made to augment the treatment capacity. In 1900, sheep were introduced to

Table 8.2. The quality of effluent when discharged to Bass Strait

Parameter (units)	Median limit		90 th Percentile limit		Maximum limit	
	Result		Result		Result	
BOD5 (mg/L)	NS	25	NS	40		54
CBOD5 (mg/L)	20	6	40	10		31
Suspended Solids (mg/L)	30	9	60	18		65
pH (units)	7.2			7	6-9 7.5	6.6
Ammonia as Nitrogen (mg/L)	30	19		26	40	31
Total Combined Nitrogen (mg/L)		27		37		42
Total Phosphorus (mg/L)		7.5	15	9.2		10
Anionic Surfactants (mg/L)	0.4	0.2	0.7	0.4		1.2
Cadmium (mg/L)			0.005	0.0001	0.01 0.0003	
Chromium (mg/L)		0.006	0.075	0.008	0.15	0.021
Copper (mg/L)		0.014	0.05	0.027	0.1	0.05
Lead (mg/L)		0.002	0.05	0.004	0.1	0.006
Mercury (mg/L)			0.0005	0.00005	0.001 0.0001	
Phenol		0.5		1	100	1
Toluene		0.5		0.5	50 0.5	
Benzene		0.5		0.5	25	1
PAHs total		4		4	15	4
Flow (ML/L)	540	418		445	770	471
Total Residual		0.07			1.0	
Chlorine (mg/L)			0.11		0.17	
E. coli (org/100 mL)	200	14	1000	78		190
Dissolved Oxygen (mg/L)	7			7.4	>6.0	6.1-9.5

graze the sewage-irrigated land in the summer months and cattle were introduced 10 years later.

With the further acquisition of land two pumping stations were constructed, one in 1927 and another in 1932 to pump the wastewater to

Table 8.3. Users of recycled water

Type of scheme	Product type	Volume used 2002/03 (ML)	Percentage
Horticulture	Nursery/turf farm/flowers/ vineyard/orchard	500.0	29.8
Agriculture	Hydroponics/market garden	426.6	25.5
Silviculture	Foliage	20.0	1.2
Dust Control	Biosolids dust control	58.6	3.5
Municipal	Golf courses/recreational reserves	666.2	39.8
Aquacultural/ ornamental	Wetlands	3.8	0.2
Total		1,675.2	100

irrigate the land in higher areas at the Western part of the farm, which could be delivered by gravity. Currently the Western Treatment Plant utilizes three modes of land-based treatment facilities, namely:

- (a) Land filtration system
- (b) Grass filtration system
- (c) Lagoon oxidation ponds

5.3.1 *Layout of the Land Filtration Treatment System*

Land filtration mode of treatment is practised from October to April each year. During these warmer months, evapo-transpiration is higher than precipitation. The soil is not clogged and it also facilitates the percolation of water through it. The wastewater, while passing through the soil, microbes breakdown the organic matter and purify the wastewater.

Depending on the terrain, the bays are prepared either as a flat plots surrounded by banks, or as graded areas 180 m long by 10 m wide and have permanent pasture growth. The influent enters the bay at their higher end. The banks all around the bay prevent overflow of the applied sewage directly into the effluent drains. The irrigation of each bay is adjusted according to the prevailing environmental conditions, the average application being about 100 mm. Each bay is given approximately 1 to 2 d irrigation followed by 5 to 8 d drying and 10 to 14 d livestock grazing, making a total operating cycle of 18 to 21 d. The irrigant is purified during infiltration through the soil, most of the nutrients and heavy metal compounds being removed in the process. About 50 to 60% of the effluent is collected in a system of open drains 1.2 to 1.8 m deep, constructed throughout the area at 180 m intervals. The rest of the water applied is lost

by evaporation, transpiration or seepage into the lower subsoil. Wastewater irrigation promotes a high rate of pasture growth and this plant material must be regularly removed to maintain the area in a proper condition, both from the point of view of continuing growth and irrigation. The pasture is removed by grazing the animals.

5.3.2 Grass Filtration or Overland Flow Mode of Waste Water Treatment

During the cooler months of the year (May to October), the soil gets water logged, evapo-transpiration will be less than precipitation leading to ponding the land filtration bays. The percolation of water through the soil is almost non-existent and the soil microbes, which were active during warmer months in treating the pollutants are no longer available to do their job. Hence the land filtration mode of treatment water was not effective in winter months and an alternative mode of treatment was to be found. In early 1930, the overland flow sewage treatment process, locally known as grass filtration areas was introduced to meet the purification needs during winter. The system occupied 1463 hectares during 1970 and treated some 270ML or 60% of daily sewage inflow during the cooler months. The process relies on a filter formed by a thick mat of grass deposition of suspended solids and on the saturated shallow surface layer with a high organic matter contents. The vegetation and surface soil layer serves as a filter media where biologically active slimes develop to absorb and stabilize the wastewater pollutants. Italian Ryegrass (*Lolium multiflorum*), which grows in the form of slender erect stems, is used as the filter media. It survives extremely well in the wet conditions. It also supports the growth of slime on the submerged portion of the stems. The slime microbiota include amongst others, bacteria, fungi, actinomycetes and other predatory microbes. The system is sometime compared to a horizontal trickling filter.

6. A GENERAL LAYOUT/DESCRIPTION OF THE TREATMENT SYSTEM

The irrigation areas are laid out on a conventional gravity border-check system with bays usually 10 m wide and 2000 m to 400 m long. In order to reduce the suspended solids in the system sedimentation also removes the material that has the potential to block the distribution system and creates a short circuiting within the treatment bays. At Werribee, sedimentation is carried out in large open units and sludge passes to open tanks cold digesters. The anaerobic gases, mainly methane and hydrogen sulphide escape into the atmosphere. The effluent is distributed via concrete lined trapezoidal chambers. Each year, the grass areas are established in late summer/early autumn for the germination of the Italian Rye grass seeds

and rapid growth to some 150 mm by mid autumn. At this stage a small continuous flow of the influent is applied to establish the microbial slime. After about two weeks the flow is increased to the design criteria and maintained until the end of the season. Suspended solids accumulate at the influent end creating anaerobic conditions, which can extend into halfway down the bay. The anaerobic grass emanating from the zones create odour problems. The hydrogen sulphide concentration in the wastewater promotes the population of atmospheric sulphur bacteria. Those autotrophs utilized hydrogen sulphide as the electron donor for carbon assimilation, instead of water, as is the case of algae and other autotrophs. The added benefit of hydrogen sulphide at the inlet end is that hydrogen sulphide combines with the heavy metals in the influent and form metallic sulphides. These being sparing soluble settle and accumulate at the inlet end. As the wastewater reaches the effluent end it absorbs oxygen and fern aerobic. The leachate from the dead grass containing humic and fulvic acid turn amber. The average detention time in each of the grass filtration bays is about 36 h. When the irrigation ceases in September/October each year, the area is dried and cattle graze heavily, still sufficient seed is left to provide self-germination for the next season. The loading of the grass filtration system has been determined over the years on an empirical basis to achieve an efficient quality of 20 mg/L BOD₅ and 30 mg/L suspended solids. The quality has been related to a standard design hydraulic loading of 0.23 ML/day. The quality of the influent and the final effluent from the process are tabulated in Table 8.4 (Scott and Fulton 1979).

Table 8.4. Summary of data showing mean and standard deviation (in parenthesis) of wastewater of concentration in mg/L

Parameter	Incoming sedimented sewage	Effluent	Parameter	Sewage	Final effluent
B.O.D.5	507 (68)	12 (5)	Ortho. P	7.6 (1.4)	8.3 (1.7)
S.S.	233 (78)	19 (25)	Total P	9.0 (1.3)	8.4 (1.7)
T.O.C.	350 (61)	60 (20)	Fe	2.9 (1.1)	3.0 (1.4)
pH	6.8 (0.2)	7.4 (0.1)	Cu	0.26 (0.23)	0.02 (0.02)
M.B.A.S.	4.3 (0.0)	0.5 (0.1)	Cr	0.42 (0.11)	0.07 (0.02)
ORG. N.	24.6 (9.3)	8.4 (11.8)	Cd	0.017 (0.009)	0.009 (0.006)
AMM.N	31 (3)	31 (3)	Pb	0.23 (0.16)	0.01 (0.01)
NITRITE	0.05 (0.01)	0.06 (0.02)	Ni	0.39 (0.33)	0.06 (0.03)
NITRATE	0.06 (0.11)	0.34 (0.34)	Zn	0.87 (0.26)	0.05 (0.03)
Total N	56 (11)	40 (13)			

The results clearly demonstrate the effectiveness of the land-based process in the treatment of wastewater, especially during winter when the environmental conditions are not very congenial. The reduction of carbonaceous demand (BOD and TOC), suspended solids and MBAS clearly demonstrates the role of microbiota in the sludge as well as in the slime especially at the effluent end of the treatment bay.

The removal of nitrogen was complex and to some extent unexplained. The main loss could be attributed to the plant uptake and stripping of ammonia from the wastewater. The overall reduction in nitrogen concentration was 30%. There is no reduction in phosphorus concentration during the process. Many of the heavy metals were removed in the anaerobic section due to the formation of metallic sulphide. However, the concentration of iron increases in the final effluent due to the complexing of the metal with the organic acids such as humic and fulvic acids.

5.3.3 Lagoon /Stabilization Ponds

Lagoons have been utilized all over the world as a land-based wastewater management system. These have been referred to by various terms including, oxidation ponds, maturation ponds, aeration ponds, stabilization ponds etc. General lagoon performance as a treatment system is evaluated in terms of biochemical oxygen demand and suspended solids removal. However, the effluent quality criteria often goes beyond the concept: nutrients, heavy metals and microbiological characteristics are of prime importance in view of water reclamation and/or eutrophication of receiving waters.

The use of lagoons for sewage treatment in Melbourne dates back to 1936, when a large area of 271 hectares was converted to a huge pond for final polishing of effluent from grass filtration areas. During 1937, the system was extended to purify wastewater during peak flow and wet weather flows throughout the year, which exceeded the capacity of land or grass filtration processes. Since then the system has been extensively tested, developed and used as a stand-alone viable wastewater treatment alternative. The Western Treatment Plant currently offers the most exclusive development of lagoons and their development for the treatment of liquid waste in Australia.

At present, about 1500 hectares of lagoons are in operation and treat over 50% of sewage arriving at the Western Treatment Plant. In this mode of treatment, sewage passes through a series of ponds. The lagoon system on the east the Little River, treat unsedimented sewage whereas the one on the west treat the sedimented sewage because of the local legislature requirements. The average depth of each pond is just over a metre. The first pond in each series is deeper than the rest to accommodate and digest the accumulated solids. The wastewater is purified through a natural process of sedimentation, anaerobic/aerobic microbe stabilization. Due to the high

organic loading and the anoxic nature of the sewage, the first flow ponds in each of the series are anaerobic. As the wastewater passes through the ponds system, the organic load is progressively reduced and dissolved oxygen appear along with the associated microbes. During warmer months, there is a potential for these ponds to remove nitrogen through the process of nitrification and denitrification:

Functionally the lagoon system can be classified into (a) anaerobic, (b) facultative and (c) aerobic. The treatment processes in each of these are described in the following.

1. ANAEROBIC PONDS

The initial pond in each of the series is invariably anaerobic, both in character and function. Settleable solids settle to the bottom of the pond and undergo unaerobic breakdown. Complex carbohydrate component of the liquid waste is also anaerobically broken down to mainly methane, hydrogen sulphide and some fatty acids. The gates facilitate the mixing of the digesting solids with the incoming wastewater. The hydrogen sulphide component of the gas also assists in the removal of heavy metals from sewage. During warmer months anaerobic activity is usually restricted to pond one, however, during cooler months of the year the activity may extend to further ponds depending on the temperature and organic loading.

2. FACULTATIVE PROCEDURES

During this process the ponds support anaerobic microflora at the bottom and micro-aerobic organism at the surface. Carbon dioxide produced by the aerobic leaching is utilized by the atmospheric microbes at the surface. Oxygen released during photosynthesis is consumed for the aerobic stabilization of the organic matter. Despite the intense carbon assimilation, the dissolved oxygen concentration in the final effluent remains below 30% saturation as most of the dissolved oxygen is utilized for the stabilisation of organic matter.

3. AEROBIC PROCEDURE

The final portion of the lagoon system mostly functions as a polishing pond. During this process a quick succession of micro-organisms in the lagoon system. The microbial community structure can be very diverse. They include producers such as algae, consumers such as rotifera, protozoa, and lowering of the biochemical oxygen demanded in the effluent, there is an increase in the concentration of dissolved oxygen. When the conditions are conducive there is a potential for the reduction of ammonia due to nitrification. Species diversity in these processes is invariably proportional to BOD and ammonia concentration. The quality of raw sewage and the final effluent are given in Table 8.5. Table 8.5 (Hussainy 1979) also provides data on the quality of effluent produced by the various treatment processes at the Western Treatment Plant testing sedimented and unsedimented sewage.

Table 8.5. Characteristics of raw sewage and the effluents from various treatment processes at Werribee farm, Melbourne

Parameter	Inflow raw sewage (mg/L)	*LF.		*Sed.		*GFPS.		*LRSL.		*LPEI.	
		Outflow (mg/L)	Percent removal (%)	Outflow (mg/L)	Percent removal (%)	Outflow (mg/L)	Percent removal (%)	Outflow (mg/L)	Percent removal (%)	Outflow (mg/L)	Percent removal (%)
5-day BOD unfiltered	570	6	99	420	26	21	96	10	98	25	96
Suspended solids	620	15	98	180	71	28	95	40	93	83	87
Volatile suspended solids	510	10	98	150	71	13	97	30	94	63	86
Total dissolved solids	1200	2200	...	1200	...	1075	...	1230	...	1230	...
Total organic carbon	360	22	94	250	31	37	90	55	85	58	84
Colour Pt./Co units	300	50	...	300	...	300	...	350	...	350	...
pH(units)	6.9	7.2	...	6.9	...	7.7	...	8.0	...	8.0	...
Dissolved oxygen	-	0.60	-	...	...	0.29	...	5.1	...	4.7	...
Nitrite as N	0.05	0.24	...	0.05	...	0.07	...	S0.84 - W0.78	...	1.14	...
Nitrate as N	0.10	2.02	...	0.05	...	0.34	...	S9.43 - W2.52	...	1.29	...
Ammonia as N	32.0	1.6	95	33.0	.5	25.9	20	S7.0 - W25.0	80S-20W	13.7	55
Organic Nitrogen	24.0	2.7	90	14.4	40	4.8	60	S6.2- W5.8	75S-75W	10.1	60
Total Nitrogen	56.2	6.6	90	47.5	15	31.1	45	S23.5- W34.1	60S-40W	26.2	55
Orthophosphate as P	6.0	0.9	...	6.5	...	6.5	...	7.5	...	6.5	...

contd.

Table 8.5 contd.

Total phosphorus	9.0	1.1	90	8.5	5	6.5	30	7.5	15	7.5	15
Anionic Surfactants	3.6	0	100	3.6	0	0.7	80	...	...	0.4	90
Copper	0.35	0.02	95	0.20	45	0.08	90	0.02	95	0.03	90
Chromium	0.40	0.03	90	0.25	35	0.06	85	0.05	85	0.08	80
Cadmium	0.015	0.002	0.5	0.010	35	0.002	85	0.003	80	0.002	85
Iron	3.3	...	...	2.5	25	1.9	40	1.1	65	1.4	60
Lead	0.30	0.01	95	0.2	35	0.02	95	0.03	90	0.03	90
Mercury	0.003	0.0004	85	...	...	0.0005	85	...	...	0.0004	85
Nickel	0.15	0.04	75	0.10	35	0.06	60	0.06	60	0.07	55
Zinc	0.80	0.04	95	0.50	35	0.08	90	0.04	95	0.12	85

Key to symbols used in Table 8.5.

A * indicates a use of an abbreviations in Table 8.5. Their full representation is as follows: Land Filtration is denoted LF, Sedimentation is denoted by Sed., Grass Filtration plus sedimentation is denoted by GFPS, Lagoons Raw Sewage Input is denoted by LRSI., and Lagoon Primary Effluent Input is denoted by LPEI.

The Western Treatment Plant (WTP) is often described as a system operating in harmony with nature, converting waste into wealth. The cattle and sheep farmed at the WTP are sold at the wholesale market and slaughtered under rigid meat inspection. Condemnation of carcasses of WTP animal from all causes run about 0.02%, a figure approximately half the average recorded for animals from rest of the state (McPherson 1979). Heavy metals in liver and kidney tissue of cattle grazed sewage irrigated pastures do not show significant increase in heavy metals. Copper concentration is depressed and this may be due to a metal complexing (Evans et al. 1979).

The revenue varied from the sale of live stock partly offsets the cost of purification. Depending on the market conditions it can be up to 25% of the operating cost.

The WTP is being upgraded at a cost of \$ 124 million to reduce nitrogen entering the Port Philip Bay by 500 tonnes by the year 2006 (Annual Report, Melbourne Water 2003-04). Nitrogen reduction is being achieved through the installation of new treatment facilities at the lagoon allowing the phasing out of land and grass filtration areas. Work also includes the installation of activated sludge plant to enhance nitrogen removal, expulsion of the biogas, handling capacity and extension of the cover over the anaerobic ponds to improve biogas capture, water recycling, biosolids use, agriculture practice, conservation management and achieving environmental objectives and actions (Hussainy 1990).

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9

Drinking Water Contaminants and Human Health

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INTRODUCTION

Of all the natural resources necessary to ensure human, plant and animal health, water is the most important. Water is a basic biological necessity and having access to safe and reliable sources of drinking water is extremely important for human health and civilizations around the globe. Changes in chemical composition of water sources due to natural hydro-geological processes, rapid population growth, industrial development and intensified agricultural production has influenced the natural balance of water constituents in water supplies resulting in the pollution of water bodies around the world. Human exposure to pathogenic and non-pathogenic elements through consumption of unreliable drinking water sources has recently become a global concern. The impact of water quality on human health is multi-factorial and two main factors are to be taken into account: 1) natural inorganic and organic components and 2) man-made compounds.

Surface and groundwater used as drinking water sources exhibit a wide range of chemical compositions and in ecosystems unaffected by humans, the range of compositions can vary considerably. For example, in areas of sub-zero temperatures like the Antarctic Lakes CaCl_2 (calcium chloride) is found in high concentrations. Also wide variations in pH can be found in natural hyper-alkaline spring waters found in Yellowstone Park. Although, there are geographical influences on water chemistry the average compositions globally are: pH around neutral to slightly alkaline, major

ions which are considered are bicarbonate, sulfate, silica, nitrate, chloride, Ca, Mg, and Na as well as dissolved organic carbon and found at levels greater than 1 mg/l (milligram per litre), minor trace elements are found in the range of 1 mg/l to 1 µg/l and consist of K (potassium), F (fluoride), B (boron), Bromide, Sr, Barium (Ba), iron (Fe), (Mn), zinc (Zn), Copper (Cu), lithium (Li), Aluminum (Al), and uranium (U), trace elements which are usually found at levels less than 1 µg/l and consist of transition metals such as cesium (Cs), rubidium (Rb), selenium (Se), Arsenic (As), bismuth (Bi), and iodine (I), and organic components which include algae and bacterial at sub µg/l levels (Drever 1997).

The chemical composition of surface and groundwaters is primarily linked to the bedrock sources within the catchment or aquifer and influenced by hydrological factors such as the hydrological mixing processes and frequency and duration of rainfall (Drever 1997; Neal et al. 2000a). However, anthropogenic pollution from urbanization, industry and agriculture can also influence water chemistry. For example, mining activity can increase the concentrations of As, Fe, Cu (Drever 1997, Neal et al. 2000). Thus the composition of surface, ground and water used for human consumption can be highly influenced by both a wide range of geological and anthropogenic processes.

There can be no doubt that water quality, both natural and anthropogenic elements, materials and chemicals found in surface, ground and drinking waters have the potential to harm human, animal and plant health. Drinking water quality and its chemical composition varies throughout the world suggesting that possible health risks associated with water consumption may also vary globally. For example, in some regions of the world, levels of certain trace elements such as arsenic, fluoride, nitrate is found to exceed the average range of 1µg/l to 1 mg/l. These elements possess unique influences on health. In other parts of the world high levels of pathogens are commonly found in drinking water sources. Yet in other areas constituents of drinking water more closely reflect average compositions and pose no health threat.

It is known that many elements in drinking water influence human health. Some inorganic components of water are essential to human health and metabolism. These include, for example, carbon, sulfur, nitrogen, phosphorous, selenium, iodine and iron and other transition metals. Although, these are essential, the level of consumption determines the harmful effects and the relationships between the different elements consumed. For example, in some areas of the world, health risks are associated with deficiencies of Se, F and I. However in other areas excess ingestion becomes a problem. For example, there are two geographical areas (Bangladesh and China) where consumption of Arsenic-contaminated drinking water has resulted in a major environmental health problem

affecting millions of people (Naidu et al. 1999; Finkelman et al. 1999). Other elements in drinking water, such as chemicals and pathogenic micro-organisms have adverse effects on human health. Pathogenic contamination of drinking water poses the most substantial health risk to humans and there have been numerous cases of disease epidemics throughout the world that have been the result of human exposure to inadequately treated drinking water (Ashbolt 2004). Although, exposure to micro-organisms, through drinking water supplies, is a primary health concern, significant human health risks may result from exposure to environmental chemicals present in water supplies used for drinking water (Nowell et al. 1999). There have been a significant number of drinking water constituents identified and suspected to pose a risk to human health but the human health risks have not yet been clearly established. The list of chemical substances is extensive and due to the significant number that have been identified the contaminants covered in this chapter will be limited to trace elements such as arsenic, pharmaceuticals, pesticides and chlorination products. Environmental hazards and risk to the aquatic ecosystem is also important and there is overlapping and interconnecting effects to both environmental and human health (Schaeffer et al. 1988). However, the human health effects will be primarily addressed here. Through this discussion it is anticipated that a better understanding of the potential human health risks posed by drinking water contaminants will be gained which is valuable knowledge for development and global application of better drinking water maintenance and management strategies.

Trace elements present in drinking water supplies are primarily inorganic components that are naturally occurring and are utilized by plants and animals and some are essential for human metabolism and nutrition (e.g. carbon, sulfur, nitrogen, phosphorous, selenium, bromium, iodine, iron, arsenic, zinc and many other transition metals). The impact of transition elements on human health is usually related to the amount consumed, the speciation of the element and the relationship between the different elements consumed (Edmunds and Smedley 1996). The issue of elevated health risks from one particular trace element, arsenic, has received worldwide attention in recent years (Brown and Ross 2002). In the following section the toxic and harmful effects on human health due to exposure of arsenic through drinking water will be highlighted.

TRACE ELEMENTS

Arsenic

Arsenic (As) is a naturally occurring element, ubiquitous in the environment

and exists in both organic and inorganic forms. Arsenic is present at low concentrations in nearly all aquatic and soil environments. Arsenic is the 20th most abundant element of the earth's crust (NAS 1977). Sources of environmental arsenic are primarily geological and are related to the dissolution of sulfide minerals (Chowdhury et al. 1997) or desorption from iron oxy-hydroxides (Bhattacharya et al. 2001) and/or upflow of geothermal water (Welch et al. 1988). Arsenic is also released into the environment from a number of anthropogenic sources. These include primary copper, zinc and lead smelters as well as glass manufacturers that add arsenic to raw glass materials. Another common anthropogenic source of arsenic is from chemical manufacturing companies that add arsenic to their chemical formulations. However, the primary source of arsenic in drinking water is leaching of arsenic from arsenic-bearing rocks (Jekel 1994). Arsenic exists in organic and inorganic forms. Organic arsenic exists as dimethylarsinic acid (DMMA) and methylarsinic acid, (MMAA) (Smith et al. 1998) and are considered to have a low order of toxicity. Inorganic arsenic exists in two primary oxidation states As^{3+} and As^{5+} , of which As^{3+} is the more toxic form (Donohue and Abernathy 1999). Inorganic forms of arsenic are commonly found in groundwater, surface water and many foods.

The major pathway for arsenic exposure is through drinking water and this source of exposure is considered to be the most significant, on average, over exposure via food (Brown and Ross 2002). The maximum allowable drinking water concentrations (MCL) for arsenic set by the United States Environmental Protection Agency (US EPA), The World Health Organization (WHO) and Health Canada are 10 $\mu\text{g/l}$, 10 $\mu\text{g/l}$ and 25 $\mu\text{g/l}$ respectively (EPA, 2000, WHO 2004, Health Canada, 2004). However, many developing countries still have guideline standards set at 50 $\mu\text{g/l}$ (Ng et al., 2003). Although these standards have been assigned, there is considerable uncertainty about the number of drinking water systems that actually contain concentrations of arsenic equal to or below these standards. The EPA recently estimated that approximately 30 million Americans are exposed to drinking water arsenic levels that exceed the MCL (NRDC 2000). This is also a common occurrence in other countries worldwide which include countries like Chile, China, Ghana, Hungary, India, Mexico, Taiwan, Thailand and the United Kingdom (Mazumder et al. 1998; Zhou et al. 1994). Drinking water contamination by arsenic varies worldwide and is an international public health concern.

Groundwater is often a major source of drinking water and arsenic contamination of groundwater has been reported in many countries. High arsenic groundwater concentrations have been documented in many areas of the world including the western mountain ranges of the United States such as New Mexico, Utah, Arizona and Nevada (EPA 2000), in countries of South East Asia such as, Bangladesh and India (Ahmad 2001; Shraim et

al. 2002), Vietnam (Berg et al. 2001), Nepal (Shrestha et al. 2003), China (Zhang et al. 2000; Su et al. 1999) and areas in Canada (Meranger et al. 1984). Drinking water arsenic levels in these areas are reported to range from several hundred to 1000 $\mu\text{g}/\text{l}$ which are well above the MCL guideline values (Brown and Ross 2002). A recent analysis by the US Environmental Protection Agency and reports by the National Research Council and the World Health Organization suggest that an arsenic MCL of 50 $\mu\text{g}/\text{l}$ is not sufficiently protective of public health (EPA 1988; NRC 2001).

The effects of arsenic on human health have been studied for centuries. There have been numerous toxicological and epidemiological studies in animals and humans that have demonstrated the adverse health effects of inorganic arsenic from oral exposure through drinking water (Morales 2000; Chen et al. 1985; Tseng 1977; Thorgeirsson et al. 1994; Kroes et al. 1974). Arsenic poisoning appears to be one of the major public health problems of pandemic nature. The recent concern over its adverse health effects originates from data collected from several countries over the last two decades demonstrating its toxic and carcinogenic potential in humans when exposure, through drinking water, to high levels for prolonged periods occurs (Tseng et al. 1968; Tseng 1977; Chen et al. 1985; Hopenhayn-Rich et al. 1996, Sancha and Castro 2001). Public health issues related to arsenic in drinking water have been reported as early as the 1960's and the controversy over arsenic's effects on human health still remains. One of the first reports of arsenic toxicity dates back to 1968. A study ('The Tseng Study') conducted in the region of southwest Taiwan, where there was a high prevalence of black foot disease (gangrene due to vascular occlusion), indicated an association between the prevalence of nonmelanoma skin cancer and ingested arsenic (Tseng et al. 1968). Tseng et al. reported arsenic intake through drinking water in the range from 400-600 $\mu\text{g}/\text{l}$ was strongly associated with cancer. Based on the Tseng Study the US EPA classified inorganic arsenic a human carcinogen by the oral route in 1988. The US EPA also used the study for the quantitative risk of skin cancer in the United States. The US lifetime estimate of risk was projected as an additional 3-7 skin cancer cases per 1,000,000 persons for each microgram per liter inorganic arsenic in drinking water (NRC 1999). That is to say, that ingestion of arsenic at levels of 10 $\mu\text{g}/\text{l}$, there would be an additional 3-7 cases of skin cancer per 10,000 lifetimes (NRC 1999). Recently it has been estimated that for people who are exposed to arsenic levels greater than 50 $\mu\text{g}/\text{l}$ in drinking water, the risk of cancer is as high as 1 in 100 (Morales et al. 2000).

A current comprehensive assessment of published data indicates that long-term exposure to arsenic through drinking water can result in impairment and severe health disorders of which cardiovascular disease, developmental abnormalities, neurologic and neurobehavioral

dysfunctions, diabetes, hearing loss, hematologic disorders and various types of cancer have all been reported (Tchounwou et al. 2004). The list of effects is extensive, however the severity of the health effects observed is highly related to the chemical form, time and dose of exposure to arsenic. Typically long-term exposure to arsenic in humans can result in chronic arsenic poisoning or arsenicosis (Ng et al. 2003). Skin lesions that include change of pigmentation (melanosis) and keratosis of the hands and feet are characteristics of arsenicosis and are suspected to appear after approximately 5-15 years after exposure (Tseng 1977). Classically chronic arsenic poisoning occurs in individuals who inhabit areas of the world where a large proportion of their drinking water is contaminated with high concentrations of arsenic (Hopenhayn-Rich et al. 2000; Liu et al. 2002). Continued exposure to arsenic at 50 µg/L has been implicated in causing arsenicosis (Abernathy et al. 1997) as in the situation in Bangladesh and West Bengal, India. For example, it has been reported that 30,000,000 people living in the area of West Bengal and Bangladesh are exposed to arsenic concentrations that exceed the country's guideline value of 50 µg/L and range from 370 µg/L to 500 µg/L (Chowdhury et al. 1997). Of the 30,000,000 people living in West Bengal and Bangladesh, 175,000 people have skin lesions caused by chronic arsenic poisoning which is believed to be due to exposure through drinking water (Das et al. 1996). Short-term exposure (days/weeks) to very high levels of arsenic in drinking water can also result in adverse health effects. Abdominal pain, vomiting and diarrhea; muscular cramping or pain; weakness and flushing of skin, skin rash; numbness, burning or tingling sensation or pain in extremities (hands and feet); thickening of the skin of the palms of the hands and soles of the feet; and deterioration of motor and sensory responses are all common symptoms that have been reported (Chappell et al. 1999).

There is no doubt that the most significant consequence of chronic arsenic exposure is cancer. Chronic exposure to high levels of arsenic has been found to be causally associated with multi-site cancers in humans (ATSDR, 2000; IPCS 2001). Skin, lung and bladder cancer have commonly been reported. Populations with exposures to arsenic, generally at levels of several hundred micrograms per liter or higher are reported to have increased risks of cancer (Chen et al. 1985). Research has pointed significantly higher standardized mortality rates for cancers of the liver, bladder, skin, and colon in many areas of arsenic pollution (Tchounwou et al. 2004). Current evidence suggests that the risks of cancer may be increased following long-term exposure to inorganic forms of arsenic through drinking water (ATSDR, 2000; NRC 1999).

Exposure of people to arsenic represents one example of a human health hazard related to the consumption of unreliable drinking water supplies. The public concern over arsenic contamination of drinking water and the

large number of individuals exposed to high levels of arsenic worldwide has sensitized government, national and international non-government organizations working on water quality division to carry out water quality assessment of arsenic in affected communities worldwide. The present focus is on controlling exposure to arsenic by either treating drinking water supplies or providing alternate clean sources of water. However, strategies for affordable treatment and those that are socially acceptable need more research. Though some steps are being taken by governments and private organizations to combat the current problem, the challenge for the future will be to assess arsenic occurrences, effects and quantify exposure to devise and provide appropriate mitigation strategies.

NON-POINT SOURCE POLLUTANTS OF WATER SUPPLIES DUE TO AGRICULTURAL PRACTICES: PESTICIDES AND NITRATES

Pesticides

Constituents entering ground, surface and drinking waters occur naturally but may also arise from non-point and point source pollution. Point source pollutants entering water supplies include chemical constituents from industrial effluents such as pulp and paper mills, steel plants, municipal sewage treatment plants and land disposal sites. Non-point source pollutants include contaminants associated with agricultural run-off (pesticides, pathogens and fertilizers), storm-water and atmospheric deposition (deposits of persistent organic pollutants). Many point and non-point pollutants have been identified from surface and groundwater resources that serve as the primary source of drinking water throughout the world (Larson et al. 1997; Wycisk et al. 2003). Contaminants identified include metals, pesticides, persistent organic pollutants (endocrine disrupting chemicals), chlorination by-products, and pharmaceuticals. Due to the significant number of non-point and point pollutants identified in water supplies, this section will be limited to a discussion on agricultural elements. The agricultural industry is one of the most noteworthy non-point sources of contaminants to surface and groundwater used for human consumption. Contaminants associated with agricultural practices include nutrients (nitrates, for example), pesticides, and pathogens. The relative degree of each contaminant to the impairment of water quality and human health risk depends on numerous factors that include agricultural activity (for example, tillage), application rates (manure, fertilizers and pesticides) and soil type. There is no doubt that pathogenic contamination of drinking water poses a significant human health risk and there have been accounts of disease outbreaks documented globally that have been associated with agricultural practices. This section therefore will focus on the human health risks associated with pesticides and nitrates.

Groundwater contamination by pesticides and nitrates is a water quality issue in Canada (Infante-Rivard et al. 2001; Krishnan et al. 1997; Thompson et al. 2001; Grover et al. 1997), the United States (Lin et al. 1996) and Europe (Van Maanen et al. 2001). Pesticides used in modern agriculture and nitrate leaching from geological formations, decaying matter, livestock operations, and nitrate-based fertilizers are major rural drinking water contaminants (Krishnan et al. 1997; Thompson et al. 2001; Wang et al. 2001; Calderon, 2000). Groundwater serves as the primary source of drinking water for approximately 5 million people living in rural towns, municipalities and the First Nation's reserves (Environment Canada, 2000). Groundwater used for drinking on farms and remote rural communities is typically untreated and has a high probability of experiencing contamination by nitrates and pesticides (Larsen et al. 1997; Ritter et al. 2002). It is suspected that rural people may be routinely exposed to pesticides and nitrates in drinking water, and it is therefore important to investigate and discuss whether chronic exposures pose a human health risk.

It is well documented that pesticides such as the chlorinated organics, chlordane, aldrin, dieldrin and DDT, previously used to control insects in crops were shown to be lipophilic (fat soluble), bioaccumulate, and to induce endocrine disruption resulting in serious developmental and reproductive problems in wildlife and humans (Davis and Muir 1995; Wartenber et al. 2000). Subsequent to these findings most chlorinated pesticides were removed from the commercial market, although some countries presently still allow their use (Miller and Sharpe 1998). Today pesticides in use are more hydrophilic (water soluble) thus making them more mobile in the environment. Hence it is not surprising that today's pesticides are commonly demonstrated to be present in many surface, ground and drinking water supplies. Although this is the case, levels detected are significantly lower than drinking water guidelines set out by world regulatory agencies [WHO, USEPA and Health Canada].

Pesticides can enter water supplies through accidental spills, atmospheric transport and deposition, spray drift, runoff from crop fields and leaching of soluble pesticides through soils (Grover et al. 1997). Loading of pesticides to water supplies usually occurs in areas of high agricultural activity however water samples collected outside agricultural areas have been shown to contain low-level pesticide concentrations (Gillion et al. 2001). Once pesticides enter the environment they are subject to microbial transformation, ultraviolet degradation and hydrolysis that can alter movement into water supplies. Transformation processes in most cases yield metabolites (breakdown products) that are less environmentally toxic than the parent compounds, however in some cases more toxic compounds can be formed. Although, it is known that pesticides enter water systems, and can be detected in drinking water supplies at low levels very little is

known about the human health risk associated with long-term exposure. Public concern of safe and reliable drinking water is mounting and pesticide residues are certainly an issue being raised in the present day.

Many different types and classes of pesticides are in use today for example herbicides, insecticides, fungicides, algicides and rodenticides. However the vast majority of pesticides presently utilized in the farming industry are classed as herbicides. Currently 2,4-dichlorophenoxyacetic acid (2,4-D) is the most widely used herbicide in North America, with approximately 20 million kilograms applied annually to the Canadian prairies (Manitoba Agriculture, 1991) with a similar amount applied in the United States (Government of Canada, 1996; Larsen et al. 1997). 2,4-D is known to have a short half-life in soil and aquatic environments, however, it is one of the most frequently detected herbicides in drinking water supplies drawn from both surface water and groundwater sources throughout many parts of Canada (Halberg 1989; Gustafsson 1993; Frank et al. 1987). Although 2,4-D concentrations (0.07 µg/l) in the majority of water samples tested were shown to be lower than the Interim Maximum Acceptable Concentrations [IMAC(s)] of 100 µg/l (2,4-D) set out by the Canadian drinking water quality guidelines (Health Canada, 2004), a small proportion of tested water supplies had herbicide residues that exceeded the IMAC (Ontario Ministry of the Environment, 1997). 2,4-D was also shown to be stable in all water samples tested on a seasonal basis (Grover et al. 1997).

Classical toxicological analyses of 2,4-D in animals that use vastly higher concentrations and artificial exposure scenarios that do not reflect what actually occurs in human populations exposed to low-levels of 2,4-D through drinking water, indicate that 2,4-D elicits a number of adverse biological effects, including carcinogenesis (Rueber 1983), immunotoxicity (Lee et al. 2001), teratogenesis (Morgan et al. 1996), and endocrine disruption (Garry et al. 2001; Kobal et al. 2000). 2,4-D has been shown to have carcinogenic potential in rodents (Reuber 1983). Rodent exposure to high 2,4-D levels in drinking water is known to reduce serum thyroid hormones (Kobal et al. 2000) and increase 2- and 4-catechol estrogens (Badawi et al. 2000). As estrogen homeostasis disruption has been implicated in liver, kidney and mammary tumor development (Devanesan et al. 2001; Cavaliere et al. 2001), there may be an association between 2,4-D exposure and cancer.

Human health risks related to 2,4-D have been examined in farm workers who experience high exposure levels through the skin and respiratory tract. Epidemiological evidence suggests an association between 2,4-D exposure and increased human cancer incidence, such as Hodgkin's disease, non-Hodgkin's lymphoma, leukemia, multiple myeloma, soft tissue sarcoma, colon cancer, ovarian cancer, liver stomach and breast cancer (Davis and Muir 1995; Hayes et al. 1995; Gosselin et

al. 1984; Hoar et al. 1990) and a weak association between 2,4-D and birth defect rates (Garry et al. 2001). Taken together, toxicological and epidemiological studies suggest that high-level 2,4-D exposure poses a health risk. This raises the possibility that chronic low-level 2,4-D exposure in drinking water may pose a health risk but at this time it is not clearly understood.

Other examples of pesticides commonly used in agricultural practices and found in surface, ground and drinking water supplies include triazine herbicides (atrazine and simazine), organochlorines (endosulfan, trifluralin, permethrin, lindane, DDT, aldrin, dieldrin) and organophosphate insecticides (chlorpyrifos, dichlorvo, demethoate) (Solomon et al. 1996, Ragnarsdottir et al. 2000; Zetterstrom 1999; Wegman and Greve 1978). Triazine herbicides are highly water soluble and mobile in soils (Halberg, 1989) and are one of the most widely used herbicides applied to maize crops worldwide (Halberg, 1989). Triazine herbicides possess a very high leaching potential from soil to groundwater and subsequently non-agricultural use of atrazine and simazine has been banned in many developed countries (Miller and Sharpe 1989). The concern for potential human health risks resulting from long-term chronic exposure to triazine herbicides through drinking water is a consequence of the known persistent occurrence of triazine herbicides in water supply systems (Goss et al. 1998). Additionally, atrazine and simazine are suspected endocrine-disrupting chemicals (EDCs) and may have the potential to induce hormonal interference that results in both reproductive or developmental disorders (Sanderson et al. 2000). Interestingly exposure to low concentrations of atrazine has been shown to increase the production of males in water fleas (*Daphnia pulex*), a species in which males are typically rare (Dobson et al. 1999). More recently both atrazine and simazine were shown to alter the activity and expression of several key cytochrome P450 enzymes involved in the normal biosynthesis of steroid hormones suggesting that these herbicides may have hormonal disrupting or tumor-promoting properties (Sanderson et al. 2000).

Organophosphate insecticides are another type of pesticide commonly used today to control crop insects. The organophosphates have been considered safe since sunlight and summer soil temperatures are known to readily degrade these insecticides. However, recent studies have indicated their presence, although at low levels in soils surface, ground and drinking water sources. Organophosphates have been shown to possess the ability to persist in groundwater sediments and soils for years. This may be due to their absorption to soil particles (Ragnarsdottir, 2000). Organophosphate insecticides are well known for their acute toxic effects in humans exposed to high concentrations, nonetheless they are highly toxic and their presence in drinking water supplies does raise a concern.

To date there are no reports indicating adverse health effects due to chronic long-term exposure to organophosphate insecticides through drinking water.

Pesticides are present in groundwater supplies used for human consumption, however the long-term health consequences associated with the exposure to pesticides through drinking water are unknown. The examples outlined in this section strengthen the need for government agencies to monitor all hazardous materials in water supplies, whether from municipal or individual wells regardless of the many and distinct chemicals potentially present.

Nitrates

In addition to pesticides, nitrates are drinking water contaminants that continue to be an important human health concern (Thompson 2001; Schubert et al. 1999; Dorsch et al. 1984). Nitrogen-based fertilizers from intensive agricultural production, nitrogenous wastes from livestock and poultry production as well as urban sewage treatment have contributed to the presence of nitrogenous wastes in soil and water. Leaching, runoff and atmospheric transport are the primary mechanisms by which nitrate enter water sources. Nitrate is highly water-soluble and mobile in soil and water environments therefore nitrate has the potential to contaminate groundwater to unacceptable levels. Gradual increases in nitrate concentrations in ground and surface waters used for drinking have been reported. Exposure to high levels of nitrate in drinking water are an important health issue due to the potential for nitrate toxicosis or methemoglobinemia. Methemoglobinemia is a condition where oxygen transport in the body is affected and infants are known to be susceptible to this condition. Nitrate poisoning in infants (blue-baby syndrome) has been reported as early as 1944 in the United States. Thousands of infant methemoglobinemia cases in rural areas of the United States were reported and were shown to be associated with high nitrate levels in well waters that ranged from 22 mg/l to 200 mg/l (Craun et al. 1981; Knobeloch et al. 2000).

Recent epidemiological studies suggest elevated nitrate concentrations in drinking water are associated with other disorders such as teratogenicity (malformation of the fetus) (Dorsch et al. 1984), thyroid hypertrophy (Van Maanen et al. 1994), and childhood diabetes (Parslow et al. 1997). Numerous studies have suggested a link between nitrate consumption in water with various cancer forms (Huges et al. 2001; Cantor, 1997; Xu et al. 1992; Morales-Suarez-Varela et al. 1993). Children living in areas with elevated nitrate concentrations in drinking water have been seen to have increased chromosome breakage in blood cells (Tsezou et al. 1999; Van

Maanen et al. 1996). Although the WHO and Canadian guidelines have recommended limits of 50 mg/l and 45 mg/l, respectively, lifetime exposures to levels above 10 mg/l (MCL set by USEPA) have been reported to cause spleen hemorrhaging (US, EPA 2000). In addition, metha-moglobinemia has been reported in infants exposed to nitrate levels of 22 mg/l.

Nitrate concentrations in domestic wells in areas of high agricultural activity often exceed the water quality criteria. A recent evaluation of Saskatchewan rural drinking water has identified nitrate levels to be above (up to 500 mg/L) these guideline values (Thompson, 2001). The drinking water samples analyzed in Thompson's study had nitrate levels above 10 mg/L suggests that human health risk is a fundamental possibility and requires further study. Furthermore, monitoring programs should be in place in areas where drinking water has a high probability of nitrate contamination.

Drinking Water Disinfection Byproducts

The development of chemical disinfection of water is a major public health triumph of the 20th century (Simmons et al. 2002). In fact, most surface and groundwater in North America would be unpotable without some form of treatment to remove pathogens and contaminants (Naiman et al. 1995). Water may be disinfected using a number of treatment methods (WHO, 2000): 1) chlorination, in which water is treated with elemental chlorine; (2) chloraminatin, in which water is treated with monochloramine; (3) chlorine dioxide; (4) iodination (generally only used for short-term disinfection); (5) ozonation, in which water is injected with ozone to destroy organic compounds that impart taste or odor to drinking water; and (6) irradiation with ultraviolet (UV) light. However, of these six methods, the most commonly used to disinfect drinking water on a global basis is chlorination. As a result of the chemical disinfection of water, dramatic reductions have been observed in both mortality and morbidity from waterborne diseases caused by infectious microbial contaminants present in drinking water (Regli et al. 1993). The World Health Organization currently estimates that, on a global basis, 4 billion annual cases of waterborne diarrhea result in more than 2 million deaths per year (Standridge, 2003). Waterborne disease is not just a problem in underdeveloped countries. Recent outbreaks of waterborne disease in Canada, United States and South America can only be a strong indicator of the importance of water treatment and a reminder that we should not become complacent with how we treat and view our drinking water supplies (Parshionikar et al. 2003; Auld et al. 2004; Cardenas et al. 1993).

There can be no doubt that chemical disinfection of water supplies has led to important public health benefits. However the use of this method of water treatment leads to the formation of a number of chemical disinfection byproducts (DBPs) in water used for human consumption. The presence of DBPs in drinking water was first discovered in the early 1970s following a US nation-wide survey of treated drinking water (Crossby, 1998). This was the first evidence that indicated the process of chemical disinfection could serve as a source of drinking water contaminants. Chemical disinfection byproducts are formed through reactions of the chemical disinfectant with inorganic and organic materials naturally present in water supplies. Disinfected water can contain more than 500 chemical DBPs (Richardson 1998) however many more are suspected of which some cannot be identified. The identification of DBPs in drinking water has caused concern over the consumption of treated water and the potential human health risks posed by low-level chronic exposure to DBPs.

Toxicology studies in animals suggest that human health effects from DBP exposure may be a concern. Animal toxicity tests have demonstrated a small number of DBPs have the potential to cause either carcinogenesis or target-organ toxicity (reproductive and developmental abnormalities) (Klinefelter et al. 2004; McDorman et al. 2003). However, a causal relationship between DBP concentrations and human health risks has yet to be demonstrated since toxicity studies typically use high overt toxic levels of single chemicals not reflective of those encountered in water supplies used for human consumption. Additionally the vast majority of DBPs have not been investigated toxicologically. In fact, fewer than 20 individual DBPs have been subjected to toxicity studies and of these studies, only a small number could be used to assess potential human health risks (US; EPA 2000). It has been reported in some epidemiological investigations that low-level DBP exposures have the potential to cause adverse human health effects. These include spontaneous abortions, low-birth weight, bladder and rectal cancer and developmental effects (Bove et al. 1995; Klotz and Pyrch, 1999; Cantor et al. 1998). However, the effects suspected from current epidemiological studies may be the result of confounding factors such as exposure to other environmental pollutants present in the source water or exposures to industrial pollutants in urban areas or other factors not related to exposure to environmental chemicals. A thorough epidemiological investigation has yet to be performed and a definitive epidemiological data set needs to be compiled. Although the toxicological and epidemiological data suggest potential health effects of known DBPs, there is concern over the toxic contribution of the unknown DBPs and the interaction-based metabolites formed between the DBPs. It is evident that the chemical treatment of water results in the presence of DBPs in our water supplies, however to date the potential health risks associated with

exposure to these chemicals is not clear. More evidence is required to support the association between adverse health outcomes and DBP exposure and human health risk to DBP exposure must be measured and compared with the risks from microbial agents.

CONCLUSIONS

Water is a critical resource with which life depends. Addressing issues of drinking water quality, maintaining and managing safe water supplies requires a thorough understanding and evaluation of all types of elements and factors that affect its composition. Loading of contaminants to drinking water sources occurs through many paths, natural and anthropogenic. Thus the impact of water quality on human health is highly complex due to the many factors that influence its chemical nature.

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10

Projections of Climate Change on Precipitation Intensities, and Implications to Urban Infrastructure

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INTRODUCTION

There is now widespread acceptance that climate change is occurring, but still extensive uncertainty as to how climate change will manifest itself in terms of impact to specific regions. Projections indicate there will be increases in total precipitation in the northern hemisphere, but the increases will not be uniform. While the Intergovernmental Panel on Climate Change (IPCC 2001) is predicting an increase of 1.5 to 4.5°C in global mean temperature, and an expectation that this change will create an increase in global mean precipitation by 3 to 15%, IPCC is also predicting that there will be extended periods of drought. As a consequence, it is expected there will be growing frequencies of high intensity precipitation events. The consequence of increased frequencies of high intensity precipitation events will influence the performance capabilities of Canada's municipal infrastructure.

Climate change impacts in precipitation and temperatures will also affect Canada's water resources in terms of quantity and quality (frequency of floods and droughts, runoff regimes, and groundwater recharge). There will be changes in soil regimes (e.g. soil erosion, crop damage, loss of organic matter that changes the soil water holding capacity, implications

to soil cracking and runoff patterns, increased soil desiccation with changes, infiltration patterns, etc.) including implications for groundwater recharge, and subsequently, availability of water for supply systems relying upon groundwater as their source. In the context of urban infrastructure, changes in precipitation intensities may also greatly influence the performance of the infrastructure. Hence, the implications of climate change on precipitation patterns are pervasive, influencing virtually all dimensions of water-related considerations.

This chapter provides insights into possible climate change scenarios in southern Ontario in Canada in general, and in Waterloo, Ontario in particular, on the basis of monitoring records and assessing some of the implications in terms of performance of municipal infrastructure systems in response to the potential changes in precipitation intensities.

ALTERNATIVE BASES OF CLIMATE CHANGE PROJECTIONS

The theory of global climate change is based on increases in carbon dioxide and other greenhouse gases (e.g. methane, nitrous oxide) accumulating in the atmosphere, creating increased temperatures and greater turbulence in the atmosphere, the results of which will be more extreme droughts and extreme storms.

For assessments of the magnitudes of long-term scenarios for climate change associated with a doubling of carbon dioxide (equivalent) in the atmosphere, researchers frequently rely upon Global Climate Models (GCMs). GCMs are mathematical representations of atmosphere, ocean, ice cap, and land surface processes based on physical laws and physically-based empirical relationships. GCMs include, based on our current understanding, the most important large-scale physical processes governing the climate system. While there are numerous GCM formulations (e.g. CGCM2, CGCM1, HadCM3), they are experiments done with the assumption that the current and future climates are in equilibrium (how climate might change with doubling or quadrupling of atmospheric CO₂, and some of which may be run in transient mode where the rate and magnitudes of climate change could be modeled). However, GCMs are limited by virtue of their crude parameterization of key sub-grid processes such as clouds that make them unsuitable for direct regional climate change assessments.

One of the main problems using direct GCM outputs is that they cannot be directly used for local climate impact studies (Arnell, 1996). GCM output ranges in the order of horizontal spacing from 250 to 600 km, while hydrological studies are limited to basin or sub-basin scale, requiring climate scenarios with different spatial and temporal scales. Therefore, there is a scale mismatch between what GCMs can provide, and the information

needed for local climate impact analyses, including municipal infrastructure systems, due to the nonlinearity and heterogeneity of the natural processes. To bridge the gap between coarse GCM resolution and subgrid processes required, empirical relationships, one approach has involved statistical downscaling procedures (Wilby et al. 2000). Downscaling of coarse-resolution GCMs are generally based on a coupling of large-scale and regional-scale meteorological parameters and the existence of functional relationships between both scales (Zorita and von Storch, 1999; Fuentes and Heimann, 2000; Cannon and Whitfield, 2004; Gebremeskel et al. 2005).

An alternative approach to predict potential impacts of climate change on precipitation intensities is to rely upon historical measurements and use these to make predictions of future scenarios. As inputs to the assessment of how climate is changing, Nicholls et al. (1996) indicated that the global mean surface temperature has increased by 0.3 to 0.6°C since the late 19th century and by 0.2 to 0.3°C over the last 40 years. Further, Zhang et al. (2000) reported an annual temperature increase between 0.5 and 1.5°C in southern Canada between 1900 and 1998. Nicholls (1995) and Karl and Knight (1998) reported that the hydrologic cycle could intensify due to the increase in temperature extremes. Zweirs and Kharin (1998) reported that the frequency of heavy one-day rains could occur with recurrence periods halved e.g. a 20-year recurrence period rainfall becomes a 10-year event. Guttman et al. (1992) and Karl and Knight (1998) have reported increases in precipitation amounts and intensity across the US and Canada. Further, Burn et al. (2004) identified trends in the timing of the spring freshet and Pacific Decadal Oscillation and wintertime flows, and minimum flows which appear to be related to climate change in the Liard Basin in northern Canada. Burn et al. also identified a shift in the importance of rain (not total precipitation) implying a shift in snow (decrease) and an increase in rain.

While both approaches referred to above have roles to play in research into prediction of future rainfall intensities, the research described in this chapter relies upon the second of the two procedures, namely analyses of historical measurements and projections into the future.

TRENDS IN HISTORICAL PRECIPITATION IN SOUTHERN ONTARIO

The approach taken herein is to characterize historical monitoring records from several different respects as detailed below.

Indicators of Trends from Measurements for the Great Lakes

Consider first, the precipitation quantities for Lake Superior and Lake Huron over the period 1882 to the year 2000, as depicted in Figures 10.1 and 10.2,

respectively. The increasing trends in precipitation quantities are apparent from this 118-year period. Further, as is apparent in Figure 10.3, the increasing trends in precipitation have translated into increased discharges from the Great Lakes (as measured at Alexandria Bay, New York).

It is acknowledged that there is the possibility the trends in precipitation and flows in Figures 10.1 through 10.3 are not the result of climate change. However, the durations and progressive changes over which the long-term trend has occurred are certainly indicative that they represent response to climate change.

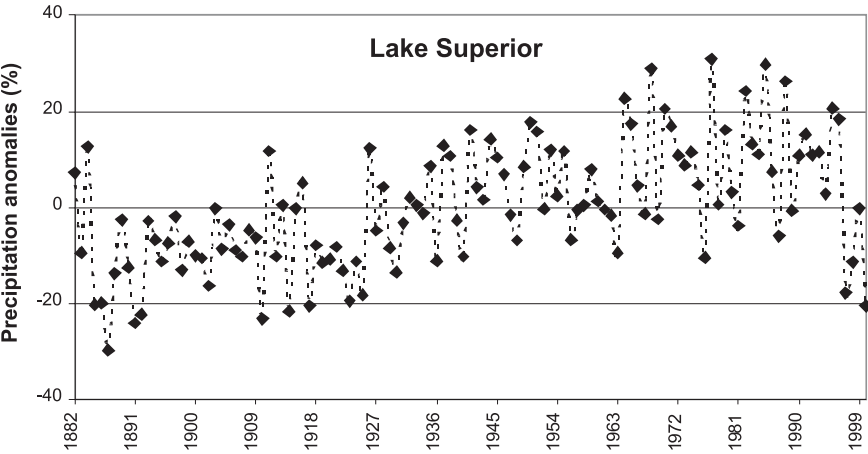


Fig. 10.1 Precipitation trends for Lake Superior

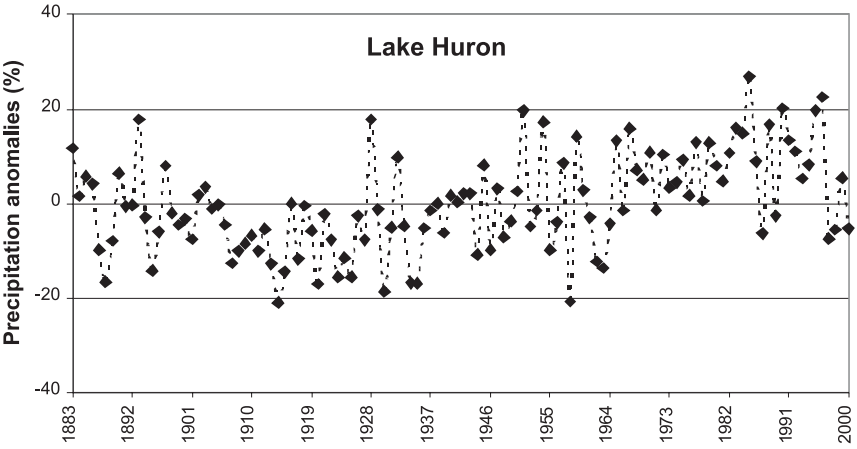


Fig. 10.2. Precipitation trends for Lake Huron

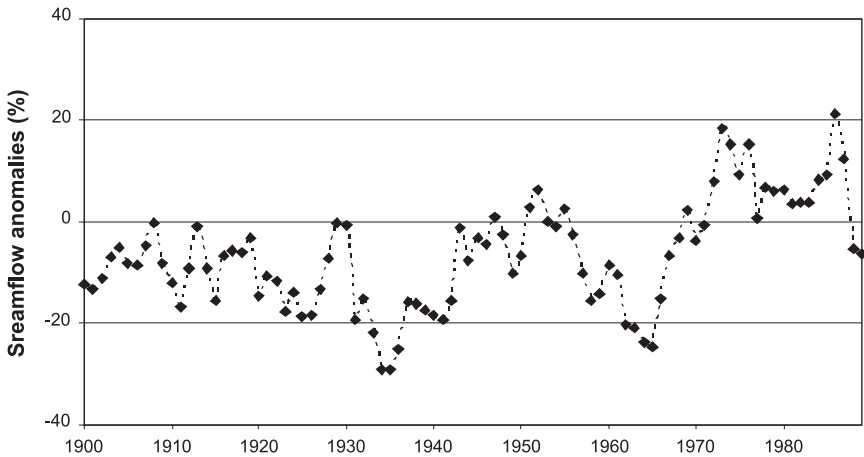


Fig. 10.3. Flow records for Great Lakes

Indications of Trends from Individual Measurements

Consider now the intensities of storms at individual monitoring locations, and how the intensities may be changing. The characterization of the intensities will be considered in the context of intensity-duration-frequency (IDF) curves as IDF curves represent core information in the design of municipal infrastructure systems.

First, consider how historical trends indicate there are changes ongoing in storm intensities relevant to municipal infrastructure systems. Adamowski et al. (2003) undertook numerical analyses on rainfall data for Ontario for short duration rainfall events (5, 10, 15, 30 and 60 min). A total of 15 stations were analyzed based on their length of record, up-to-date data, and locations to represent various regions across Ontario. Adamowski et al.’s analyses included assessment of historical trends at Waterloo, Ontario over a 24-year period, and provided trends in individual storm durations including those summarized in Table 10.1. It is noted that the trend rates are variable for alternative storm durations, from the measured data.

From the trend information in Table 10.1, and assuming that the trends continue, projections on precipitation intensities for future years may be calculated. This allows prediction of the change in intensity of storms of different timeframes for future years.

The IDF curves for current conditions for Waterloo, are illustrated in Figure 10.4 where individual values have been plotted for the storm duration magnitudes listed in Table 10.1. For purposes of explanation, the ‘5-year storm’ refers to storms which will be equaled or exceeded on an average,

Table 10.1. Trend rates for alternative storm durations for Waterloo (adapted from Adamowski et al. (2003))

Storm duration (min)	Trend increases (mm/yr)
10	0.0079
30	0.0150
60	0.0146

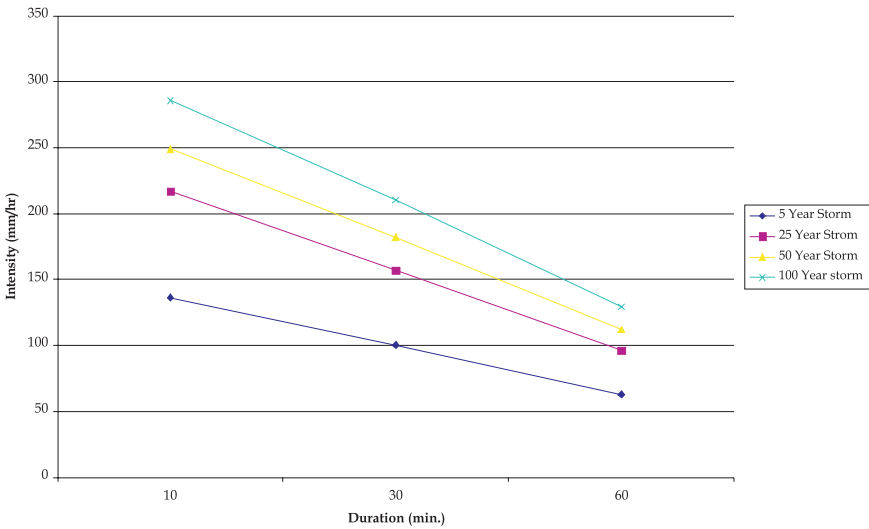


Fig. 10.4. Intensity-Duration-Frequency Curves for Waterloo, Ontario, for Current Conditions

once in a five-year period. As the duration of a storm is increased (e.g. from 10 min to 30 min to 60 min) for a five-year recurrence frequency interval, the intensity of the storm decreases. For decreased frequencies of storms (e.g. storms that are equaled or exceeded once in 100 years, as opposed to once on average in five years), the intensity of the storm for the same duration increases as seen in Figure 10.4.

Using the trend rates from Table 10.1 associated with the alternative storm durations, IDF curves projected for 25 years hence, and for 50 years hence, were estimated. The resulting IDF curves for the two projected timeframes, for 25 and 50 years, are illustrated in Figures 10.5 and 10.6 respectively. As examples, the current 5-year recurrence frequency storm of 10 min duration is indicated as having an intensity of 97.7 mm/hr, whereas the 5-year recurrence frequency storm of 10 min duration is

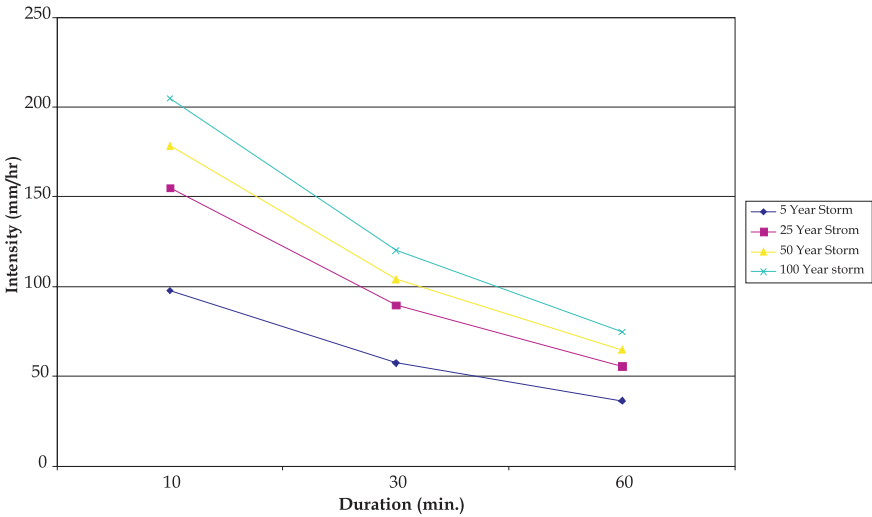


Fig. 10.5. Intensity-duration-frequency curves for projected 25 years from current conditions

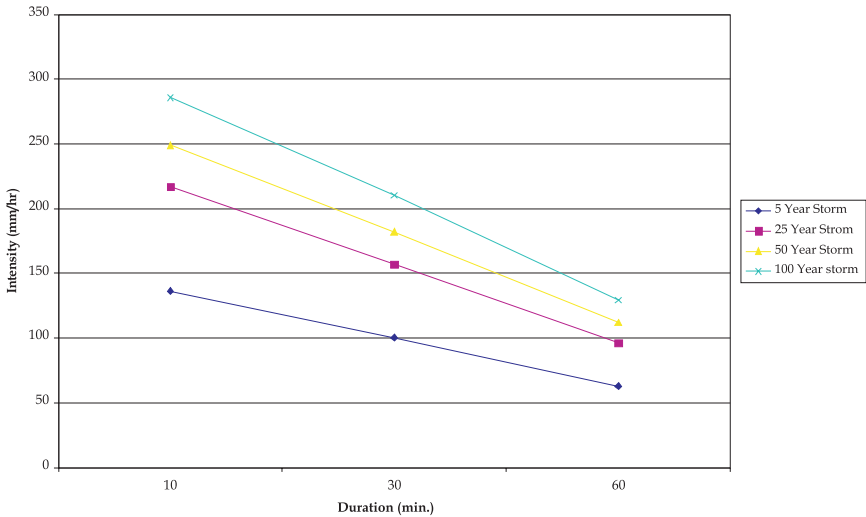


Fig. 10.6. Intensity-duration-frequency curves for fifty years from current conditions indicated as having an intensity of 117 mm/hr in 25 years, and 136.3 mm/hr in 50 years. Put in an alternative way, a 10 min duration storm in the current situation (178.4 mm/hr) with a recurrence frequency of 50 years, is similar in magnitude to a 10 min duration storm in 25 years (186.4 mm/hr) with a recurrence frequency of 25 years; the recurrence frequency for that magnitude of intensity of precipitation has decreased from 50 years to 25 years.

An alternative assessment of projected future precipitation events is demonstrated in Figure 10.7 where ‘Intensity’ is plotted against the logarithm of the (Recurrence) ‘Frequency’ for storms of 60 min duration. The three individual lines indicate the Intensities for storms of duration 60 min under (a) current conditions, (b) projected storms in 25 years, and (c) projected storms in 50 years. This depiction allows comparison of intensities of future storms, with the current storms. As a demonstration, the projected 5-year recurrence frequency storm which will occur in 25 years time, has a similar intensity (mm/hr) as a storm in current conditions of approximately 13 years on the horizontal axis. Further, the 5-year recurrence frequency storm which will occur in 50 years has a similar intensity to storms in current conditions of approximately 36 years on the horizontal axis. Additional future storm intensities, quantified in the context of current storm conditions, are summarized in Table 10.2.

Table 10.2. Future storm intensities quantified in context of current storms

Current storms of specified recurrence interval	Storms of 25 years projected in future, characterized in current context	Storms of 50 years projected in future, characterized in current context
5	13	36
25	100	445
50	220	-nc-
100	-nc-	-nc-

Note: ‘nc’ means ‘not calculated’ because it represents a considerable extrapolation of available data

Given that many municipalities design storm sewer pipes for the 5-year storm for current conditions, it is quite clear that the increased magnitudes of storms projected to occur in response to climate change, will result in more frequent street flooding. For example, the results in Figure 10.7 indicate that a stormwater system designed for a 5-year frequency in 25 years is equivalent to the stormwater for a recurrence frequency of approximately 2 years, in a period of 25 years from now (this is obtained by projecting the 25-year future storm back to the same intensity as the 5-year storm for current storms).

It is cautioned that all of the above analyses are premised that the historical trends in intensities as characterized over the period 1971 to 1996 continue into the future.

To put the above into another context, municipal infrastructure designed to carry a 5-year storm changes. Specifically, for the current 5-year storm, where a 10 inch diameter pipe is needed, a 5-year storm in 25 years needs

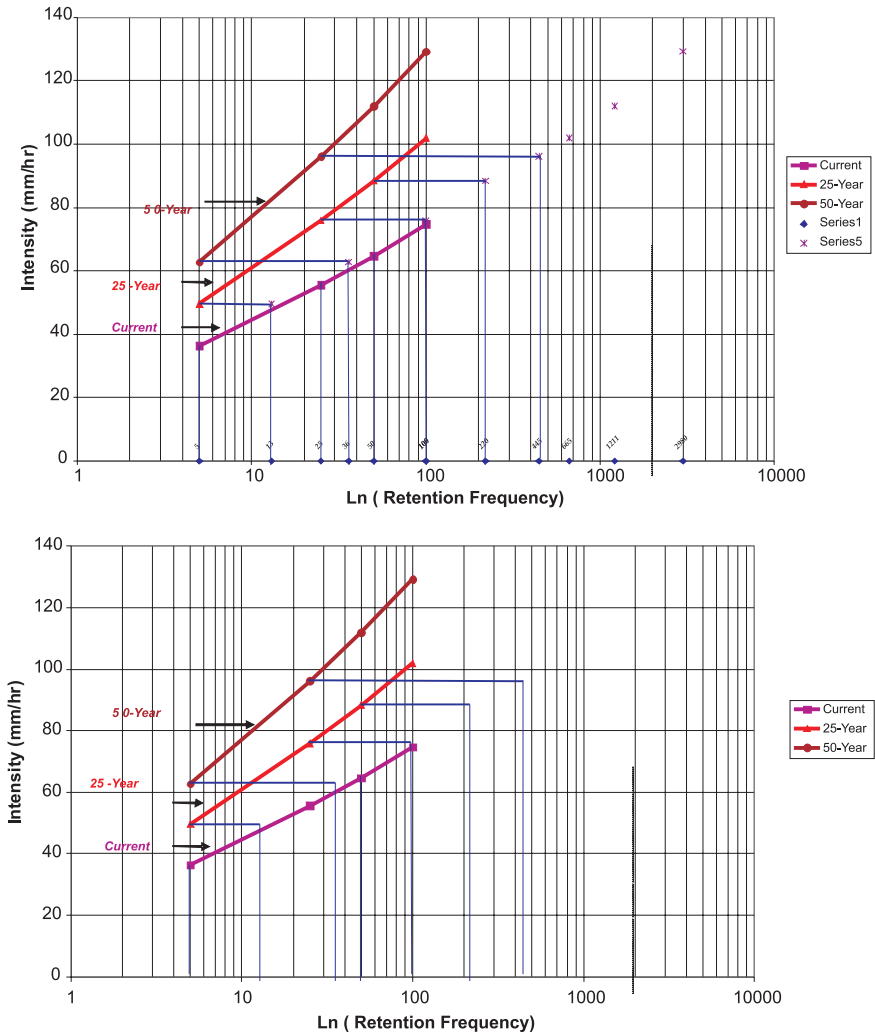


Fig. 10.7. Future storm intensities in terms of current storms

a 15 inch diameter sewer; and a 5-year storm in 50 years needs a 21 inch diameter sewer. As storm intensities increase as a result of climate change, storm sewers need to be larger, to allow them to carry the 5-year storms, as they increase in intensity.

CONCLUSIONS

Long term trends in precipitation and flows associated with the Great Lakes system are substantial and it appears reasonable to consider them at

least partly in response to climate changes. In addition, historical trends for precipitation records for Waterloo and the existing intensity-duration-frequency (IDF) curves were used to predict possible IDF curves for 25 and 50 years from the present. These results indicate significant changes in storm intensities are likely to occur including, for example, that a 5-year return frequency storm in 25-years will correspond to a storm equivalent to a 13-year return frequency storm in today's current context and a 5-year return frequency in 50 years will correspond to a 36-year return frequency storm in today's context. In different words, the analyses herein indicate a 5 year return frequency storm intensity in Waterloo, Ontario may now be recurring on a 2 year return frequency. The increased intensities of storms have substantial consequences to municipal infrastructure design.

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11

Climate Change, Water and Poverty in the Morogoro Region, Tanzania

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INTRODUCTION

Climate change, water and poverty are intimately intertwined in the developing world because climate change will manifest itself primarily through variation in the availability of water. Lack of clean, fresh water is one of the primary reasons for adverse health outcomes. Water-borne diseases such as diarrhoea, typhoid and cholera, increase infant and child mortality as well as morbidity and mortality among the adults. Lack of water also impairs general hygiene and contributes to spreading of other contagious diseases (Cairncross, 2003; Johnstone et al. 2002). The other main contributor to adverse health outcomes – malnutrition – is tied to the availability of water for cultivation and livestock rearing and the time needed for collecting water for human consumption. As health and nutrition are important preconditions for the capacity to work and to generate income (Fogel, 1994; Sreter, 1997), their lack is also a reason for poverty.

Poverty, ill health and malnutrition are also sources of vulnerability to climate change because they reduce the capacity of households to adapt to changing climate and climate change impacts (Paavola, 2006). Climate change also has the potential to aggravate adverse health outcomes, malnutrition and poverty as well as vulnerability to all forms of environmental stress. It goes without saying that any reasonable plans and policies calculated to assist in adapting to climate change must look

closely at the water resources and how they interact with livelihood strategies and other natural resources that are important to livelihoods.

This chapter starts from a position according to which coping with current climate variability exemplifies coping with changing climate in the future, as climate change will be experienced primarily as increased climate variability. The chapter investigates the complex interactions between climate variability, water and poverty in the Morogoro region in South-Eastern Tanzania. The region's Uluguru mountains are the source of the Ruvu river, which supplies a large proportion of water used in Dar es Salaam on its way to the Indian Ocean. The region also hosts parts of the watersheds of the Great Ruaha and Rufiji rivers. Intense conflicts take place between the farmers and pastoralists who have relocated to the region with their cattle from drought-stricken highlands. Farmers have responded to ongoing drought by switching crops, expanding cultivations and engaging in charcoal production which have resulted in deforestation, reduced water retention, increased flooding after rains and reduced water flow between the rains. These environmental changes have many adverse local impacts but they also affect water availability for external users.

The second section will review climate changes and climate change impacts that are likely to be experienced in Tanzania and in the Morogoro region in particular. The third section examines in greater detail livelihoods, developmental outcomes and patterns of vulnerability in the Morogoro region. The fourth section examines how people in the region have responded to past and present climate variability. The fifth section concludes by discussing the implications of responses to climate variability for adapting to changing climate in the future.

PREDICTED CLIMATE CHANGES AND CLIMATE CHANGE IMPACTS

Tanzania will experience moderate warming, changed rainfall patterns and increased climate variability by the end of the 21st century. The country is predicted to warm by about 2-4°C by 2100, somewhat less than North-western Africa and South Africa. Inner parts of the country are predicted to experience higher temperature increases than the coastal areas and cold and dry seasons will warm more than warm and wet seasons. Rainfall is predicted to decrease by about 0-20% in the inner parts of the country, with dry season(s) becoming longer and drier. In contrast, rainfall is predicted to increase by 30-50% in the coastal areas and in the Lake Victoria basin. Rainfall will increase mainly during the rainy season and during the primary rainy season in the equatorial region which has two rainfalls in a year (Hulme et al. 2001; IPCC, 2001; Mwandosya et al. 1998).

Climate change will be experienced in Tanzania predominantly as increased climate variability (Clark et al. 2003; IPCC, 2001). Changes in mean temperature, rainfall patterns and rainfall variability are likely to prolong dry seasons and to increase the severity of periodic droughts. This will be pronounced in the interior part of the country which will experience reduced rainfall. The Lake Victoria basin and the coastal region will be less exposed to droughts. However, these areas are likely to experience more frequent and severe flooding. The predicted sea level rise of 0.10-0.90 metres will aggravate flooding in the coastal areas.

Predicted climate changes will significantly impact food production. Warming will shorten the growing season and, together with reduced rainfall, reduce water availability. Warming will also increase crop losses due to weeds, diseases and pests. Regional predictions suggest that Tanzania may lose 10% of its grain production by 2080 (Parry et al. 1999; Downing, 2002). Maize – a staple crop grown by half of Tanzanians and providing a third of their daily calorie intake – is going to be particularly hard hit. Average maize yield is predicted to decrease by 33% by 2075 if CO₂ concentrations will double and temperature increase by 2-4°C. Maize Yields may decrease by 80% in the central Tabora-Dodoma region (Mwandosya et al. 1998). There is considerable uncertainty regarding the yields of cash crops such as coffee, cotton and tea. Land cover is also predicted to change as a result of climate changes and the increased frequency and intensity of fires. Grassland savannah and dryland forest are predicted to become more common. This can have significant adverse consequences because rural livelihood partly depend on forest resources and because biomass accounts for 90% of the total energy use in Tanzania.

Tanzania's water resources will experience varied climate change impacts. Some watercourses such as the Rufiji will have slightly increased water flows but the Ruvu supplying Dar es Salaam and the Pangani supplying Tanga will have reduced waterflows. While the annual flow changes are only about 5-10%, predicted minimum flows in the dry season are less than half of the present ones in Ruvu and Pangani and the predicted peak flow in the rainy season is about twice the present one for the Rufiji (Mwandosya et al. 1998). Increased water flows contribute to floods which adversely affect human settlements and health. Reductions in water flow will impact the use of water for power generation, irrigation and public water supply. This is of national concern as the Ruvu river supplies an important proportion of water for Dar es Salaam and the power plants on the Great Ruaha, together with those on the Pangani river, provide the backbone of national hydroelectric generating capacity. Increased evaporation and reduced rainfall may also affect the groundwater.

Floods will become more frequent especially in the coastal region. This will result in the destruction of infrastructure, buildings and belongings especially in the floodplains, which in the larger cities are usually populated by poor households. Droughts will impact all settlements, requiring more time for water collection and resulting in reduced water use (Johnstone et al. 2002). This will impair hygiene and contribute to the spreading of contagious diseases (Cairncross 2003). Flooding of pit latrines pollutes wells and surface waters with human wastes and increases the incidence of water-borne diseases such as diarrhoea, typhoid and cholera. Warming, flooding and increased rainfall also increase the spread and incidence of many insect-borne diseases such as malaria. Predicted climate changes will impact on human health through other pathways as well. For example, warming will aggravate the impacts of indoor and outdoor air pollution on respiratory illnesses (IPCC, 2001; McMichael et al. 1996; Patz et al. 2002; Rogers and Randolph, 2000).

The Morogoro region lies between the central highlands and the coastal region and it will experience a mixture of these climate change impacts. It will be affected by both droughts and flooding which will have adverse effects on food production, land cover, water availability, human settlements and human health. In fact, the region already experiences climate variability which exemplifies the likely effects of climate change in the future. However, the significance and challenges of present climate variability and predicted future climate changes can only be appreciated by first looking at the sources of vulnerability in the region.

VULNERABILITY, LIVELIHOODS AND POVERTY IN THE MOROGORO REGION

Research on adaptation to climate change frequently defines vulnerability as a function of exposure, sensitivity and adaptive capacity (Adger, 2003; Smit and Pilifosova, 2003; Yohe and Tol, 2002). The key element of this definition of vulnerability is sensitivity – the sensitivity of vulnerable individuals and groups to climate change impacts. The definition also reminds us that vulnerable groups are not helpless and that they have capacity to cope with environmental stress. Moreover, it draws attention to the determinants of adaptive capacity such as different types of social capital (Adger, 2003). However, this definition of vulnerability also has its problems such as the inclusion of ‘exposure’ into it. Exposure depends on the attributes of physical systems such as the climate system or the hydrology of a river basin. It is important to understand how these systems can impact people but people’s vulnerability is best assessed as independent of these physical systems that expose them to environmental risks and dangers.

Natural disaster literature offers a useful social-scientific definition of vulnerability for the analysis at hand. Wisner et al. (2004) define vulnerability as “the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard” (Wisner et al. 2004). This definition regards vulnerability akin to sensitivity of the broader definition used in adaptation research. The natural disaster literature definition draws attention to multiple factors such as assets, sources of livelihood, class, race, ethnicity, gender and poverty which are likely to demarcate vulnerable groups. This view of vulnerability influences the author’s analysis of responses to current climate variability in the Morogoro region, which lies in the South-Eastern Tanzania between the central highlands and the coastal lowlands.

The region’s physical geography has several notable features. The Uluguru and Rubeho Mountains which lie in the region form the southern prong of the Eastern Arc Mountains – an internationally important biodiversity hotspot (Burgess et al. 2002). Parts of the watersheds of the Great Ruaha and Rufiji rivers extend to the region’s southern parts. Wami and Ruvu rivers – the latter of which is an important source of water for the three million inhabitants of Dar es Salaam – in turn have their origins in the foothills of the Ulugurus. The Morogoro region also hosts the Mikumi and Udzungwa National Parks and a proportion of the Selous Game Reserve. These protected areas comprise almost half of the region’s land area and forest reserves make up a significant proportion of the rest (URT 1997).

Morogoro is one of Tanzania’s largest regions with 72,939 square kilometres. In 2002, the region had a population of 1.75 million people and a population density of 24 people per square kilometre – clearly below the national average. However, pressure on land is great as a result of a small proportion of arable land of the total and the large proportion of protected areas. Population densities can be very high in settled areas. For example, the Mgeta division on the western side of the Uluguru mountain has a population density of 160 people per square kilometre (Jones 2002). Two thirds of the population live in the northern districts of Mvomero, Kilosa, and Morogoro urban and rural while the southern districts of Kilombero and Ulanga are less densely populated (Table 11.1). Slightly over a quarter of the population lives in urban areas. Morogoro town is the region’s administrative centre and the largest city with about 200 000 inhabitants. Other larger urban centres in the region include Kilosa, Ifakara and Kitadu. The region is relatively well connected to other urban centres such as Dar es Salaam, Dodoma, Iringa and Mbeya by roads. However, the region’s average road density is only 0.05 km per km² – half of the national average. Bad internal connections mean that many villages are not accessible by

Table 11.1. Population of the Morogoro region, 1967-2002

Administrative area	1967	1988	2002
Morogoro Urban	24 999	117 601	227 921
Morogoro Rural	291 373	430 202	263 012
Kilosa	193 810	346 526	488 191
Mvomero			259 347
Kilombero	74 222	187 593	321 611
Ulanga	100 700	138 642	193 280
Morogoro Region	685 104	1 220 564	1 753 362

Sources:

National Bureau of Statistics Tanzania (NBST). 2002b. *2002 Population and Housing Census*. National Bureau of Statistics Tanzania, Dar es Salaam.

United Republic of Tanzania (URT). 1997. *Morogoro Region Socio-Economic Profile*. The Planning Commission, Dar es Salaam and Regional Commissioner's Office, Morogoro.

road at all and that access to markets is limited for most. Railroads provide connections to Dar es Salaam, Dodoma, Tabora, Kigoma and Mbeya.

Agricultural and livelihood conditions in the region are diverse. The average annual temperature in the highlands is 18°C but reaches 30°C in the lowland river valleys. Rainfall varies from 1200 mm in the highland plateaus to 600 mm in lowlands. The region has three agro-ecological zones. The highlands above the altitude of 600 metres are suitable for the cultivation of perennial crops such as coffee, fruits, and cocoa as well as maize and vegetables. The plateaus at the altitudes of 300-600 metres are used for growing maize, sorghum, cotton and sunflower. Finally, paddy rice, sugar cane, banana, cocoyams, cassava, and sweet potatoes are grown in the lowlands and river valleys.

Subsistence farming of maize, rice and beans forms the mainstay of agriculture. Almost half of the agricultural land is used for growing maize and another quarter is used for cultivating other staple crops such as rice, beans, root crops such as cassava, and sorghum (Ellis and Mdoe, 2003). About two thirds of these staples are consumed by the producing households and the rest is sold (Ibid, 1377). Today the most important cash crops include fruits, vegetables and sesame seeds while the cultivation of cotton, coffee and sunflower has declined. Livestock is an important store of value for wealthier households, as well as to Maasai pastoralists who have relocated to the region from the drought-stricken highlands.

Over a half of the cash income in the Morogoro region is generated from agriculture and livestock husbandry. The remainder is obtained from non-farm sources such as wage income, self-employment and remittances which are relatively unimportant. According to the Household Budget Survey of

2000/01, the mean monthly income in the region was 18400 Tsh. Mean urban incomes are clearly higher 37 400 Tsh per month than the mean rural incomes of just 13 100 Tsh. Mean urban income in the region is about 15% above the corresponding national mean while the mean rural income is slightly below it (NTSB 2002).

The Morogoro region has slightly less poverty than Tanzania on an average (URT 2002). In the region, people spend about two thirds of their income on food. In the cities the figure is about 60% and in the rural areas about 70%. Almost a third of households suffer from basic needs poverty and 14% of households are below the food poverty line (NBST, 2002a). Poverty is related to access to land and natural resources. Mean household land holdings of 4.5 acres are small in the light of average household size of 4.8 persons and they are also 25% below the national average. While the recent Household Budget Survey finds that only 5% of rural households are landless in Morogoro region (NBST, 2002a), in places up to 40% of households do not own land (Ellis and Mdoe, 2003).

Also the region's human development outcomes such as literacy rates and child mortality rates are slightly better than the national average (Table 11.2 and URT 2002). In 1997, almost half of the region's child mortality was attributable to malaria. Other important causes of child mortality included acute diarrhoea (about 15% of deaths), injuries (about 10% of deaths) and malnutrition (about 5% of deaths) (AMMP 1997). Among adults, AIDS was the leading cause of death (about 20% of deaths), followed by malaria (about 12% of deaths), diarrhoea (about 10% of deaths) and pulmonary TB (about 5% of deaths) (AMMP 1997). The region has the highest incidence (22.3%) of seroprevalence of HIV/AIDS for low-risk populations in the country (US Census Bureau, 2003).

About 40% of urban dwellers in the Morogoro region are connected to electricity distribution network. However, as rural communities are not connected, only 10% of the population in the region has connection to electricity distribution network (NBST 2002a). Even those with a connection typically use charcoal and fuel wood for cooking and use electricity only for lighting. Almost all urban dwellers are connected to a networked water supply system but only a quarter of rural households have piped water supply. The region's figures are representative of the national average, with urban dwellers enjoying somewhat higher connection rates than urbanites in other regions (NBST 2002a).

Low levels of income and consumption, dependence from agriculture and limited access to markets are factors that characterize the vulnerability of all people in the Morogoro region to current climate variability as well as to future climate change. Yet the region's rural dwellers are clearly more vulnerable than the urbanites. Their income and consumption levels are clearly lower and they also suffer from greater levels of poverty, lower

Table 11.2. Social indicators for the Morogoro region and Tanzania

Indicator	Morogoro	Urban	Rural	Tanzania	Urban	Rural
Female-headed hh.		20%	20%		26%	22%
Electricity		41%	0%		39%	2%
Adults without education		11%	31%		11%	29%
Adult literacy		88%	66%		88%	67%
Piped water supply		91%	27%		79%	28%
Expenditure on food		60%	71%		59%	67%
Household size	4.8			4.9		
Agricultural income	64%			62%		
Mean land holdings	4.50 acres			6.0 acres		
Food poverty	14%			19%		
Basic needs poverty	29%			36%		
Infant mortality	99.7			104		
Child mortality	139.3			165		

Sources:

National Bureau of Statistics Tanzania (NBST). 2002. *Household Budget Survey 2000/01*. National Bureau of Statistics Tanzania, Dar es Salaam.

United Republic of Tanzania (URT). 2002. *Poverty and Human Development Report 2002*. Dar es Salaam.

United Republic of Tanzania (URT). 2003. *Poverty and Human Development Report 2003*. Dar es Salaam.

human development outcomes and more limited access to markets, public utilities and public services. Female-headed households and pastoralists are also more vulnerable than others because of their more limited and insecure access to resources and livelihood alternatives.

RESPONSES TO CLIMATE VARIABILITY

People adopt and modify livelihood strategies as a response to environmental stress. Agricultural intensification (applying more inputs on units of land), agricultural extensification (bringing new units of land under cultivation), livelihood diversification (which involves creating a portfolio of natural resource-based and other livelihood activities) and migration are examples of broad livelihood strategies (Scoones 1998). Depending on the impact of livelihood activities on household assets, a distinction can also be made between accumulative, adaptive, coping and survival activities. Accumulative and adaptive activities augment or transform the household asset base while coping and survival activities

draw down the assets to maintain the level of consumption (Ellis, 2000). As will be seen, households have used a broad spectrum of livelihood activities as a response to past and current climate variability in the Morogoro region.

The Morogoro region experiences climate variability both directly and indirectly and these experiences are intimately tied to water. The rains have either failed or been erratic in much of Tanzania since 2000. Severe droughts were also experienced in 1992 and 1977. There have been several less severe episodes of drought such as that of season 1996/97 in the last few decades. Yet flooding is also frequent. Tanzania experienced widespread flooding in 2000 and during the El Niño episode in 1997/98. However, much of the flooding is local and seasonal in nature. For example, the beginning of the main Masika rains in Spring 2004 resulted in local flooding in Magombera Village in Kilombero District, making 2600 households homeless.¹ Local floods like this destroy property, belongings and crops, threaten food security, contaminate water supplies, and cause epidemics of water-borne diseases.

Climate variability has also more indirect effects. For northern Tanzanian pastoralists such as the Maasai, Nyaturu and Barabaig, transhumance and the sale of cattle have been traditional responses to seasonal and other climatic variations. Transhumance involves population movements over relatively small distances which enables the maintenance of social links and organization (Ndagala, 1998). The strategies of pastoralists have changed over the last few decades as a response to adverse climatic conditions, population pressure, cattle diseases, unfavourable price ratios between livestock and crops, restrictions of mobility imposed by the encroachment of sedentary agriculturalists and their relatively clearer property rights and deepening poverty in the pastoral communities. New strategies include the cultivation of staple and cash crops, long-distance relocation with cattle and migration to cities to wage employment (McCabe 2003; Ndagala, 1998).

The Morogoro region has been a destination for the pastoralists who have relocated as far to the south as the Lindi region and the neighbouring countries Zambia and Malawi (Mwampufe, 1998). The Maasai have been argued to have introduced up to 250 000 heads of cattle to the Morogoro region by the early 1990s. Conflicts ensued in the fall 2000 when agriculturalists confiscated Maasai cattle that had strayed and damaged their cultivations. Escalating exchange of retaliations first resulted in the killing of two Maasai tribesmen and three dozen heads of cattle. In December 2000, 35 people died in battles and 400 agriculturalists left their homes in fear of further retaliations. Later in 2002 the National Defence and Security

¹ Bilal Abdul-Aziz, 'Floods Wreak Havoc', *The Guardian*, 19 April 2004.

Committee identified the Morogoro region as one key destination area for illegal trade in small firearms.ⁱⁱ

Agriculturalists have responded to climate variability in their own ways, many of which involve agricultural practices. Farmers switch between crops, alter the mix of crops they plan to grow and change the timing of planting in the light of evidence they obtain of the growing season (O'Brien et al. 2000). For example, farmers may switch from maize to sorghum and/or cassava when there is a threat of drought and switch to rice or banana when rain appears to be abundant. Crop switching can make a difference. The average yields of maize and rice per ha dropped in dry years such as 1996/97 and 1999/2000 by up to 75% and 50%, respectively. In contrast, sorghum yields have varied much less and yields of sweet potato have increased in these dry years. Rice and bananas have in turn given about 25% better than average yields in wet years such as 1997/98 and 2000/01 (Table 11.3).

Table 11.3. Average yields of common crops per hectare in Morogoro region

Crops	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Maize	1905	1590	439	1600	1300	1200	2000
Sorghum	1271	1400	1175	1600	1000	1000	1200
Millet	182	18	182	900	300	600	1000
Rice	1358	1566	1564	2600	2000	1500	2600
Sweet potatoes	1273	1318	2048	1300	2200	2300	1700
Pulses	698	870	550	800	500	800	2000
Bananas	1000	2250	2250	2500	1200	1800	2200
Cassava	2603	2605	2608	2600	2100	2100	3000

Source:

Tanzania Ministry of Agriculture and Food Security (TMAFS). 2002. *Agricultural Statistics Basic Data: Production Area and Yield of Food Crops*.

O'Brien et al. (2000) have found that the majority of their respondents from the Morogoro and Iringa regions used some of the strategies discussed above and below as a response to the seasonal weather forecasts of above average rains during the 1997/98 season. Also the regional agricultural statistics for Morogoro seem to substantiate that farmers can and do adjust their practices successfully to cope with climate variability. The cultivated area of staple crops such as maize has decreased and that of sweet potatoes has increased in dry years (Tables 11.3 and 11.4). The increases in the

ⁱⁱ Tanzania: Cattle Clash Sparks Bitter Feud', *IRIN News*, 14 December, 2000, and 'Tanzania: Focus on Small Arms Impact and Control', *IRIN News*, 29 May, 2002.

Table 11.4. Change in the area of cultivation from the mean in Morogoro

Crops	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Maize	+	-	-	+	0	0	+
Sorghum	0	+	+	-	0	+	-
Millet	+	+	+	-	+	+	-
Rice	+	+	+	-	-	-	-
Sweet potatoes	-	-	-	-	-	+	+
Pulses	+	+	0	-	+	+	0
Bananas	+	-	-	-	-	+	+
Cassava	0	0	0	+	0	+	-
Total area	+	+	0	-	0	+	-

Source:

Tanzania Ministry of Agriculture and Food Security (TMAFS). 2002. *Agricultural Statistics Basic Data: Production Area and Yield of Food Crops*.

planting area of cassava in turn seems to follow years which had bad maize yields and tell of its 'insurance' function (Table 11.4).

Another potential response to climate variability and especially droughts is to expand cultivations so that the larger cultivated area will compensate for the reduced yields. Extensification can be achieved by taking fallowed land for cultivation or by clearing forest. However, land is already scarce in many villages and so it is not fallowed at all or fallow periods are short. As a result, yields have dropped dramatically over the last several decades (van Donge, 1992). For example, the interviews conducted as part of the Uluguru Mountains Biodiversity Conservation Project indicate that in a third of the eighteen covered villages land is not fallowed at all and that in most others only a small proportion of land is fallowed for a year or two. The interviews also suggest that maize yields have dropped by 50-70% and rice yields even more in most villages in the past three decades.ⁱⁱⁱ

Extensification has also been sought by clearing forest and transforming it to agricultural land. Almost half of the original forest cover of 500 km² on the Uluguru Mountains was lost already by 1955 when the forest cover was assessed to be 260 km². Another 30 km² or over 10% of the remainder was lost between 1955 and 1977. A recent estimate of remaining forest cover is 230 km² (Burgess et al. 2002). Extension of farm land is the primary reason for forest loss on the Uluguru Mountains. Practically all larger

ⁱⁱⁱ Summaries of these interviews are available from the website of the Uluguru Mountains Biodiversity Conservation Project. The internet address is <http://africanconservation.org/uluguru/downloads.html>

patches of forest outside the Forest Reserves have already been lost and there is little forest left for agricultural use (*ibid.*). For example, the interviews conducted as part of the Uluguru Mountains Biodiversity Conservation Project indicate that forest was cleared to obtain new agricultural land only in two villages out of eighteen.^{iv}

Responses to climate variability also involve attempts to reduce dependence from agricultural production. In parts of Morogoro non-farm income has become consistently more important since the mid-1980s and it has compensated for the decline in farming (Ponte, 1998). Another strategy that has become common is to reduce the number of dependents to be fed by sending some of the children to work in the cities for upkeep and cash income. Of course, temporary or permanent migration to the cities or to more favourable farming areas is also an increasingly used option among adults. Perhaps the most often used strategy is, however, to save food for consumption during the anticipated period of stress (O'Brien et al. 2000). In more extreme situations households sell their seeds, animals or other assets.

Finally, many households tap into the forests in order to earn cash income and to cater for their subsistence needs. Forest resources are of central importance for livelihoods in the Morogoro region. Forests provide timber, firewood, fruits, spices, fodder, traditional medicines and meat for subsistence needs. Moreover, trees are harvested for the production of timber and charcoal for local and more remote markets and the fuel wood obtained from the forests is used for energy-intensive production of bricks. Morogoro town's good road connections have made it a prime area for charcoal and brick production for the markets of Dar es Salaam (Luoga et al. 2000). Peri-urban communities also benefit from access to markets for non-timber forest products. While there is no definitive information on the exact contribution of forests and other natural resources to the total income of households, existing studies indicate that it is significant. Monela et al. (2000) report that households in the Morogoro and Dodoma regions may obtain up to 68% of their total income from forests. The role of natural resources was the greatest in the peri-urban communities which have access to urban markets for forest products such as charcoal and firewood (Morris et al. 2002: 64-65). Forest resources contributed about 50% of total income also in the more remote communities. For them, honey was particularly important non-timber forest product (*ibid.*). These studies are in line with those from other parts of Tanzania. For example, Meshack (2003) reports that households obtain at least a third of their total income from forests in the West Usambaras in northern Tanzania.

^{iv} Summaries of these interviews are available from the website of the Uluguru Mountains Biodiversity Conservation Project. The internet address is <http://africanconservation.org/uluguru/downloads.html>

CONCLUSIONS

Households use a wide range of strategies as a response to current climate variability in the region. Cultivation has been expanded and people are increasingly growing crops for market exchange where access to markets is not a constraint. Non-farm activities are also important and in places already form the main source of income for households. A wide range of natural resources are also tapped. Charcoal production and timber production are an important source of additional income and artisanal mining of gem stones and gold has increased lately. Pastoralists have migrated to the area from the North in search of grazing land and water. The region's farmers are also migrating temporarily to areas that provide more favourable conditions for cultivation and to locations that provide good access to markets.

The extension of cultivations, charcoal production and timber harvesting all play important roles in livelihood strategies that have been adopted as a response to past and current climate variability. Extension of cultivations can maintain or augment income and consumption levels when the maintenance or improvement of soil productivity by using agricultural inputs is costly or impossible. Engagement in charcoal production and timber harvesting can in turn maintain or increase levels of income and consumption and diversify the sources of income so as to reduce the overall risks to livelihoods. These livelihood strategies are not, however, unproblematic in the light of predicted future climate changes. Perhaps their most problematic consequence is deforestation. Deforestation is a problem for adaptation to climate change in the future for several reasons. Reduced forest cover will not provide the water retention services in the more variable climate of the future. This will mean increased flooding and soil erosion during the rains as well as greater scarcity of water during the dry seasons. The scarcity of water will be an impediment for irrigated cultivation, livestock rearing as well as for public water supply. Deforestation will also constrain the use of forests as safety nets for supplementing subsistence and earning cash income. In essence, deforestation will limit livelihood strategies based on both farm and non-farming activities.

In the past several decades, the most important reason for deforestation has been the extension of cultivations, which has been driven by several factors such as the scarcity of water, loss of soil productivity and population growth. Charcoal production is another important contributor to deforestation as it is usually based on non-selective harvesting and use of all available tree species. Its significance has increased in the recent past because the markets of other major cities have become more easily accessible. Timber harvesting and production contribute less to deforestation as

artesanal timber production is not mechanized and uses selected tree species. The adverse effects of deforestation are already being felt in the region and they will become more pronounced in the future. Deforestation has altered water retention and flow regimes in the region's watercourses, increasing peak flows and decreasing minimum flows. Watercourses are likely to become increasingly seasonal. There is already evidence of this as the Great Ruaha has now dried up in ten consecutive years.^v The reasons for this change lie in the land cover and land and water use changes in the Usangu wetlands and plains outside the region.^{vi} Flooding has also become more frequent after rains in the Morogoro town and elsewhere in the region, causing property damage and typhoid epidemics.

Deforestation also contributes to soil erosion and to the sedimentation of watercourses. Jones (2002) argues that farmers in Mgeta differentiate between 'large' soil erosion which they associate with land slides and consider a problem, and 'small' erosion (sheetwash, rilling) which they think is not a problem and which they think they can control. Landslides occur during intensive rainfall events approximately once in a decade which, Jones (1996) argues, may explain why large soil erosion is sometimes considered an unavoidable, natural phenomenon. Apart from contributing to the loss of soil productivity, soil erosion also results in the siltation of watercourses. For example, the reservoir of Morogoro town is silting up which reduces the storage capacity of the city's public water supply system. Siltation also reduces the quality of Dar es Salaam's water supply downstream. Deforestation and agriculture are not the only causes of siltation, however. Artesanal mining of gemstones and gold contributes to the siltation and artisanal gold mining also pollutes the river with mercury (Maganga et al. 2002).

There is no single solution or measure which would provide a satisfactory response to current climate variability and maintain adaptive capacity for the future. However, several elements of a package of necessary measures are evident. Pressure on the use of forest resources for timber and charcoal production can be reduced by tree farming, which in turn requires reforms in the tenure of forest resources so that households and/or communities can gain control over these assets and have incentives to invest in them. Improvement of market access and promotion of market participation will give incentives to greater specialization and intensification in agriculture.

^v The opening speech of Morogoro's Regional Commissioner, The Honourable Stephen J. Mashishanga (MNEC) at the "Ruaha+10" event, ICE Conference Hall, Sokoine University of Agriculture, Morogoro, Tanzania, 11 December 2003. Transcript of the speech is available online at <http://eng.suanet.ac.tz/swmrg/outputsdownloadable_files/wordpapers/speech_RegionalCommissioner.pdf>. Accessed 15 May 2004.

^{vi} Zephania Ubwani, 'Government Bars Pastoralists from Grazing in Usangu Wetlands', *The Guardian*, 18 March 2004.

However, these predominantly market-based alternatives need to be complemented with other measures. Effective environmental governance solutions have to be adopted for protecting forest and land cover – this is necessary in order to control flooding, mitigate seasonal scarcity of water and to limit soil erosion. Conflicts over the use of water resources are also going to increase and governance solutions have to address both conflicts within the local community of users and between upstream and downstream communities. Solutions for governing forests, other land cover and water resources will have to have an element of user/local participation but they cannot be completely decentralised if they are to be effective.

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Section 2

**Governance, Institutions,
Laws and Policies**

12

Water Governance and Water Economics

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Governance is the process by which stakeholders articulate their interests, their input is absorbed, decisions are taken and implemented, and decision-makers are held accountable (<http://www.iog.ca>). *Water governance* can be defined as the range of political, organizational and administrative processes through which communities articulate their interests, their input is absorbed, decisions are made and implemented, and decision makers are held accountable in the development and management of water resources and delivery of water services (<http://www.powi.ca/pdfs/governance/goodgovernance.pdf>).

The two aspects of governance normally emphasized are:

- decision-making processes (stakeholder governance)
- implementation (corporate board governance)

Governance principles, by themselves, are insufficient for good governance. Concrete objectives or goals must be specified in order to enable the practice of good governance. Chapter 18 of Agenda 21 (of Rio Declaration) on *Water Resources* is an example of a detailed set of objectives flowing from a set of governance principles (Agenda 21 Chapter 18).

- *A good governance principle of public participation might lead to an objective of community involvement in standard setting. In turn, this might lead to specific policies, for example: multi-stakeholder participation in drinking water advisory role.*
- *Similarly, a good governance principle of accountability might lead to the following objectives: clear lines of accountability; good communi-*

cation; trust. In turn, this might lead to specific policies, for example: a consumers 'right to know' (access to information) policy; holding service providers to a statutory standard of care.

Despite widespread acknowledgment of the importance of governance, definitions and models of good governance vary considerably. In this section, the general criteria for good governance are discussed. The fine-grained structure of a governance model will, however, vary from one organization to the other.

At the core of good governance are sets of principles, which guide governance practices. Principles of good governance and the prioritization accorded to each principle vary between organizations and jurisdictions. This variation is in part due to the fact that governance is embedded in broader frameworks of political governance. Regulation in England and Wales is, for example, relatively non-legalistic and discretionary when compared to North American governance models. Also implicit in different definitions of good governance are assumptions about the legitimacy of different stakeholders and decision-makers, about robust decision-making structures, and about accepted processes of decision-making. Good governance is thus to some degree dependent upon how a society interprets the practice of deliberative democracy. There is accordingly no one 'menu' of good governance options. Table 12.1 shows selected examples of governance principles for water supply management.

Good governance is articulated a set of principles, expressing a "vision". It is important that governance principles be 'homegrown', or developed through meaningful participation by stakeholders. Some consensus does, however, exist on good governance principles for water supply management:

- protection of public health and safety
- accountability for stewardship and performance
- transparency
- participation
- equity, efficiency, and effectiveness

The governance principles are coherent and are ranked in order of priority.

Coherence implies a high degree of internal consistency between the different principles. In many cases, governance principles will fall into one of the three generic governance models; this does not necessarily ensure coherence. With hybrid models (such as corporatization), it is important to ensure coherence between different aspects of the governance model. In operational management situations, policies and objectives that flow from governance principles may at times be at conflict. For this reason, it is important to prioritize governance principles.

Table 12.1. Selected Examples of Governance Principles for Water Management

Type of governance	Principles
Walkerton Inquiry Issue Paper on water governance	<ul style="list-style-type: none"> • Accountability • Responsiveness • Effectiveness • Efficiency • Transparency • Participation • Respect for the rule of law
Walkerton Inquiry Issue paper on a 'model water utility'	<ul style="list-style-type: none"> • Openness in decision making and actions • Integrity based on honesty and objectivity • Accountability for stewardship and performance • Criteria for action • Clear understanding of roles and responsibilities • Effective practices in place • Capacity to govern assured • Accountability and transparency
Global Water Partnership	<ul style="list-style-type: none"> • Open and transparent • Inclusive and communicative • Coherent and integrative • Equitable and ethical • Performance and operation • Accumulative • Efficient • Responsive and sustainable
Dublin Principles	<ul style="list-style-type: none"> • Freshwater is a finite and a vulnerable resource, essential to sustain life, development and the environment • Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels • Women play a central part in the provision, management and safeguarding of water • Water has economic value in all its competing uses and should be recognized as an economic good
Agenda 21	<ul style="list-style-type: none"> • Full public participation • Multi-sectoral approach to water management • Sustainable water use
Federation of Canadian Municipalities Policy on Municipal Infrastructure (FCM 2003)	<ul style="list-style-type: none"> • Quality of life • Shared responsibility (between governments) • Municipal government leadership • Adaptability • User pay • Maintenance and rehabilitation • Continuous improvement • Partnerships

Source: <http://www.powi.ca/pdfs/governance/generalguidelinesfinal.pdf>

Models Pertaining to Water

Water is the essential prerequisite for human life, environmental integrity, social well-being and economic activity. There is no substitute for water.

Water is becoming scarcer everywhere and is attributed to global atmospheric change. Unless arrested and reversed, climatic warming, together with the long range transportation of acidic and toxic pollutants, will increase demand for water, decrease water supply reliability, increase vulnerability to droughts and floods, damage the integrity of aquatic ecosystems, and increase the potential for social conflict in many regions of the world. This could be attributed to an increasing population pressing on limited water resources. It has been observed that where water is in abundance, much of the water is wasted, put to uses that people do not value highly, or used in larger amounts than they really wish. A trivially low price does not motivate people to conserve water. This is shown by impressive declines in domestic and industrial consumption whenever water is metered. The end result is that some people (in the areas where water is scarce) are so desperate for more water that even a small increase in the amount available would be very valuable to them, while other people, with access to freely available water, not only do not conserve it but let it run down the drain.

As the demand increases – the question arises: how can this demand be fulfilled? This question can be answered by looking at it from the supply side – by turning the attention from demand side to supply side. This in turn raises the question of jurisdiction over the sources of water.

The debate over water supply governance and how control should be shared between the state, the private sector, and citizens revolves around three idealized models of resource management: the planning model, the commercial model, and the community model. As shown in Table 12.2, these three stakeholder governance models also apply to public services more generally.

In practice, there is a great deal of variation in the stakeholder governance models associated with different business models. There are also hybrid models: municipal services boards or commissions, delegated management contracts, and corporatized utilities adopt elements of both the planning and commercial models. A municipal services board, for example, might have a hybrid model of governance, falling somewhere between the market and planning model. A corporatized utility, if publicly owned, might adopt only selected aspects of the market governance model.

There are important differences between the planning, market, and collective action governance models, including:

- Representation of consumers: as citizen-voters, customer-ratepayers, or as users and community members

Table 12.2. Generic governance models for locally-provided public utility services

	Planning model	Commercial model	Community model
Organizational structure	Civil Service	Corporation	Association/network
Accountability mechanism	Hierarchy	Contract	Community norms
Primary decision-makers	Administrators, experts, public officials	Individual households, experts, companies	Leaders and members of community organizations
Primary goals	Guardian of public interest Conformity with legislation/policy	Maximization of profit Efficient performance	Serve community interest Effective performance
Key incentives	Expert/managerial feedback in public policy process Voter/ratepayer opinion	Price signals (share movements or bond ratings) Customer opinion	Agreements and shared goals Community opinion
Key sanctions	State authority backed by coercion Political process via elections Litigation	Financial loss Takeover Litigation	Livelihood needs Social pressure Litigation (in some cases)
Consumer role	User and Citizen	User and Customer	User and community member
Participation of consumers	Collective, top-down	Individualistic	Collective, bottom-up
Cognate business models	Municipality-owned utility	Private-corporate utility	Community co-operative

Source : www.powi.ca/pdfs/governance/general_guidelines.pdf

- Accountability
- Goals-leading to distinct policy and management outcomes

When making a transition from one model to another or in attempting to create a hybrid between two models, governments must carefully consider the implications of changes in incentives, sanctions, goals, accountability structures, and the role of consumers. This is particularly important when considering a hybrid model, as problems are likely to arise when different aspects of the governance model are incoherent. For example, a disjuncture between (shorter) political time cycles and (longer) infrastructure life cycles can compromise sustainability of financing.

Different people have different perspectives on water – how they look at it becomes the major factor on how water is managed. For example under riparian perspective water is seen a common shared element between riparians depending on water from that particular body and have equal

right to share the water available. The next few paragraphs discuss the different perspectives people have about water.

Riparian perspective: The riparian perspective is essentially one of the rights to the waters of a river flowing through different regions and can occur from household level to a community level but is generally observed at the level of administrative units at the national level. As pointed out by Iyer, water is allocated among different riparians with each party receiving a certain allocated share to be used while theoretically better results could be achieved through a joint, cooperative, integrated planning and management of the river as a system instead of dividing it up into fragments to be managed separately; and whether (as has been argued) a sharing of benefits may not be better than sharing of water. The main limitation of riparian perspective is that the focus is on the river and not the ecological system of which that river is an integral part.

Federalist perspective: Under this perspective rights are divided between different levels of governments like federal, provincial levels and municipal levels. The conflict is between division of power among different levels and which level of the Government controls which water body or what comes in their jurisdiction. Some times, lack of clarification of jurisdiction, overlap among jurisdiction and lack of communication leads to a lot of confusion. (Iyer 2003)

Towards National Legislation

Role of the state: Although the state does not really own water – it being a natural resource, the state does have some responsibility in performing certain functions such as

- Protection of water sources and systems
- Promote conservation of resources
- Regulate the use of water resources
- Oversee quality
- Undertake the provision of water infrastructure
- Prevent or resolve conflicts
- Enter into treaties and agreements

Legal Perspective

The legal perspective changes with the way a natural resource is perceived. In most of the countries with abundance of water, riparian perspective is prevalent but with the awareness that water is not unlimited any more, trend is moving away from riparian perspective to state control. But some of the legal issues associated with water are:

- Right to water as a fundamental right or human right
- After the Stockholm Declaration, some countries enshrined the right

to water in their constitutions, for example, in the Indian constitution, right to clean air and water is a fundamental right

- There is also an issue about indigenous peoples right over water
- Legally the countries who are part of International Treaties are bound by them. When national laws and strategies are developed, international commitments should be kept in mind.
- Some controversial legal issues which rarely arise are rights over groundwater – does the right or ownership of the water lie with the individual who owns the land or is it still a Global Common?

Stakeholder participation perspective: Stakeholders can be defined as all the different actors involved in using the particular water body. Participation can vary from involvement of people right from the beginning of the project to the formality of asking for comments or just formal consultation at the conclusion of the project.

Participation is “a process through which stakeholders influence and share control over development initiatives, decisions and resources which affect them.” Participation can take different forms, ranging from information sharing and consultation methods, to mechanisms for collaboration and empowerment that give stakeholders more influence and control. (Source: *World bank toolkit*). Participation can also be defined as the process of people being involved in, and sharing, a variety of activities with a communal goal. <http://www.irc.nl/download.php?file=publ/op34e.pdf>.

Stakeholders *can also be defined as* all those who affect, and/or are affected by, policies, decisions and actions within a watershed system. Thus, stakeholders could also include:

- People likely to be affected, or their representatives, including those who may have little or no knowledge of Integrated Water Management and lack the means to participate.
- Public sector agencies, including at various levels, with mandates in the watershed.
- Private sector organizations and companies with interests in the watersheds, and
- Professional and/or Non-Governmental Organizations (Source: Boehmer, 1997)

Community participation is:

- *Efficient* – with the community’s help, essential information that may not be known otherwise is made available and important issues identified quickly
- *Financially beneficial* – costly mistakes and obstructions should be avoided
- *Interactive* – helps build up the community’s commitment to and continued involvement with initiatives
- *Ethical* – in a world that calls for more justice and respect for human rights

Benefits of Community Participation

1. Local Knowledge

It is increasingly recognized that for environmental management initiatives to be successful they must be carefully adjusted to the circumstances of the communities involved. An integrated view of these local circumstances is required and this can be best obtained through discussions with the people who live in those circumstances. In particular, *indigenous technical knowledge (ITK)* combined with external scientific expertise can often contribute to the solution of particular problems. Recognizing indigenous knowledge can, at the very outset, make communication more effective by addressing the right segment of the population and by making use of the appropriate vernacular terms or concepts pertinent to explanations based on formal or scientific knowledge.

At its fullest, this type of contribution to problem solving can involve participatory research where proposed solutions are developed through investigation by the public on their own land, to take one example, involving some discussions with scientists, rather than by relying upon the research conducted by scientists in laboratories or on research stations.

2. Mobilizing Bias

Public participation in the development of environmental management solutions helps to ensure that the proposed interventions will receive support from the community. This is essential if they are to be socially sustainable, that is acceptable to the community in the long term. Public involvement in the design of interventions does not only ensure that they are relevant and effective, but also that the public identify with and have a stake in them because they have been involved in their design. They become biased in favor of specific projects, thus ensuring that such initiatives are more likely to receive support and ultimately succeed.

The deliberate mobilization of bias in favor of a project is vulnerable to abuse. Participation can become a purely nominal consultation, a public relations exercise to dupe people into supporting a measure without their full understanding and involvement. Such an approach may gain some support in the short term but because people have not been involved fully it is unlikely that long term support will be maintained.

3. Legitimization of Environmental Policies

An extension of the mobilization of bias in support of specific initiatives involves participation to provide an opportunity for the public to endorse or reject policies of political parties or managing agencies. Formal and informal public discussions are necessary to ensure that environmentally sensitive policies are investigated fully before agreement is given for their go-ahead. Again, the public must have an opportunity to play an active role in decision-making rather than have proposals thrust upon them.

4. Empowerment

Participation may be encouraged in some cases in order to empower the public or a group of people. Empowerment involves the public or a group taking control over the circumstances in which they live. With respect to environmental issues, it may involve efforts by a community to take over the management of environmental resources which they use, rather than relying upon the state to advise and legislate about the appropriate levels of management. Hence, empowerment participation involves the fullest level of participation where communities identify and solve problems themselves and work out their own management practices.

Empowerment may be achieved in various ways. At a national level, empowerment requires an open democratic process, which provides opportunities for minority interest groups to be heard and have a say in policymaking. It may involve the development of interest groups and lobbies, and require a change in attitude on the part of the government to ensure that the interests and rights of communities are not ignored or overruled. Empowerment may also be facilitated by decentralization, where this involves the return of power and rights over the environment to local communities and groups, provided these are democratic. Clearly, the problem with empowerment is that it raises the conflict over power and who is in control over resources. Governments are often averse to giving away their power to communities. Consequently, decentralization can often establish a façade of power reallocation while the real decision making and resources remain in the central government's hands.

5. Sustainability

Public participation gives a local ownership of the project to the stakeholders involved – in the sense it involves people in understanding the problem and formulating a solution (with due acknowledgement to the local knowledge). This ownership keeps people interested to make sure the implementation goes on the way they want – making the process and project sustainable.

It should be emphasized here that women group is an important stakeholder – that is, women play an important role in the water sector. Women should be involved in the decision making for the location of water supply, technology used etc. since it is they who will have to deal with the problems and fetch water. Women are the main users of domestic water – starting from fetching water, using it for cooking, washing, and other household purposes and deciding on how and where to reuse the water.

Human Rights Perspective: Human rights perspective can be viewed from two different angles:

- Right to water as a fundamental right or human right
- Right to resist displacement for big dams

The right to water as a human right refers to safe water being available for drinking and personal hygiene to everyone. It can include other personal needs such as cooking, bathing etc. but cannot really extend to availability of water for agriculture and industrial use. In a way this can be looked in relation to fulfillment of basic needs of human being.

NGOs and certain lawyers are also formulating the rights of people being displaced for large hydro dams in terms of human rights. A special case of human rights are also being formulated by some lawyers for indigenous or tribal people.

Environmental Perspective: The roots for this perspective lie in the conflict between preservation of natural environment (in this case water) and human need for development. The concern for this is reflected in the Stockholm Declaration too.

Economic Perspective: Water is mainly seen as an economic good when used for agriculture and industry, and as a social good when used by hospitals, in firefighting and for sanitation. But with increase in demand of domestic consumption and, higher maintenance cost of infrastructure and purification the concept of full cost accounting for domestic use is also being explored in some countries. This essentially means recovering the cost of water supply from consumers including domestic users. The main principle of economics is based on demand and supply theory – as the price increases the demand decreases and as price decreases demand increases. How does one determine the cost/price of water as based on demand of water - this calls for a common definition of demand. *Demand can be seen in different ways based on technical design, economic perspective, social context etc.* Used in the economic sense, demand has a very different significance, being equated with a person's willingness to pay for a specified good or service. Demand expressed in this way is often termed 'effective demand'. Although the word 'pay' could refer to any financial or economic contribution, in practice it is usually equated with a cash payment.

This interpretation of demand implies that improved water supply and sanitation services are economic goods. Certainly, with some exceptions, governments in the developing world cannot afford to provide or sustain water and sanitation services without economic support. At the same time, there is strong evidence that many people are prepared to make significant economic contributions to receive services and service levels they desire.

By reflecting how people value the improved service, willingness to pay is a more reliable measure of demand than one based on an assumed level of affordability. In spite of these arguments, there are legitimate concerns that such an approach may marginalize those least able to express their demands in the way or ways required – poor households and women in particular.

To define effective demand management, it is important to understand three basic concepts of water use:

1. *Need* – Need is used normally to represent the biological need of the individual of water and other multiple purposes like cooking, washing, cleaning etc.
2. *Consumption* – Consumption implies the quantity of water used by a consumer(s) in any given time period. At times it also specifies the quality of water used. Most often it is represented graphically – where the vertical axis depicts cubic meters per unit time and horizontal axis measures the passage of time.
3. *Effective demand* – Effective demand defines relationships between price per unit of a product and the quantity in each time period that consumers would be willing to purchase at each price, within a defined time and defined market. Graphical representation of effective demand has price on a vertical axis and quantity on a horizontal axis. It is interesting to observe how consumers would respond to product price differences – and this concept of responsiveness is known as price elasticity of demand.

From an environmental economic perspective, pricing can be an extremely valuable public policy tool. Prices can be more than a means of meeting revenue requirements or even turning a profit. One of such pricing mechanisms is 'full cost' also called 'full cost pricing' or 'polluter pays principle'. It refers to the complete societal costs (environmental, social and actual) that pertain to the production and consumption of a good or service. Another method is traditional pricing method – known as 'cost-based pricing' – which is an accounting system designed to ensure the financial self-sufficiency of water and wastewater systems. This pricing method quantifies the costs of capture, treatment and conveyance.

Subsidies and Water Pricing Practices

The occurrence and calculation of subsidization is fairly straightforward if identifiable monetary transfers are involved, whether these be in the form of direct payments, low interest loans or debt reductions. On a more abstract level, however, the concept of 'subsidy' implies that the actual price paid for a good or service does not cover for all of the 'real' costs of providing that good or service. This conceptual perspective highlights the close relationship between water subsidies and water pricing practices. Even in the absence of 'explicit' monetary transfers, one can speak of 'water subsidies' if the system of water prices in place does not adequately reflect all of the costs involved in producing water services. In turn, the effective implementation of the principle of *full cost recovery* in the formation of

water prices would eliminate water subsidies. Methodologically, the identification of 'water subsidies' created by 'underpricing' water services requires the establishment of benchmarks for correct prices. The concept of 'correct pricing' in turn largely depends on decisions on the types of costs to be included in 'correct' water prices. In principle, three types of cost need to be considered when discussing correct prices : direct economic costs, social costs, and environmental costs.

Privatization: 'Privatization' in the water sector involves transferring some or all the assets or operations of public water systems into private hands. There are numerous ways to privatize water, such as the transfer of the responsibility to operate a water delivery or treatment system, a more complete transfer of system ownership and operation responsibilities, or even the sale of publicly owned water rights to private companies. Alternatively, various combinations are possible, such as soliciting private investment in the development of new facilities, with transfer of those facilities to public ownership after investors have been repaid. When the services being privatized has 'public good' characteristics like water, government regulation or oversight has traditionally been applied. Economists and others argue that goods and services previously provided by public officials or agencies may become less vulnerable to political manipulation when privatized, but private entities may also become less responsive to public interests. Examples include protection of water quality, commitment to efficiency improvements that reduce the volume of water used, maintenance of basic service levels, transparent prices and billing practices, and investments in water reclamation or additional sources of water supply.

Virtual Economics: To meet the growing demand for food (with the increasing population), the role of irrigation and hence water cannot be underestimated. Hence, food security is intrinsically bound up with water security. However, food security is related to global food markets while regional water scarcity becomes problematic. Since, water is not an international tradable commodity, self sufficiency in food security would normally require self sufficiency in water and food security is compromised as soon as water becomes scarce.

However, both food and water security objectives can be achieved through international trade if the country has the purchasing power to meet domestic food needs through imports. Since, food would be imported self sufficiency in water is no longer required and limited available water can be used for other needs. As water is traded in the form of water that has gone into producing internationally traded food, this is called *virtual water*. Importing food from water-rich countries to water-scarce countries is a much cheaper and easier option than importing water or ice blocks, and it also removes pressure on the importer's water supplies. With the development of the

concept of this virtual water economics, the formulation of national water strategies and policies in regions with less available water requires an analysis of international grain market and the performance of key producers, as well as assessment of global water supplies and how they are likely to affect the patterns of global production and trade in cereals. Many policies impact a country's balance of trade in food/virtual water, such as subsidization or taxing of domestic production of food and, or water. In the end, a country's ability to overcome water scarcity is closely linked to the strength of its economy and its capacity to trade on the world market, especially the grain market. Water policy is intrinsically linked to wider economic policy as well as to social, economic trends that drive patterns of water consumption.

Towards a Total Perspective: Integrated Water Resource Management (IWRM) is a simple concept with exceedingly complex implications for water professionals around the world. It has been defined as "a process, which promotes the coordinated development and management of water, land and related resources in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (Global Water Partnership - Technical Advisory Committee, 2000). It is goal-oriented and seeks "to develop a consensus-based vision of ideal water resources conditions for the area of interest".

An IWRM plan should involve aspects of the hydrologic cycle, land use, climate, geography and pollution, economics, social interactions and institutional aspects relating to IWRM. It should also deal with the issues of water taking, quality, conservation and legislation, monitoring and regulation, as well as the physical aspects of flood control, dams and water and waste treatment engineering works. The confluence of all of these aspects, usually at a river basin or watershed level, is central to the practice of effective IWRM. Of course, there are many external impacts on IWRM such as the effects of global climate change, water transfer between watersheds, movement of populations and the consequent changes in human activities and the effect of atmospheric transfer of pollutants – sometimes occurring on a continental or even global scale.

CONCLUSION

So far, it is believed that water is indestructible and is recycled through the hydrologic cycle. But recent experience has shown that water cannot be treated as a perfectly renewable resource. Withdrawals from our watersheds for drinking and industrial water and subsequent wastewater treatment processes, at today's scale, have large 'unpriced' external effects such as water quantity depletion, land use consequences and biological degradation. With expansions in water and wastewater capacity posing

significant environmental problems in most major metropolitan areas, the need for conservation and planning is greater than ever.

Water is also considered as a 'public good'. A public good is defined by two characteristics: (1) non-excludability (it is difficult to exclude some one from using the good) and (2) non-rivalness in consumption (one person's enjoyment does not affect another person's enjoyment, up to the point of congestion). The characteristics of public goods necessitate government responsibility and action. Although, many goods and services provided by government exhibit some 'publicness' (such as street lighting), there are few pure public goods like air and water. Being a public good and being a necessity of life, water should be available to everyone. With increased demand of water the amount of water withdrawn from hydrological cycle is much more than it can replenish, so it cannot be considered infinite and renewable and used mindlessly and free. Today, the water allocation problem is more difficult than ever due to a number of forces: increased population, periodic drought, depletion of groundwater, degradation of water quality, land use concerns and competition among water users (agriculture, recreation, urban drinking water and industrial use). With the change in consumption and thinking of natural resources, water and sewage services which do possess some elements of public goods, they more closely approximate 'private goods', and thus, it is desirable to charge for them. This brings in the responsibility of the Government and their policies on water conservation and allocation. Section 2 is devoted to the Governance, Institutions, Laws and policy area issues and presents a mosaic collection on experiences in Europe, North America, Australia, Brazil and Turkey.

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13

Water Basin Regimes in Europe and Institutional Conditions for their Sustainability

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INTRODUCTION

This chapter is based on the results from the European research project EUWARENESS, which stands for European Water Regimes and the Notion of a Sustainable Status. In this project the authors focused on sustainable use of water resources to be achieved by means of integrated water management. They aimed to develop a better understanding of the dynamic relationships between various conflicting uses of water resources, the regimes under which these uses of water resources are managed, and conditions generating regime shifts towards sustainability. The authors of this chapter have coordinated the project, while research groups from six European countries (the Netherlands, Belgium, France, Spain, Italy and Switzerland) participated. For these six countries the authors studied the long term evolution of national regimes over a period of more than hundred years. They also studied in depth the specific regime transitions of two selected water basins in each country during the last three decades. Important questions addressed are:

- Do integrated water regimes lead to more sustainable water use?
- What are important indicators for integrated water regimes?
- Under what conditions can integrated water regimes be achieved?
- What could be the influence of Europe and national conditions to achieve regime transitions at the water basin scale?

The authors looked at the accessibility of water systems as a natural resource for various users and use functions. In that context they considered rivalries between users and use functions as an indicator for insufficient sustainable use of water systems. A water system means a discrete and homogeneous element of surface water or groundwater such as an aquifer, a lake, a reservoir, a stretch of stream, river or canal, an estuary or a stretch of coastal water. The authors assume that sustainable use of water systems requires an optimal distribution of use options among present and future users and use functions. As an example of distribution of use options one could think of the distribution between upstream and downstream users. An upstream water polluting activity (use of a stream for discharge of waste or waste water) could interfere with the downstream use of that stream for drinking water supply. Or an upstream weir could impede the downstream flow and flow dependent use options. Such rivalries not only exist between different (heterogeneous) use types, they may also appear among homogeneous uses (uses of the same type). In arid areas farmers may feel the need to coordinate the water use for irrigation. Or in the field of fisheries, quota may be used as an instrument to prevent overuse of fish stocks.

A water system is often demarcated as a river or water basin, which means the area of land from which all surface water run-off flows through a sequence of streams, rivers and, possibly, lakes into the sea at a single river mouth, estuary or delta. This implies that a water basin not only includes the water beds, but also the surrounding area of land for which the water bed adopts and transports the water run-off. In this view the land use of river flood plains for urban development should be considered as a use that interferes with the use of flood plains for river dynamics and flooding. Another example of a water-use rivalry in a water basin could be the rivalry between drainage of land for agricultural development versus the function of a minimum groundwater level for nature conservation in that area.

The main question for the researchers in this project was if the regime for the management of a water system provided sufficient guarantees for a sustainable use, by means of diminishing or preventing rivalries between users and use functions. To answer this question the authors focused on institutional regimes for natural resources both from a public governance perspective (Bressers and Kuks, 2003) and a perspective of private property and use rights (Ostrom, 1990; Bromley, 1991). The first perspective focuses on the management of natural resources from a public domain (although in interaction with private actors). The second perspective focuses on the accessibility of a natural resource in a broader sense, including the private domain, the domain of collective property and use, as well as the domain of 'no property' (*res nullius*). By applying both perspectives in a complementary way, the authors have developed a framework for

understanding of water basin regimes¹. For instance, the option to have an intervention from the public domain could be blocked by the existence of a private domain on basis of long term concessions for water use (which especially in Spain and Switzerland appears to be a problem of redistributing water access rights). On the other hand, attempts initiated by the public domain to redistribute private property and use rights could be effective in providing a better access or protection to alternative users and use functions.

The authors aim to examine when, whether, under what conditions and in what form integrated water resource regimes are established which can successfully regulate all of the use demands and thus react to the growing scarcity of goods and services provided by a water resource or the depletion of its stocks. A historical screening of water resource regimes in the different countries is used to examine whether the emergence of resource regimes corresponds to our theoretical phase model and whether the suggested transitions from complex to integrated regimes can be identified. This development of national regimes has been examined for a period extending over more than hundred years (from the early 19th century until the end of the 20th century) (Kissling-Näf and Kuks, 2004).

Since the authors are particularly interested in the change from complex to integrated regimes, they subsequently studied two cases of water basins in each of the six countries involved, to get a better understanding of the specific conditions under which regime transitions towards integration appear. The case studies focus on the last three decades of the twentieth century (1970-2000), in which all countries have attempted to achieve integrated water management (Bressers and Kuks, 2004).

In the next section some theoretical backgrounds of the study will be addressed. Section 3 will describe, compare and explain the water management national regime changes in six European countries. Section 4 will revisit the theoretical considerations for the purpose of case comparison and also present the result of the analysis of 24 attempts to gain more integral management in 12 water basins. Section 5 presents some conclusions in the perspective of European water basin management policy.

INSTITUTIONAL SUSTAINABILITY BASED ON EXTENT AND COHERENCE OF THE REGIME

Ecological sustainability depends on institutional sustainability and sustainable management as preconditions. The authors were especially

i This framework has its roots in the framework of a Swiss project that was developed by Peter Knoepfel, Ingrid Kissling-Näf and Frédéric Varone. For more information see www.idheap.ch, Knoepfel et al. (2000, 2001) and Kissling-Näf and Varone (2000a, 2000b).

interested in the interaction between property rights and public policy and how this interaction could contribute to more ecological sustainability. They look at institutional arrangements or regimes that have been developed through the years to manage conflicting water uses and to guide these uses in a sustainable way. Part of the regimes is that they do establish property rights and use rights towards water resources, in order to clarify the ownership, but also to restrict the owner's water use by allowing others to make use of the same water resources. The possession of titles, the exclusion of uses, and the access of users are organized by this. Another part of the regime is that supplementary policies are formulated to help these property and use rights work in the targeted directions. Studying the evolution of resource regimes, there is a focus on the 'extent' of a regime (i.e. the uses and use functions that are regulated by a regime and therefore belong to the regime's domain) and on the 'coherence' of a regime (i.e. the match between the regime's elements, especially the match between property rights elements and public policy elements).

The *extent* or fullness of a regime refers to the number and the restrictiveness of its rights. It can be compared to a continuum, with *laissez-faire* arrangements on the extreme one side, under which individual participants are free to use a resource without any constraints imposed by some system of property and use rights (i.e. the case of 'no regime') and institutional arrangements featuring central planning combined with extensive structures of rules governing the actions of users on the opposite extreme side. Most of the real-world regimes fall somewhere in between these two polar cases. If a certain use of the water resource (e.g. fishing) is not regulated or considered by any of the regime elements, it does not belong to the extent. Likewise if only professional fishing is regulated, but not sports fishing, the sportsmen involved do not belong to the extent. Change in extent will often mean that more uses or use functions are incorporated. It is typical for many cases that nature (living environment) gets recognised as a use function and considered by the regime. A larger extent makes the regime more 'meaningful' for the use of the resource. But there is also a danger. If the incorporation of additional uses/users in the regime takes place by new separate property rights and/or public governance aspects, this might lead to a decline of the coherence of the regime. In this way simple regimes evolve into complex ones.

The concept of *coherence* refers to the degree of consistency among the elements of a resource regime. For instance, use rights frequently come into conflict with private ownership rights. Young (1983) argues that resource regimes need to be accompanied by administrative organizations and policies, especially to cope with problems of interpretation and dispute settlement. We understand regime coherence as the degree of consistency within and between the property rights structure and the governance

structure of a resource regime. Therefore, we distinguish between the following regime variables:

1. Extent of a regime
2. Internal coherence of the property rights structure of a regime
3. Internal coherence of the governance structure of a regime
4. External coherence between the property rights structure and the governance structure of a regime.

The governance structure of a regime can be analysed along five dimensions or elements. Thus, the internal coherence of the governance structure of a regime can be parsed into (Bressers and Kuks, 2003):

- Coherence of levels and scales of governance;
- Coherence between actors in the policy network;
- Coherence of problem perception and objectives;
- Coherence of strategy and instruments;
- Coherence of responsibilities and resources for implementation.

An example of an inconsistency between the elements of public governance is when a new problem perspective is accepted, but no new targets are formulated for that newly recognised problem or it is not recognised that the new targets are contradictory to the existing ones. It would thereby create the risk that 'the left hand is undoing what the right hand is doing'. These are examples of a mismatch within an element. When the new objective is not followed by instruments to attain it, this leads to a mismatch between elements of governance. An example of a misfit in the property rights system is when new users are granted use rights without recognising that this may harm existing use rights, for instance when water scooters are allowed in a lake where a sports fishing association holds an exclusive fishing right. An example of lack of coherence between property rights and public governance occurs when policy instruments address other actors than the ones that hold relevant use rights.

So they interpret 'regimes' as institutional resource regimes, comprised a public governance component and a property rights component. The combination of those components can be more or less integrated and influences the sustainability of the use of the given natural resource. In turn, these regimes, or rather their property rights and governance components, are influenced by external change agents, which leads to regime change. Figure 13.1 illustrates these dynamicsⁱⁱ as will be investigated in the case study comparison.

ⁱⁱ We acknowledge the existence of several other possible feedback relations, but they are not presented in the graph since they receive less attention in our discussion.

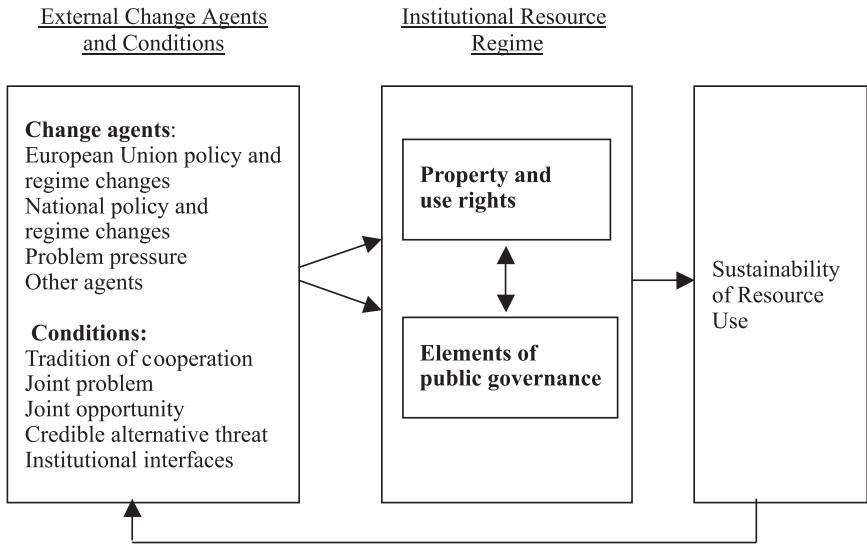


Fig. 13.1. Research model

As the figure shows there are three groups of variables. These are linked by the central relationships in the research questions:

1. How far do more integrated water resource regimes lead to more sustainable resource use?
2. What change agents and conditions cause shifts towards more integrated regimes?

The integration of the ‘institutional resource regime’ is the central variable. Question 1 should show the results of such integration and Question 2 should provide explanations for it.

In general, the authors expect the elements of public governance (and the regime in general, i.e. including property rights) to exert a stabilizing influence on each other. This stabilizing influence occurs through processes of mutual adaptation of values, cognitions and resources. Thus, while changes in the elements of the governance pattern can be caused by changes in other elements, ultimately these changes must have external sources affecting one or more elements from the outside. Mutual adaptation mechanisms that, without external ‘disturbances’, have a stabilizing influence become the mechanisms by which substantial changes in one of the elements are followed by responding changes in other elements, resulting in complete regime changes.

Sources and Nature of Change

In principle, external change agents can enter the scene through all of the

elements that are discerned in the regime. There is a difference, though. Property rights might be conceived as somewhat more stable and less oriented towards invoking change than the elements of public governance. This means that, although property rights may act as a powerful context for developments in public governance, changing governance patterns is not their subject per se. On the other hand, interventions from the governance side often have the specific and deliberate intent to change property rights.

External change agents for the governance pattern stem from changes in political institutions, in the general policy process or policy processes in related fields, the spectrum of technological, demographic, and cultural developments mentioned above, as well as feedback from the actual problem situation. While these fundamental sources of change agents are grouped by separate elements of the regime, the authors in the empirical research use a general categorization of the more direct change agents that evolve from these fundamental ones:

- a. European Union originated policy pressures;
- b. National regime developments;
- c. Problem pressures;
- d. Various other pressures (e.g. rise of environmental NGO's).

These groups of change agents can be related to the development of regimes. The regime can be portrayed as moving from one stage to another. As long as one acknowledges that various intermediate and mixed situations are possible and probable, such stages can be a useful heuristic. The integration of regimes can be described in terms of extent and coherence. The extent of a regime is the scope of the uses and users that are regulated by one or more of the regime's elements. Coherence is the degree to which these elements fit together. Very simple regimes regulate only one resources use or user. It is the way – in theory previously unregulated – resources begin to be a subject of regimes. Furthermore, relatively singular (or simple) regimes (one level, one governing actor, one problem aspect – e.g. a certain use or user – one instrument, one implementing agency) will not need coherence. Only after growth in complexity does coherence become a relevant concept. But then, it is by no means a logical follow-up. Complex but fragmented regimes are empirically quite common. In fact, while integration has clear theoretical advantages, it comes with a price. Every form of integration creates the need for additional interaction and increases transaction costs, at least initially. While more complexity is part of a stream of societal developments that seem to increase as time goes by, both coherence and fragmentation seem to be common developments.

Complexity means that regimes can be characterized by multiple formats in most of their elements. The most eminent feature is the gradual increase of the domain of the regime, that is the uses and users regulated by one or

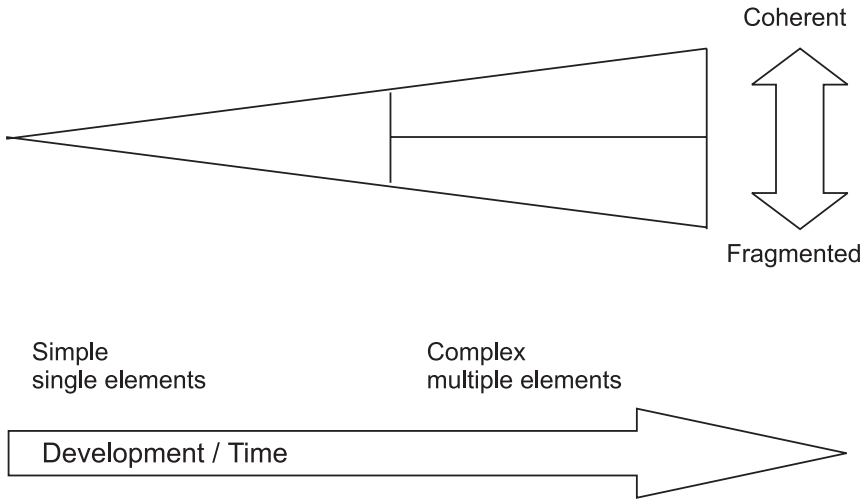


Fig. 13.2. Regime developments

more parts of the regime. This crucial variable will be referred to as the regime’s *extent*. Regimes with an insufficient extent are by definition weak as guardians of sustainable use, while some relevant parts of the domain go unregulated. With it also comes an increase in relevant property and use rights. The elements of governance tend to differentiate too: more layers and scales, more actors, and more perceptions of the problem and accompanying goals are involved, more instruments are part of the policy mix and more organizations share responsibilities for implementation.

Thus, complexity as such is not wrong. Most of the time, growing complexity is an answer to real needs and developments. Societies generally grew into more complexity during most of modern times. The sector of water management is no exception to that general course of development. A growing complexity in governance can be viewed as a logical adaptation to that development. This leads to the first hypothesis:

Hypothesis 1

The observed change agents (in the period and context of our cases) will lead to more differentiation in the regime (resulting in more complex regimes), but not without additional prerequisites to more coherent regimes.

While the term ‘integration’ is common in most policy papers (e.g. ‘integrated water management’), in this project the authors have chosen to use the term coherence instead, for the reason that, in most policy papers the term integration is used in a sense that implicitly or explicitly includes an increase in the domain of the regime, the extent to all relevant users and

uses. Therefore, the authors believe that integration as it is used in the policy sphere is a combination of what they call *extent and coherence* (see section 2). For the sake of conceptual clarity and the possibility to adapt to the meaning of the term integration in policy practice, they use these terms further when appropriate, and reserve 'integration' for the combination of the two.

Conditions for Coherence

Change agents and conditions belong to the same set of causal factors, but a distinction has been made because the 'conditions' are often forgotten. Causal explanations are often sought in the form of 'new' and 'provocative' factors that are labeled as the 'causes'. In reality, this image of causality often forgets the array of factors to which the analyst is used as being the 'normal' status (causal factors that one is inclined to forget about). It might then be delusory to think that the 'causes' really are the complete explanation of what happens.

A simple example may clarify this. When a fire burns a house and one seeks the cause, one will be looking for sources of fire (e.g. an electrical short circuit) and exceptional forms of flammable material (e.g. a leaking cooking gas container). The presence of a great deal of flammable material and sufficient oxygen in a house will be considered 'normal' or will not be even considered at all, while these factors are, of course, as essential as the previous ones.

In the case studies described in this chapter, the division between the 'extraordinary' causes (labeled 'change agents') and the 'normal' conditions are not as clear cut as in the example. Nevertheless, also in the case studies analyzed in this chapter similar change agents sometimes set in motion a development towards coherence. The reasons why similar problem pressures all over Europe and similar EU and even national developments have dissimilar effects on water management regimes at the case level are interesting. Here the 'conditions' enter the picture. The authors hypothesize the following relationships:

Hypothesis 2

Attempts to change regimes into a more coherent status will have relatively more success when:

- There is already a longer *tradition of cooperation* in the water management sector.
- There is a common understanding that the counteracting (side) effects of non-integrated water management harm sustainability and that this sooner or later will have to be stopped somehow (*joint problem*).
- There is a notion of possible joint gains from coherence, so-called 'win-win situations' (*joint opportunities*).

- There is a credible threat of a dominant actor accumulating power and altering the public governance pattern in his interest when no solution is reached (*credible alternative threat*).
- There are well functioning institutions that provide fertile ground for coherence attempts (*institutional interfaces*).

Sustainability Implications of More Integrated Resource Regimes

The sustainability of a given institutional resource regime depends on its property and use rights component, the public governance component, and the interaction between these. The expectation that more integrated regimes will *ceteris paribus* perform better for sustainability is part of European political ideology on water management. This section will briefly, theoretically underpin this relationship starting with some remarks on how the variable ‘sustainability of the use of the natural resource’ was dealt with.

The overall sustainability of resource use is beyond the capacity of authors as social scientists to judge and the main focus was the effects of the observed regime changes. This starting point is also part of the solution to the first problem. The assessment was concentrated on the *implications of the observed regime changes* for indicators that are relevant to sustainability. Developments in sustainability of use that clearly had nothing to do with observed regime changes, for instance climate change or rapid economic development, were excluded from the judgment.

The balance between environment, natural resource protection and risk avoidance on one hand and the economic and social implications of these ecological changes and/or measures taken to achieve them on the other hand is a hard nut to crack. The authors were not inclined to judge in favor of increased sustainability without some ecological improvements, even though economic or social indicators might have improved. Attention was also paid to the relevant EU ‘good status’ indicators.

Sufficient *extent* as a precondition for a benign effect on the sustainability of the use has been previously explained. Non-regulated uses and users will tend to disrupt the regime effects on sustainable use. The *internal coherence of the property and use rights component* is important for the sustainability of resource use since such coherence enables stakeholders to better come to an agreement to guard a sustainable use even without government interference (Ostrom 1998; Sandler 1992).

The *internal coherence of the public governance component* is important because it lessens the chance that negative side-effects of one element (level, actor, instrument, etc.) undo the positive effects of another element (cf. Ligteringen 1996). Stronger coherence will also increase the visibility and feasibility of chances to create more synergy of the various elements. More

coherence can also lead to less initial uncertainty, and increase in information exchange and trust, important for dealing with uncertainties (cf. Arentsen et al. 2000). The chances also get better for productive combinations of motivation, information and balance of power with the actors involved in policy implementation processes (cf. Bressers 2004).

The *external coherence between the property and use rights component and the governance component* deals with the degree which the proper connections are made between the elements of governance (for instance policy instruments) and the relevant aspects of property and use rights. For instance: are the actors that hold the relevant property and use rights also the designated targets of such policy instruments?

This leads to the last hypothesis:

Hypothesis 3

- a) Regimes with a deficient extent will more likely lead to degradation of water resources or inability to protect the ecological functions of the water resource, than regimes with a larger extent.
- b) Regimes with a large 'extent', but with low coherence will more likely lead to degradation of water resources or inability to protect the ecological functions of the water resource, than regimes with a similar extent but a higher degree of coherence.

In the next section developments on the national level will be discussed. The case study comparison, including the testing of the above hypotheses will be done in section 4.

CHANGES IN NATIONAL WATER REGIMES IN EUROPE

Introduction

This section presents a comparative survey of regime development in the six European countries that are studied. The survey focuses on the main regime transitions in each country and explains what has actually changed in terms of water rights and water policies. The idea behind screening the evolution of the national water regime in various countries has been to determine whether an evolution occurred from simple to complex to integrated regimes and to explore in particular the transitions from one regime phase to another. Although a common evolution pattern has been observed in all our selected countries, from simple to complex to integrated, the transition moments appear to vary in time. It is interesting to see when and how a regime changes in a country, and to identify the triggers and circumstances that have generated or allowed change. Especially the transition from a complex regime to an integrated regime appears to be a complicated one. While all countries are showing attempts towards

integration, they vary in the degree to which these attempts have improved the institutional sustainability of the national water resource regime. The Netherlands, France and Switzerland were relatively early in their attempts at integration, while Belgium, Spain and Italy are lagging behind in very different ways.

The Netherlands

The Netherlands includes a delta area for three European river basins. The need to protect the land from high water from rivers and sea, and the tradition of artificially draining low-lying areas, has given the country a complex hydraulic infrastructure. In the 1960s and the 1970s the traditional water engineering approach was criticized, which resulted in the adoption of rival water values and the greening of water engineering. From 1985 on ecological aspects of water systems are incorporated in water management, shifting the regime from a complex to an integrated status. Since the early 1990s the country is involved in a paradigmatic change of its flood protection approach, trying to store water in retention areas, while maintaining but not expanding the country's infrastructure of dyke fortifications. Especially in flood plains new rivalries evolve between water use and other land uses. This requires not only integrated water management, but also integration between water and land use management. This is a new integrative challenge for the country, although it initially decreases the coherence of the water regime until that regime has developed mechanisms for a better control over land use rights to protect floodplains.

Belgium

Belgium is a federal state with three regions (Brussels, Flanders and Wallonia) which are rather autonomous in their water management since 1993, when the Belgian state became a full federal state. However, the complicated process of federalisation delayed – compared to other European states – an effective approach of water problems. The Belgian case is interesting in that it shows two regions with different types of public domains. Although both main sub-states show an expanding public domain, in Flanders the public domain is based on private ownership by the state, while in Wallonia the regulation of use rights on the basis of public law is a way to get public control. In Flanders water management procedures are more centralised and more submitted to central planning, while in Wallonia the local level is much more autonomous and water management is characterised by bottom-up decision-making. Both regional systems are insufficiently integrated. The Flemish system is lacking participation of local actors, while the Walloon system is poor in planning.

The country performed good integration attempts in the 1990s, but delayed a great deal in its implementation of its water policies, especially the one for surface water protection. Compared to the other European countries studied, Belgium has a very poor performance in wastewater treatment. The complicated, drawn-out process of institutional reform in this country is a significant explanation for the delay. Since the mid-1990s, in both regions a lot of work has been done to create a coherent water management framework of legislation, institutions, policies and plans. New water pricing and wastewater charge and tax systems have been in place since the early 1990s to help finance the investments being made in new sewers and wastewater treatment plants. Industrial pollution discharges have been reduced since then.

France

Water basin management in France had an early start. In 1964 the country had already adopted water legislation which created water agencies at basin scale, recognising regional variation and the need for specific solutions. Almost 30 years later, in 1992, France adopted another important water act, based on improved integrative thinking, promoting planning, creating local institutions, better addressing environmental issues, for instance by introducing a better application of cost recovery and the polluter pays principle. The French regime is strong in taking into account regional differences by means of innovations in administrative organisation and planning. However, water management has mostly been governance driven; the property rights structure is hardly affected. Until now, this is a weak point in achieving a further integration of French water management.

The Water Act of 1992 was a crucial transition, while water basin management had an early start in that country. However, a weak point is still that the regime is very much policy driven and that it is reserved in affecting the property rights structure. This appears clearly in case of regulating the agricultural target group.

Spain

In Spain water scarcity is dominating the agenda for water management. The strategies to deal with water scarcity seem quite diverse and broadly confront those in favour of a supply approach and demand approach. While policies at the national level seem to favor the first of the two approaches, that consists of the construction of large hydraulic infrastructures transferring water between river basins, there are few experiences in which the traditional approach has been replaced by a new one in which rationality of water use is a guiding principle. The two cases

analysed in this chapter constitute two experiences with demand management. Both cases show regime changes that are property rights driven, but they vary on the strategy that has been followed. One case depicts a bottom-up process opening doors to a multi-actor negotiation pattern, while the other one utilizes a top-down process in which central actors have initiated a change of the property rights structure.

The late start of a democratization process in 1978 and the relatively new entrance to the European Community in 1985 are responsible for a delay in water management performance and a late environmental policy in Spain. Although the country has been very active since the mid-1980s to harmonise with European standards, its water regime is focused on dealing with water scarcity and therefore quantity and quality management are still not well integrated. Water scarcity is dominating the agenda for water management. The strategies to deal with water scarcity seem quite diverse and broadly confront those in favour of a supply approach and those in favour of a demand approach. While policies at the national level seem to favour facilitating water supply by means of the construction of large hydraulic projects, transferring water between river basins, there are few experiences in which this traditional approach has been replaced by a new one in which demand control is a guiding principle. Although the 1985 Water Act and the institutionalisation of a new environmental ministry in 1996 are clear attempts at resource protection, private property rights and granted long-term concessions still obstruct policies that aim at ecosystem protection. However, the 1985 Water Act and its amendment in 1999 have been attempts to strengthen the public domain, to impose restrictions to the exploitation system, and to achieve more efficiency (demand management). On the other hand, the failed attempts to adopt a National Hydrological plan in 1993 and 1994, and the opposition surrounding the adoption of that plan in 2001, reveal an absence of regime coherence. The National Hydrological Plan of 2001 is firmly based on huge inter-basin transfers of water as a way of redistributing water on Spanish territory. In this way, the plan does not face the scarcity problem by adopting efficiency criteria based on the rationalisation of its use and the modernisation of irrigation systems, but by constructing large infrastructural projects having an impact on ecosystems at a large scale.

Italy

Despite its European membership from the beginning, the country has been very late in the implementation of European water policies in its national water management. Until 1986, it left most responsibility for water management to regional and local authorities. The delayed integrative thinking at the national level, as well as fragmented integration attempts

at the national level, are responsible for a complex and still very fragmented national water regime. Water management in *Italy* is incoherent due to the fact that it struggles with three competing integration principles introduced in the last 15 years. These principles have a different definition of the problem, they assume different constellations of actors involved, and they have different implementation problems. The first integration principle was adopted in 1989. It promotes integration at the scale of river basins, mostly concerned with the quantitative dimension, and managed by a network of water basin authorities. The second principle, adopted in 1994, advocates integration at the scale of the optimal area for water supply and purification, mostly concerned with the establishment of an integrated water service, and therefore with water as a commodity, and managed by a network in which the regional governments and local authorities play a major role. The third principle, adopted in 1999, introduces integration at the scale of the water body, mostly concerned with the qualitative dimension, and managed by a network in which the regional governments and the environmental administration seem to be the key actors. The implementation structure for these three principles is not only too complicated but also too simple. The local authorities especially have too many roles to play at the same time, which results in an unstable regime, because they have to choose which role to play.

Despite this regime fragmentation, Italy has clearly chosen in 1994 to claim the public ownership of all water resources and to set a hierarchy between various uses of water, giving priority to human consumption. By this, environmental and sustainability considerations were explicitly addressed.

Switzerland

Switzerland is often typified as the “water tower” of Europe due to its high precipitation and relatively huge freshwater stock. It is remarkable that this country always has been very proactive in resource protection and water management and tried to harmonise with European standards for water management, but that it did not build up an integrated regime. Although its regime could be highly qualified in terms of its contribution to ecological sustainability, the regime is fragmented into three persisting policy communities. Switzerland has a (con)federalist system where cantons often function as laboratories for national solutions. The heterogeneous geographical situation leads to very different solutions to water problems. The strong position of the cantons gives room for highly varying resource regimes at the regional level, in which the property rights structure appears to be stronger than in most other European countries (except for Spain). At the level of the confederation, Switzerland is somehow silently and

gradually adapting to European standards and directives, due to strong economic and trade relations with the EU. However, the country is not easily adopting the river basin approach as advocated by the EU, since its water regime is fragmented and organised according to rivalries. Three important institutional arrangements for water management are identified, which are separated along three traditional issues: flood protection (recognised by 19th century legislation); utilisation of water, mainly for hydropower (recognised by early 20th century legislation); water protection (recognised by water quality legislation in the 1950s, and strengthened by additional legislation in 1975 and 1991, which added a quantitative dimension). These three separate policy communities appear to be very persistent and only tend to open up under very heavy pressure. In the 1990s there was great awareness in Switzerland of how crucial water is to the quality of life and how crucial it is to develop an integrated approach. Numerous projects reflect this integrating function. However, water policy has hitherto benefited little from integrated management that takes account of all functions and resource users (e.g. nature, agriculture, energy, land use planning). Long-term water use concessions for hydropower generation very much obstruct ecosystem protection.

Conclusion: Highly Complex Institutional Regimes Struggling with Fragmentation

In this section the authors have considered institutional sustainability in terms of the extent and coherence of resource regimes. A combination of high extent and high coherence indicates an integrated resource regime. They conclude that all the national resource regimes considered have been evolving towards an integrated regime from the 1980s onwards. France and the Netherlands have established the most integrated regimes. The regimes of the other countries should be typified as complex regimes (high extent but low or medium coherence). However, all these countries (including France and the Netherlands) struggle with complexity and all suffer at various degrees from fragmentation. So the better conclusion might be that the French and Dutch regimes are less fragmented than the others. With respect to coherence, a distinction is made between the external coherence of public policies and property rights, and the internal coherence of the property rights subsystem and the public policy subsystem – each considered separately. The French and Dutch regimes in particular are integrated in terms of a high internal coherence of the public policy subsystem. They are still struggling to improve the external coherence between their public policies and existing property rights. Although both countries have developed a strong public domain (in 1992 water became a ‘res nullius’ in the Netherlands and France proclaimed water an object of

national heritage, which could be interpreted as proclaiming that it is 'state property'), they still have problems with effectuating use rights that interfere with the policy objectives of water management (for instance, land use rights in floodplains in the Netherlands, and agricultural water use rights in France). Countries like Italy and Spain have formally proclaimed that water belongs to the public domain (Italy in 1994; Spain in 1985), but Italy suffers from a low internal coherence of its public policy subsystem, while Spain has not been able to eliminate pre-existing private property rights over water. Furthermore, the long term character of Spanish water use concessions and the way inter-basin transfers are allowed are detrimental to the public good claim on water resources. The Spanish regime therefore suffers from external incoherence between property rights and public policies, as well as incoherence within the property rights subsystem. In the case of Switzerland, the country also has developed a strong public domain, but the national regime suffers from internal incoherence of the public policy subsystem (based on three separated policy communities) and from external incoherence between federal policies and the rigid property rights structure which is strongly in favour of protecting disposition rights by the cantons and existing concessions for hydropower generation. In Belgium the picture is mixed due to the autonomy that the regions possess to develop their own water regime. The regime in Wallonia seems to be more public policy-driven, while the regime in Flanders is more property rights-driven. Belgium suffers from a relatively slow development of extent, which appears especially from the late recognition that surface water protection policies had to be effectively implemented. This is particularly due to the process of institutional reform (federalisation) which enforced a severe delay on the evolution of the Belgian water regimes.

In all six countries we noticed in general a strongly increasing complexity of bundles of property rights and a strongly evolving public domain in terms of a communalisation of water ownership and use rights. Young has already explained that "though private property is often regarded as sacred, the rights of private owners have been significantly curtailed in many areas through the actions of public authorities, and the power of eminent domain is regularly used to take private property for public purposes in the absence of voluntary consent" (Young, 1983). He indicated that "there has been some tendency for these restrictions to become more extensive in modernised and densely populated societies" (Young, 1983). We also notice that in Western European countries, even in the early 19th century, water resources and the benefits they could generate were never entirely subject to private property. There have always been restrictions on private ownership and private use rights by the legal definition of some public domain. However, during the 20th century, and especially after World War

II, an increasing nationalisation or communalisation of water resources could be perceived, in spite of the ownership arrangement. States are increasingly controlling the access to water resources and are allowing more and more users to claim some form of access. Since the 1970s, new forms of access are especially being given to recreational, environmental and ecological use functions of water bodies. On the other hand, in terms of restricting private use rights, it still appears to be difficult for Western European states to get a grip on water use rights that cause diffuse water pollution or water depletion, and on land use rights in floodplains that indirectly contribute to problems of flooding as well as droughts. So the public domain of these countries is still weak in terms of restricting private property in these aspects, and thus national regimes are weak on external coherence in this respect.

Considering the public policy subsystem of resource regimes and its internal coherence, the following discussion is based on the five dimensions of governance 1. multi-level; 2. multi-actor; 3. multi-perspective; 4. multi-instrument; 5. multi-resource. With respect to the multi-level dimension the authors conclude that most countries are struggling to develop an effective structure for co-governance between the various administrative levels involved in water management. The French and Dutch structures are the most elaborate; Belgium has set its final structure just recently (1993); Spain is struggling with interventions in the autonomous regions from the central level (inter-basin transfers); Italy is weak on providing integration from the central level; Switzerland is struggling with incoherence between federal attempts to integrate and a strong cantonal autonomy, on which the implementation of federal initiatives depends completely. With respect to the multi-actor dimension, it is observed that in all the six countries an increased participation of new users, environmental NGOs, and the general public in water issues. However, the degree to which this participation is institutionalised varies a great deal among the countries: participation is more institutionalised in the Netherlands, France and Switzerland than it is in Belgium, Spain and Italy. With respect to the multi-perspective dimension the authors conclude that all countries are rather similar in the evolution of extent. Although there are great ambitions for water management in all countries, the effectiveness of this ambition very much depends on the two dimensions related to the availability of policy instruments and resources for implementation. With respect to the multi-instrument dimension and considering the adoption of integrated water legislation as an important indicator, it is observed that the Netherlands and France have adopted such streamlined legislation, considering the resource as an integral one (in terms of quantity, quality, surface and groundwater, as well as the ecological aspects of the water system) in 1989 (the Netherlands) and 1992 (France). Italy and Switzerland show attempts

at integrated legislation in 1989 (Italy) and 1992 (Switzerland). Although these attempts have an integral appearance, they are based on an incomplete integral approach. Belgium and Spain have not yet developed integrated legislation. With respect to the multi-resource dimension the authors conclude that the countries show a huge variation. The availability of resources for implementation partly depends on the creation of an effective structure for co-governance between the various administrative levels. It also depends significantly on the availability of money for implementation, important indicators of which are the public expenditure per capita on water management and the application of full cost recovery of water services. The authors noticed that the Netherlands, France and Switzerland have a much greater public expenditure and have more strictly applied the full cost recovery principle than Belgium, Spain and Italy.

To summarise the evolution of national water regimes: property rights on water resources have developed into more complex bundles of rights, especially from the 1950s on. The need for coordination increased. A public domain evolved in which public authorities are restricting private use rights to guarantee access by rival users and to protect use functions of water resources (especially environmental and ecological functions) which are not very well represented by specific target groups. Despite the fact that a strong public domain is in place, this domain still has problems with getting a grip on specific private use rights when certain activities cause diffuse pollution, when economic activities require water uses, and the problem of land use in floodplains. Furthermore, the public domain is struggling with incoherencies in the public policy subsystem of the regime. Aspects that especially deserve attention are an effective, multi-level organization of water management (in terms of co-governance between central and decentral authorities), institutionalization of participation opportunities for rival users, developing integrated legislation, and creating sufficient resources for implementation in terms of public expenditure and based on full cost recovery of water services.

EXPLAINING CHANGES TOWARDS MORE INTEGRAL LOCAL WATER BASIN MANAGEMENT

Introduction and Methodology

The case studies are described in two different parts: the first one is a descriptive one, in which the emphasis lies on the story or stories to be told. The second one is an analytical one in which presents assessment of values of the variables that play a role in the theory that is used in the intra- and/or inter-case comparisons to arrive at an answer to the research

questions of the project (Dente et al. 1998). In many cases, the case study will contain more than one story of regime change. This may imply developments that can be seen as partial coherence in geographical sub-units of the case study territory or between certain aspects of the resource use but not between othersⁱⁱⁱ. These sub-stories have not been submerged to force them into one over-all case description, but separate attention is paid to them against the background of descriptions of the more general case situation and development. In this way the 12 case study areas are discussed in 24 sub-cases. In many instances, this also means that not only regimes on the water resource, but regimes on land use, nature protection and other natural resources (e.g. fish) were also at stake.

The analytical part of the case studies consists of the assessment of relevant variables (translating 'real life' observations into theoretical language) and the inferences and conclusions that can be based on these variables and their relationships. As an aid to the comparative analysis, questionnaire forms were used for the case study researchers to fill in. These 'case study fact and assessment sheets' represent the variables and indicators of the theoretical model. Their purpose was to summarize the case information in a uniform format so that the case is comparable along the lines of the theoretical variables and hypotheses. The exercises of filling in the forms also proved very helpful in getting a grip on the case analysis itself. Apart from the few short statements per variable ('key facts'), the researchers were asked to use a five-point scale to score the variables in order to make the cases comparable.

The great advantage of this procedure is that the people who do the assessments have extensive and intensive knowledge about the cases at hand, often even more than they described in the reports. In this way, the authors have tried to combine the best of both worlds: the depth of information realized in extensive case studies and the clarity and overview of a data-matrix enabling all kinds of comparative analysis (cf. Patton 1980). Compared with the direct, qualitative comparison of the case studies as reported, the approach diminishes the risk of bias that the comparative analyst is misled by surprising, but anecdotal evidence of only one or two cases not representative of the relationships in the whole sample.

This section presents the results of the comparative analysis. This is based on the assessments of cases (including sub-cases) by the researchers of the main variables of the theory. These assessments were based on ordinal scales with five values. The 24 (sub)cases and 13 variables per case are of

ⁱⁱⁱ Compare a detective story in which more than one murder takes place. If these are interconnected it makes no sense to divide them into sub-cases, but if they are just connected by the fact that they take place in more or less the same period, they will probably have quite different plots that require separate attention when analyzed.

course too many to be handled in a purely qualitative way. Therefore the analysis below mostly uses descriptive and analytical statistics that are apt for ordinal level variables. Some of the main conclusions are illustrated by real life examples from the case studies.^{iv}

In this section first the developments for the central variable are presented, the regime changes, followed by relating them as independent variable with the sustainability of the resource use. In the last part regime changes are considered the dependent variable and it is observed how incentives and circumstances have influenced them.

Regime Changes

What interests the authors is the degree to which the listed aspects of the regime, separately and as a set, moved in the direction of more integration (extent and coherence) in the cases studied.

The *extent* is the degree of completeness of the domain of the regime in terms of relevant uses and users. In most of the cases and sub-cases in the study the extent of the water resource regime changed positively, in many cases even to include more or less all relevant uses and users. Almost always the introduction or the increase in valuation of the protection of the environment and nature are part or even the core of the extent changes. Sometimes new human uses like tourism are the extra issues that are taken into account. Where ecological values were already incorporated, new issues might arise, like diffuse agricultural pollution.

The *internal coherence of public governance* is the degree to which the interdependencies in the water system and its management occur in reality, and are reflected within and between the contents of the elements of public governance. The internal coherence of public governance generally increased too, but less than the extent. Almost nowhere could a 'full coherence' statement be made and in several instances only small improvements occurred. The changes in the internal coherence of public governance in most cases included aspects of all five elements of public governance: levels and scales, actors and networks, perspectives and objectives, strategies and instruments, and responsibilities and resources for implementation.

Illustration 1: Remaining difficulties with non-river basin jurisdictions

In France the SAGE process has generated a collective dynamic. Among other things the extent of the regime that was slowly built before, was quickly enlarged. The SAGE process could build on the gradually

^{iv} These illustrations are derived from the case studies that are described in Bressers and Kuks (2004).

increased openness to cooperation that emerged over the last 25 years. The SAGE procedure has led to awareness of most (and new) stakeholders that they are not the only one 'main' user. But that doesn't always imply that there is participation from all actors or this participation is dedicated to reinforcement of collective action, but rather considered by some powerful users as a way to get information that helps them to keep their power. They proceed actually in behind-the-scene negotiations. Therefore, the participation is often only to defend one's own interests. Some powerful actors, like industrialists, abstain from further participation once their interests are safeguarded, mainly because their management of water and wastewater relies upon technical supports (i.e. when their demand is satisfied they often do not see an interest in participating any more since they cannot really get more assets). The main problem remains that there can be lack of coordination or even competition between state administrations at the regional and departmental levels. There can be incoherence in rules and public actions when administrations share the same river. In the case of the Sèvre Nantaise, where the river is the boundary between two departments, you can take all the water you want on one side, while it is forbidden on the other side. (*Isabelle Verdage, Jean-Marc Dziedzicki & Corinne Larrue, Sèvre Nantaise case study*)

The *internal coherence of the property rights* is the degree to which the interdependencies in the water system and its management that occur in reality, are reflected within and between the property and use rights. The essence of this variable is that property and use rights of the one do not inherently or under the given circumstances cause rival uses to unavoidably affect the sustainability of the resource, without external intervention. With the internal coherence of the property rights the picture is somewhat more differentiated. In two cases no improvement or even new inconsistencies occurred. But there were also four cases with a rather complete (change to) coherence in this respect. Generally when absolute limits of the resource are at stake (water, fish) the property and user rights are used more for self-regulatory regimes, than when the protection of the quality of the resource (water, landscape, shores) is at stake. For the water resource in a stricter sense this means that predominant protection by property and use rights occurs more in the 'dry' cases than in the 'wet' cases. In 'wet' cases property and use rights are often restricted and must give way to public governance in order to improve the sustainability of the resource use. At least, this seems to be common practice.

Here, for instance, developments were reported like the transfer of shares in relevant private and public companies, privatization, gradual acceptance of the water body as a common good, the lack of introduction of concession system with new uses, introduction of tradable fishing rights, multi-level issues like state ownership as a basis to allow new uses (e.g. to issue gas drilling concessions), while provinces and municipalities hold the public

authority to protect other uses, the redistribution of property and use rights, disposition rights, the buying of land by a user or a public authority to solve conflicting property and use rights, expropriation for similar reasons (rarely and sometimes on the basis of 'expropriation agreements', as in Spain), regulatory unification of the property of land and water, the organization of users, the acknowledgement of traditional and 'de facto' use rights of some users, agreements (between fishers and kayakists or irrigators and fishermen) to share water use and the withdrawal of informal use rights.

The *external coherence between public governance and property rights* is the degree to which the interdependencies in the water system and its management are reflected in the interdependencies between public governance and the property and use rights. External coherence between public governance and property rights changed considerably in half of the cases for the better and only modestly or less in the other half.

Here the following developments were reported, among others: expired use rights were gradually transferred to other (public or semi-public) institutions, the aim of minimal water flow was incorporated as a sort of use right for environmental protection, an EU inspired program gave compensation to farmers for not exerting their use right to part of their farm land, some technical measures required new responsibilities and resources for implementation that demanded changes in property rights, adaptation of use rights to public policy aims, voluntary restrictions of the property right holder accepting public policy aims (one of the Belgian cases), the localization of drinking water industry was problematic but not considered as a question per se, subsidies allowed the regional administration to influence nature management by owners, modification of property rights by creation of zones that were liable to flooding, concessions were given by law to user communities, a policy plan to improve the information for self-governing user communities by the development of a census to prevent free riders and by studies, creation of (semi-)public bodies or platforms where practically every user is represented, policies opening up to take also other users than those with a use right to the water itself into account (tourists, fishermen, nature), incorporation of relevant use right holders (farmers, tourists) as targets in public water policy.

The *overall assessment of the regime change* is clearly that in most cases there were considerable improvements on many of the important aspects. Nevertheless seven occasions of more or less failed attempt to regime change and three occasions where the results were better than average and where at the end of the case period one could really speak of integrated water management also occurred.

Illustration 2: An example of broad improvements

In the Matarranya river process, there are clear signals of regime change, both regarding extension and coherence of the water regime. The extension of the water uses increases as it includes irrigation, population supply, cattle rising, nature protection and tourism. Rivalries between users can be interpreted in territorial terms (intra-basin driven rivalries). There is also an increase of public governance coherence, as it regards levels and scales, multilevel interaction and networks. The most relevant event proving the increase of governance coherence is the Water Agreement reached by the main actors operating at the river basin level. This agreement is the outcome of a process in which a wide range of actors operating at different scales of governance interact: the regional government promotes environmental initiatives; local actors appeal to EU regulation as a legal resource by local actors; the Central Union of Irrigation Communities is created as a body representing all irrigation communities at the basin; PLADEMA – an ad hoc local association – aggregates and mobilizes actors against the construction of hydraulic works; the Ebro river basin administration negotiates with the local irrigation communities; and the Ministry of Environment finances the construction of lateral pools. These actors, especially those located at the river basin, share a perception of risk caused by an extreme situation of drought among the basin actors and progressively adopt a new water culture.

Regarding the internal coherence of property rights, some improvements can be identified: the Ebro river basin Plan establishes water needs and uses as well as a minimal ecological flow; some maladjustments between legal aspects and real practices of the CHE and the Central Users Community increase its level of influence regarding decisions on the watering out of the Pena dam and the distribution of water; traditional use rights of some users are respected; and a kind of de facto use rights are given to illegal users of water by the Irrigation Communities of the basin. After the signature of the Water Agreement, the external coherence between public governance and property rights improves to a certain extent. All the main water users have proved to be able to negotiate and reach an agreement based on a common perception of the river as a key element for the future development of the basin. (*Meritxell Costejà, Nuria Font & Joan Subirats, – Matarrana River case study.*)

Implications of Regime Changes for Sustainable Use

The approach to the assessment of this variable (-group) is the following: the researchers started with the rivalries that are at stake in the case story or stories. In the first instance, the assessment of the changes in the sustainability of the resource use is limited to the natural/environmental indicators that are directly at stake in these rivalries. Without any ecological improvements the researchers were not inclined – in wealthy Western Europe – to judge an improved sustainability even when economic

parameters would have improved. In the second instance, the social and economical development consequences of the changes in these indicators and/or the measures taken for this purpose are also taken into account. In the last instance, a marginal check was performed to see whether the observed changes had important side effects on other natural resource/environmental indicators and whether these in turn had indirect social and economic consequences.

Illustration 3: Rivalries and ecology

In the Idro Lake and Chiese River case the problem generates from conflicting interest of the various users of the lake and the water basin. The conflicts occur between water uses for agriculture, hydropower production, tourism, ecological balance, and protection from risks related to flooding, soil erosion, and land sliding. As a response the use of water was managed not only accounting for water needs, but also for water availability. Environmental and land conservation was supported by the maintenance of a constant minimal vital flow, even in summer and controlling the speed of lake depletion. The maximum water-storage level was reduced to avoid the risk of flooding. (*Bruno Dente & Alessandra Gorla, Idro Lake and Chiese River case study*).

Often the picture for the *economic consequences* is somewhat mixed. As negative economic consequences we found the financial costs and/or restrictions for the sectors involved (agriculture, fishery, resource extraction or industry) and in some cases higher water prices are mentioned. On the positive side the following economic phenomena were often mentioned: gains for tourism, avoidance of future costs, job creation and job safeguarding, and an improved natural resource basis for further economic development. Occasionally lower water costs and increases in productivity were also reported.

Illustration 4: Tourism development in the Vesdre basin

The low quality of the Vesdre creates rivalries. Pollution prejudices the development of tourism, the only economic reconversion expected for this former industrialized area. At the same time purification of urban wastewater has become compulsory. The tourist sector and the water purification sector are mutually supportive. In both cases the European Union plays the role of institutional interface. In the first place it allocates structural funds. The valley of the Vesdre is classified as an area in economic reconversion. Both tourism development project and purification plants benefit from the subsidies. In the second place, the EU compels the Member States to purify domestic wastewater. As a consequence, the competence authority, i.e. the Walloon Region, developed an ambitious catch up policy and raised the necessary funds. The Vesdre river basin is one of the main recipients. This context should allow of tourist activities in the valley to take off. (*David Aubin & Frédéric Varone, Vesdre River Basin case study*).

While the economic consequences were mixed, the *social consequences* were often very positive and remarkably varied. The only negative social consequences mentioned were limitation of land ownership rights and a negative impact on the landscape, both mentioned once. By contrast, the positive social consequences include: modernization of agriculture, development of new associations of people, more open public debates and more information for the people in general, improved feeling of safety, prevention of population decline and maintenance of young population, fairer distribution between upper and lower communities, resolution of conflict in the local area, improved living conditions, and the reinforcement of the qualities of the river as a key element of social identity.

Illustration 5: Negotiated agreement

In Wallonia, the tributary basin of the Hoëgne-Wayai hosted a conflict between the fishers and the local mineral water producer. Fishers were complaining about accidental discharges of caustic soda that caused fish disease. During the case, the actors exchanged violent arguments via the press. In order to come out of the conflict, the fishers' federation proposed to the mineral water producer to make a river contract. The river contract is a non-binding, voluntary local concertation mechanism. All the local actors meet and discuss their problems. A monitoring network is put in place. The rivalry is broadened to the whole range of uses. All the quality aspects are taken into account. However, every action is done on a voluntary basis by the actor concerned actor and at its own expenses. Even if results in terms of water quality are mitigated, the initial conflict moved into cooperation and then every local water actor adopted a resource logic. (*David Aubin & Frédéric Varone, Vesdre River Basin case study*).

The author's expectations (hypothesis 3) regarding the relation between the regime (change) and the sustainability of institutional resource regimes were: Regimes with a deficient *extent* will be more likely to lead to degradation of water resources or inability to protect the ecological functions of the water resource, than regimes with a larger extent. Regimes with a large extent, but with low *coherence* will be more likely to lead to degradation of water resources or inability to protect the ecological functions of the water resource, than regimes with a similar extent but a higher degree of coherence.

Indeed, the relation between the extent and the sustainability estimates is rather weak and hardly significant. The relation between the general assessment of regime change and the assessment of sustainability is however much stronger (Spearman's $\rho = .533$, $p = .004$, all calculations $n = 24$). Of the separate regime aspects, by far the most important factor was the coherence of public governance. It correlated even more strongly with the assessment of sustainable resource use than the general regime change.

Illustration 6: Sustainability and regime changes

Regime changes in the case of the Mula river have some positive impacts on sustainability including the environmental, economic and social dimensions. Regarding the environmental dimension, energy and water savings are considerable, there is a decrease in water losses, some measures to avoid the overexploitation of wells and aquifers are adopted, and a minimal ecological flow is established. Regarding the economic dimension, the price of water to farmers is lower than it used to be and the productivity of the huerta improves. Finally, regarding the social dimension, there are some training programs for farmers and an improvement of life quality. In general terms, the positive impacts on sustainability seem to be more related to the increase of internal and external coherence rather than to the increase of extent. (*Meritxell Costejà, Nuria Font, Anna Rigol Joan Subirats – Mula River case study*).

The conclusion is that there is only weak support for the first expectation (hypothesis 3a): that an increased extent contributes as such to a more sustainable resource use. The support for the second expectation (hypothesis 3b) – that increased coherence contributes to a more sustainable resource use – is much stronger. Though this can be regarded as supportive evidence for the proponents of ‘integral water management’, it should be considered that this is not a sort of ‘mechanic’ causal relationship. It still holds true that ‘the devil is in the details’.

Explaining Regime Changes by Change Agents and Conditions*Change Agents*

This is the combined force of the listed change agents as an impetus to set in motion regime changes in the direction of more integration. The joint force of the identified change agents in the cases was assessed as moderate (4x), strong (12x) or even very strong (5x). Only in 3 (sub)cases was it assessed as weak or absent.

The types of change agents mentioned were EU originated pressures, national regime developments, problem pressures and various other case circumstances. In 13 of the 24 cases *EU policies* were mentioned as relevant. As such a great variety of EU policies were mentioned as relevant: the standard for minimal flow of rivers (national laws that were triggered by) directives on the water basis system, the 1991 waste water treatment directive (5x), phosphate and nitrate standards, fishery policies, the 1972 wild birds and 1992 habitat directives with their special protected areas (3x), the 1975 drinking water directive (3x) (and the role of the European Court of Justice to force implementation), the regional development policy with its structural funds (2x). More generally various EU regulations were used as arguments in the debates, even when not self-enforcing.

In all but two cases *national policy* and regime changes were influential. Apart from various 'normal' water (and some nature) policies, some more regime oriented pressures were also mentioned: promoting regime development at the level of the water basins (3x), laws demanding (land-use) planning (4x), acts that allow the government as owner of the water to regulate fishing on the basis of considerations of nature protection, environmental impact assessment, white papers pushing for 'integral water management' (3x), federalization (Belgium), legislation allowing expropriations and indemnities in favor of flood protection, and the designation of parts of the basin as nature protection area. Note that several of these are not or might not be independent from the relevant EU policies!

In 19 cases there was influence from *problem pressure*. With the problems at hand there is a clear division between 'wet' cases (the majority) and 'dry' cases. In the dry cases increased use of water by agriculture and tourism industry are main problem causes. In the wet cases pollution and the risk of flooding are the most mentioned problems. For almost all cases the increased value attached to nature and environment considerations makes these enter the picture as 'new' problem pressures.

In 10 cases various other circumstances were mentioned. Some examples are: the expiration of concessions for irrigation, changing market regulations pushing for new economic developments, state withdrawal from participation in economic developments, expanding land use for building, the break-down of traditional management regimes, experts providing new information, local and environmental associations and devoted individuals.

Maybe national policy support is a necessary, though not a sufficient condition. Often the national government provided crucial resources like formal rules and money. The two cases where such influence was not reported had a very low overall force of change agents. But generally it is not the type of change agents or the presence of a variety of them that matters. Each change agent can 'do the job' of exerting a major 'force of change agents' if it is pressing enough.

The author's expectations (hypothesis 1) regarding the relation between the general force of the change agents and regime change was: "The observed change agents (in the period and context of our cases) will lead to more differentiation in the regime (resulting in more complex regimes), but not without additional prerequisites to more coherent regimes." As expected of the various forms of regime change, only the extent proved directly related to the force of the change agents ($\rho = .446$, $p = .015$). For the other relations to materialize more is necessary. Attempts to attain more coherence are expected to depend on several conditions.

Illustration 7: Bottom-up regime changes

Sometimes it was not national regime change influencing the extent of the regime at the case level, but the other way around. Here are two examples of bottom-up processes and subsequent 'legitimization' of local developments through national legislation in Switzerland.

The process of regional regime inventions arising from local problem pressure which are subsequently supported and thus legitimated by changes in the policy design at federal level can be observed in both Swiss case studies. In the Seetal valley, the canton of Lucerne had already issued a notice in 1988 reducing the restrictions on the number of production animals on farms from four to three livestock units per hectare. Even if this restriction was never really implemented at the regional level, it served as a model for the introduction of the same restriction into the Federal Law on Water Protection of 1991. In the Maggia valley in the canton of Ticino, quantitative protection of the water resources dates back to 1976, anticipating the changes in the federal regime by a wide margin. At the level of the water basin, protective measures in terms of minimal residual flows were applied in 1982, a full 10 years before the enactment in the Federal Law on Water protection of 1991. (*Corine Mauch and Adèle Thorens – Swiss case studies*).

Conditions

This is the degree to which the conditions listed in hypothesis 2 provide, separately and as a set, favorable or unfavorable conditions for regime changes in the direction of more integration (extent and coherence).

Generally the researchers assessed that in their (sub)cases there was not a very stimulating tradition of earlier cooperation between the actors involved in the rivalry/ies. Joint problem awareness has been present to some extent in several cases, though often only for some relevant aspects or only with some of the relevant actors. There has been considerable differentiation between the cases in terms of the degree to which the actors involved saw chances to actually gain by solving the rivalry with a more integrated regime. In one case there was even a sense of joint loss. With the condition of a credible threat of interventions by a dominant actor to solve the disputes to their own benefit there has been a considerable differentiation among the cases. Generally speaking the condition of institutional interfaces was somewhat better than most of the other conditions. Nevertheless, in many cases these were only a part of the relevant aspects or not functioning very well.

All in all, the assessments of the conditions for regime change in many cases are rather favorable. In nine cases the conditions are viewed less favorably. Especially the awareness of joint chances and good institutional interfaces – and to a lesser extent an existing tradition of cooperation were all seen as important positive conditions for regime change. Lower assessments of the general conditions indeed correlate with smaller regime

changes, as expected in hypothesis 3. The correlation is .687 ($p = .000$). The *favorability of the conditions* not only correlated with the general regime change, but also with all separate aspects of regime change (correlations ranging from .527 tot .798). Hypothesis 2 mentions the conditions separately. This implies that the various circumstances can have different effects. Of the separate conditions (and the force of change agents) the *joint opportunities* and the *institutional interfaces* conditions stand out in the explanation of the various forms of regime changes.

Illustration 8: Joint opportunities and institutional interfaces around the IJsselmeer

Sometimes rival uses can nevertheless be turned into win-win situations. The shores of the Dutch IJsselmeer (Lake IJssel) have rival uses of inter alia nature (bird habitat) and tourism (boating marinas). Of course tourism on the other hand benefits from beautiful nature. Seeking the balance between the two uses can therefore be beneficial for both. With a homogeneous use like IJsselmeer fisheries there is rivalry between the users, but on the other hand all users have a certain interest in a just distribution of rights, and therefore may favor a regime that guarantees this while preventing a 'tragedy of the commons'. This creates a basis for joint action that can be further exploited by having the right institutional interfaces in place.

These institutional interfaces can be triggered by European and national measures. In the IJsselmeer case the national government founded a negotiation platform, a steering committee on the so-called corner lakes, a producers' organization on fishery, environmental impact procedures (gas drilling) and land use planning procedures with open participation. Such institutions catalyzed the involvement of users and other citizens (cf. the EU WFD) and functioned sometimes as 'policy brokers' and sometimes as forms of 'institutional leadership'. (*Dave Huitema, IJsselmeer case study*).

CONCLUSIONS IN THE PERSPECTIVE OF EUROPEAN WATER BASIN MANAGEMENT POLICY

European water policy has developed along two lines – water quality and emission standards – that reflect different national views. The new European Water Framework Directive (WFD) is an attempt to reconcile the two approaches and to integrate water quantity aspects. The purpose of the WFD is to achieve good ecological quality for all water bodies inside the European Union, at the scale of water basins, where an authority implements integrated management programs. The WFD guarantees, as of 2015, a 'good status' for all ground and surface waters, in quality and quantity, according to an eco-centered logic. In order to achieve this goal it promotes an integrated water management, i.e. a management that

considers all the water aspects and legislation in a single picture and on a delineated territory, the water basin. The integration of control and action should occur for quality and quantity aspects, surface and groundwater, exploitation and preservation, objectives of quality and emission limit values and water policy vis-à-vis other policies. The WFD sets up guidelines and leaves significant room for maneuver to the Member States. The guidelines allow an evaluation and a comparison of the efforts developed by the Member States and their results.

The main concepts of this chapter relate closely to the central themes of the new European water policy. The 'good status' of the WFD is related to the ultimate dependent variable in the analysis, the degree of 'sustainable use', especially to the ecological aspect of sustainable use. However, even in the 1996 communication leading to the WFD due attention is also paid to the 'evaluation of costs'. This aspect is reflected in the 'economic consequences' aspect of sustainable use. The authors observed that besides costs, economic consequences could be observed both positively and negatively. A third aspect that was included in the research was that of the social consequences. Here a remarkable number of positive developments were reported from the case studies. Generally, a higher degree of sustainable use correlated with a more integrated regime at the water basin level, just as was expected by both the theory described in this chapter and the 'practical policy theory' underlying the WFD. Though this can be regarded as supporting evidence, it should be considered that this is not a sort of 'mechanical' causal relationship. Under certain circumstances it can even be envisioned that more integration leads to deterioration of sustainable use. It still holds true that 'the devil is in the details'. Nevertheless, empirically in the 24 cases the relationship between integrated management and the status of the water resources corresponded with the ideas guiding the WFD.

The main venue by which the new European water policy seeks to improve the good status of European waters is by 'integrated water management at water basin scale'. In this chapter the cases that are studied were not at the full water basin scale, but at the lower level of tributary river basins. The reason for this is that the authors believe that integration of management is a multi-level endeavor. At the higher level of international rivers like the Rhine or even large national rivers like the Loire, circumstances vary to such a degree that there is not one, but several sets of uses and users and consequently also multiple resource regimes needed at a sub-basin level. This is not to state that the full water basin should not be in need of coordinated management, but only that for impacting many uses and users, sub-regimes at a tributary river basin level are also needed. This idea is in accordance with the principle of subsidiarity that is explicitly endorsed in European water policy. The case studies concentrated on this

level (with areas of some 500 to 2500 km²) found many interesting experiences with (attempts to achieve) more integrated water management. This illustrates the assumption of the European water policy that it is necessary to accept some variation of the institutional arrangements that are used to promote integrated management. Though the organization of management on a sub-basin level is left predominantly at the discretion of the member states, the authors think that at least devices for Europe-wide communication and exchange on experiences with integral water management on that level could be helpful for the actual practical implementation of the WFD. This could be part of 'joint implementation' arrangements.

Integrated water management in this chapter was conceptualized with the help of the concepts of extent and coherence. The 'extent' of the regime reflects the elements of integration in the WFD that stress that all relevant directives and all waters in the area should be managed in a combined approach. The authors stress the completeness of the regime to regulate all relevant uses and users. The elements that stress multi-level (even international if necessary) and multi-actor (stakeholders and citizens) involvement and the coherent action guided by management plans are reflected in the concept of 'public coherence'. As a special feature of the research, not only the coherence of public governance, but also the coherence of the property and use rights regime and the coherence of the relation between public governance and property and use rights are included in the assessments. The study illustrates that these are important aspects of the water management regimes, especially – but not exclusively – when quantity issues are at stake. The discussion in this chapter has shown that special attention to the property and use rights affected and the relation between those and the public governance measures is a worthwhile extension of the focus of integrated water management.

The integration between water management and other sector policies in the new European water policy envisioned by the mechanisms is embedded in 'full cost pricing'. In this chapter the authors did not specifically encounter this issue. Consequently, there is no conclusion on full cost pricing. However, the authors did encounter a number of cases in which issues other than direct water issues entered the process of development of new water regimes. Examples are issues of landscape, wetlands and fishery, which were entered into the debate by interested actors. Though 'full cost pricing' could be important to send the right price signals to all actors, there will probably remain various rivalries that need a form of integrated water management that deliberately tries to bridge externally to other sector policies for coordination.

The authors in this chapter did spend a great deal of effort in providing better insight into a variety of change agents and conditions that stimulate

more integrated water management. They have learnt that integrated management regimes are not something that one can 'proclaim into reality'. Deliberate attempts by motivated actors are surely needed to realize it in practice. All the conclusions are not repeated here, but the emphasis is on the points where EU policies come in.

Among the change agents the authors have seen that in more than half of the cases EU directives and other policies play an important role. Among these directives are also some that are not directly 'water directives'. Another observation is that national policies that are mentioned as leading to regime changes were often in their turn triggered or in any case related to EU directives.

Even more important than the change agents mentioned proved to be the conditions for change. The EU can have important – indirect – effects here too. A first observation is that European policies are often used in the internal debate at case level as arguments to pursue a certain position. This holds especially for NGOs and other actors with little formal power and of course when they want to move in the same direction as the relevant EU policy involved. Even when these policies are non-obligatory, in this way they have a certain influence. Of course, part of this influence is generated by the prospect that these policy lines will become more compelling after a while. So for the WFD aim of participation in water management, EU policies can play an important role. Of the several conditions, joint chances and institutional interfaces proved to be the most important. Both can be seen as venues at which to aim supplementary EU measures in the context of joint implementation, to improve the chances for regime changes in the direction of integrated water management.

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14

Public Participation in Water Management

The outcomes of an experiment with two participatory methods under the Water Framework Directive in the Netherlands : Analysis and Prospects

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1. THE EU WATER FRAMEWORK DIRECTIVE AND CITIZEN PARTICIPATION

An integrated approach towards water management, in which the different functions of the water, such as fisheries, nature, agriculture, drinking water, and recreation, are considered in a coherent way, is the main principle of the European Water Framework Directive (WFD). WFD places 'public participation' at the center stage of water management, which is remarkable for this traditionally relatively technical field. *'The success of the Directive relies on close cooperation and coherent action at Community, Member State and local level as well as on information, consultation and involvement of the public, including users'* (2000/60/EC).

The emphasis on public participation is not entirely new to water management, though, as public participation in water infrastructure projects has become quite common (e.g. Creighton et al. 1998). It does seem however that currently – at least in academic circles – the desire for more participation has resulted in a plea for truly fundamental changes: water management is to change from a predominantly technical policy area to the phase of interactive water management (Van Ast, 2000) or even water 'self management' at the local scale (Janssen and Goosen, 2002).

Whether or not such a dramatic change is realistic will depend to some extent on the evaluation of the currently available experience with participation methods. This chapter seeks to evaluate two of these methods.

The WFD comes nowhere near the 'ideal' of interactive water management or self management but continues to place public participation in the wider context of decision making by public bodies. As such, the directive distinguishes three levels of participation, with an increasing degree of control over the outcomes of the process: 'information', 'consultation', and 'active involvement'. How information, consultation and active involvement take place, is communicated in a 'Guidance document on public participation' that was developed to facilitate the implementation of the WFD in respect of its public participation requirements (Drafting Group, 2002). 'Information' can be provided by means of brochures, briefings, press releases, etc. It is as a one-way flow of information, downwards, from the initiators to the participants. 'Consultation' can be organized by means of interviews, opinion polls, and public hearings. The flow of information is still one-way, but this time upwards, from the participants to the initiator. 'Active involvement' can be organized by means of citizens' juries, planning cells, consensus conferences, etc.¹ This level of participation calls for interaction and deliberation between water managers and the public.

Which level of participation to choose, depends on the objectives of the participatory approach and the stage of the policy process. For instance, if water managers want to increase public awareness, the level of 'information' may be sufficient. However, if water managers also want to take into account the viewpoints and opinions of the public in the development of a policy plan that is yet to start, the public must at least be involved at the level of 'consultation'. 'Active involvement' will be required if the water managers want to explore the possibilities to collectively manage a river basin.

The WFD distinguishes between 'stakeholders' and the wider 'public' in that it prescribes information and consultation for both categories, but active involvement only for stakeholders. How ambitious does this make the WFD in terms of public participation? In terms of the 'participation ladder' developed by Arnstein (1969 – see Figure 14.1) information is a symbolic form of participation in which the citizens do not really gain a certain degree of decision-making power. Arnstein also considers consultation to be 'tokenism', which is not a very positive qualification either. However, we do not share Arnstein's preoccupation with control as the only criterion for judging participatory processes. Meaningful participation should not be

¹ For an overview of participatory methods, see: Van Asselt and Rijkens-Klomp (2002), Toth (2001), Creighton et al. (1998), Mayer (1997), and Olsen (1982).

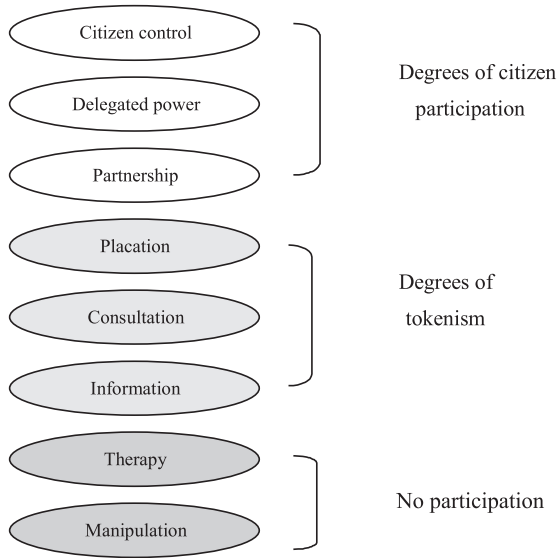


Fig. 14.1. Eight rungs on the ladder of citizen participation (Arnstein, 1969)

equated with decision-making authority, as – for instance – a very powerful yet information-lacking group of citizens or stakeholders cannot ‘do’ much with their authority (Coenen et al. 2001, 1998).

Bearing this in mind, the authors note that the stark distinction between stakeholders and the wider public under the WFD may become problematic when ordinary members of the public start organizing and requesting active involvement. The formulation in the WFD may be used to restrain the involvement of such groups and this is likely to lead to litigation over the proper meaning of the word stakeholder.ⁱⁱ Keeping the distinction between stakeholders and the public implies the need to precisely define what is a stakeholder? The Guidance on public participation defines a stakeholder as: any person, group or organization with an interest in an issue, either because they will be directly affected, or because they may have some influence on its outcome. It needs to be taken into account, however, that, in the case of any complex issue, it is not always clear what the stake(s) of each actor is (are). Different actors may have a different perception of their own and each others stakes, and the stakes may change over time. Also,

ⁱⁱ Legal verdicts tend to have the effect of hollowing out distinctions between stakeholders and non-stakeholders as practice in the UK, Canada and the Netherlands shows (Huitema, 2002). In the Netherlands, the distinction was rendered irrelevant under land use planning and environmental law in the course of time through court verdicts, and this has had hardly any consequences for the practice of decision-making, except to save a lot of litigation over the status of participants.

the relevant group of stakeholders may vary; the number of stakeholders involved in the issue is not necessarily fixed but may change over time. As the decision-making process develops, new stakeholders will enter the scene and others will leave (Van de Kerkhof, 2004).

The Guidance document emphasizes that no blue print exists for public participation and that the public participation process should be organized and adapted to national, regional and local circumstances. The Guidance document calls for a 'learning' approach in which the involved actors get insight into each other's perspectives, views and knowledge thereby providing the basis for exploring the best way to implement the WFD. The Guidance document also draws attention to a number of factors that competent authorities will need to be aware of to assess and inform their own current practices and provide a basis for developing a learning approach to participation. It distinguishes between content, process and context as three types of factors that influence the public participation process. In its Annex I, the Guidance gives several examples of tools and methods that can be used to facilitate public participation processes. It distinguishes between: techniques to use in the preparatory steps of the participatory process, communication techniques, and specific interaction techniques (Drafting Group, 2002).

In this chapter, the authors discuss two methods that are considered 'interaction techniques' under the WFD Guidance with the purpose of helping water managers consider whether these two methods might be useful in their situation. The basis for discussion of this chapter is the authors' involvement in the research project 'River Dialogue', which was funded by the European Commission and intended to deliver results that would help the EU-stated to implement the WFD, as far as the public participation aspect was involvedⁱⁱⁱ. For this purpose, the researchers involved in the River Dialogue experimented with two different methods: focus groups and citizens' juries. These methods were applied in three European river basins: the Motala Ström in Sweden, the IJsselmeer in the Netherlands, and the Emajõgi River in Estonia. This chapter relates the experience with the two participatory methods in the Netherlands. Section 2 describes the rationale and procedure of both focus groups and citizens' juries. Section 3 presents the Dutch case and explains how the focus group and citizens' jury methods were used in this. Section 4 evaluates the experience with the two participatory methods, in terms of both content and process. Section 5 draws conclusions and presents a number of recommendations on the use of the two methods in different settings than the Netherlands and briefly touches upon their applicability in situations of transboundary water bodies.

ⁱⁱⁱ See <http://www.riverdialogue.org>. Support from the European Commission's Fifth Framework Program, contract RPAM-2002-00057, is gratefully acknowledged.

2. FOCUS GROUPS AND CITIZENS' JURY

2.1 The Focus Group Method

A focus group can be described as an informal discussion among selected individuals about a specific topic. There are many variations on the basic method, but in general, a focus group involves one or more group discussions, in which participants focus collectively upon a topic selected by the initiator, usually presented to them as a small set of questions (Wilkinson, 1998). Fundamentally, focus groups are a way of listening to people and learning from them: they create lines of communication. The method can be used to generate a rich understanding of participants' experiences and beliefs with regard to a specific topic (Morgan, 1998a).

The number of participants may vary, but the typical group size is six to ten participants. Usually these participants come from similar backgrounds (e.g. members from a fishing club), but it is also possible that the initiator brings the participants together specifically for the issue under consideration (Morgan, 1998b). The focus group is guided by a moderator who is a well-trained professional who works from a predetermined set of discussion topics (Morgan, 1998a). It is generally considered most important that the participants are at ease with each other and speak freely, which is of course more difficult when the participants meet each other for the first time. The groups need not necessarily be representative for a wider social collective and especially when organizing focus groups of people that meet each other regularly, it is possible that there is less diversity of opinions (to achieve diversity, one would need to have various focus groups). Focus groups require little commitment from participants in the sense that they can generally be held in locations near them and that the average duration is only 1.5 to 2 h. No preparations need to be made by the participants.

The focus group method is neither bent on involving all relevant actors nor on getting a representative sample of the population. This implies that it is entirely possible to not include certain relevant groups and to manipulate the process this way. On the other hand, if the focus group is run well and in a 'fair' way (Webler, 1995), all the participants have the opportunity to express themselves ('to contribute'), to ask each other questions ('to discuss') and thereby influence the collective outcomes ('to decide'). If necessary, the moderator intervenes in the process in order to stimulate this. In a focus group, there tends to be a predefined topic for the focus group and, even though the participants may wander off, the starting point remains determined by the organizers.

Focus groups rely on the information that is present amongst the participants. The discussion is hardly influenced by scientific information, which allows for a sound impression of the viewpoints and opinions in the group. However, because of this focus groups offer little correction

mechanisms for incorrect claims or for 'incorrect' problem analyses. But that is somewhat beside the point, as focus groups are intended to assess participants' perceptions of issues. Certainly in groups that know each other for a long time, taken for granted assumptions and group hierarchy can strongly influence the course of the focus group. The degree to which this actually happens depends in part on the behavior of the moderator (the one overseeing the discussion) but is likely to occur despite the best efforts of a moderator. In groups where people do not know each other yet, or where backgrounds differ somewhat (i.e. combining professional and amateur fishermen in one focus group), there may be more of a critical exchange of arguments (although hierarchy may be a factor here too as people may know each other by reputation).

2.2 The Citizens' Jury

A citizens' jury can be understood as a group of randomly selected citizens who attend a series of meetings in order to learn about and discuss a specific issue and make their recommendations public (Crosby, 1995). The citizens are gathered through a quota system in such a way as to represent a microcosm of the community from which they are drawn^{iv}. Typically, the criteria include demographics such as age, gender, and education, or else rely on balancing the attitudes of the jurors on the question under consideration so that they resemble their community. At the start, the jury gets a 'charge', which is a question that they have to answer or a topic they must address. The initiators of the jury, or the organization paying them, set the charge. Basically, the participants (the jurors) hear evidence, question witnesses, discuss the issues that are raised, and then make an informed judgment with regard to the charge (Kuper, 1996). The jury hears 'witnesses' that are selected to represent different (conflicting) viewpoints on the topic under consideration. The jury tries to take a decision based on consensus, but if a consensus cannot be reached, votes may be taken. The number of participants may vary from 12 to 24. Sometimes, two citizens' juries are organized at the same time. If both arrive at the same conclusions, this is considered a strong indication that most members of the public would agree to the outcomes given the time to deliberate the issue. Certain groups tend to be overrepresented in the group of volunteers. This can be compensated by introducing minimal quota for various types of jurors (e.g. no less than 40% women, etc.).

^{iv} It appears that the criteria by which jurors are selected differ per country. In the UK, the criterion of social class was used, whereas in the USA, the criterion of race was used. In a broader sense, it is difficult to determine of which community the jurors need to be representative. This is especially relevant for large-scale water bodies that are shared by several different communities or even countries.

Citizens' juries are quite demanding for the participants in the sense that they do require preparation, tend to last several days, and require intensive concentration. Due to this, it needs more effort to commit participants to a citizens' jury than to a focus group. This means that, in order to secure the commitment of the jurors, it is preferable to conduct face-to-face interviews with each juror, rather than phone interviews. Furthermore, commitment tends to be secured by signing a contract with the jurors. Moreover, some additional measures can be taken, such as the provision of day-care for children and financial compensation for lost wages. It appears that the percentage of people who are willing to participate in a citizens' jury varies from 5 to 40% of the group that is invited to participate (Huitema, 2003).

Jurors are normally allowed to alter the agenda somewhat, but the broad agenda tends to be determined by the organizers or a 'commissioning body'. A citizens' jury is much more intended as a means to have all relevant actors have their say than a focus group. The witnesses that give their presentation to the jury are selected to reflect different interests ('to contribute'); the jurors have ample opportunity to question the witnesses ('to discuss'); and they are responsible for formulating the verdict ('to decide'). There have been warnings of organizations wanting to buy a citizens' jury. This could be attractive even if an organization cannot control the actual outcomes of the process. This is because the instrument itself draws a certain level of attention to a specific problem (Huitema, 2003).

Compared with a focus group, in citizens' juries (scientific) information plays a relatively prominent role. A citizens' jury includes witnesses (e.g. scientists, other stakeholders) who give presentations and who are selected with the help of the jurors. The witnesses tend to have different views, making clear areas of disagreement and uncertainty, and can be questioned by jurors. A jury is designed to have an intensive exchange of argumentation. This is both the case for the presentation of witnesses (they are questioned by jurors) and for the process of reaching recommendations. The recommendations are normally reached after an entire day of group deliberations and often contain motivations. When the jury members disagree (this is fully acceptable) a vote may be taken and 'voting blocks' may motivate their preferences.

3. THE DUTCH CASE: FOCUS GROUPS AND A CITIZENS' JURY IN THE IJSSSELMEER BASIN

3.1 The IJsselmeer Basin

The term 'IJsselmeer' (IJssel lake) is popularly used to indicate the whole water basin (see Figure 14.2), but professional water managers make a

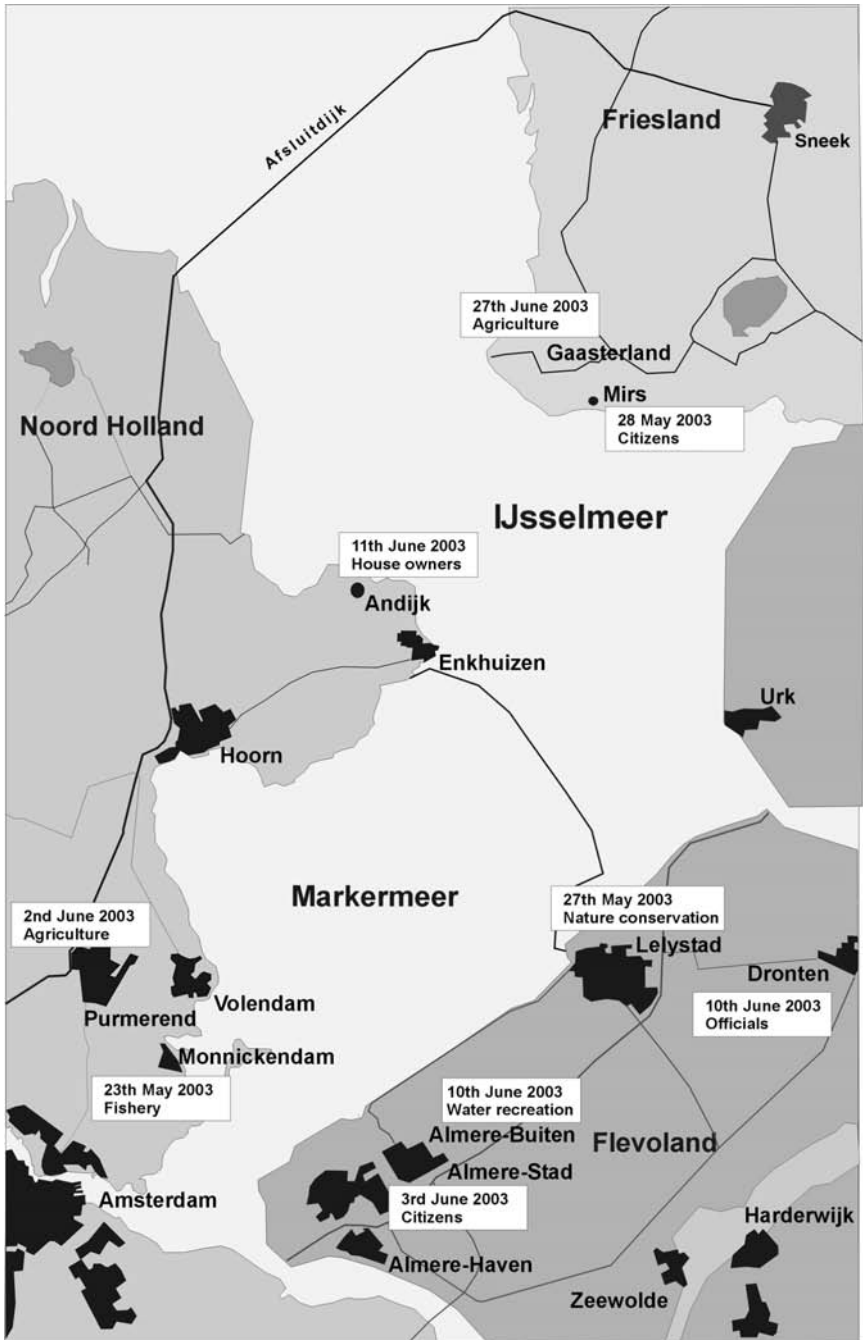


Fig. 14.2. Map of the IJsselmeer and Markermeer

distinction between the IJsselmeer (Northern part) and the Markermeer (Southern part). The lake itself used to be an inland sea ('Zuiderzee' or South Sea) but a 30-km dam built in the 1930s turned the water into fresh-water.

The current shape of the lake is formed by land reclamation (polder construction), which reduced the size of the lake considerably. An additional polder was planned in the Southern part of the lake (Markermeer) and a dam that was to serve as the outer border of that polder (between Lelystad and Enkhuizen – see Figure 14.2) was completed in the 1970s. The actual construction of the polder (tentatively named the Markerwaard) was stopped because of various reasons and was never completed. The completed polders were governed by the national government until 1986, and then merged into a province called 'Flevoland' with six municipalities embedded in it.

3.2 The IJsselmeer Focus Groups

Nine focus groups were held including farmers (two groups, respectively in Friesland and in Noord Holland), citizens (two groups, respectively in Friesland and in Almere) fishermen, water recreation, nature conservation groups, house owners, and public officials (bureaucrats). In order to recruit participants for the nine focus groups the organizers followed two different approaches. The first approach was to find a contact, which could help to find participants or give names of potential participants. The second approach was to contact potential participants directly. The advantage of the first (indirect) approach is that the contact knows whom to ask and that the response is rather high. People appeared to be more inclined to say yes to someone they know. A disadvantage may be that the organizer to some extent loses control over the recruiting process. A possible effect of the indirect approach is that mainly the active and prominent members of organizations will participate.^v Although this also occurred in the Dutch focus groups, it was not considered too much of a concern. After all, the focus group approach did not claim that the opinions gathered from the group participants are representative, neither for the general public nor for the members of their own communities.

Figure 14.3 shows that the willingness to participate of those approached by phone varies from 24 to 100%. The 100% score for the agricultural group is strongly influenced by the fact that the authors received a list of names of active farmers from their representative organization. The 'normal' willingness to participate rate is thus in the range of 24 to 44%, which

^v In the Dutch agricultural sector, there is actually a term for the publicly active farmers who tend to be called 'vergaderboeren' ('meeting farmers').

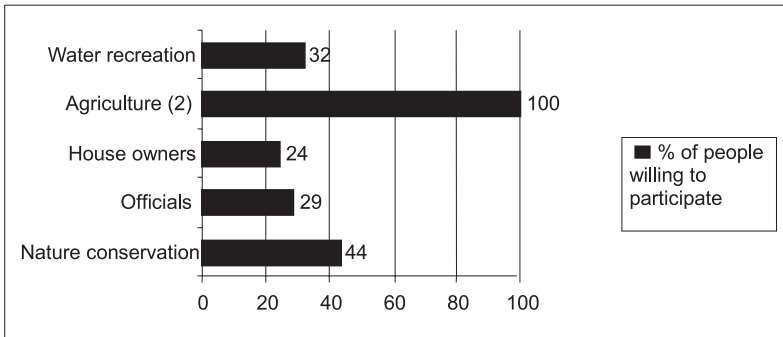


Fig. 14.3. Percentages of people who were willing to participate per focus group

seems relatively high given the fact that people had to give up spare time (usually in the evening). There are generally very pragmatic reasons that explain why people do not want to participate (lack of time, interest).

In order to get the groups debating on water management, the project team devised a list of 15 questions. These questions related to issues of water management and the environment in a broad sense. For instance, the participants were asked to give their opinion about the environment they live in, about the role of the European Union in the water management of the IJsselmeer basin, and about the way in which the media pays attention to water issues. Furthermore, the participants were asked to reflect on two newspaper clippings. The first clipping addressed the water quality of the IJsselmeer, whereas the second clipping was about the water level of the IJsselmeer.

3.3 The IJsselmeer Citizens' Jury

The Dutch jury was a three-day affair, with two evenings of preparations and one evening of evaluation (Huitema et al. 2004). The two evenings for preparation were spent on training the jurors in issues relevant to water management but also in the skills required for participating in the jury (i.e. asking the right questions). One part of the evenings was an information market, where the jurors could freely walk around and talk to four experts that were present at their own initiative. The actual jury took place in the provincial building in Lelystad and included two days of hearings and an excursion to a wastewater treatment plant. The proceedings were open to the public, but the public was not allowed to join the discussions. The third day of the jury was deliberation day, the whole day was utilized by the jurors to reach their recommendations. These recommendations were written out by the organizers and the report discussed and approved by the jurors in a separate evening session. They were handed over to the authorities during a session in the provincial building a few weeks later.

With regard to the jury's 'charge', the project team initially intended to select a topic that was relevant for the entire IJsselmeer. However, interviews with the water managers in the area made clear that the problems of the Northern part (IJsselmeer) are rather different from the problems of the Southern part (Markermeer), and are probably difficult to cover in one process. In line with the outcomes of the focus groups, the project team chose the water quality as the topic for discussion and the Southern part of the lake became the main focus. The reason for choosing for the Markermeer was that this part of the lake had not received much public attention yet. The charge the jury received was: "What should be the points of attention in the policy that the government carries out with regard to the quality of the water in the Markermeer?"

To get jury members a letter, a flyer, and a reply card were sent to 2,000 addresses in the capital city of Flevoland, which is Lelystad. This resulted in 61 responses, which means that the response rate was 3.05%. Figure 14.4 shows three graphs that indicate the gender, age and education characteristics of the people willing to participate in the jury, as compared to the general population of Lelystad. The figure also shows the characteristics of the people that were actually selected for the jury. Two facts stand out: the great majority of the prospective jurors were males and the age group 20-29 was underrepresented in the group of candidates and, as a result, also in the actual jury.

Fisheries, recreation (particularly from an economic point of view) and agriculture are important economic sectors in the area and have quite a stake in water management. Due to this, representatives of those sectors were invited to act as a witness before the jury. Furthermore, the IJsselmeer region is important as a natural area, especially for different bird species, and environmental NGOs were therefore also invited. After consulting the jury on the initial list, the decision was made to invite three more witnesses from the policy-making bodies (two ministries and the province).

4. AN EVALUATION OF THE METHODS ON THE BASIS OF THE DUTCH EXPERIENCE

4.1 Evaluation Criteria

In order to properly evaluate the Dutch experience with focus groups and citizens' juries, the authors take into account three aspects: the content, the process, and the usefulness for policy makers. In order to evaluate the content of the methods, the authors report on the main outcomes of the focus groups and the citizens' jury, and evaluate the learning-effect of the two methods. In the case of the focus groups this concerns the percentage

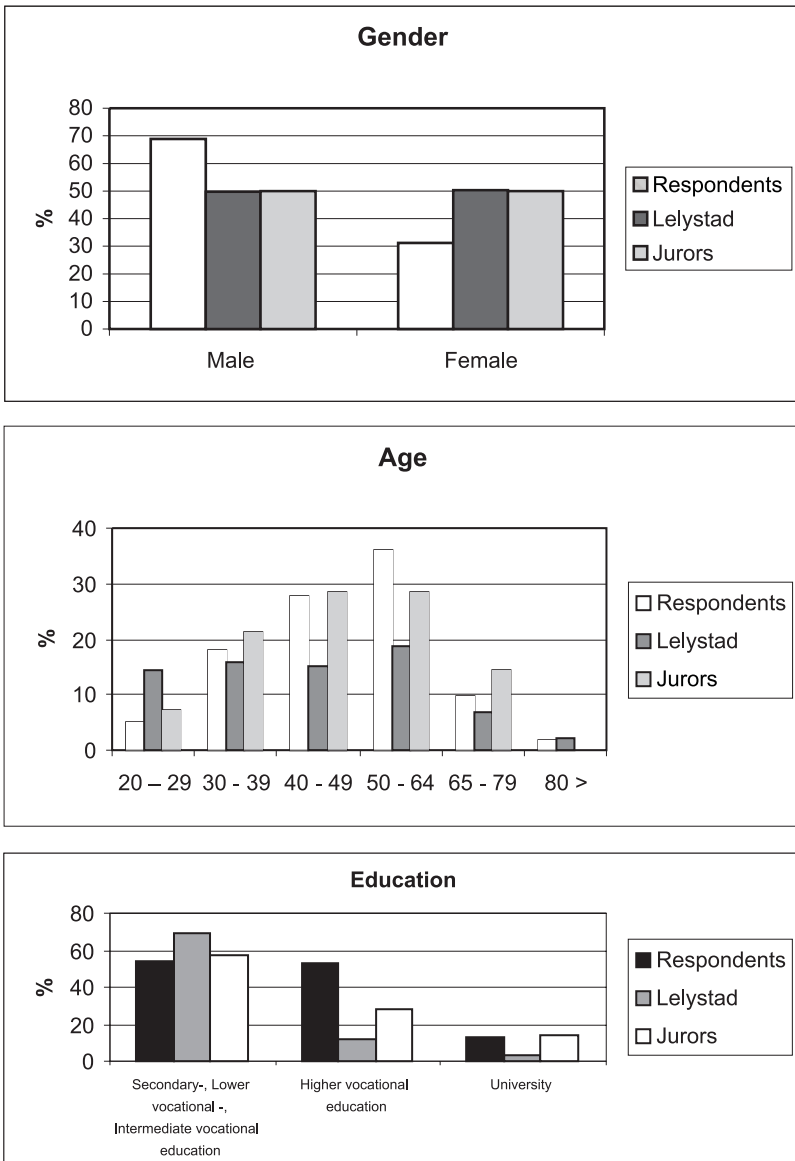


Fig. 14.4. Overview of gender, age, and education characteristics of the respondents, the population of Lelystad, and the jurors

of participants that claimed to have gained new insights during the focus group discussions, whereas in the citizens' jury, the learning effect by means of 'cognitive maps' before and after the jury is evaluated. In order to

evaluate the process in the focus groups and the citizens' jury, the authors take into account two aspects: group dynamics and participants' satisfaction. In order to evaluate the usefulness of the participatory methods for water managers the authors look at the strengths and weaknesses of the methods and also take into consideration – what stage of the policy-making process the methods are most appropriate to apply.

4.2 Evaluation of the IJsselmeer Focus Groups

Main Outcomes

The IJsselmeer focus groups made it clear that water quality is a topic of interest to all the focus groups. In most groups, good water quality was equated with clear water and the absence of mosquitoes, algae and litter. Almost all focus groups were aware of a notable improvement in water quality in recent decades. Only the fishermen reported a decrease of water quality, related to the fact that the nutrient load to the lake has decreased because of various (policy) measures including non-phosphate detergents and improved wastewater treatment. This does however imply less food for the fish and, therefore decrease in fish stock. The environmental NGOs agreed that the water quality should improve further. They indicated that the IJsselmeer still contains too many chemical substances, such as PCBs and phosphates. They complained that water quality improvements are mainly aimed at parameters that are relevant for human consumption (drinking water) and recreation (swimming water), and that water quality improvement efforts should actually be aimed at improving ecological conditions. In diametrical opposition to this stood the citizens in the city of Almere, who argued that, to them, water quality is only important from the perspective of human uses.

The water level in the IJsselmeer and more specifically flood safety are important concerns for the water managers in the area, but were issues that did not automatically come up in either of the focus groups. This could be a reflection of the more general attitude of the Dutch public that this issue is more or less under control and need not be worried about. Although an increasing European influence in water management was seen as unavoidable and probably for the better of all, there was a clear sense that something will get lost in the process. For the citizens in Friesland and the farmers, the process of scale enlargement of the Dutch water boards was already a reason for concern. They felt that under the newly established water board, too much money was wasted on bureaucracy and housing, and that contact with the region would get lost. For the policy makers, the increased role of the EU seemed to especially imply a loss in flexibility in the regulations.

Learning Effect

Table 14.1 reports on the outcomes of a questionnaire that the participants in the focus groups were asked to fill out. From Table 14.1, the authors conclude that 24% of the participants gained a lot of new insights from the focus groups (Score 1 and 2), whereas 53% of the participants gained hardly any or no new insights at all (Score 4 and 5). The generation of new insights was lowest in the two agricultural groups and in the group with public officials, whereas the house owners, the fishermen and both the citizens groups gained new insights.

Table 14.1. The generation of new insights in the focus groups (in percentages)

Score groups		1	2	3	4	5
		Many new insights				No new insights at all
Fishermen	(n=6)	33	0	33	17	17
Houseowners	(n=5)	20	20	40	0	20
Citizens in Friesland	(n=8)	0	50	13	37	0
Citizens in Almere	(n=7)	0	29	29	29	13
Nature conservation	(n=4)	0	25	25	25	25
Water recreation	(n=5)	0	20	0	0	80
Public officials	(n=7)	0	14	0	58	28
Farmers in Friesland	(n=8)	0	12.5	50	25	12.5
Farmers in Noord Holland	(n=6)	0	0	17	50	33
Total average	(n=56)	5	19	23	27	26

The overall learning effect from the focus groups was relatively modest. How can this be explained? Apart from the fact that the organizers did not provide the participants with new information and, therefore, did not assist the learning process, it seems that familiarity amongst the participants plays a role. In the groups in which the participants were less familiar with each other, such as the house owners, the citizens and the nature conservation organizations, the learning effect was relatively high.

Group Dynamics

As organizers, the authors observed the groups and checked for the presence of group hierarchy. Their observations (Huitema et. al. 2003) suggest that in three out of nine groups there was a certain level of hierarchy present in the groups. In each of these groups, there were one or two participants to whom the other participants were deferent in the sense that they would allow these people to talk more, interrupt others and take cues from them for the rest of the conversation. The authors' impression is that professional

status, social position, or knowledge of water management played a role in the emergence of hierarchy within the groups. In the case of pre-existing groups (e.g. the farmers from Friesland), the hierarchy that may already have existed is likely to also have had an impact on the discussion in the focus groups.

Another aspect of group dynamics is the fairness of the process. The IJsselmeer focus groups aimed to get a sound impression of the viewpoints and opinions of the specific participants. When necessary, the moderator intervened in the process and encouraged the silent participants to contribute to the discussion. In order to evaluate the extent to which the focus group process was fair, the participants were asked whether they had been able to say the things that they considered important (see Table 14.2). From the table, it can be concluded that no less than 83% of the participants indicated that they were able to say (most of) what they considered important to the discussion (Score 1 and 2). Only 6% of the participants were dissatisfied with the extent to which they had the opportunity to equally participate in the focus groups (Score 4 and 5). One of these participants argued that this was caused by a lack of knowledge about the topic under consideration. The rather high number of 83% justifies the conclusion that the focus group approach encourages an equal participation of the participants.

Participants' Satisfaction

In order to get an impression of the satisfaction among the participants with the focus group, we asked them whether they would be willing to participate again in a focus group if they were asked to. A ringing 79% of

Table 14.2. Ability of the participants to say what they consider important (in percentages)

Groups	Ability to have a say	1	2	3	4	5
		Yes, completely				No, not at all
Fishermen	(n=6)	66	17	17	0	0
Houseowners	(n=5)	40	60	0	0	0
Citizens in Friesland	(n=8)	25	50	0	12.5	12.5
Citizens in Almere	(n=7)	43	14	29	14	0
Nature conservation	(n=4)	75	25	0	0	0
Water recreation	(n=5)	40	20	40	0	0
Public officials	(n=7)	43	29	14	0	14
Farmers in Friesland	(n=8)	63	37	0	0	0
Farmers in Noord Holland	(n=6)	50	50	0	0	0
Total	(n=56)	49	34	11	3	3

the participants would be willing to participate again if they were asked to. The participants gave several reasons for this. The main reason was that the focus groups gave them the opportunity to express their opinion about a topic of their concern. Another important reason was the opportunity to bring certain problems to the attention of the policy makers, and to have a possible impact on the policy-making process. A minority of 19% of the participants doubted whether the focus group was interesting enough to participate again. Some argued that the focus groups would be more interesting if the groups were heterogeneously composed, or if the groups received more concrete information input. Only one participant indicated that he would not participate again.

Usefulness for Water Managers

In terms of the WFD, the focus group approach can possibly be considered participation at the level of 'consultation'. 'Proponents' of focus groups claim that the approach is useful mainly for getting insights in the way people construct problems and for enhancing awareness and perhaps even empowerment. Although the second claim was not explicitly evaluated for the IJsselmeer focus groups, it seems reasonable to suggest that the focus group method does cause a certain level of awareness raising but not as much as one would perhaps like. This is caused by the fact that one reaches a relatively small number of people, that participants receive little outside information, and (in some cases) agree on many assumptions and issues. The effect of the IJsselmeer focus groups on the informal networks that might have been touched is unknown. However, it does seem that people that are already interested in the Water Framework Directive are more likely to participate than those who know nothing about it yet.

From the outcomes of the IJsselmeer focus groups it does appear that focus groups are helpful in getting an idea of how people construct problems. The question however is how valuable such insights really are. This depends crucially on the situation wherein a water manager finds himself. If there is little experience with participatory policy making, or when many new policies are in the process of being prepared, getting to know problem constructions of certain groups may be useful information. Perhaps overlooked problems come to the surface, priorities may have to be adjusted, or valuable insights for the communication process on policy are learned. From conversations with local politicians and the people implementing the Water Framework Directive it appears that the IJsselmeer focus groups did not result in a great deal of new findings for them. This is partly caused by the high level of sophistication of water management in the lake (with extensive participation schemes) and the plethora of research already done on most aspects talked about in the groups. In this, perhaps unique, context, the focus group method has a charming simplicity for the participants who tend to feel they are 'being participated' often enough

already. For the political decision makers, one downside of the outcomes of the focus groups is likely to be their one-sidedness and lack of general overview. Most focus groups did talk mainly from their own perceptions and priorities, but policies are (and can) not be made that way.

Yet, our recommendation is that focus groups have more added value in areas where one really still has to start professional water management and/or where policy makers really have little insight yet in how certain groups think, and/or where very controversial issues have arisen. Regarding the latter, researchers have tried and approached the fishermen in connection with previous research projects and met with a great deal of resistance. The fact that they were willing to participate in a focus group does mean (under certain conditions such as organizers who are not too close to policy makers) that the method can be used when other methods fail. One dilemma the authors feel to be present when one starts a focus group is whether one takes groups that are more or less coherent or uniform (as in they know each other already or come from the same profession) or a group with more diversity. There are clear advantages to choosing groups that are coherent/uniform, but the disadvantage is that the learning effect is quite moderate and people become less aware of their own taken for granted assumptions. Certainly the citizens' jury offers an opportunity for this.

4.3 Evaluation of the IJsselmeer Citizens' Jury

Main Outcomes

The citizens' jury reached a conclusion after three days of meetings and discussions. An important step in implementing the WFD will be the designation of a status to the water basin in question. The basic possibilities are designation as natural water basin or as human influenced water basin. From this basic distinction flows a range of decisions, boiling down to setting water quality standards that are more ambitious for natural water basins than human influenced water basins. In this light it is very relevant that the Jury decided that the IJsselmeer should be assigned the 'heavily influenced by humans' status and standard setting should proceed from there. The jury acknowledged that the protracted and now completed discussion about whether or not to turn the lake into land (reclamation of polder construction) still has an effect on its situation. With a view towards reclamation, there has been little consideration about the value(s) and possibilities of the lake as a stretch of open water now and in the future. These value(s) and possibilities, for the flora and fauna as well as for humans, are fully recognized by the jury. The jury therefore developed a vision: according to all jury members, the IJsselmeer should remain an open water body (prohibiting land reclamation in the corners of the lake), with considerably more biodiversity than at present, with moderate

transitions between land and water, greater access to nature for recreation and another role for agriculture and the fishing industry. The lake would hereby also become more or less automatically suitable for the possible extraction of drinking water in the future. In order to realize this vision, cooperation, not only within the government, but also between the government and the private sector, will have to be improved. The public has to become more aware of the possibilities the lake offers, and more involvement on the part of the local residents in any planning is necessary.

It is interesting to note that the jury took a quite protective stance in respect of the lake, but did stress the importance of human use of the resulting beautiful and open natural area. Certain sectors that were seen as being detrimental to the 'ecological balance' in a broad sense – a key concept in the jury report – were to reduce or reshape their activities. The jury specifically had professional fisheries and the agriculture sector in mind. The jury recommended the commercial fishing industry in the lake to make drastic changes and develop in the direction of tourism. They emphasized however the fact that reorganization of the fishing industry must be handled in a cooperative manner which means providing sufficient financial funds to compensate the fishermen. With regard to the agricultural sector the citizens' jury recommended the sector to change over to employ biological methods and management and to use more extensive means of farming. In order to stimulate the sector in achieving this, the government should make subsidies available. The funds for these subsidies were to be generated by dispensing with the current farming subsidies.

Learning Effect

In order to evaluate the learning effect of the individual members of the jury, the jurors were asked to draw their 'cognitive map' on water quality, before and after the jury. This means that the jurors received a large piece of paper with 'water quality' in the centre, and a number of post-its that they could put on the paper. On these post-its, they were asked to write down all sorts of topics that they associated with the issue of water quality. The jurors were also asked to indicate whether the associated issue had a positive (+) or a negative (–) impact on water quality. A comparison of the *ex ante* and *ex post* cognitive maps (Terweij, 2004) reveals a strong learning effect. This is exemplified by the maps below. The two maps were drawn by the same juror, the first one before the jury (Figure 14.5), the second one afterwards (Figure 14.6). The count of items that the jurors brought in connection with water quality expanded by 77% afterwards. An analysis of the items that were mentioned indicates that jurors had a better understanding of the causes of water quality after the jury.

Group Dynamics

The implicit assumption of deliberation is that the participants are equal to one another in the discussion. In the IJsselmeer jury, this was not always

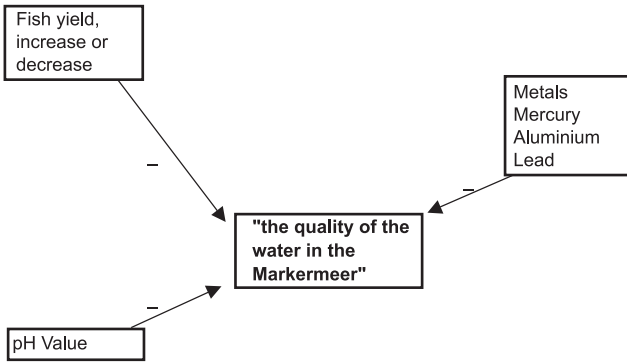


Fig. 14.5. The *ex ante* cognitive map on water quality of one of the jurors

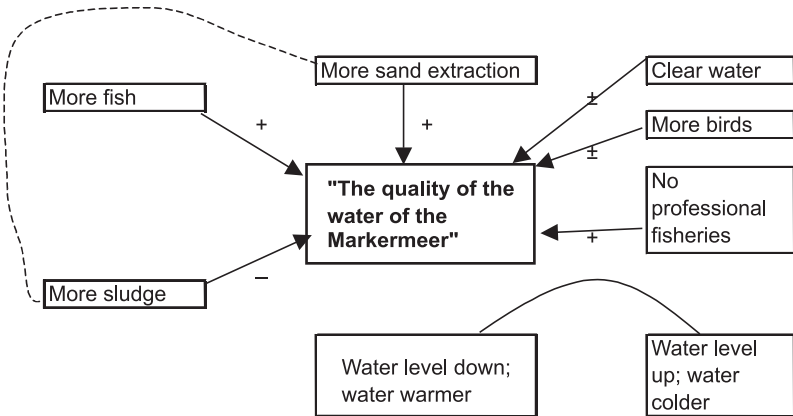


Fig. 14.6. The *ex post* cognitive map of one of the jurors

the case. Certain jurors, because they spoke a lot, were more dominant in the formulation of the recommendations than other jurors. In the post-jury questionnaire, the jurors indicated that they thought that certain jurors had been more influential than others, but they did not seem to mind it. Most dominant people had a positive intention towards the other jurors.

With regard to the decision-making process in the jury, the jurors were told that they did not have to seek for a consensus at all costs. Probably, it would not always be possible to reach agreement. It was emphasized that not only the majority, but also the minority opinion should be taken into account. Therefore, the proposal was that if the discussion tended to become unproductive, the jury could decide by voting. The jurors needed to take into account, however, that the status, and possibly the impact, of the jury's recommendations would improve if these were based on unanimity. When

the jurors discussed this issue during deliberation day, they emphasized the importance of trying to reach consensus as much as possible. At the same time, they were also a bit relieved that it was 'allowed' that differences would remain to exist. In the end, there were only a few topics on which the group did not reach an agreement, and eventually voting was used.

Most jurors indicated that the witnesses had increased their knowledge on the subject, and that the witnesses had contributed to the further shaping of their opinion on water quality and water management. They also felt that the witnesses' presentations increased their ability to make informed judgments and formulate recommendations. An important observation made by the project team was that, in the course of the jury process, the jurors became more knowledgeable about the topic and more competent to interrogate the witnesses. They confronted witnesses with (conflicting) information and claims from other witnesses and, when a witness gave vague answers, they went on asking questions in order to get the information they needed.

Jurors' Satisfaction

The *ex post* evaluation made clear that, overall, the jurors were positive about the jury (Table 14.3). They enjoyed being on the jury, were positive about the atmosphere, and appreciated the ability to express their opinion and to contribute to the jury's recommendations. Some jurors observed that not all jurors contributed to the same extent to the formulation of recommendations. A number of jurors had a relatively bigger say in the formulation of the recommendations, whereas others had contributed less. However, none of the jurors felt any pressure that they had to agree with the majority of the group members.

Table 14.3. Satisfaction of the jurors about the jury process

		5 Very positive	4	3	2	1 Very negative
Were expectations met?	(n=11)	11	0	0	0	0
Overall satisfaction	(n=11)	2	9	0	0	0
Atmosphere in the group	(n=11)	8	3	0	0	0
Atmosphere during the jury days	(n=11)	7	3	1	0	0
Did you enjoy being on the jury?	(n=11)	10	1	0	0	0
Possibility of expression of opinion	(n=10)	10	0	0	0	0
Possibility to contribute to the recommendations	(n=11)	3	4	4	0	0

With regard to the jurors' satisfaction about the preparation of the jury, the evaluation showed that most jurors felt well prepared for the jury and were positive about the pre-jury meetings. The jurors were a bit less positive about the training on questioning. Some jurors were not sure whether this training was really valuable in the sense that it helped them to interrogate the witnesses. The large majority of the jurors felt that the information market, the literature, and the training on decision making had contributed well to their preparation.

Another indication of the degree of satisfaction is the willingness of the jurors to participate again in a citizens' jury. It turned out that all jurors indicated that they would without doubt participate again.

Usefulness for Policy Makers

It is very worthwhile to be an organizer of a citizens' jury. The most rewarding part is the high level of interaction one gets with the jurors, but the contacts with government bodies are quite interesting too. There is a moral pleasure related to the fact that one helps to strengthen democracy and thereby counters the macro-societal forces that seem to the way of less political involvement or single-issue movements. The jury goes beyond the more common ways of participation and latches on the fact that our societies have become far more educated than 30 years ago.

The strengths of the jury are in the sphere of awareness raising and strengthening the democratic fabric of our society. These effects are certainly there for the members of the jury themselves, which is already quite an achievement. The degree to which these effects are also achievable in the wider societal context is uncertain at the time of writing this chapter, although media attention and audience presence at the Dutch Jury was probably less than the organizers had hoped for. The Dutch political system does seem to regard the jury as an interesting innovation and one of the authorities involved in this jury is willing to sponsor an additional set of juries.

Although citizens' juries are often described as a method for deciding controversial issues, in the Dutch system, where this method is largely unknown, this would probably not work. Therefore, the jury needs to operate in a context of representative government and not replace it. Although government bodies can run juries, this would probably not be a good idea as the yet feeble status of the instrument could then be undermined by accusations of manipulation. On the other hand, it is possible to envision a situation wherein citizens' juries become part of the civic duty that citizens in a society like ours have. The outcomes of the IJsselmeer jury can be considered replicable in the sense that a completely different group of jurors is likely to have reached the same conclusions as the current group. Perhaps within the context of overseeing bodies that guard the integrity of the jury process and the experience of tens of other

juries under the belt, communities would come to accept this logic and therefore delegate a certain level of decision making to citizens' juries in the future if this can properly be connected to the wider political decision-making system.

5. CONCLUSIONS AND RECOMMENDATIONS

The authors feel that both focus groups and citizens' juries can be important methods in the tool kit of the water manager. The methods are useful in different ways, however, with the focus group being a relatively low-cost method that is relatively easily accessible for participants and can be used in a well-known environment for the participants. As a result, the participants are mostly at ease and are likely to behave almost as if they are unobserved. It is possible to get better insights in the topic that the public finds important through the focus group method and this knowledge can be used in communicating with the public. The citizens' jury is more expensive and is for the small group of citizens that is involved in quite an intensive method. Although water managers may consider their field technical and complex for 'ordinary citizens', our experience is that jurors are able to handle technical and complex matters very well.

5.1 Comparison and Conclusion

Despite the positive conclusions about these specific methods of involving the public in water management, the authors do not share the high expectations of some of the authors mentioned in the Introduction. In the authors' opinion, the days of water self management are not here yet, neither can we declare the age of interactive water management. Rather, the context of participatory methods such as the ones we have described here is likely to be decision making by experts in combination with elected officials. The implication is that citizen participation be used for five distinct purposes (Van de Kerkhof and Huitema, 2004): (1) increase public *awareness* and *acceptance* of the problems that the water manager faces and of the measures that need to be taken to solve these problems; (2) lead to *better decisions* as it enriches the decision-making process with relevant viewpoints, interests and information about the water issue that could not have been generated otherwise; (3) increase the *legitimacy* of decision making, as it enables the stakeholders to engage in deliberation about the decisions that need to be taken; (4) increase the *accountability* of decision making, as participants get an inside view in the decision-making process and they become co-responsible for the decisions that are made and the actions that are taken; and (5) result in *learning*, as stakeholders, government and scientific experts

enter into a dialogue and, by interaction and debate, they learn how to collectively manage a river basin and deal with conflicting views and interests.

Using a scale from – to ++ we indicate in Table 14.4 whether the two methods have achieved these purposes in the case of the Dutch focus groups and citizens' jury.

Table 14.4. Evaluation of the purposes of participation in the case of the Dutch focus groups and citizens' jury

Goal	Aspects (if more than one)	Achieved in Dutch focus groups?	Achieved in Dutch Jury?
<i>Raising awareness</i>	- Amongst the participants	+	++
	- Amongst the wider audience	-	-
<i>Better decisions</i>	- New perspectives for policy makers	+	+
	- New 'factual' information	-	-
<i>Increase legitimacy</i>		-	Uncertain
<i>Accountability</i>	- Inside view of government	-	++
	- Co-responsibility	-	Uncertain
<i>Collective learning</i>	- Collective vision	--	--
	- Amongst the participants	+	++

With respect to raising public awareness amongst the wider audience, no miracles should be expected of a focus group or a citizens' jury. Since their membership is limited, the focus group and the jury are essentially processes that involve few people. In the case of the jury, though, the method does teach these few people a lot. Awareness raising in the wider audience is dependent on various other mechanisms, including the degree to which the media pick up the issue and the degree to which the participants tell their social environment about what is going on. In the authors' view, the jury has greater potential for media attention, but in the case of the jury for the case study, this did not bear out.

The authors also feel that one should be modest about the extent to which the focus groups and the citizens' jury actually lead to better decisions. For the knowledgeable observer of policy development in the IJsselmeer area, not many new 'facts' were heard in the recommendations of the citizens' jury. On the other hand, the jury recommendations, as did the focus groups, did give an insight into the normative aspects of water management, and showed what, according to the *citizens*, should be the priorities of water management, and what kind of choices should be made. This may be an important insight for water managers. Also, it was quite refreshing how the focus group participants and the jurors asked questions, sometimes very fundamental ones, about understandings and agreements that all insiders know about but which may look strange from the outside.

With regard to legitimacy, the conclusion must be drawn that the focus groups did not achieve this goal, but neither intended to. The degree to which the effect occurs for the jury depends in part of the role that the jury recommendations will play in the further plan making process under the WFD and this is yet at the beginning. However, it would seem that the fact that the jury method is still so new in the Netherlands does not help to give the jury's recommendations the status of unavoidability.

With regard to accountability, the authors conclude that this is an effect that did not occur (and never was supposed to occur) in the focus groups but did occur to some extent in the jury, but then limited to the jurors and the people that came to the jury hearings. One of the most commonly heard remarks amongst the jurors was that their participation in the jury had increased their understanding of the complexities of governmental decision making. Whether there is any co-responsibility in case of the jury is hard to say, as this will depend on various factors, including the degree to which the jury's recommendations will now play a role in the policy process. Also important is the degree to which the jurors will remain involved in the process of drafting River Basin Management plans, which seems to be the intention of the government parties involved.

With regard to collective learning, the authors draw two conclusions. The first conclusion relates to the dimension of '*collective*'. Neither the jury nor the focus groups have resulted in collective management, but this was by design. As organizers, the authors did not seek to alter current government decision-making procedures that allow only a limited role for ordinary citizens. The consequence is that the recommendations of the jury, that are to some extent aimed at impacting the policy process, are their own product, and the government parties do not necessarily share the opinions in it. The second conclusion relates to the dimension of *learning*. In this respect, it can be seen – for instance on the basis of the cognitive maps – that the jury resulted in a lot of learning for the jurors themselves. The learning effect of the focus groups, however, was more modest (Huitema et al. 2003).

5.2 The Usefulness of the Methods in Different Countries

Within the context of the River Dialogue project, the focus group and citizens' jury methods have not only been used in the Netherlands, but in Sweden and Estonia as well (Gooch et al. 2003, 2004; Kangur et al. 2003; Säre and Uunt, 2004). The selected river basin case studies in these countries – the Motala Ström in Sweden, the Emajõgi River in Estonia, and the IJsselmeer basin in the Netherlands – represent a diversity of cultural and socio-economic contexts in the new Europe in which the methods have been implemented. These contexts may differ, for instance, with regard to

the experience with participatory processes, and the public awareness of the urgency of the water management issue.

It seems that in all three countries the focus group was an appropriate method to have an open atmosphere and an informal discussion in which everyone had sufficient opportunity to contribute. Particularly in countries where public participation is not very common, like in Estonia, a focus group approach is an appropriate way to get insight into the way in which specific interest groups construct problems with regard to water management. These insights may be useful for policy makers who have to develop water management plans and set priorities. In countries where the decision-making process is already characterized by extensive participation schemes, like the Netherlands and Sweden, the focus group approach may have less added value. The Dutch system is characterized by a 'polder model' culture in which the involvement of interest groups has been institutionalized in the early stages of the political decision-making process. Yet, the focus group approach could also provide new opportunities here, e.g., by involving other groups than the regular 'polder partners'.

With regard to the citizens' juries, in all three countries the jurors and the witnesses expressed high satisfaction grades. In each of the three juries were ordinary members of the public present that normally do not get involved in policy making. Although in all three countries a rather small percentage of those people who received an invitation wanted to participate in the jury (in Estonia, the percentage was highest with 6.1, compared with 3.3 and 3.1 in Sweden and the Netherlands respectively) the response was high enough to put together a varied group of citizens. These citizens showed a surprisingly large capability to master relatively complex issues and a fresh perspective on the issues concerned. In that sense, the decision-making process during the juries can certainly be seen as a good step towards deliberative democracy, and the juries can be used as an input to the plan forming under the WFD. Especially in the Netherlands, there was a desire amongst members of the jury to get involved in public life (e.g. in the water board council). One measure to strengthen the instrument could be a legal obligation to participate in a jury (should they be held more frequently) so that not only citizens participate who are already socially active. Also the response of the authorities involved was rather positive, although there seem to have been hesitations initially in the Netherlands, where the 'participation density' is already quite high.

5.3 The Application in Transboundary Settings

As a final remark, the authors would like to draw attention to an important challenge for those who advocate more citizens' participation in water

management. This challenge is related to the fact that so many water resources are shared between jurisdictions and communities. Transboundary water management compounds the difficulties associated with citizen participation at the national scale. This is not only because of language and cultural differences, but also because of the intrinsically political character of the process of designing participatory methods (Denters et. al. 2003). In a transboundary setting, there may be strong disagreements about problems, causes and consequences, and blame. In such a context, the setting of a jury charge for instance may lead to political bickering, as maybe the choice of a location for the proceedings, the choice of witnesses, etc. The scientific literature on public participation is yet to address such issues, although at least one trans European citizens' jury has been held (Huitema, 2003). During an international conference on transboundary water management, which was part of the River Dialogue project^{vi}, the authors explained the citizens' jury method to water managers dealing with transboundary water and then challenged them to devise a citizens' jury process that would work. Remarkably, even water managers operating from both sides of the Kyrgyzstan and Kazakhstan border (Chu and Talas rivers), were able to reach an agreement on how a citizens' jury could be organized even though water management in that area has given rise to enormous political tensions between the two countries. Such an agreement is easier to reach in the safe settings of an international conference than in real life. However, the authors see this is an indication that it is not *a priori* impossible to use participatory methods in the complicated transboundary setting. Given the potential benefits, including conflict reduction, water managers are likely to be served with the generation of systematic knowledge in this area. The authors would like to contribute to this knowledge, for instance by participating in the 10.5 million EURO research project NEWATER.

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^{vi} Meant here is the United Nations Economic Commission for Europe Transboundary Water Convention and the EU Water Framework Direction Conference on implementation through participatory approaches in Europe and the NIS countries, Tartu (Estonia), 16 June 2004. See for a report: http://www.riverdialogue.org/files/seminar_report.pdf.

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15

Intergovernmental Challenges of Watershed Management: Strategies for Improving Watershed Governance

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INTRODUCTION

Ecosystem management has growing support from practitioners, government officials, and researchers and has been utilized in a variety of settings to address a wide range of resource management problems (Cortner and Moote 1994; Grumbine 1994; Slocombe 1998; Slocombe 1993)ⁱ. A prominent application of the ecosystem-based approach is watershed management. Since watersheds are defined by their hydrology, they provide a logical boundary for managing water resources and problems like nonpoint source pollution (NPS) and habitat protection. Accordingly, it should not be surprising to find numerous examples of efforts to 'manage'

ⁱ For a discussion of ecosystem management see: Hanna J. Cortner and Margaret A. Moote, "Trends and Issues in Land and Water Resources Management: Setting the Agenda for Change," *Environmental Management* 18 (2, 1994), pp. 167-173; R. Edward Grumbine, "What is Ecosystem Management," *Conservation Biology* 8 (1, March 1994), pp. 27-38; D. S. Slocombe, "Defining Goals and Criteria for Ecosystem-Based Management," *Environmental Management* 22 (4, 1998), pp. 483-493; D. S. Slocombe, "Environmental Planning, Ecosystem Science, and Ecosystem Approaches for Integrating Environment and Development," *Environmental Management* 17 (3, 1993), pp. 289-303.

watershed problems in various estuaries, lakes, and river basins (Lubell, 2004; Imperial and Hennessey, 2000; Imperial and Hennessey, 1996; Kenney et al, 2000; Mackenzie, 1996).ⁱⁱ Characteristics of these efforts include:

- Approaching problems from an integrated or systems perspective;
- Promoting a stronger scientific basis behind government policies;
- Integrating and coordinating policies and programs across the government;
- Improving relationships between governmental and nongovernmental organizations;
- Broad public participation and stakeholder involvement in decision making;
- Changing or expanding policies, programs, and interorganizational relationships; and,
- Improving the performance of programs that address watershed problems (Born and Genskow, 2001; Leach and Pelkey, 2001).ⁱⁱⁱ

However, hydrologic boundaries rarely correspond to political boundaries. Accordingly, watershed problems are often addressed by agencies at different levels of government. This can produce governance problems such as: (1) fragmentation and duplication of responsibility; (2) poor use of information and resources; and, (3) inconsistency of policies across levels of government (Imperial, 1999). It is also common that the capacity (e.g., knowledge, power, authority, and resources) for solving complex watershed problems is widely dispersed such that no organization can solve the problems by acting alone (Bressers, 1995).

ⁱⁱ For examples of different types of watershed management programs see: Mark Lubell, "Resolving Conflict and Building Cooperation in the National Estuary Program," *Environmental Management* 33 (5, 2004), pp. 677–691; Mark T. Imperial and Timothy Hennessey, "Environmental Governance in Watersheds: The Importance of Collaboration to Institutional Performance," in *environment.gov: Transforming Environmental Protection for the 21st Century. Research Papers 7–10 Volume II*. (Washington, DC: National Academy of Public Administration, October 2000), pp. 8.1–8.196; Mark T. Imperial and Timothy Hennessey, "An Ecosystem-Based Approach to Managing Estuaries: An Assessment of the National Estuary Program," *Coastal Management* 24 (2, 1996), pp. 115–139; Douglas S. Kenney, Sean T. McAllister, William H. Caile, and Jason S. Peckham, *The New Watershed Source Book: A Directory and Review of Watershed Initiatives in the Western United States* (Boulder, CO: University of Colorado School of Law. April 2000); Susan H. Mackenzie, *Integrated Resource Planning and Management: The Ecosystem Approach in the Great Lakes Basin* (Washington, DC: Island Press, 1996).

ⁱⁱⁱ For a discussion of common characteristics of watershed management programs see: Stephen M. Born and Kenneth D. Genskow, *Toward Understanding New Watershed Initiatives – A Report from the Madison Watershed Workshop* (Madison, WI, 2001); W.D. Leach and N.W. Pelkey, "Making Watershed Partnerships Work: A Review of the Empirical Literature," *Journal of Water Resources Planning and Management* (November/December, 2001), pp. 378–385.

This suggests that watershed management is as much a problem of 'governance' as it is a question of science and designing effective policies. Governance refers to the means for achieving direction, control, and coordination of individuals and organizations with varying degrees of autonomy in order to advance joint objectives. It involves more than the configuration of governmental and nongovernmental organizations. Governance includes enabling statutes, organizational and financial resources, programmatic structures, and administrative rules and routines. It also includes the formal and informal rules, social norms, and structures that govern relationships between organizations (Milward and Provan, 2000; Lynn et al., 2000; Frederickson, 1996). It is inherently political and involves bargaining, negotiation, and compromise. Therefore, the central challenge for watershed managers is finding ways to improve governance when the capacity for solving problems is widely dispersed and few organizations accomplish their missions by acting alone (Teisman and Klijn, 2002; Mandell, 1989; Milward and Provan, 2000).

This chapter draws upon the growing research on watershed management, intergovernmental management (IGM), (Agranoff and McGurie, 2001; Agranoff and McGuire, 2003; Agranoff and McGuire, 1999; Gage and Mandel, 1990), interorganizational networks (IONs) (Kickert, 1997; Alter and Hage, 1993; Marin and Mayntz, 1991), and collaboration (Bardach, 2001; Huxham (ed.), 1996; Gray, 1989; Gray and Wood, 1991)^{iv} to identify strategies for improving watershed governance. The chapter begins with a discussion of IGM and how these strategies build, manage, and reconfigure governance networks. Common IGM strategies are then discussed:

- Coping and adjusting arrangements;
- Collaborating to get things done;
- Interorganizational planning;
- Developing shared policies or priorities;
- Creating watershed management organizations (WMOs);
- Capacity building and leveraging resources;
- Performance management systems

The final section identifies factors that influence these strategies including: (1) how contextual factors influence watershed governance; (2)

^{iv} For examples see: E. Bardach, "Developmental Dynamics: Collaboration as an Emergent Phenomenon," *Journal of Public Administration Research and Theory* 11 (2, 2001), pp. 149-164; C. Huxham (ed.), *Creating Collaborative Advantage* (Thousand Oaks, CA: SAGE Publications, 1996); Barbara Gray, *Collaborating: Finding Common Ground for Multiparty Problems* (San Francisco, CA: Jossey-Bass, 1989); Barbara Gray and Donna J. Wood, "Collaborative Alliances: Moving from Practice to Theory," *Journal of Applied Behavioral Science* 27 (1, 1991), pp. 3-22.

problems due to the human side of IGM; (3) the importance of minimizing transaction costs; and, (4) the challenge of maintaining accountability.

Intergovernmental Management Strategies

The participation of multiple governments in a policy or program is a governance norm worldwide. Consequently, it is important for watershed managers to understand the concepts of intergovernmental relations (IGR) and intergovernmental management (IGM) (Agranoff, 1996). IGR is primarily concerned with interactions between governmental units of all levels and types and is characterized by:

- (1) IGR recognizes a wider array of inter- and intra-level interactions between units of government than does federalism, which emphasizes national-state relationships;
- (2) Its human dimension focuses on the attitudes and actions of persons occupying official positions in government;
- (3) Relations among officials are not occasional occurrences but are continuous day-to-day patterns of interaction and information exchange;
- (4) Involvement of all types of public officials including legislators, administrators, and judges in decision-making processes; and,
- (5) A policy component where policy consists of the intentions and actions (or inactions) and the consequences of those actions (Wright, 1988).

Strategies commonly used to manage IGR include fiscal instruments (e.g., intergovernmental transfers, tax policy, expenditure controls, etc.), regulations (e.g., total or partial preemptions of authority, grant restrictions, mandates, cross-over regulations, prohibitions, etc.), and the actions of political and governmental leaders (Agranoff, 1996).

Intergovernmental management (IGM) is a narrower concept that emphasizes IGR's goal achievement processes. Whereas IGR emphasizes the general patterns of interconnected behaviors, IGM focuses on understanding the routine transactions and working relationships between governmental units for the purpose of achieving specific policy goals (Agranoff, 1996). The features that distinguish its limited focus include:

- (1) Activities focus on joint problem-solving, policy making, and coordination;
- (2) Managing ongoing relationships and coping with interorganizational networks as configured;
- (3) A broad mix of actors including relationships between the public, private, and nonprofit sector;
- (4) Lead actors tend to be mid to low level professionals rather than high-level administrators;

- (5) Nonhierarchical communication networks and interagency collaboration designed to improve service delivery or increase goal achievement; and,
- (6) Uses coping, cooperation, bargaining, and negotiation to resolve disputes (Wright, 1990).

A wide range of IGM strategies exist that are permanent, temporary, project-based, or ad hoc in nature (Mandell, 1990). Some strategies are extensions of traditional agency behavior while others are significant departures. However, all of these strategies involve network relationships.

Using IGM to Build, Manage, or Reconfigure IONs

Networks are structures of interdependence involving multiple organizations that exhibit some degree of structural stability but include both formal and informal linkages or relationships (O'Toole, Jr., 1997; Hall and O'Toole, Jr., 2000). Relations can involve something as simple as passing along needed information or consist of complicated relationships that exchange goods, services, or resources.

It is useful to distinguish between three types of network relationships. An *organization set* consists of organizations with direct links to some focal organization (Aldrich and Whetten, 1981). Of more interest to this study are action sets and interorganizational networks (IONs). An *action set* is a group of organizations that form temporary or permanent alliances for limited purposes (e.g., cooperating to complete a habitat restoration project). Whereas an organization set is concerned with a focal organization's relationships with other organizations, the action set is oriented towards the collective activity of a group of organizations. Thus, the collection of organizations involved in a specific IGM strategy would be an action set. An *interorganizational network* (ION) is the set of organizations bounded by a common orientation such as a policy area, problem, type of service, or a geographic area (Aldrich and Whetten, 1981). Accordingly, watershed governance networks can be defined in terms of a geographic area (i.e., the watershed) or the collection of organizations involved in specific policies, programs or watershed problems.

Understanding network structure is important because IGM strategies are designed to build, manage, or reconfigure networks. For example, collaborating on a habitat restoration project builds a new network. A joint planning effort that produces shared policies that guide future habitat restoration projects is an attempt to better manage an existing network of programs. Creating a new watershed management organization (WMO) that promotes habitat restoration would reconfigure the structure of the existing network and its activities may result in subsequent efforts to build and manage networks.

Network participants are also autonomous in that they retain independent decision-making powers and typically cannot be forced to participate in IGM activities (Wood and Gray, 1991). Instead, activities are governed by social exchange mechanisms based on communication, relationships (personal and organizational), mutual interests, and reputation rather than formal authority structures (Powel, 1990). Fortunately, however, there are a number of reasons why organizations choose to participate in IGM strategies:

- *Self-interest*: individuals and organizations collaborate because they achieve something that cannot be obtained in any other way but this does not imply that self-interest is at the expense of others;
- *Acquire resources*: collaboration provides way for organizations to obtain needed resources;
- *Political pressure*: collaboration is the by-product of demands from politicians or the public to do more to address a problem;
- *Institutional forces*: participants come to view collaborative processes as an effective way to solve important economic, technical, and strategic problems because other successful organizations collaborate;
- *Reduce transaction costs*: organizations collaborate when these activities offer some promise of reduced transaction costs (or at least no significant increase in costs) or provide some tangible benefits.

At the heart of each rationale is the idea that participation produces more public value (real or perceived) than would be achieved by working alone (Huxham, 1996; Bardach, 1998; Alexander, 1995; Osborn and Hagedoorn, 1997). The following sections describe common IGM strategies used to improve watershed governance.

Coping and Adjusting Arrangements

Network members routinely employ informal coping and adjustment strategies. IGM specialists solve a variety of interjurisdictional problems through informal contacts designed to seek advice, information, or approval (Agranoff, 1996; Agranoff and McGuire, 2003). These contacts are also used to understand administrative interpretations of rules and procedures, resolve differences, reach agreement on a mutual course of action, and to establish acceptable norms of behavior.

Instead of seeking what is allowable, administrators may request uneven treatment or seek ways to operate outside existing rules, standards, regulations, or guidelines. This may require getting a waiver, suspension, or approval to program requirements. IGM specialists could also alter requirements by redefining proposed activities as pilot or demonstration programs. It is also common to find that when regulatory provisions create impediments to program operations or prove excessively costly,

administrators try to change the regulations and secure adjustments to programs on a permanent basis (Agranoff, 1996).

Collaborating to Get Things Done

Collaboration is any joint activity by two or more organizations intended to increase public value by working together rather than separately (Imperial, 2005). It is an interactive process involving an autonomous group of actors who use shared rules, norms, or organizational structures to:

- Solve problems;
- Reach agreements
- Undertake joint actions; and,
- Share resources such as information, money or staff.

There appears to be a high latent potential for using collaboration to improve watershed governance. Watersheds span political, geographic, and ideological boundaries. Policies and programs governing watersheds are specialized by medium (e.g., air, water, soil, land use, etc.), geographic location (e.g., wetlands, coastal zone, tidal waters, agricultural land, forest land, etc.), function (e.g., permitting, enforcement, public education, installing BMPs, issuing grants, etc.), and legislation. The corresponding fragmentation limits any organization's ability to accomplish its mission alone but simultaneously creates opportunities for joint action.

Collaboration takes many forms with a lot of the activity oriented towards enhancing service delivery (e.g., coordinating permit programs) or improving environmental conditions by restoring the habitat or installing best management practices (BMPs). For example, in a habitat restoration project different organizations may provide funding, land, technical expertise, engineering or design work, construction, recruit volunteers, and manage the completed project. Many IGM strategies can also be defined as collaborative activities that focus on getting things done in an indirect fashion (Imperial, 2005).

Interorganizational Planning

Watershed problems are complex and affect a wide range of interests and values. Thus, many watersheds form interorganizational work groups, task forces, advisory committees, or other mechanisms to reconcile competing interests and values, usually after broad public participation and some effort to characterize problems. The end result is typically a watershed plan. These interorganizational planning processes are a useful IGM strategy. They identify and establish connections between organizations. It also provides network members with an opportunity to find ways to work together, generate ideas, share knowledge, and solve problems (Imperial, 2005).

These interactive processes also provide a forum for building relationships and trust. The interactions also provide channels for information exchange, which can improve decision-making and promote policy-oriented learning.^v As information is exchanged, it becomes part of the shared knowledge base that is 'owned' by all participants in the process. As a result, network members are better informed and presumably make better decisions. Politicians and high-level government officials get information about management issues while low-level staff learns about political and resource allocation issues (Wondolleck and Yaffee, 2000). Resource managers also function in a political environment where there is competition for resources and direction. These interactions provide agency leaders with an opportunity to build support for desired courses of action.

Developing Shared Priorities and Policies

Since there are different laws, programs, value preferences, and competing constituency groups, there are many legitimate objectives and competing views about how watersheds should be managed (Wondolleck and Yaffee, 2000). Thus, an important result of an interorganizational planning process is the development of shared priorities and policies. These activities perform a "steering" function that improves communication between actors, coordinates actions, and integrates policies in ways that advance collective goals (Peters and Pierre, 1998). Thus, they provide a means of coordinating in the absence of a centralized coordinator.

In many cases, shared priorities and policies are contained in formal documents such as a watershed management plan or memorandums of understanding/agreement (MOU/MOA). They can also be incorporated into higher-order rules (e.g., state planning documents, local comprehensive plans, zoning ordinances, etc.) that are binding on network members (Imperial, 2005). Finding ways to institutionalize shared priorities and policies is important because it provides a mechanism for holding network members accountable. It also makes future efforts less dependent on personal relationships or leaders. This minimizes problems produced by staff turnover such as the loss of institutional memory or trust embedded in relationships.

In other cases, shared priorities and policies develop informally as a result of routine interactions associated with interorganizational planning or other IGM processes. In these instances, priorities and policies are based more upon tradition, shared norms, and the informal agreements that govern much of our political and social lives (Axelrod, 1997). While social

^v For a discussion of the concept of policy-oriented learning see: Paul A. Sabatier and Hank C. Jenkins-Smith, "The Advocacy Coalition Framework: An Assessment," in Paul A. Sabatier (ed.), *Theories of the Policy Process* (Boulder, CO: Westview Press, 1999), pp. 117–166); Paul A. Sabatier and Hank C. Jenkins-Smith, *Policy Change and Learning: An Advocacy Coalition Approach* (Boulder, CO: Westview Press, 1993).

norms will not be sufficient in all cases, they are particularly important in IGM because participants typically lack the authority to compel other organizations to act. Instead, social norms and peer pressure at the political, professional, and individual level as well as formal (e.g., being removed as a partner) or informal (e.g., verbal and nonverbal) sanctions are used to enforce agreements.

Creating Watershed Management Organizations

One way to make interorganizational relationships endure is by creating new organizational structures, frequently referred to as watershed management organizations (WMOs).^{vi} WMOs come in a variety of forms. Some are informal citizen-based structures that function as other interest groups would. However, of more interest here are agency-based WMOs whose membership consists of other organizations. When a group of individuals or organizations begins to embrace collaborative processes, makes joint decisions, or act as a single entity they in effect begin acting as a new organization (Imperial, 2005; Jones, Hesterly, and Borgatti, 1997; Finn, 1996). Researchers refer to this organizational form in different ways including partnerships, coalitions, alliances/strategic alliances, consortiums, network broker, collaborative organizations, and network administrative organizations.

These second order organizations can enhance network governance by performing a variety of functions: serving as a convener; catalyst for action; conduit for information; advocacy; organizer; funder; technical assistance provider; capacity builder; partner; dispute resolver; or facilitator (Himmelman, 1996). For example, WMOs often: serve as a convener for discussing watershed problems; sponsor research and disseminate information to network member; serve as an advocate for the watershed; organize projects to address watershed problems; provide financial support to organizations addressing watershed problems; and provide technical assistance to governmental and nongovernmental members of the ION (Imperial, 2005). In other cases, WMOs may be created fill specific institutional needs that improve the ION's capacity for addressing watershed problems.

Membership varies in WMOs. Some are restrictive, limiting membership to a small selected set of organizations. Others have a large membership

^{vi} For a discussion of WMOs see: Imperial, 2005; Mark Lubell, "Collaborative Environmental Institutions: All Talk and No Action?" *Journal of Policy Analysis and Management* 23 (3, 2004), pp. 549–573; Elizabeth A. Moore, and Tomas M. Koontz, "A Typology of Collaborative Watershed Groups: Citizen-Based, Agency-Based, and Mixed Partnerships," *Society and Natural Resources* 16 (2003), pp. 451–460; W. D. Leach, N. W. Pelkey, and P. A. Sabatier, "Stakeholder Partnerships as Collaborative Policymaking: Evaluation Criteria Applied to Watershed Management in California and Washington," *Journal of Public Policy Analysis and Management* 21 (4, 2002), pp. 645–670; Leach and Pelkey, 2001; Born and Genskow, 2001.

representing a wide range of federal, state, local, private, and nonprofit organizations. While organizations typically comprise membership, it is common to find citizens or interest groups serving as members, much the same way they participate on advisory boards and policymaking bodies in the human service area. Membership can be voluntary or required (e.g., statute) but in either case it has consequences. Constituent organizations are expected to adhere to shared policies, behavioral norms, requirements, or other expectations associated with membership, some which may be significant departures from normal behavior.

Regardless of a WMO's membership, there tend to be no formal hierarchies among the constituent organizations, even though outside the organization there may be significant differences in power and authority (Huxham, 1996). This can limit a WMO's ability to address controversial problems because its members are other organizations rather than employees. Thus, they rely on consensus building to compensate for imperfections resulting from other decision rules (Bardach, 1998).

It is also common for WMOs to vary in formality (Imperial, 2005). Some WMOs rely on informal structures based primarily on social relationships. Others are established by statute, binding legal documents, interagency agreement, resolutions adopted by local governments, or by incorporation as chapter 501(c)(3) nonprofit organizations. There are a number of reasons why it is beneficial to formalize informal agreements and shared social norms and to establish formal rules governing such things as membership (i.e., access rules), decision making (i.e., decision rules), parameters for action (i.e., what the WMO will and will not do), and conflict resolution. This makes a WMO less reliant on personal relationships and the leadership of the 'champions' that created them.

WMOs also improve network governance by building relationships and trust among network members and connecting them in new ways and ensuring that interactions are repeated over long periods of time. This can promote the development of social networks, cooperation, and most importantly trust (Axelrod, 1997). Trust is an important governance mechanism because it lowers transaction costs by promoting smooth and efficient resource exchanges (Tsai and Ghoshal, 1998; Wicks et al. 1999). Information from trusted individuals or organizations is also more likely to be viewed as reliable and accurate (Granovetter, 1985). Accordingly, the relationships and trust can facilitate other IGM strategies.

WMOs can also enhance the ION's problem-solving capacity. Through repeated interactions, network members gain a greater appreciation of their interdependence. New perspectives on shared problems can result and, by working together, network members have the opportunity to craft creative responses to shared problems. Moreover, many WMOs are staffed directly (i.e., partners contribute funding for dedicated staff) or indirectly (i.e., one

partner provides staff support). This provides resources to support other IGM strategies. For example, while some collaborative efforts (e.g., habitat restoration projects) require capital funding, others depend on resources such as staff time, technical expertise, or equipment. WMOs can also absorb the transaction costs associated with organizing, supporting, or conducting many IGM activities. They also create a form of institutional infrastructure that subsequent IGM strategies can build upon. For example, if a WMO adopts a habitat restoration plan, other network members can link funding decisions to the shared priorities of network members.

Actors engaged in frequent, recurring interactions are more likely to develop specialized network governance structures such as WMOs because they help lower transaction costs (Dyer and Singh, 1998; Williamson, 1985). Creating a WMO provides a certain measure of stability by allowing network relationships to endure over long time periods. The stable pattern of interaction also promotes a particular form of organizational learning termed "collaborative know how" (Simonin, 1997). In essence, organizations, and the individuals that comprise them, learn how to cooperate by collaborating. For example, it is common to find that it takes watershed participants a great deal of time to plan, design, secure funding, and then complete their first habitat restoration project. However, subsequent efforts often require less time and resources. It also takes time to learn how to govern network processes (Dyer and Singh, 1998; Kraatz, 1998). For example, it takes time for WMOs to learn how to manage grants, contracts, and personnel involved in IGM processes. The implication is that public managers need to maximize learning opportunities and allow sufficient time to scale up and expand IGM activities.

Creating a WMO also encourages network members to invest in other relation-specific assets to demonstrate a credible commitment to the watershed governance effort. Organizations make these investments when they believe that the benefits outweigh the costs of initial investments or when there is a strong likelihood of repeated interactions with other network members (Cropper, 1996; Zaheer and Venkatraman, 1995; Huxham, 1996). Examples of relation specific investments include developing shared databases, resource inventories, strategic plans, or other resources that are shared and used to support a WMO or some other ongoing IGM strategy. Organizations may also hire staff whose skills, knowledge, or experience are tailored to support IGM activities. Organizations may modify their decision-making or service delivery to support the needs of IGM strategies. While these investments improve watershed governance, network members are advised to exercise some caution. The more specialized these investments and governance structures become, the more difficult it will become to deploy them in alternative ways when they are no longer needed (Dyer & Singh, 1998; Park, 1996).

While creating a WMO can enhance watershed governance, it is also a difficult endeavor. A certain amount of "collaborative inertia" must be overcome before a WMO can be formed (Bardach, 1998). Time and effort is required to build relationships and trust. Network members have to decide on a structure and collectively negotiate such things as decision rules, membership structure, and what the organization will or will not do. Resources required to support the WMO must be obtained. Other organizational issues such as human resource management, grants and contract management, and even staff and board member liability will have to be addressed. These efforts often take longer than expected and it is common for many WMOs to experience growing pains, or even become overwhelmed by the effort required to develop and maintain the new organization (Bardach, 1998). These difficulties are one of the reasons that researchers generally agree that the risks of death (i.e., failure) are higher for all new organizations (Bruderl and Schussler, 1990; Freeman, Carrol, and Hannan, 1983; Singh, Tucker, and House, 1986).

Moreover, while some measure of stability is beneficial for a WMO, public managers should be mindful that too much stability creates its own particular set of problems. Staff in the WMO may view their careers as being dependent on its success. This can result in investments that primarily benefit the WMO rather than the network members it is designed to serve. It is also possible that the WMO will become involved in turf fights with other network members as it tries to secure the resources needed to survive.

The same organizational processes that promote stability can make it difficult to adapt and respond to changing political, social, economic, or watershed conditions (Milward & Provan, 2000). Network members may be reluctant to reopen negotiations on contentious issues to change shared priorities and policies even though watershed researchers frequently note the importance of learning, adaptation, and change (Leach & Pelkey, 2001; Born & Genskow, 2001; Imperial, 1999).

Capacity Building and Leveraging Resources

Another common IGM strategy is building capacity within an ION for addressing watershed problems (Agranoff, 1996). Capacity refers to an organization's ability to: anticipate and influence change; make informed and intelligent policy decisions; attract, absorb, and manage resources; and evaluate current activities to guide future action (Honadle, 1981). Accordingly, a wide range of leadership, training, and management development programs can be used to build capacity by increasing the professionalization and performance of administrators and staff. Alternatively, professional specialists or development persons can be hired to build capacity within existing governmental and nongovernmental organizations. Capacity can also be increased by adding new resources (e.g., personnel, material, or technology), restructuring how work is done and

organized, and by changing the way services are delivered (Wondolleck & Yaffee, 2000; Bardach, 1998).

A common complaint is also the shortage of resources (e.g., staffing, funding, expertise, etc.) available to support implementation efforts in watersheds (Leach and Pelkey, 2001; Born and Genskow, 2001). One way to overcome these limitations is for network members to leverage their resources (e.g., funding, staff, equipment, expertise, etc.) in ways that improve the ION's ability to solve watershed problems or improve service delivery. Various forms of resource sharing can be employed. Some activities are informal and involve something as simple as sharing expensive monitoring equipment. More complex activities include co-locating staff, allocating staff to support another agency's efforts, or pooling financial resources in new and creative ways. For example, a state's department of forestry may hire staff from the department of fish and wildlife to work on habitat restoration projects to expedite their approval. Similarly, a state department of transportation may fund positions in the department of water quality to expedite stormwater approvals for transportation projects.

Performance Management

As the old axiom goes, 'what gets measured gets done.' Thus, performance management can encourage network participants to work together in ways that improve watershed governance. It also increases accountability and helps public managers, politicians, and the public to gauge the effectiveness existing programs by documenting:

- What was done?
- How well it was done?
- What difference these activities made?

Simply put performance management lets public managers know how they are doing and whether their programs are working. The following sections review common rationales for using performance management as an IGM strategy.

Evaluation and Accountability: Even when performance measures are collected for some other purpose, there is always the possibility that the information will be used in evaluations (Behn, 2003). Accordingly, it is common to find that some public managers resist performance measurement or making monitoring information available even though politicians, journalists, stakeholders, and citizens desire it. In network settings, this resistance is amplified when network participants have competing objectives or they lack control over the resources needed to achieve the measures. Nevertheless, information that supports evaluation and enhances accountability are frequent rationales for measuring performance in watershed settings (Imperial, 2004).

Steering, Coordinating, and Priority Setting: Many elected and appointed officials believe that performance management provides a means of controlling the activities of organizations and helps public officials determine where to spend limited resources. In network settings, performance management is unlikely to offer much control due to the autonomous nature of organizations. Instead, the focus shifts from control to steering, coordinating, and priority setting. Performance management provides a steering function by improving communication between the actors, coordinating actions, and integrating policies such that each organization advances shared objectives (Peters and Pierre, 1998; Wondolleck and Yafee, 2000; Bardach, 1998).

There is also a tendency for many watershed programs to go after the 'low hanging fruit' and look for opportunities for joint action that are easy to accomplish (Wondolleck and Yafee, 2000; Bardach, 1998). While this 'entrepreneurial' spirit should be applauded and is often appropriate in the early stages of a watershed management effort, when pursued over the long term it becomes difficult for network actors to systematically address problems. This creates the potential for 'random acts of environmental kindness.' Individual projects produce isolated environmental improvements but are too limited in scale, scope, number, magnitude, or duration to significantly change the underlying problem when viewed from the perspective of the larger watershed system (Imperial, 2004; Imperial and Hennessey 2000). However, making the transition from a series of isolated projects to systematically addressing specific watershed problems is not easy, particularly when network participants are left to rely on funding from federal or state agencies that have priorities differing from those established by basin actors. Performance management helps offset this problem by encouraging a systematic, long-term efforts to address specific problems.

Motivational Tool: Establishing performance measures that are specific and difficult but also are realistic and achievable provides an important motivational tool that:

- Focuses attention
- Encourages action
- Mobilizes effort
- Increases persistence
- Motivates the search for effective strategies

Performance management can grab the attention of agencies, politicians, interest groups, and citizens. Consequently it encourages network participants to resolve disagreements and motivates them towards joint action (Imperial, 2004; Behn, 2003; Metzenbaum, 2003). Performance management also provides a way to sustain momentum and generate peer

pressure to fulfill agreements. Clear and understandable goals also provide a strong motivator for citizens to volunteer time to support IGM activities.

Promoting and Celebrating: Collaboration research is replete with advice to 'promote accomplishments' and 'celebrate success' in network settings in order to:

- Give partners a sense of their collective relevance
- Motivate participants
- Promote the work of the collaborative
- Recruit new partners
- Attract resources to support future collaborative efforts (Behn, 2003; Bardach, 1998; Imperial, 2004).

Performance management allows network participants to mark milestones and promote accomplishments. Releasing performance reports also provides an opportunity for media coverage and allows network members to celebrate other programmatic accomplishments that demonstrate to politicians, journalists, stakeholders and the public that they are accomplishing something.

Demonstrating progress is important because it can attract new resources and promotes what is often referred to as the 'bandwagon effect.' When actors engage in cooperative efforts there is a certain amount of 'collaborative inertia' that has to be overcome and initial efforts are often slower than expected (Simonin, 1997). However, once a threshold level of success is achieved, the situation can change rapidly and collaborative processes take on a new dynamic when efforts build momentum, pick up speed, attract new members and resources, and begin addressing a wider set of issues (Imperial and Kauneckis, 2003; Bardach, 1998). Promoting accomplishments and celebrating success helps get the bandwagon rolling and provides a way to sustain momentum despite changing political, economic and social conditions.

Learning and Enhanced Governance: Performance management also helps network actors to learn why policies and programs are working (or not working) and improve how programs work (Behn, 2003). Learning occurs at different levels in an ION. As managers and staff learn about how their policies and programs they should be better informed and make better decisions. That is why many researchers recommend 'adaptive management.' Performance management allows watershed managers to treat policies as experiments and adapt them in light of changing knowledge and information in watershed settings.

Learning also occurs at the network and societal levels. Organizations adopt concepts, ideas, policies, practices and even performance management systems when they are demonstrated to be effective. Thus, performance management can stimulate innovation diffusion and adoption

both within and across networks.^{vii} It also stimulates policy-oriented learning by allowing competing stakeholder interests to have objective evidence about how programs are working (or not working). It also stimulates learning among the professionals from various disciplines and backgrounds that share normative beliefs and values within the ION. While these individuals often constitute a relatively small proportion of an agency, profession, or policy network, they have a disproportionate affect on organizational learning and behavior due to their influence on the policy process.^{viii}

Some Factors Influencing IGM Strategies

No single IGM strategy will be effective in all watersheds. Contextual factors associated with the watershed's setting can influence the selection of IGM strategies. The human side of IGM introduces other factors such as the importance of relationships and trust, the disposition and skills of staff, and the leadership required to initiate and carry out strategies. The autonomous nature of organizations in IONs also creates opportunities for strategic behavior and raises accountability concerns.

Context Matters

A consistent finding from watershed research is that context matters (Leach and Pelkey, 2001; Born and Genskow, 2001; Imperial and Hennessey, 2000). These factors can help practitioners determine the proper scale for a watershed governance effort. The factors can also influence the use of some IGM strategies.

Physical Setting: A watershed's size and physical boundaries delimit the set of organizations comprising the governance network. As size increases, so does the ION. Discernible boundaries such as mountains, highways, or other features are also important because it helps create a unique sense of place that provides a motivator for joint action (Wondolleck and Yaffee,

^{vii} For a discussion of diffusion within and across networks generally see: N. Phillips, T.B. Lawrence, and C. Hardy, "Interorganizational Collaboration and the Dynamic of Institutional Fields," *Journal of Management Studies* 37 (1, January 2000), pp. 23–43; T.B. Lawrence, C. Hardy, and N. Phillips, "Institutional Effects of Interorganizational Collaboration: The Emergence of Proto-Institutions," *Academy of Management Journal* 45 (1, 2002), pp. 281–290; E.M. Rogers, *Diffusion of Innovations*, 4th ed. (New York, NY: Free Press, 1995).

^{viii} Researchers refer to this network of individuals as an epistemic community. See: Craig W. Thomas, *Bureaucratic Landscapes: Interagency Cooperation and The Preservation of Biodiversity* (Cambridge, MA: MIT Press, 2003); Craig Thomas, "Public Management as Interagency Cooperation: Testing Epistemic Community Theory at the Domestic Level." *Journal of Public Administration Research and Theory* 7 (2, 1997), pp. 221–246.

2000). Physical proximity of the organizations within a watershed's ION is also important. When located close together, organizations and their members may be more likely to share the values, norms, and language that comprise the local culture. Physical isolation may also create incentives for organizations to recognize their interdependence and to work together to solve shared problems (Wondolleck and Yaffee, 2000).

Configuration of Watershed Problems: The configuration of watershed problems also determines the ION's size and composition. Policies and programs tend to aggregate around challenging public problems, particularly when there are multiple causes (Elmore, 1985). Accordingly, the size of the ION may increase as the number or complexity of problems increases. Characteristics of problems may also influence the use of IGM strategies. When problems are perceived to be increasing, severe, or approaching crises the incentives for interaction and cooperation is likely to increase, particularly when no one agency can "solve" the problem by working independently (Born and Genskow, 2001; Wondolleck and Yaffee, 2000; McCaffrey et al., 1995).^{ix} The general public and political officials may also be more likely to pressure network members to take action. Consequently, organizations may cooperate if for no reason other than to respond to political pressure (McCaffrey et al. 1995). Others argue that organizations are more willing to work together to address problems that are new, unfamiliar, or unprecedented, particularly when there are no clearly demarcated lines of authority restricting cooperative efforts (Phillips, et al, 2000; Chisholm, 1995). In these instances, IGM processes may be a way to attract new resources or accumulate new 'turf'.

Institutional Setting: Three interrelated features of the institutional setting merit attention. The watershed's size and configuration of problems will determine the ION's size and composition. Accordingly, the distribution of functions, responsibilities, authorities, and resources among network members will influence the selection and use of IGM strategies. Equally important is the pattern of actual or potential interaction among network members. Some institutional settings have functions and responsibilities divided such that there is little reason for organizations to interact. In these instances, a useful IGM strategy may be joint planning to stimulate interactions among network members. Conversely, an ION may be configured such that organizations interact on a regular basis due to overlapping functions and responsibilities whether they want to or not. In

^{ix} Born and Genskow, 2001; Wondolleck and Yaffee, 2000; D.P. McCaffrey, S.R. Faerman, and D.W. Hart, "The Appeal and Difficulties of Participative Systems," *Organization Science* 6 (6, Nov.–Dec. 1995), pp. 603–627. For a discussion of how different network members can perceive problems differently see: Mark Lubell, "Cognitive Conflict and Consensus Building in the National Estuary Program," *American Behavioral Scientist* 44 (4, December, 2000), pp. 628–647.

these IONs, different strategies such as shared priorities, collaboration, capacity building, and creating new WMOs may be more useful. Accordingly, the structural properties of IONs reflect the patterns of actual or potential interaction and this is information can be used to identify potential IGM strategies.

Situational History: Whether due to previous watershed planning efforts or the ION's structural properties, a history of interactions facilitates IGM (Imperial and Hennessey, 2000). A history of interactions may make it easier to reframe problems in ways that produce mutually acceptable solutions. It may also produce the trust and personal relationships that can be leveraged to facilitate future IGM strategies. Conversely, if the history of interactions produced mistrust it could complicate the deployment of some IGM strategies.

Programmatic Context: The final set of factors is the attributes of the community where a watershed is located. This includes factors such as: (1) the norms of acceptable behavior in the community; (2) the level of common understanding that potential participants have about problems, policy solutions, and collaborative processes; (3) the degree of homogeneity of preferences of those living in the community; (4) socio-economic conditions; (5) urban versus rural settings; socioeconomic conditions; (6) political culture. The term culture is often used to describe this set of factors (Ostrom, 1999).

The Human Side of IGM

One of the features that distinguish IGM is the relationships and interactions between mid and low level professionals in public, private, and nonprofit organizations. Accordingly, it is important to understand the human dimension of IGM.

Importance of Trust and Relationships: During early IGM efforts there was often less trust and weaker personal and organizational relationships. As trust and relationships built, IGM became easier, making trust both an antecedent to and outcome of network processes. Thus, a "virtuous circle" of escalating trust and further interaction developed when initial IGM efforts were effective (McCaffrey et al, 1995). Research finds that this "social capital" facilitates cooperative efforts because there is a widespread preference for transacting with individuals or organizations with known reputations. Information from "trusted" informants is also likely to be viewed as more reliable and accurate (Lenna and Van Buren, III, 1999; Tsai and Ghoshal, 1998; Granovetter, 1985; Ostrom, 1990).

While there is no magic recipe for developing trust and relationships, creating a forum for repeated interactions over a period of time is an important ingredient (Axelrod, 1997). Once trust and relationships develop,

it becomes equally important to maintain this social capital and socialize new participants to the norms, values, and routines associated with network interactions (Leana and Van Buren, 1999). Otherwise, trust and relationships will quickly erode, especially if there is a high turnover in staff or agency leadership. Conversely, while trust builds slowly, it is destroyed quickly as a result of negative experiences. Thus, during the early stages of a watershed governance effort, it may be wise to avoid utilizing IGM strategies that have a high risk of failure or a high likelihood of generating conflict.

Disposition and Skills of Participants: The skills, abilities, and managerial talents of IGM participants are also important. Many watershed 'managers' are trained in the physical, biological, or environmental sciences. However, IGM requires a broader range of professional and managerial talents (Agranoff and McGuire, 2001). IGM participants need strong interpersonal skills and the ability to resolve disputes and broker agreements. Political skills are needed to encourage cooperation while avoiding existing interorganizational conflicts. Leadership and persuasion skills help encourage network members to voluntarily work together towards collective goals.

The disposition of IGM participants is also important. For some, participation increases job satisfaction and motivation because they enjoy working in teams and learn or discover new skills and abilities. It also provides an opportunity for IGM participants to move beyond their normal organizational routines, provides new career opportunities, or even creates additional job security (Bardach, 1998; Imperial and Hennessey, 2000). Conversely, IGM can be stressful, time-consuming, laborious, and involve working with individuals and organizations that are disliked. Some participants may also be reluctant to cede control, share risks, share credit, or make themselves dependent upon other organizations for their success (Himmelman, 1996). While some like working in teams, others dislike these experiences (Imperial and Hennessey, 2000). The 'politics' associated with IGM may produce frustration and disillusionment, particularly when scientists and technical staff are not accustomed to working in political settings. Reduced job satisfaction and motivation can also result when upper management fails to appreciate the difficulties of IGM processes or fails to reward employees for their participation.

Leadership: Given the autonomous nature of organizations, it should not be surprising that various forms of leadership are important in order to initiate and sustain IGM strategies. Entrepreneurs view IGM as a way to attract new resources to address local problems. Coordinators call meetings, provide a point of contact, and keep the effort going as interest naturally ebbs and flows over time. Facilitators help resolve disputes the inevitably arise from time to time. Fixers or brokers find opportunities for joint action

by 'thinking differently,' help keep participants 'eye on the ball,' and make sure that the group is not sidetracked by peripheral issues. The devil's advocate challenges the group's assumptions and keeps everyone grounded in political and practical realities. Unsnarlers navigate the bureaucratic maze of institutional constraints and search for ways to 'bend the rules' and conduct activities given existing rules and regulations. Champions advocate specific courses of action and then use their powers of argument and persuasion to encourage others to commit to these actions (Imperial, 2004; Born and Genskow, 2001; Khator, 1999).

Minimizing Transaction Costs

Transaction costs are resources expended as a result of imperfect information. Three general categories of transaction costs can influence IGM processes: (1) information costs; (2) coordination costs; and, (3) strategic costs (Ostrom, Schroeder and Wynne, 1993). Reducing information and coordination costs can provide a strong motivator for participating in IGM activities. Information costs are associated with searching for and organizing information and the errors resulting from an ineffective blend of scientific and time and place information. An important rationale for IGM is to reduce information asymmetries among network members. Coordination costs are those invested in negotiating, monitoring, and enforcing agreements (Ostrom et al. 1993). As jurisdictional complexity increases and the actors' interests become increasingly heterogeneous, transaction costs often rise. Coordination costs will also be higher when there is a lack of trust (Imperial, 1999).

Conversely, IGM can create strategic costs that provide a disincentive for participating in IGM activities. Strategic costs result when asymmetries in information, power, or other resources make it possible for some to obtain benefits at the expense of others. There are many forms of strategic behavior. Adverse selection, moral hazard, shirking, free riding, and corruption occur when an individual (or organization) tries to improve their own outcome by consciously or unconsciously misleading others. Rent seeking occurs when some participants accrue unearned benefits as a result of participating in these activities (Ostrom et al. 1993).

The tendency for an organization to protect its 'turf' is another type of strategic behavior that complicates IGM activities. 'Turf' refers to the exclusive domain of activities or resources that an agency exercises operational control or policy responsibility. All else being equal, the individual (or organizational) preference is towards maintaining or increasing turf since it secures the agency's strategic position and enhances its long-term survival (Bardach, 1996). Many IGM strategies raise the potential for turf conflicts due to:

- *Threats to job security or career enhancement:* The results of interorganizational decision making could threaten staffing levels or employees' job security;
- *Challenge to professional expertise:* Laymen or rival experts in another agency could challenge an agency's claim to professional expertise;
- *Loss of policy direction:* Participants are likely to fight over policy or priorities because they are concerned about questions like value and cost and the outcome of these struggles can influence turf; and,
- *Undermining traditional priorities:* While IGM strategies can create new responsibilities that are welcome additions to turf, it might be viewed by other organizations as an unwelcome competitor for existing resources or priorities (Bardach, 1996).

While fights over turf are an inevitable reality, it is also possible that IGM strategies can be crafted in ways that minimize these problems or even expand turf.

Maintaining Accountability

Due to the autonomous nature of organizations involved in watershed governance, accountability and managing the diverse expectations generated within and outside the network is important. However, accountability is a 'two-edged' sword with constant tension between organizational autonomy and accountability (Imperial, 2004; Fredericksen and London, 2000). On the one hand, accountability mechanisms and peer pressure at the political, professional, and individual level helps enforce agreements and reduces incentives for organizations to become engaged in strategic behavior. Conversely, excessive monitoring and enforcement create disincentives when there is concern that participation will produce reprisals or criticism. This is particularly problematic when network members develop performance management systems and network actors rely on others outside the network for the resources needed to achieve desired outcomes. Public managers should also be cognizant of the political implications associated with reporting performance information. Accordingly, it is often useful design accountability mechanisms that focus on collective goal achievement so that credit and success is shared and avoid singling out particular organizations for criticism (Imperial, 2004).

Summary and Conclusions

Watersheds are 'managed' by a myriad of governmental and non-governmental organizations whose decisions and actions influence the health of the ecosystems. The corresponding institutional fragmentation can create conflict, but also creates opportunities for organizations to work

together in ways that improve environmental conditions or enhance watershed governance (Imperial and Kauneckis, 2003). Thus, watershed management is as much a challenge of governance as it is a question of science and designing effective policies.

While the positive virtues of IGM have been highlighted, public managers should remember that IGM strategies are no magical cure for all watershed governance problems. Nor should IGM be viewed as an end in and of itself; it is a means to an end. IGM strategies should only be valued when they produce better organizational or network performance than can be achieved using alternative strategies such as unilateral action, litigation, legislative intervention, markets, or hierarchical control. Practitioners also should avoid embracing IGM simply to avoid interorganizational conflict. Some conflict is unavoidable, and at times beneficial because it promotes a healthy competition of ideas that stimulates policy change and learning.

Intergovernmental management (IGM) can also be limited by other factors. Organizations have institutional constraints that prevent them from participating in some activities. Even when an organization's formal rules do not conflict, its behavioral norms, professional values, knowledge, experience, and abilities may cause it to resist participation. Limits also exist with respect to whether organizations can or should be willing to sacrifice their priorities (or those of their constituencies) for the sake of cooperation, no matter how noble the goal. Public managers should also consider whether they have the resources to participate in IGM strategies. No amount of creativity will overcome the shortage of resources (e.g., staff, money, expertise, authority, etc.) that is an imposing obstacle for getting things done (Bardach, 1998).

Fortunately, these constraints and obstacles are often less formidable than they appear. When IGM highlights common interests and values, network participants often find productive ways to work together that generate public value (Oliver, 1991). Thus, IGM is both an individually rational strategy and a collective means of enhancing watershed governance (McCaffrey et al. 1995).

Accordingly, while the watershed (or ecosystem) approach encourages network members to think holistically about problems, it is important for public managers to act strategically when trying to improve watershed governance. Critical issues in any watershed governance effort will be determining the proper geographic scale and selecting the focal problem(s) around which to focus governance efforts. The larger the watershed, the greater the size of the corresponding ION. When the size of the ION becomes unwieldy, it becomes difficult to employ and manage many IGM strategies. That is one reason why many larger watersheds develop nested arrangements with separate governance efforts designed to manage problems in various tributaries or sub-basins. Similarly, as the number and complexity

of problems increases, so will the ION's size. Accordingly, it is useful to organize watershed governance efforts around a focal problem(s) because it provides a means of limiting the network's structure. The focal problem(s) also help forge the network's collective identity and mission, which in turn becomes a motivator for IGM (Imperial and Hennessey, 2000). It also creates a measuring stick against which the public and politicians will use to hold the watershed governance effort accountable for its progress.

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16

Sustainability and Freshwater in the Western United States

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When residents of the arid western United States turn on their faucets, they expect to draw from an abundant, clean, good-tasting water supply. Current policies focus on water as a commodity that should be used efficiently to promote a prosperous economy for current generations; the resource, however, has additional values. All non-marine species depend upon freshwater for basic survival. Water in healthy ecosystems provides food, water purification, flood mitigation, drought mitigation, wildlife habitat, soil fertility maintenance, nutrient delivery, beauty, recreation opportunities and biodiversity conservation. (Postel, 2003). Many Indians revere water for its spiritual properties, depending on the presence of fish for sustenance and traditional ceremonies. Indians, acequia members (Rivera, 1998), farmers and ranchers and urban dwellers all find that possession of an adequate water supply provides community security.

Demands for water have escalated, harming the ecosystem, creating inequities in the distribution of the resource and fostering political and economic competition that threatens to reduce water quantity and quality for future. To explore what a sustainable water regime would require, this chapter defines the goals of water sustainability; utilizes Sabatier and Jenkins-Smith's Advocacy Coalition framework (ACF), (Sabatier, 1993), to discuss water policy making, discusses the development of water policy over time, and evaluates water policy reform to promote stability.

WATER SUSTAINABILITY

Sustainable water policy will allow "development that meets the needs of

the present without compromising the ability of future generations to meet their own needs.”ⁱ. Water is important as an economic tool, a recreation venue, a source of community security and as a necessary ingredient in a healthy ecosystem. To obtain water sustainability, policy should be guided by the goals of efficiency, respect for nature and equity (Bates et al., 1993).

Three Goals of Sustainable Water Policy

Efficiency: Prior appropriation needs to promote the efficient use of water. The doctrine has traditionally accepted almost any use of diverted water as a beneficial. As a result, senior appropriators may use an inefficient system of irrigation because they have the luxury of sufficient water, even in dry years. States need to monitor the amount of diversions (a minimal step in sanctioning waste) and levy user charges to promote efficiency. At present, states do not effectively use sanctions and almost completely lack positive incentives to promote efficiency.

Respect for and Protection of Nature: Second, state water policy should promote respect for nature that is necessary for environmental protection and human well-being. Unfortunately, prior appropriation fails to deliver in this respect. Prior appropriation focuses on water as a commodity to produce profit rather than a natural resource that is respected for its intrinsic value. One important reform is instream flow laws. Federal and state protections exist but with mixed results. For example, of the six federal tools that can increase instream flows and be imposed on unwilling parties, four are available only if a reservoir or other water facility requires authorization under federal law (such as Federal Energy Regulatory Commission) or is managed by a federal agency. The other two methods, the Clean Water Actⁱⁱ and Endangered Species Act, often are not aggressively

ⁱ Western Water Policy Review Advisory Commission (WWPRAC), *Water in the West: Challenge for the Next Century* (Springfield, VA: National Technical Information Service, 1998), 3-1. This definition quotes the President’s Council on Sustainable Development (1996) available at <http://waterwest.org/reading/readingfiles/fedreportfiles/chapt3.pdf>.

ⁱⁱ The Clean Water Act was created “to restore and maintain the chemical, physical and biological integrity of the Nation’s waters.” It is most often used to use issue permits that limit pollution discharges. The CWA also has responsibilities to protect fish and wildlife and promote instream flows for recreation. It has three provisions likely to affect water quantity. First, dredge and fill requirements are used to evaluate projects in which dredged or fill material may be discharged (Section 404). Second, Section 303 defines designated uses and water quality criteria that must be met for irrigation, domestic water supply and other types of water. These criteria may be used with Section 401 (states certify water projects are compliance with state water-quality requirements) to effectively protect instream flows. The CWA has already affected instream flows and is likely to have a larger impact in the future (Gillilian and Brown, 259-263).

implemented because of the political hostility they engender.ⁱⁱⁱ Worst of all, the ESA provides incentives for private landowners to ‘shoot, shovel and shut-up’ in order to kill or run off a listed species before the owner’s land use options are limited.^{iv}

There are nine instream tools available to the state,^v but their effects are limited because the instream flow right is usually so junior that they do not provide water in dry years. Private water management agreements can be effective but they cannot be imposed on unwilling water rights holders (Doremus and Tarlock, 2003). Only the public trust (see discussion below) can be imposed (Doremus and Tarlock, 2003). The use of federal and state tools have limitations.

Equity and Social Justice: Prior appropriation promotes secure property rights but it fails to provide equity.^{vi} The lack of equity is reflected in the lack of government authority to reallocate water on the basis of citizens’ collective welfare.^{vii} States may adopt the public trust doctrine in which “the state holds water in trust for the people and cannot convey it for private uses without considering the impact on public uses like fish, wildlife and recreation.” (Getches, ‘Metamorphosis’) The doctrine was applied to water in the 1983 “Mono Lake” case^{viii} which dealt with Los

ⁱⁱⁱ The 6 federal tools that can protect existing instream flows as well as increase them are federal reserved rights, issuance of special permits, management of existing federal dams, FERC licensing of nonfederal hydroelectric dams and Clean Water Act and ESA regulations. The 7th federal tool that cannot increase instream flows or be imposed upon unwilling parties is Wild and Scenic River Act designation (Ibid., 299-301).

^{iv} Ibid., 61. Habitat Conservation Plans (HPCs) were developed to provide incentives for private landowners to protect endangered species. HPCs are voluntary yet binding agreements in which property owners take steps to preserve species at the same time they are given approval to develop their property with a “no surprises” guarantee (i.e, the government cannot require more stringent protection in the future) (Michael E. Kraft, *Environmental Policy and Politics*, 3rd ed. (New York: Person, Longman, 2004): 205.

^v The nine state tools to protect instream flows are: requirements for minimum flows; case by case evaluation of prior appropriation permits; instream flow rights; temporary or permanent transfer of offstream rights to instream flows; movement of senior offstream rights downstream; restiction on the movement of senior offstream rights to an upstream location; public trust doctrine; state river program and private management agreements (Gillilan and Brown, 298-301).

^{vi} According to the criteria of Bentham and Rawls, prior appropriation rights are not equitably distributed. However, the allocation equity of water is irrelevant according to Nozick’s theory (Doremus and Tarlock). The choice of social justice theory dictates how positive or negative water policy is evaluated.

^{vii} One exception that allows government to reallocate water more equitably is the authorization of the secretary of interior to decide to whom scarce water in federal project goes (Glennon and Culp, 939; Disdell, 408-414). That prior appropriation does not promote equity is defined as a problem in this chapter but those with a different definition of social justice may reach a different conclusion (Tisdell, 408-414; WWPRAC, 3-22; Cosens, 980).

^{viii} *Audubon Society v. Superior Court*, 1983 (WWPRAC, 3-63 to 3-64).

Angeles' diversion from Mono Lake tributaries that had reduced the lake's water level, made the water more saline and destroyed bird habitat. Even though Los Angeles had used the water for 40 years, the California Supreme Court held that these appropriations must be reduced because they violated the public trust (Getches, 'Metamorphosis'; Bates et al. 1993). Nonetheless, the public trust doctrine has limitations: it can only be used after environmental harm has occurred (Bates et al. 1993) and the doctrine has not been accepted in other western states (Getches, 'Metamorphosis').

One of most egregious inequities in water policy is the difficulty that delayed or still prevents Indians from using the federal reserve rights that were recognized by the Supreme Court in *Winters v. United States* in 1908. Many tribes have yet to quantify their rights and gain the use of their water. They also received few of the benefits of the big dam era, allowing prior appropriators to use water that Indians had federal reserved rights claims to. To resolve historical inequities, tribes need to quantify all rights, acquire economic development funds and gain the authority to market water off the reservation (see discussion below). Despite the difficulties, tribal consumption of water is expected to increase, suggesting progress in resolving water inequities (Glennon and Culp, 2002).

In summary, the interdependence of man and the natural world requires that water policy balances efficiency, respect for nature and equity as well as economic profit. The challenge of sustainability is to remedy current harms and injustices and find a balance among competing water demands that leaves adequate water for future generations. In addition to these policy requirements, it is necessary to create a fair and efficient decision-making process that facilitates sustainability.

Decision-making Process Goals

Cosens sets forth the following criteria that are necessary to such a process (Cosens, 2003). First, decisions must efficiently solve water issues in a timely and cost effective manner. Second, the process should be inclusive and fair, involving water rights holders as well as competing interests in the formulation, adoption and implementation of water policy. Federal environmental standards and officials from all levels of government have a responsibility to consider a broader public interest along with the advocacy coalition concerns. The third requirement is a durable solution that is comprehensive and equitable; furthermore, its implementation must be politically and technically feasible. In summary, sustainable water law makes huge demands of both the policy making process and the substance of the policy.

THE ADVOCACY COALITION FRAMEWORK

To explain how existing policy came to be and to evaluate the possibility of water policy reform, the Advocacy Coalition framework (ACF) is utilized (Sabatier, 1993). The framework assumes there are subsystems that focus on a particular policy such as water, energy or education. The basic components of the model of subsystems are advocacy coalitions comprised of political interests who act according to their policy goals, stable external parameters and external events that may prompt policy change.

Advocacy Coalitions

Advocacy coalitions have public and private participants (elected and appointed officials from different levels of government and interest groups who share policy beliefs and problem definitions and work together to achieve their policy goals. There will normally be two to four coalitions that are stable over time. Shared beliefs are the catalyst that brings and keeps a coalition together. The success of each coalition largely depends on its possession of resources such as money, expertise, supporters, legal authority and cooperative relations with government officials (Sabatier, 1993). Some water coalitions operate more effectively and are accordingly advantaged and they are loath to give up the benefits they enjoy.

The policy belief system of each coalition consists of different components, some of which are more fervently held than others. Deep-core beliefs define basic personal philosophy that is not easily changed. These might include the notion that man should dominate nature or perspectives on distributive justice. Near-core beliefs are views that affect policies such as the proper scope of government authority and the appropriate role of the market. These beliefs are also deeply held but are more open to change if their logic is successfully challenged. Secondary aspects, which pertain to laws, governmental processes, information about problem severity and policy success, are moderately easy to change (Sabatier, 1993).

Stable External Parameters

Coalitions are affected by stable parameters of the decision-making system that may change over a period of decades. The first parameter is basic attributes of the problem area. For reform to occur, current laws and practices need to be perceived as needy of change. Second, the availability of the resources limits the reforms that can occur. If a river has been over-appropriated, policy options are limited to alternatives such as transferring water from one use to another or 'creating' water when efficient technologies free up water for additional users. Cultural values are a third constraint

that create expectations about the appropriateness of government regulations, private property rights, environmental protection and the use of markets to make natural resource decisions. Finally, existing laws and legal and administrative processes tend towards inertia, making reform a difficult process (Sabatier, 1993).

External Perturbations

External perturbations in the decision-making context provide opportunities for change. First, socioeconomic conditions and technology will affect water policy. Changes in the economy can make voters fearful of costly changes to protect the environment. On the other hand, technological innovations that conserve water facilitate protection of environmental resources. Second, a change in governing coalitions can produce policy modification. A president with strong environmental opinions who is backed by majorities in Congress may strive for and sometimes produce policy change. And most important of all, policy decisions and pressure from another subsystem may impinge upon water policy. An energy subsystem that utilizes large quantities of water to extract coal bed methane or petroleum may force the water subsystem to accept policy change (Sabatier, 1993).

Policy Change

Policy reform may occur as the result of policy learning and/or changes in factors external to the subsystem. Policy learning occurs because of change in the attitudes of existing coalition members or the infusion of new members with different views. It is most likely to alter secondary aspects of the belief systems under the following circumstances: low conflict; intermediate conflict among individuals who are well informed; accepted quantitative data supporting a compromise; and professional participation in the decision-making forums (Jenkins-Smith, 1993).^{ix} Policy learning may lead to changes in secondary aspects of the coalition's belief system that may promote policy compromise. Often this learning occurs when perturbations external to the subsystem such as economic or political regime change alter the coalitions' resources (Sabatier, 1993). The next section discusses how water policy was created and evolved.

^{ix} Hank C. Jenkins-Smith and Paul A. Sabatier, "The Dynamics of Policy-Oriented Learning," in *Policy Change and Learning, An Advocacy Coalition Approach*, eds. Hank C. Jenkins-Smith and Paul A. Sabatier (Boulder: Westview Press, 1993), 41-56. This chapter provides a more extensive discussion of policy learning.

OVERVIEW OF WATER DEVELOPMENT

The Beginning

As settlers moved into western territories^x from the mid-19th century onward, they quickly realized that mining and farming depended upon an adequate supply of water. In response, two basic decisions were made: the prior appropriation water doctrine was created and water projects were established that were congruent with settlers' values of economic development, individualism and efficiency.^{xi} This was the beginning of the water development advocacy coalition (WDAC) that included support from state and federal governments.

Those two basic choices continued to have ramifications for 21st century residents. First, 8 of the 11 states^{xii} established prior appropriation systems that allocated most of their water.^{xiii} Prior appropriation conveyed water rights upon those who first put the water to beneficial use. During a water shortage, those with junior rights had to forego all use of water if senior appropriators consumed the entire river flow. The doctrine was (and still is) more concerned with failure to divert water (which can result in the forfeiture of the right) than the failure of junior appropriators to receive water in a dry year.

Contrary to the opinions of many water rights holders, they owned the right to use water rather than the water itself. The states administered water for the public benefit although the definition of public benefit

^x For the purposes of this article, western states include the Rocky Mountain and Pacific Coast states: Washington, Oregon, California, Nevada, Arizona, Utah, Idaho, Montana, Wyoming, Colorado and New Mexico. Much of the land within these states averages less than 20 inches of rain a year, WWPRAC, 2-1.

^{xi} Water was a commodity that was put to work to provide economic prosperity. Although westerners prided themselves on the individual hard work it took to build water delivery systems, they eventually came to rely upon federally subsidized water projects. Efficiency was defined as diverting and storing water for irrigation and mining. Critics argue that water projects and application were often more a response to political demands than an activity that produced the greatest economic benefit. Sandra K. Davis, "The Politics of Water Scarcity in Western States," *Social Science Journal* 38, no. 4 (2001): 528.

^{xii} The three Pacific Coast states adopted hybrid systems of prior appropriation and riparian principles. In a riparian system, landowners obtain rights to water by owning land location on rivers and lakes. These rights are restricted to reasonable use. If drought occurs, all water users must proportionally reduce their water consumption. Failure to use water does not result in forfeiture of the rights, as it does under the prior appropriation doctrine. David H. Getches, *Water Law in a Nutshell* (St. Paul: West Publishing Co. 1997), 4-5 and 190.

^{xiii} The federal courts established that the federal could preempt state law but it has seldom chosen to do so. David H. Getches, "The Metamorphosis of Western Water Policy: Have Federal Laws and Local Decisions Eclipsed the States' Role?" *Stanford Environmental Law Journal* 20, no. 3 (2001): 6-8 and 13.

remained unclear. The states' 19th century constitutions said that water was a "...common resource to be administered for the benefit of society," (Getches, *Water Law in a Nutshell*, 1997) but in reality the states' primary focus was to insure that appropriators did not take water out of priority (Getches, *Water Law in a Nutshell*, 1997). Initially prior appropriation did not include protection of instream flows, water quality or the rights of Indians to divert water.

The prior appropriation doctrine created a water law system in which permanent water rights were created by the diversion of water and water was used without payment).^{xiv} This doctrine, well-suited to the 19th century, drove the settlement and development of the western territories.^{xv}

Second, water projects were necessary to store and deliver water. The WDAC was instrumental in seeking irrigation water. Private for-profit ditch companies developed water structures but often failed to be economically viable. With an exemption from state taxes, some ditch companies reorganized into public irrigation districts that succeeded in controlling about half of all water currently used in western states (Getches, *Water Law in a Nutshell*, 1997).^{xvi}

Much of the success of these organizations came when irrigators enlarged the WDAC coalition to include the U.S. Bureau of Reclamation, the U.S. Army Corp of Engineers, their U.S. representatives and senators, congressional committees and farm organizations. They brought about a Reclamation Era (1890s to the mid-1970s) (Tarlock, 2001) in which federal resources and expertise were applied to build even larger and more complex water projects. Local members of the WDAC, who paid only a small part of the projects' costs, became the beneficiaries of porkbarrel largesse.

Water projects have made major changes in water allocation and delivery. First, more than the prior appropriation doctrine, they have created relatively stable water supplies despite unpredictable precipitation. Second, as federal and state contracts from the projects became more important, federal authority over allocation of western water increased (Tarlock, 2001; Getches, 2001). Third, the parties who were disadvantaged by the projects such as the Indians and future environmentalists were not organized to influence Congressional decisions to build projects (Davis, 2001). Fourth, water projects had unintended environmental consequences that are discussed below.

^{xiv} Prior appropriation rights are permanent unless abandoned or forfeited. Sarah F. Bates and others, *Searching out the Headwaters* (Washington, D.C.: Island Press, 1993), 150.

^{xv} Getches, *Water Law in a Nutshell*, 101; Sarah F. Bates and others, 101 and 150.

^{xvi} Public irrigation districts are also called conservancy, conservation, reclamation water control and freshwater districts. Getches, *Water Law in a Nutshell*, 418-435.

Changes over the 20th Century

Water law and policy in 2000 is far different than it was when early miners and farmers struggled to provide food, shelter and safety for themselves. Contemporary values place much greater emphasis on instream flows, recreation, beauty of nature and environmental protection. Modifications have been spurred by change in values, plus population increases, greater urbanization and reduction in the number of ranchers and farmers (Gallilan et al. 1997). One result of these changes was the emergence of the urban development advocacy coalition (UDAC) that successfully sought water to sustain urban economies and populations. Cities such as Los Angeles and Denver built their own water projects and acquired rights to irrigation water. At first, they held goals in common with the WDAC: expansion of the water supply. As the populations in more cities grew, however, the UDAC came into competition with the WDAC. Over time, urban interests had greater financial resources with which to acquire water, initiating the purchase of agricultural water. The growth of urban populations, combined with and the degradation of natural resources, strengthened the influence and activities of conservation interest groups. By the late 1960s and 1970s, Audubon Society and the Sierra Club were joined by a plethora of new environmental groups that worked with supportive government officials to pass 21 major federal environmental laws between 1964 and 2002.^{xvii} Together these political actors plus journalists and researchers comprise the Environmental Advocacy Coalition (EAC) that has very different core and near core values and policy goals than the WDAC. Today we see a clash of cultural values that drive demands on water policy.

Although environmental sentiments also exist among many state citizens, environmental interests have made fewer changes at the state level (Tarlock, 2001). Furthermore, while the value of instream flows became evident as the decades passed, attempts to provide protection were difficult because a lot of the west's water had already been appropriated (Gillilan et al. 1997). States, however, have been prompted by federal laws, Indian federal reserve rights, interstate compacts and international treaties to modify their instream flow policy. Of the 11 western states, 10 have adopted a variety of instream flow provisions, but none of them offer complete and satisfactory protection.^{xviii}

Along with changes in water law, the west has witnessed the construction of water projects to store and deliver water. The number and capacity of western reservoirs has increased many times since 1900. Experts estimate

^{xvii} See a more detailed discussion in Kraft, 94-107.

^{xviii} Only New Mexico lacks statutory or common law protection. Jesse A. Boyd, "Hip Deep: A Survey of State Instream Flow Law from the Rocky Mountains to the Pacific Ocean," *Natural Resources Journal* 43, no. 4 (2003): 1152-1153 and 1208.

the number of western reservoirs to be between 30,000 (Gillilan and Brown, 1997) and 75,000 (Getches, 2001). The existence of this water infrastructure is testament to the success of the WDAC. To remedy this problem, some states turned to watershed collaboration (discussed in a later section) or general stream adjudications (state court or administrative procedures) in which all water rights holders are required to defend their rights as the state quantified competing water rights. Today the water rights most likely to remain unquantified are Indian water rights, preventing the tribes from using their water.

Throughout the 20th century, prior appropriation and water projects dominated decision-making, succeeding as economic development tools. Each year irrigation water is used for US \$9 billion of crops, US \$700 million of electric and flood control (Getches, 2001). Population increases and urban economies of western states were enabled by water provided from these projects.

But other less desirable changes were evident by the 1950s. There are few free flowing rivers remaining in western states as water projects regulated and diverted vast quantities of water. Decreases in stream flows endangered fish (particularly anadromous fish), reduced recreational opportunities (or at least, transferred them from rivers to reservoirs) and harmed water quality (Gillilan and Brown, 1997). Irrigated agriculture produced nonpoint source pollution of surface and groundwater and accelerated the loss of wetlands.

In addition, economic and efficiency concerns arose. Repayment of construction costs for Bureau of Reclamation projects were much smaller (14% of total costs) than architects the Big Dam era anticipated. Project water was heavily subsidized, making it subject to wasteful use (Bates et al. 1993).

The Big Dam era came to a close as the EAC flexed its political muscle and the Carter, Reagan and Bush administrations reduced federal support for construction of water projects. Demands for water increased but farmers and cities could no longer rely on federal projects to provide subsidized water supplies. In addition, Indians forcefully pressed to obtain their reserved water rights, creating an Indian Advocacy Coalition (IAC) comprised of tribal governments, lawyers, interest groups and supportive officials.^{xix} In the last 50 years the IAC has relied on lawsuits, negotiated settlements and general stream adjudications to quantify their water rights.

^{xix} The 1908 *Winter's* case (see endnote 3), the Indian right to water was recognized. At this time, neither courts nor federal agencies advocated on behalf of these rights. Few of tribes had quantified their rights (a necessary step to put the water to use) by the beginning of the environmental era (Sandra K. Davis, "Limits of the Law: Indian Water Rights in the American West," unpublished manuscript).

In conclusion, the 19th and 20th century water policy lacks many essential components of sustainability. To better understand this, the Advocacy Coalition Framework (ACF) is used to explain existing policy and evaluate the prospect for change.

CONSTRAINTS AND OPPORTUNITIES IN ACHIEVING SUSTAINABLE WATER POLICY

Stable Parameters

Basic Attributes of the Problem Area: According to ACF, over time, even stable parameters defining the problem area may change. For example, the definition of good water policy has changed from unchallenged acceptance of consumption and diversion to a spirited debate between economic consumption versus protection of environmental resources. This conflict, which emerged early in the 20th century, was well established by the late 1960s and continues to this day. ACF holds that policy change is best promoted by intermediate level conflict among informed participants. At present, the conflict is often intense with participants whose knowledge is limited to the advocacy of their own interests. Thus, the movement toward change has begun but missing ingredients slow the process of policy change (Sabatier, 1993; Jenkins-Smith and Sabatier, 1993).

Basic Distribution of Natural Resources: The distribution of water resources has given irrigators and urban water providers substantial economic and political influence but the EAC and IAC have challenged the current water allocation. According to the ACF, water policy is categorized as an intractable issue because participants often have such dissimilar belief systems that they do not agree on common criteria with which to evaluate policy alternatives.^{xx} This conflict slows policy change but policy reform has begun and almost will surely continue, albeit incrementally.

Fundamental Cultural Values and Social Structure: As ACF suggests, cultural expectations have changed as environmentalists, recreation interests, urban water providers and Indians have promoted environmental regulations, instream flows, urban transfers and Indian federal reserved rights, incremental change has begun. Entrenched water rights holders are forced by regulations, general stream adjudications and lawsuits, to consider and sometimes accept change. The pace of reform, however, is far too slow to satisfy those in the EAC and IAC.

Basic Legal Structure: The basic legal structure comprised federal and state water laws plus government institutions and their decision-making processes that are resistant to change. The discussion begins with two of

^{xx} *Ibid.*, 51.

the most important laws: the prior appropriation doctrine and the Endangered Species Act.

A. Prior Appropriation and the Endangered Species Act. Prior appropriation provides the underlying principles of most states' water policy. The doctrine was created to encourage the use of water at a time when there were few concerns about water scarcity and environmental harm. Under prior appropriation, the first party who diverted water and put it to beneficial use had a right to the water ("first in time, first in right"). There were no requirements that the water be used efficiently; rather, over the years, water rights became recognized as a property right entitled to legal protection.^{xxi}

In 1973, at the height of the environmental era, the Endangered Species Act (ESA) was passed to protect threatened and endangered species. The statute requires that federal agencies refrain from harming protected species but it also limited actions by private persons on private land. It can be used to challenge new water projects that require federal permits. And, to the exasperation of prior appropriators, it can be used to limit state recognized water rights, although the ESA's challenge to private water rights is much less frequent than its restrictions on federal agencies and their projects (Benson, 2001). With its reputation for being a tough regulatory law that threatens water property rights, the ESA has been an important catalyst for collaboration that promotes both water use and environmental.^{xxii}

Not surprisingly, prior appropriation and the ESA differ in important ways. Prior appropriation is state law that was designed to encourage maximum utilization of water and establish and protect property rights. The ESA, on the other hand, is a federal regulatory law designed to protect species and their habitat (Benson, 2004). Yet despite these major differences, these legal approaches share important similarities. First, both provide almost exclusive protection for one interest (water rights holders versus species). Each promotes the status quo at the cost of flexibility for change. And, finally, both appear more restrictive than their actual implementation and are prone to encourage lawsuits as a means of settling disputes (Benson, 2004).

Government Institutions and their Decision-making Processes: Just the prior appropriation doctrine limits change, political institutions and their decision-making processes also restrain water policy reform. Fragmentation

^{xxi} There is a debate between those who think diversion rights may not be altered or regulated in any way and others who argue that waters rights are subject to public claims on water and may be limited (Bates and others, 131-132 and 147-149).

^{xxii} CALFED is the best known collaboration prompted by the ESA but it also facilitated a cooperative program to address long standing problems on the Walla Walla River, the Carson-Truckee water settlement and the Upper Colorado Endangered Fish Recovery Program. See Benson, 42-43 and 74-75 for more detailed discussion.

of the political system has major effects on policy. Separation of powers and federalism have created a highly fragmented system with multiple decision-making venues. Multiple advocacy coalitions attempt to influence different branches and levels of government. With this many venues and opportunities, comprehensive policy can be formulated but is seldom done (Tarlock et al. 2002). To make matters worse, water policy is made separate from energy, timber and grazing policy. As a result it is not uncommon to find policy gaps or water programs located in different units of government that contradict each other or conflict with other policy areas. Making coordinated water policy that systematically integrates natural resource protection, economic development, equity and other factors is extremely difficult in the American system.

The fragmented system also makes it difficult for one venue or jurisdiction to bring about system-wide reform. One set of officials may attempt broad reform but the outcome is uncertain. For example, despite fierce resistance to changes in water rights, in the 1980s the Western Governors Association embraced the need for reform that would protect a broader array of interests and provide for fuller public participation in water decision-making. Although ACF suggests this prestigious forum of experts was likely to facilitate reform, (Jenkins-Smith and Sabatier, 1993) the 1990s passed with very little change (Getches, 2001).

Dynamic Systems Events

Socioeconomic Conditions and Technology: Consistent with ACF, socioeconomic and technological factors produced change by challenging assumptions underlying current policy and by changing the political influence of one of the advocacy coalitions. First, by the 1960s, environmental protection values dramatically strengthened and challenged the notion that good water policy's primary focus was to promote consumption of water for economic gain. As the public adopted stronger environmental orientations and the number and influence of the environmental groups increased, candidates and government officials successfully promoted federal environmental protection statutes and regulations that impinged upon prior appropriation rights. In addition, the federal courts recognized Indians' rights to water that competed with prior appropriation rights.

Second, although technological gains were made in irrigation and the operation of dams to mimic natural stream flows and processes, the subsystem lacked the accepted quantitative data that ACF says is a catalyst to policy learning and change (Jenkins-Smith and Sabatier, 1993). While science must inform water policy decisions and provide new technologies for more efficiently managing water, it cannot find the balance point at which the various coalitions can compromise. The water policy debate is

inherently political and it is characterized by too much core value disagreement to enable science to dictate an answer (Doremus and Tarlock; Vaux, 2002).^{xxiii}

Systemic Governing Coalitions: The Carter and Reagan administrations both challenged the practice of subsidizing water via federal projects, helping to end the Era of Big Dams. The civil rights movement laid a foundation that assisted the tribes and their supporters who coalesced into the IAC that took a greater leadership role in the acquisition of their water rights. Yet, neither the presidential administrations nor the IAC and EAC were influential enough to accomplish major reform of state water policy.

Policy Decisions and Impacts from Other Subsystems: ACF argues that other subsystems are most likely to stimulate reform; and, certainly, water policy has been influenced by factors outside the subsystem. As mentioned earlier, the civil rights subsystem helped pave the road for the IAC to develop. As more Americans espoused conservative views in the 1980s, devolution of responsibility to states and local governments became a battle cry, helping states protect the prior appropriation system. Finally, federal budget limitations acted as constraints on spending for water projects and, as we will see later, economic development funds that accompanied Indian water settlements.

ACF expects that policy changes are a result in policy learning and, even more important, perturbations outside the subsystem.^{xxiv} In the 20th century, these disturbances prompted some water policy reform. For example, states' control of water was reduced as they had to accommodate environmental regulations, federal water project contract and management stipulations and federal reserve rights challenges but despite these pressures, the basic underlying assumptions of prior appropriation remained the same. At the turn of the 21st century, prior appropriators controlled most of the water and much remains to be done to encourage widespread conservation and protection of aquatic resources.

WATER REFORMS TO PROMOTE SUSTAINABILITY

Changes in the decision-making process are evaluated for the goals of sustainable policy and decision-making.

Reform 1

A holistic approach to natural resources is needed to deal with the interrelationships of the multi-facets of water (surface water,

^{xxiii} Doremus and Tarlock, 287, 324, 341 and 343. Henry Vaux, Jr., "A U.S. Water Agenda for the Twenty-First Century," *Environment* 41, no. 4 (2002). Accessed from Academic Search Premier database, July 21, 2004.

^{xxiv} *Ibid.*, 19-20.

groundwater, water supply and water quality) as well as other environmental policy related to land, pollution and wildlife. Although more integrated planning would be beneficial,^{xxv} a holistic approach would go beyond this, recognizing that management decisions in water will affect programs in other areas such as energy, employment, zoning and development policies. The interrelationships of different natural resources should inform the creation of water policy that recognizes the carrying capacity of the environment. The natural resources that supply basic human survival needs must be protected as the first priority (Postel, 2003), but using water for economic development, recreation. The Indian's spiritual values and environmental protection are also worthy objectives.

Goals: Creation of a holistic water policy would improve policy by striving to bring a balance among competing water demands. Consideration of the many demands on water and the interrelationships of water to human and ecosystem survival increases the likelihood that water would be allocated more equitably and utilized more efficiently.

ACF and Basic Attributes of the Problem Area: ACF recognizes that policy is affected by value expectations such as man's relation to nature and the appropriate role that the government should play in policymaking. First, Americans tend to see humans as separate from a natural world in which it is relatively easy to make one change and accomplish a specific policy goal in nature. This is the antithesis of a holistic approach that would consider the ripple effects resulting from the interdependence of man and nature. Second, at present, there are many water policies made by different levels and branches of government because of the fragmentation of the political system and the existence of competing advocacy coalitions. The substance of policy itself is fragmented into separate programs such as water, land and wildlife policy that are made independently of each other, sometimes with contradictory effects. Both the substance of policy and the decision-making process needs to consider the myriad factors affecting water.

Feasibility: Policy change is generally constrained by inertia to change. Since the American political system produces more incremental than large-policy change, it would be difficult to adopt the holistic policies necessary to create water sustainability. Thus, policy expectations and the operation of the American political system, make it very difficult to take a holistic approach to natural resources.

^{xxv} Doremus and Tarlock, 345, advocate the need to adjudicate different types of water rights and land rights to create more integrated policy. Getches, "Metamorphosis," 71, argues for integrated water planning.

Reform 2

Environmental harms should be redressed and current experiments and programs may provide solutions. When dams were built, most sought to provide water that would be diverted and consumed for economic benefit. Today, many are aware of the environmental harm that projects have done. First, fish have been seriously harmed by the construction and operation of dams. Today the release of water from dams can be used to support fish populations. The Bureau of Reclamation has conducted experiments at the Glen Canyon Dam (Colorado River) to compensate for floods that supported habitats and built river beaches. These simulated floods, it was hoped, would stir sediment downstream to restore beaches, provide nutrients for vegetation, and reestablished backwater habitat necessary for the humpback chub. Similarly, the Northwest Power Planning Council has released additional water down the Columbia River during the downstream migration of salmon smolts (Lowry, 2003; Gillilan and Brown, 1997).

Second, dam breaching is another remedy for the environmental harm that water projects have done. One study concluded that only two (Hoover and Grand Coulee) of 5,000 large dams produce more benefits than costs. More than 500 dams have been removed and another 100 dams are being evaluated for breaching (Lowry, 2003), but those removed to date tend to be smaller older dams. There is an advocacy for removal of four larger dams on the Snake River and the Glen Canyon Dam on the Colorado River, although this is unlikely to occur.^{xxvi} Some argue that restoring natural flow by removing the dam is the best solution to repair habitat and increase fish populations in many situations (Getches, 2001), while others suggest that a variety of innovative techniques such as adaptive management and marketing will more often be the prudent choice (Lowry, 2003).

Third, CALFED Bay-Delta Program, a massive planning effort to deal with water quality issues, watershed protection, ecosystem restoration, flood control, water storage and distribution, has been undertaken in California. It seeks to rely on scientific expertise, state-federal management cooperation and stakeholder representation to restore ecological health to the Sacramento-San Joaquin River system. Although it is still a work in progress, CALFED has improved California water policy and promoted

^{xxvi} None of these dams is likely to be removed in the foreseeable future. The National Marine Fisheries Service recommended that discussion of breaching the 4 Snake River dams be put on hold while other restoration techniques are tried to increase fish populations (Brad T Clark, "Agenda Setting and Issue Dynamics: Dam Breaching on the Lower Snake River," *Society and Natural Resources* 17 (2004): 605. The discussion of breaching the Glenn Canyon has remained just that – a discussion.

communication among potential adversaries (Getches, 2001; Jacobs et al, 2003)^{xxvii}.

Finally, another restoration option is exemplified by the Arizona Water Protection Fund (AWPF) that was authorized to conserve and restore water resources. Private individuals as well as state, federal and local agencies may apply for AWPf grants to conduct research, feasibility studies and restoration. While AWPf is one of the best programs in existence, it is hampered by the low priority that Arizona gives to recreation and wildlife. And, of course, the perennial problem of funding has reared its ugly head. AWPf failed to receive any state funding in 2002 and 2003 (Boyd, 2003). *Goals:* Simulated flows, dam breaching, research and collaborative planning seek to provide environmental protection, reestablishment of river flows for recreation (which can also promote the local economy) and balance among competing water demands. They also aim to promote comprehensive policy that eases implementation.

ACF and the Basic Distribution of Natural Resources: The distribution and use of water resources has created substantial harm to the environment. Although the lack of political support and funding can prevent policy change, there are some instances in which the awareness of the environmental damage created by water projects creates opportunities to prevent future harm and remedy existing damage.

Feasibility: Although simulated flows are easier to adopt than dam breaching, there are still many factors that work against it. The 1996 experiment on the Colorado River produced only temporary changes and it has been difficult to get authorization for additional experiments. More simulations need to be carried out and evaluated to provide more information about the effectiveness of river flow simulation. Funding is another problem. The cost of fish protection on the Columbia has been high and the fish populations appear to continue in decline (Lowry, 2003; Gillilan and Brown, 1997). The desirability of simulated flows remains to be demonstrated and accepted.

The limited experience with dam removal has raised questions about impacts that can be anticipated from such actions. For example, the Fort Edward Dam on the Hudson River was removed in 1973, releasing PCB laced sediment down the river. Sediment also silted up the river's navigation course and increased the possibility of flooding (Baish, 2002).^{xxviii} Although

^{xxvii} Getches, "Metamorphosis" 42-45; Katharine L. Jacobs, Samuel N. Luoma and Kim A. Taylor, "CAL FED," *Environment* 41, no. 1 (2003). Accessed from Academic Search Premier database, July 21, 2004.

^{xxviii} Sarah K. Baish, Sheila D. Davis and William L Graf, "The Complex Decisionmaking Process for Removing Dams," *Environment* 44, no. 4 (2002). Accessed from Academic Search Premier database, July 21, 2004.

these were unintended consequences that can be anticipated in future actions, they indicate that dam removal will require extensive administrative effort and expense that will depend on political support. Since support for dam breaching is likely to exist when the dam is older, needs costly repairs and is providing little revenue from hydroelectric power sales, the situations in which dam breaching will occur is probably limited (Lowry, 2003).

Neither simulated flows or dam removal are currently used on a large scale. They are controversial and unlikely to occur more frequently unless their effectiveness in restoring habitat and fish populations can be established. Collaborative planning is more extensively used but seldom on the scale of the CALFED effort. Thus, 'the jury' on these restorative efforts is still out.

Reform 3

The third reform, more extensive use of water markets and transfers,^{xxix} is one that is recommended with reservation. Economists advocate water markets because they help mitigate water shortage by transferring water to more productive uses, more efficiently allocating water. The use of water transfers and marketing varies widely across the states and federal water projects and it may result in temporary or permanent water reallocation.^{xxx}

The inevitable transfer of water will be from agricultural uses to higher value municipal and industrial uses. Although irrigators in the WDAC maintained their power over water policy for decades, the future has arrived as urban interests have increased their influence and ability to acquire water via purchases, transfers and markets (Glennon and Culp, 2002). When the transfers are voluntary, rural communities can determine whether the transfer is in their self-interest. For example, in 1997, irrigators in the Imperial Irrigation District (southern California) agreed to use conservation measures to produce surplus water (Glennon and Culp, 2002) that they sold to the city of San Diego. Farmers who paid US \$12.50

^{xxix} Although the terms water transfer and water marketing will be used interchangeably in this chapter, they can be differentiated according to whether water rights are defined as a property right. Water transfers reallocate or move water from one region or type of use to another. They may be accomplished by water leases, water banks, option agreements or salvaged water. Water marketing requires that the water rights are recognized as vested property rights that may be freely traded at the price that buyers are willing to pay (Janis M. Carey and David L. Sunding, "Emerging Markets in Water: A Comparative Institutional Analysis of the Central Valley and Colorado-Big Thompson Projects," *Natural Resources Journal* 41, no. 2 (2001): 293. Sean P. Keenan, Richard S. Krannich and Michael W. Walker, "Public Perceptions of Water Transfers and Markets: Describing Differences in Water Use Communities," *Society and Natural Resources* 12, no. 4 (1999): 280.

^{xxx} WWPRAC, 6-26 to 6-27.

an acre foot (af) were able to sell the water for \$200 af.^{xxxi} In other instances, farmers, lose out when reallocation decisions are made. When California was forced to reduce their use of Colorado River water, cities were the major beneficiaries and farmers the losers (Glennon and Culp, 2002). Such transfers may be justified on the basis of inefficient agricultural use of water. Nonetheless, the effects of these transfers out of agriculture need to be evaluated to reduce the destruction of rural communities.

Transfers and markets are relevant to the Indian's acquisition and use of their water. Settlements often depend on market transaction (such as voluntary purchases of prior appropriation or water project water) to provide tribes with their rights. When the Indians do receive water, they are often constrained by their lack of storage and conveyance projects and their inability to market water off the reservation. Transfers and markets are one tool that could help the Indians acquire and market their water.

Water transfers and markets can assist in the protection of environmental resources. In recent years, US \$100 million of water has been bought or leased to promote recreation, fisheries and wildlife. Water markets facilitate such transactions, making water use both more efficient and more environmentally friendly (Loomis et al. 2003).

There are, however, other situations in which water banking and transfers can result in environmental damage (Cosens, 2003). When water is conserved and sold to cities, the return flows from inefficient water use are no longer available to supply wetlands and provide instream flows. The Colorado River agreement that advantaged California cities over agriculture will allow California, Nevada and Arizona to capture and use much of the Colorado River flood flows that were escaping to Mexico and replenishing the Colorado River Delta area (Glennon and Culp, 2002).

Goals: The goals of water transfers and banking are to increase the efficiency of water use by using water to support economic activities that produce greater profits. This economic tool that is one component of sustainable policy. Water transfers and markets that are well established may also increase the equity of water allocation, environmental protection and efficient decision-making that is not hindered by governmental regulations or lengthy political decision-making.

ACF and Fundamental Cultural Values and Social Structure: The interesting thing about water marketing and transfers is that, on the one hand, these reforms are consistent with American values supportive of property rights and market forces that make efficient decisions. This suggests that water transfers and marketing should already be widely used methods of allocating water. On the other hand, these market mechanisms threaten the senior appropriators who have been able to use water without reference to

^{xxxi} WWPRAC, 3-23.

efficiency. If water is widely reallocated via the market, much of it will leave agricultural areas, threatening the viability of many rural communities. Whether it be from purchases or transfers, the WDAC is facing a barrage of water demands from the UDAC, EAC and IAC.

Feasibility: At present a limited number of formal water markets and transfers are in use but less formal transfers and trading are more common (Carey and Sunding, 2001). Lack of more formal market mechanisms is explained by two factors. First, it is more difficult to arrange market sales and transfers of water compared to manufactured goods. The water supply is both erratic and operated through complex natural, legal and physical storage and conveyance systems (Carey and Sunding, 2001).

Second, states are pressured by the WDAC to limit transfers and sales from the agricultural sector, from one water basin to another, and, especially, across state boundaries. States often restrict markets and transfers. For example, Colorado requires revegetation when transfers or sales dry up farmland while Oregon controls trans-basin diversions (Getches, 2001). Agreements about the allocation the Colorado River (the 'Law of the River') have worked to discourage market methods, including the ability of tribes to market water off the reservation (Glennon and Culp, 2002).^{xxxii} Another major impediment results from two conflicting provisions in *Arizona v. California*^{xxxiii} that have the potential to stymie the Arizona Water Bank and Indian interstate marketing efforts^{xxxiv}. In short, the limitations and complications of using market methods are still substantial. These and the potential damage that sales and markets can inflict, suggest that market reforms will come gradually and should be carefully crafted to balance their benefits and damage.

Reform 4

Management tools such as conjunctive management and adaptive management offer important opportunities to cope with scarcity,

^{xxxii} See Glennon and Culp, 921-925, for a more detailed discussion.

^{xxxiii} *Arizona v. California* (1963) settled a long running dispute over the amount of water that Arizona and California were entitled to from the Colorado River.

^{xxxiv} Section II(B)(4) of *Arizona v. California* holds that any water consumption within a state (which would include consumption of Indian water) is charged against the state's share of Colorado River water. Initially, Arizona wanted tribal consumption of water in California and Nevada to count against those states' allocation of Colorado River water. However, Arizona created the Arizona Water Bank to capture its unused share of Colorado River water so that California would not be able to use this water. Arizona was moved to create the bank because Section II(B)(6) allows the Secretary of the Interior to release Arizona's unused water to another state such as California (Glennon and Culp, 925). Getches (*Metamorphosis*, 41), however, argues that the Arizona Water Bank was motivated more by the desire for a subsidy to transport water to Arizona where it was stored in aquifers than by a desire to rely on market forces to apportion water.

environmental damage and political conflict among water right holders. They are and can be used by private parties and federal, state and local agencies within the parameters of existing laws and institutions.

Conjunctive Management: Conjunctive management is a tool to integrate the management of surface and groundwater to supply water when the demand is greatest. Underground aquifers, surface water reservoirs and delivery systems are operated together to capture surplus water, replenish river flows that are diminished when tributary groundwater (connected to the river) is pumped out and limit the evaporation of stored water. Underground storage lessens the need for additional surface water projects and the environmental harm they can cause. Underground water storage also offers less costly storage that can be designed to include artificial wetland construction.^{xxxv}

Conjunctive management has both physical and institutional requirements. Physical requirements include a groundwater supply in aquifers that are suitable for recharge (percolation of surface water into aquifers), storage and extraction. Water surpluses (even if they are occasional) and conveyance mechanisms provide the water and the means to deliver it.

The most important institutional arrangements are secure water rights and organizations that perform the work associated with conjunctive management. First, states need to have well-defined surface and groundwater rights that allow water rights holders the ability to control and recover benefits from water they place in conjunctive management. Second, entities such as water banks and water organizations need to carry out activities such as searching for water, bargaining for its lease or purchase and monitoring the process of water storage and release, thus lowering the management costs. Conjunction management is primarily used in California and Arizona for long-term storage of water surpluses from federal projects. In Colorado, conjunctive management helps junior appropriators who pump tributary groundwater^{xxxvi} make it through the dry seasons without infringing upon the rights of senior appropriators to river water (Blomquist et al. 2001).

Adaptive Management: Adaptive management occurs when a broad array of stakeholders adopt goals and a management plan, select indicators to measure the success of the plan, monitor the effects of the plan and make appropriate changes. It relies on a) systematic experimentation to cope

^{xxxv} William Blomquist, Tanya Heikkilä and Edella Schlager, "Institutions and Conjunctive Water Management among Three Western States," *Natural Resources Journal* 41, no. 3 (2001): 654-657; WWPRAC, 3-10 to 3-11.

^{xxxvi} Tributary groundwater is connected with river water such that groundwater pumping may reduce river flows.

with the complexity of water and biological systems as well as b) the use of water as a commodity and property right that creates profits and wealth. The decision-making process should be cooperative and inclusive, bringing in participants from conflicting advocacy coalitions. Relying on accepted scientific analysis and face-to-face interactions to build trust, stakeholders need to commit to the management plan with a willingness to make future changes based on the evidence from the experiments. When adaptive management succeeds, policy learning occurs as lessons from the experiments are used to shape future policy. The appeal of the practice is that temporary changes are made and only retained if they provide sufficient long-term benefits to satisfy stakeholders (Lowry, 2003; WWPRAC).^{xxxvii}

Successful adaptive management depends on a number of requirements. First, there is a need for flexible stakeholders and moderated conflict. Second, clear communication is a must to build trust and facilitate policy learning. Third, success depends on the models, scientific information and monitoring that underpins the experiment. Not surprisingly, adaptive management technique costs more and takes longer than traditional management. Even if the above hurdles are cleared, it may fail if the ecosystem is so damaged that it is not resilient enough to improve or the stakeholders fail to make the tough choices.^{xxxviii}

Adaptive management is currently being used to experiment with water flows from the Glen Canyon dam and restorative efforts along a segment of the Mississippi River. The Glen Canyon program has met with mixed success. Policy learning has resulted in positive changes in stakeholders' views and actions but six years after the simulated flood release, the beaches and sand bars that had been created by a simulated flood have almost disappeared. Adaptive management plans on the middle reaches of the Mississippi River include restoration projects and decreases in water flow. Despite limited success, lack of funding and inconsistent coordination, stakeholders continue work on restoration (Lowry, 2003).

Goals: The goals of the new management practices include environmental protection and remediation, inclusive participation that promotes equity and fair decisions and implementation of durable decisions that are subject to revision.

ACF and the Basic Legal Structure: Although basic government institutions and laws are stable over time, pressure by advocacy coalitions can produce change. When change occurs in administrative procedures rather than statutes, court decisions or government structure, the magnitude of necessary change is not as great even though policy success may be achieved.

^{xxxvii} Lowry, 24-25 and 130; WWPRAC, 6-40 to 6-41.

^{xxxviii} *Ibid.*, 119 and 130-131.

Feasibility: The fact that these management techniques are already in use indicates a minimum level of feasibility. Both stakeholders and agency officials are often aware that divisive conflict harms them and the resources they are concerned about. Conjunctive management offers those with the necessary physical and institutional requirements a cost effective mechanism to store and deliver water. Conjunctive management should be undertaken when the necessary conditions are met. Adaptive management has more onerous requirements because it depends on time-consuming cooperative decision-making by coalitions that oppose each other. Since, by definition, it is based on experiments, some management activities are bound to "fail." While failures can stimulate policy learning and modifications in future management, they can also discourage stakeholders from taking the risks that adaptive management requires. The costs of adaptive management are likely to limit its use to fewer water basins than traditional management techniques.

Reform 5

Technological solutions can be used to help conserve water and use it more efficiently. Farmers have made improvements, decreasing their water application rates by 20% from the 1960s to 1994 (WWPRAC, 1998). Adoption of these improvements is slowed because of the cost and lack of incentives that senior appropriators have to use water efficiently. Increasingly, those who want to buy water and put it to a higher economic use strike a deal to pay for the technological improvement in return for the right to use the water that is saved (WWPRAC, 1998). Efficiency use of water is desirable, but applying water to obtain the greater economic values does not necessarily provide the other reforms that critics wish to obtain.

Numerous other technological solutions also exist although they may not be palatable until attitudes and incentives change. First, desalting seawater and brackish water (such as agricultural return flows and poor quality groundwater) can be accomplished to provide irrigation and domestic water. New methods of desalinization such as reverse osmosis and electrodialysis have greatly reduced the cost of the process. Second, recycling and reclaiming municipal and industrial wastewater conserves water in areas where effluent flows out to sea. Thus far, federal legislation^{xxxix} has authorized and funded more than 20 projects to reuse water. Third, gray water from bathing, laundry facilities and rainwater runoff can be collected and reused for irrigation. Fourth, a variety of techniques can be used to conserve agricultural and domestic water uses: drip irrigation,

^{xxxix} The Reclamation Wastewater and Groundwater Study and Facilities Act of 1992 and the amendment to Title XVI of the Reclamation Recycling and Water Conservation Act have authorized and funded reclamation programs (WWPRAC, 3-13).

ditch and canal lining, underground pipeline delivery systems and water metering can decrease the amount of water necessary to produce crops. Xeriscape plants and low flow toilets are examples of urban conservation measures. But these improvements are unlikely to be widely adopted unless higher water prices prompt users to adopt more efficient water applications. Eliminating subsidies for water use is also necessary to provide economic incentives for efficient water use (WWPRAC, 1998).

Goal: The major goal of more broadly adopting technological solutions is water efficiency and conservation.

ACF and Socioeconomic Conditions and Technology: Although many technological solutions already exist, they must be more widely accepted and used to promote sustainability. Until public attitudes supporting current unsustainable practices change and/or a shift occurs in the power of advocacy coalitions, progress toward sustainability will be retarded.

Feasibility: Creating technological solutions is easier than gaining their widespread acceptance. Conservation and efficiency technology is hampered by many political and economic realities: the low cost of water; the expense of adopting technological solutions; uncertainties about retaining water rights to conserved water and limitations on the ability to transfer water via market transactions (WWPRAC, 1998).¹ These realities and the existing influence of the WDAC that benefits from the status quo suggest that change will come slowly.

Reform 6

Decentralized collaboration, including watershed councils, is the sixth reform. It involves a wide range of interested parties who negotiate place-based agreements on broadly defined watershed issues by building trust, policy learning and making the decision at the local level. In collaboration the traditional authority (such as a federal agency or State Engineer) may participate in the process but the decision is made by collective participants representing competing advocacy coalitions. It is based on three principles. First, alternative dispute resolution is based on the belief that, in the right venue, current adversaries can find beneficial solutions to satisfy a variety of interests. Second, an ecosystem management perspective provides a forum in which holistic decisions are made on a variety of natural systems across political jurisdictions. Third, political devolution emphasizes that it is critically important to respond to economic, cultural and social circumstances unique to the area (Singleton, 2002).

Collaboration is advocated for a great number of reasons. First, it provides greater local autonomy with broad accountability to national standards, allowing informed stakeholders and expert officials to choose the most efficient and least onerous solution to meet environmental standards.

Second, collaborative decision-making is a flexible process in which policy is revised as needed and implementation is easier because stakeholders commit to the decisions. Third, by providing a forum in which a variety of resource, economic, environmental and lifestyle issues can be debated, it provides an opportunity to create integrated policy. Finally, it brings stakeholders with environmental and equity concerns together with influential economic users to absorb scientific information, debate issues and gradually establish trust. When successful, collaboration helps build community cohesion and promotes democracy (Singleton, 2002; Cosens, 2003).

If this sounds too good to be true, it probably is. A complete discussion of the criticism of collaboration is beyond the scope of this chapter (Singleton, 2002; Cosens, 2003), but four key concerns need to be examined. First, government abdicates the responsibility because the decision-making authority shifts from government officials to a collection of private and public participants. Great care must be taken to insure that collaborative processes are held accountable to the public and decisions are consistent with federal and state laws. In particular, the Congress and the courts have an important oversight role to play. Second, watershed decisions defer to the interests of local economic interests. Local participants who are unwilling to accept federal and state environmental goals may use collaboration to reject them (Singleton, 2002).

Third, the process won't be well suited to represent interests emanating from outside the local community. Recreational users who desire access to free flowing streams may find themselves at odds with the wishes of the community. Tribes seeking to quantify their water rights by using their maximum water entitlement as a lever may find consensus decisions ill suited to their interests. Fourth, watershed collaboration puts great emphasis on the reduction of conflict. This is a positive goal but it is not sufficient (Singleton, 2002). Ultimately, watershed collaboration must be able to produce objectives such as environmental protection.

Goals: The collaboration process is an inclusive participatory system designed to create policies that are fair to all participants. It should result in durable decisions because 1) the emphasis on equity should commit participants to management plans, 2) decisions are open to revision so they can remain meaningful, 3) stakeholder support will make the implementation easier and 4) comprehensive decisions will be more likely to address the problems that brought the stakeholders together in the first place (Singleton, 2002).

ACF and Systematic Governing Coalitions: The emergence of decentralized negotiation is a 'bottom-up' response to problems in federal and state water policy. In a federal system such as the U.S. has, it should not be

surprising that changes in the governing coalition from the local level are responsible for defining who is influential and for empowering new decision makers such as the EAC and IAC.

Feasibility: Since hundreds of local collaborative efforts already exist (Getches, 1997), the political system has embraced these efforts as a promising potential solution to water policy reform. The start-up costs are substantial as stakeholders must absorb information and begin to trust each other. At present, it is too soon to know whether they will succeed in revising water policy to promote sustainability. Watershed collaboration can only be deemed a success when it promotes efficiency, respect for nature and equity via an inclusive participatory process.

Reform 7

The effects of long-term climate change should be integrated into water planning and management. An increase in greenhouse gases is expected to increase temperatures, producing global climate change.^{xxxx} Warmer temperatures may increase the severity of droughts and floods in some areas while change will be less severe elsewhere. The effects in specific regions are uncertain but, in general, the changes are likely to reduce water supplies (Frederick, 2001). Western water resources will be particularly sensitive to climate variations because of the complex relationship between precipitation and runoff that is likely to have major impacts on stream flows (Frederick, 2001; Miller, 1997).

Climate change is also likely to have a disproportionate affect on western water because of the inflexibility of current water laws, institutions and infrastructure (Frederick, 2001), that were created to reflect the conditions and needs of the 19th century. To illustrate, small changes in temperature and precipitation in the Colorado River Basin will increase the vulnerability of wildlife, fish, habitat, hydropower generation, recreation and Upper Basin users (Miller, 1997). Three changes made in conjunction with each other could help minimize the impact of climate change: reallocation of water from lower to higher economic valued activities; shifting water storage from Lower Basin to Upper Basin reservoirs to limit evaporation; and increasing instream flows by keeping reservoir water levels low (Miller, 1997). These changes, however, will be difficult. They challenge existing state water laws and the property rights that adhere to them, the ability of

^{xxxx} Greenhouse gases (water vapor, carbon dioxide, nitrous oxide, methane, chlorofluorocarbons, hydrochlorofluorocarbons and tropospheric ozone) increase temperature by absorbing radiation that cannot escape the atmosphere and returning it back to the earth (Kathleen A. Miller, *Climate Variability, Climate Change and Western Water*, Report to the Western Water Policy Review Advisory Committee (Springfield, VA: National Technical Information Service, September 1997), 19.

the Lower and Upper Basin parties to set aside historical animosities and existing storage rights that water users acquired over the decades.

To cope with the likely problems resulting from climate change, decision makers and water managers need flexible plans that are responsive to hydrological extremes.^{xxxxi} The federal government needs to encourage more efficient use of water and to protect instream flows. Water policy needs to be reformed to insure that all water rights are clearly defined; furthermore, when water agreements and laws were based on inaccurate data or have had unintended impacts, they need to be changed. In general, more flexible water policy and institutions and more integrated management will facilitate adaptation to climate-based changes (Miller, 1997).

Goals: Integration of climate change would help promote the durability of water policy by encompassing one additional factor, climate change, that seems likely to have a major impact on future water utilization.

ACF and Policy Decisions and Impacts from Other Subsystems: As ACF posits, effects from other policy subsystems are major influences on a policy subsystem. In the case of climate change, the energy and transportation subsystems have resisted policy to would slow global warming and lessen climate change. The likely result is changes in precipitation and temperatures that will challenge westerners' ability to protect water supplies and respond to drought.

Feasibility: The recommendation will be difficult to implement. First, there is scientific uncertainty about what effect climate changes will have. Second, the natural variability of western hydrological cycles complicates managers' ability to predict and respond to change. Third, while a future crisis provides a window of opportunity for policy change, the necessary reforms would require a macro-level response that is difficult to achieve. Reforms would challenge existing water rights and agreements, management strategies, agency practices and long standing hostility among advocacy coalitions.

CONCLUSIONS

Water policy has changed but, as yet, reform is insufficient to meet the goals of sustainability. Current policy does not adequately provide efficient of water use, respect for nature or equity of water allocation. Prior

^{xxxxi} Miller acknowledges that dam construction may one necessary response to floods and droughts but she also cautions that environmental damages must be considered in the decision-making process (Miller, 48).

appropriation does not promote these goals and it is unlikely to be abandoned or substantially changed.

Seven reforms were evaluated, the likelihood of their adoption varies greatly. First, holistic water policy is hindered by a fragmented political system and advocacy coalitions. An integrated policy encompassing surface and groundwater, water quality and quantity and related issues such as land use, zoning the energy policy would bring uncertainty and risks to water interests. Second, current policy is only beginning to remedy the environmental harm and injustices brought by water policy. Dam removal, experiments with water flows and other reforms are not well established. Third, more extensive use of markets and transfers may help mitigate water shortages, provide water for tribes, protect the ecosystem and increase decision-making efficiency. Unfortunately, these mechanisms can also result in damage to rural communities and the environment. The complications of using market systems are such that reforms should be carefully created to balance costs and benefits. Fourth, management tools such as conjunctive management and adaptive management have the potential to promote environmental protection, inclusive participation and implementation of durable policy. They are especially promising because they can be implemented within the boundaries of existing water policy. Fifth, technical solutions that promote wise water utilization are available but they are hampered by their cost, the low cost of water and difficulties in retaining the right to use or market the conserved water. Sixth, initial impacts of local collaboration are positive but it is too early to tell if they will live up to their promise to promote sustainability. Finally, while the need to integrate climate change into water planning and policy is important, scientific uncertainty, complexity of hydrological cycles and opposition of water rights holders and officials all mitigate against that success.

In general, policy change is constrained by current water laws and institutions. General inertia, political resistance and scientific uncertainty limit water policy and decision-making reforms that would promote sustainability. Sustainability makes huge demands of both the substance of the policy and the policy making process. There will not be one solution or even a few solutions; rather, there must be many and they will come from many sources (Gillilan and Brown, 1997). Many difficult decisions remain to be made suggesting a long road ahead.

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Governance in Abundance and Scarcity: The Development of Water Rights in the Great Lakes and Murray-Darling Basins

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The governance of water resources is a complex and challenging task in any environment, and a wide range of factors has been identified as affecting the way in which water resources are governed. Prominent among these factors is the relative abundance or scarcity of water available. Abundance or scarcity is thought to be important because it affects people's attitudes towards water, the care they take in managing water and the urgency with which they confront management tasks. In this paper, the impact of abundance/scarcity on water governance is explored through a comparison of water property rights in the Great Lakes Basin of North America and the Murray-Darling Basin of Australia. This comparison suggests that environments of water scarcity, like that in Australia, tend to encourage the development of water rights that institutionalize water user interdependence, while environments of water abundance, such as the Great Lakes, tend toward the institutionalization of water rights that allow for user independence. Furthermore, this trend is evident at the local, state, and basin levels, becoming more pronounced as conditions of scarcity become increasingly acute.

ABUNDANCE AND SCARCITY

Though the Great Lakes and Murray-Darling basins seem like an odd pairing, comparisons between these two water systems can be quite

illuminating for the study of water governance. Both of these basins are situated in highly developed economies with broadly similar cultural traditions and political institutions. Yet, the Great Lakes Basin provides a considerable abundance of water to its inhabitants while water in the Murray-Darling Basin is much scarcer. Thus, despite their socio-economic similarities, the communities and governments of these basins are confronted with very different water governance challenges and their responses to these challenges provide an interesting illustration of how similar peoples adapt their water governance institutions, particularly their water property rights, to conditions of abundance and scarcity.

Though the Great Lakes Basin is much larger than the Murray-Darling Basin in terms of water volume, this is not the case for their geographic surface areas. While the Great Lakes and their tributaries span an area of 767,000 km² in northeastern North America, the Murray-Darling covers 1,061,469 km² of southeastern Australia. This should not obscure the fact, however, that while the Great Lakes are estimated to contain about 23,000,000 GL of water, the Murray-Darling has a mean annual flow of just under 14,000 GL.ⁱ In fact, the vastly smaller amount of water in the Murray-Darling spread out over a larger surface area exacerbates the problem of water scarcity in this basin. The same is also true of precipitation patterns, which tend to be much more abundant and stable in the Great Lakes than in the Murray-Darling, where rainfall is less plentiful and varies considerably from season-to-season and year-to-year (Farid, Jackson, and Clark 1997; Murray-Darling Basin Commission 2004).

The Great Lakes and Murray-Darling basins also differ considerably in their flow characteristics, with flow issues being much more contentious among Murray-Darling users than Great Lakes users. In the Great Lakes Basin, the five Great Lakes are each fed by a number of small to moderately sized rivers throughout the basin. However, the most important flow aspects are between the lakes themselves, which flow west to east. The five lakes are linked by a number of small connecting channels so that water originating in Lake Superior flows into Lakes Huron and Michigan (which are usually regarded as one hydrologic system), then into Lake Erie, Lake Ontario, and finally the St. Lawrence River, which exits into the Atlantic Ocean (Farid, Jackson, and Clark 1997, 15). In the Murray-Darling Basin, the general flow is east to west, with the headwaters originating in the mountains and wetlands of the eastern interior and exiting into the Tasman Sea, southeast of the city of Adelaide. At the headwaters, water travels westward in a number of moderately sized rivers that eventually converge into the much larger Murray and Darling rivers. The Darling River also then converges into the Murray just west of the city of Mildura

i GL stands for gigalitre, which is defined as a billion litres of water.

so that the Murray alone carries water from the basin into the ocean. Because the upstream users in the Murray-Darling appropriate a very significant volume of water for irrigation and other purposes, the downstream users are often vulnerable to low flows and diminished water supplies (Murray-Darling Basin Commission 2004). This concern is not nearly as evident in the Great Lakes where the sheer volume of water makes low flows a relatively rare problem for downstream users.

Despite the obvious volumetric and flow differences between the Great Lakes and Murray-Darling basins, it is the popular perceptions of abundance or scarcity that are really most important since it is these perceptions that shape the motivations and interests of those involved in water governance. In general, a myth of overabundance persists in the Great Lakes while a perception of scarcity is solidly locked in the mindset of most Australians. As the largest freshwater system in the world, the Great Lakes are in no danger of running dry any time soon, and it is this blunt reality that underlies the myth of overabundance. Whether this perception is warranted, however, is another question: only one percent of the water in the Great Lakes is renewed annually, the other ninety-nine percent constituting a glacial melt deposit from the last ice age (Farid, Jackson, and Clark 1997, 5). Thus, despite perceptions of overabundance, water mining is a real danger in the Great Lakes and, once this water is lost, the damage is irreparable. Most people in the Murray-Darling are under no such illusions. Here, there is a real danger that water supplies can disappear or become degraded beyond use, through over-appropriation and salinization. Australians have long recognized the scarcity of their water resources, but over the past two decades this has become something of a national preoccupation (Fullerton 2001).

Though the Great Lakes and Murray-Darling basins are on opposite sides of the globe and on different sides of the equator, there is a surprising degree of cultural, economic and political similarity between the peoples that reside in these basins. Most evident, in this regard, are similarities in culture, which can be primarily attributed to the common social and political histories of these communities. In both North America and Australia, the original Aboriginal populations were displaced by British colonialists who 'settled' these territories through intensive immigration by predominantly white Europeans. These European immigrants brought with them broadly liberal values toward social and economic development. In this worldview, the exploitation of natural resources is assumed to be a key element in economic growth and economic growth is assumed to have priority over other potential resource management objectives such as sustainability. It is only when resource degradation or scarcity negatively affects economic growth that collective and individual restraints on resource use are viewed as necessary (Worster 1985, chapter 2).

Notwithstanding various normative objections to this worldview, it has contributed, in part, to the emergence of highly developed economies in both North America and Australia. One of the best available measures of development is the United Nations Human Development Index, which aggregates such variables as life expectancy, per capita GDP, adult literacy, and education levels, among others. In the 2001 UN Human Development Index, Australia, Canada, and the United States all finished in the top six countries worldwide, with human development scores of 0.936, 0.936 and 0.934, respectively (United Nations 2001). This indicates a very similar, very high level of development, and past Development Indexes reveal that this similarity has existed for some time. One way of interpreting this is to expect each of these states to have significant technological and economic capacity for resource exploitation. Another interpretation would expect high levels of post-materialism, including environmentalism, given the widespread affluence of these communities (Inglehart 1988). Both of these interpretations are plausible, but, more importantly, these attributes are evident in both basins.

Finally, there is a considerable degree of general commonality in the political institutions prevalent in the Great Lakes and Murray-Darling basins, particularly between Canada and Australia, the only two parliamentary federations in the world. For starters, Canada, the United States and Australia are all liberal-democracies in which the rule of law and constitutionalism are in force. Consequently, most of the political actors in these countries work within a context in which they are ultimately accountable to their electorates. This democratic accountability is brought about through different types of democratic institutions, through parliamentary systems in Canada and Australia and through a presidential system in the United States, but it is evident nonetheless. Furthermore, all three countries are constitutionally structured as federations, resulting in a considerable fragmentation of governmental sovereignty in both basins. This fragmentation may be more obvious in the Great Lakes because of the international border, but predominant jurisdictional authority over water governance is assigned to sub-national governments (states and provinces) in all three countries, so it plays a formative role in both basins. For instance, most efforts to govern water on a basin-wide level take place on an intergovernmental basis, and intergovernmental institutions have an influential role in various aspects of water governance (Saunders 1988; Bailey 1972).

Overall, the Great Lakes and Murray-Darling basins exhibit a remarkable degree of political-economic commonality given their geographic separation. The main distinction between them is the relative abundance of water in the former and the relative scarcity of water in the latter. As a result, a comparison of the two cases allows us to see how two substantially

similar polities have responded to the different challenges involved with an environment of water abundance versus an environment of water scarcity. This helps to isolate the effect of abundance/scarcity on water governance and give us a clearer idea what impact it actually has.

A WATER PROPERTY RIGHTS PRIMER

The concept of 'property rights' is particularly pertinent to the analysis of water governance because, quite simply, water property rights establish who has access to water and how much they can appropriate. By definition, a property right is a legal construct that specifies the "...sanctioned behavioural relations among men [sic] that arise from the existence of goods and pertain to their use" (Prasad 2003, 747). Analytically, property rights are best understood as multi-dimensional, possessing legal, political, social and economic characteristics. Legally, property rights are usually formalized in law, sometimes in precise statutory codes and sometimes in less precise accumulations of legal precedent such as the common law. The creation and amendment of property rights, however, is a political process where collective decisions are made about resource allocation and power relationships have a major impact in these decisions. Yet, in their application, it is the social observance of property rights that underpins their legitimacy and the economic value attached to property rights that contributes to economic development (de Soto 2000). Overall, as a multi-dimensional concept, property rights succinctly capture the empirical complexity of water governance and allow for analysis that is both cross-disciplinary and parsimonious.

Property rights pertaining to water are unusual in the respect that almost every culture and legal tradition has recognized that water has a fugitive and public character that precludes it from capture and ownership in the same sense that land can be fenced and owned by title (Wohlwend 1981). As a result, water itself cannot be legally owned as property and it remains in the public domain. However, water access and use can be more readily restricted and controlled and it is the access to water that is owned rather than the water itself. Thus, when describing a water property right, one is describing the ownership of an access or use right rather than the ownership of a specific volume or body of water.

While the public nature of water is universally common among legal traditions, these traditions diverge significantly in the principles used to define and distribute private water rights. Even in the English common law tradition inherited by Canada, the US and Australia, there are a number of rival principles defining the allocation of private water property rights. The original allocation principle is known as the riparian principle.

Riparians are those landowners whose land abuts or overlies a water source, and the riparian principle holds that riparians have a right to access and use this water subject to a 'reasonable use' or 'natural flow' limitation that allows other riparians to also enjoy this right. Exactly what constitutes a reasonable use or a river's natural flow is a matter of judicial interpretation and remains a rule that is both vague and context-specific (Worster 1985, 88-96).

While the riparian principle proved adequate for temperate areas with an abundance of surface water and dependable rainfall, it proved much less useful in more arid areas where water was scarce. Less available water meant fewer riparians and fewer people with secure water rights. Many non-riparians in arid areas, such as the American Southwest and Australia, demanded water rights and the riparian principle was subsequently abandoned in favour of two new doctrines. The first was the principle of prior allocation, which essentially allocates water on a first come, first served basis. In order to have water property rights, a person need only utilize a water source prior to other claimants and need not own the land adjacent to it. The second principle was state allocation, in which the ownership of all water rights is taken by the state and water access is then permitted to citizens on the basis of administrative discretion. In most cases, this discretion is shaped by legislatively defined ancillary principles of water access, allowing the state to set priorities for water use (Worster 1985, 88-96).

The main contrast between riparianism, on one hand, and prior allocation and state allocation, on the other, is their relative institutionalization of user interdependence. Riparianism has little regard for user interdependence, inherently assuming that in normal circumstances there will be enough water for all riparians to access and use. In exceptional cases where local scarcity develops and there are rivalries between users, the general principles of 'reasonable use' or 'natural flow' come into play to settle sporadic conflicts. Prior allocation and state allocation, however, are both created around assumptions of scarcity and user interdependence. In these regimes, water rights are defined either by order of access or order of state priority, providing built-in mechanisms to manage and settle user rivalry. Thus, despite their differences, prior allocation and state allocation both institutionalize user interdependence to a much greater degree than riparianism.

In addition to private water rights held by individual water users, governments can also hold property rights to water (Martin and Verbeek 2002, 1). State water rights can exist in two basic ways. The first is through the simple application of the prevailing riparian or prior allocation common law principles outlined above. For example, in a riparian regime, a government has water rights if it owns public lands that abut a water

source. The second way in which governments can have water rights is by treaty, legislation or judicial decision. If jurisdictions sharing a water resource come to see themselves as rivals to the resource, usually as a result of increased scarcity, they may negotiate a treaty that specifies the access and use rights of each, effectively creating state water rights. In some federal systems, state water rights may also be imposed by the courts or the federal government, if an intergovernmental water dispute is brought to them for resolution. Whether by mutual agreement or by imposition from above, the creation of state water rights is another example of the institutionalization of interdependence among water users, with the state acting as the arbiter or intermediary between them.

Finally, the interdependence of water users can also be institutionalized through the creation of common property rights – rights shared by a defined group – though this is somewhat infrequent in common law jurisdictions (Martin and Verbeek 2002, 1). Common property water rights are an institutionalization of user interdependence because these rights can only be exercised through collective action among those sharing the right, effectively forcing them to manage their potential rivalries. One type of common property water right that has begun to emerge in recent years is the environmental allocation. This is a volume of water that is set aside for the preservation of natural riverine and wetland environments, created by treaty or legislation, but held in common for the benefit of all residents in a basin. Environmental allocations are particularly necessary in conditions of water scarcity, where existing water resources may be almost fully allocated to human uses, and they are a clear institutionalization of a basin's interdependent water users.

Based on this discussion of water rights and the hypothesis put forward at the beginning of this paper, the types of water rights regimes that we would expect to find in the Great Lakes and Murray-Darling basins become somewhat clearer. In the Great Lakes Basin, we would expect to see riparianism with limited state and common property water rights, reflecting the relative abundance of water in this region. In contrast, we would expect to see either prior allocation or state allocation in the Murray-Darling Basin, along with clearly specified state water rights and possibly some tendency toward common property. These expectations are well borne out by the empirical evidence presented below.

RIPARIANISM AND THE GREAT LAKES BASIN

In the Great Lakes Basin, the property rights that exist today are best described as state-modified riparianism. In other words, the riparian principle remains predominant in most Great Lakes jurisdictions, but, in

recent years, Great Lakes governments have modified and limited riparian rights in order to regulate a number of specific water uses. Most of these regulated uses involve the extraction of large volumes of water or the diversion of water across sovereign borders; otherwise, riparians retain their access rights to water adjacent to their land subject to reasonable use limitations. This has created a situation of relatively open-ended, independent water appropriation among the users of Great Lakes water, a situation that is only sustained by the considerable abundance of water in the basin.

As mentioned above, the riparian principle originated in the UK, a temperate climate where water was relatively plentiful and most landowners had access to water from their land. When British settlers moved into the Great Lakes Basin, they encountered a situation of even greater water abundance and riparianism served the purpose of securing water access for most people.ⁱⁱ Accordingly, the riparian principle was adopted by the courts and governments of the Great Lakes jurisdictions whenever conflicts over water rights arose, which, in a situation of such abundance, was not that often (Percy 1988).

In addition to these private riparian rights, which were assumed to exist as part of the common law, sovereign governments were also implicitly recognized as the holders of riparian water rights by virtue of the US and Canadian constitutions. In both constitutions, the sub-national governments (the states in the US and the provinces in Canada) were designated as the owners of most of the public lands within their borders. Because many of these lands lay adjacent to water sources, this also made them some of the most important holders of riparian rights in the basin. The US and Canadian federal governments had claims to riparian rights in waters adjacent to federal lands such as military bases, but the extent of these rights was much more limited (Kennett 1991; Farid, Jackson, and Clark 1997, 40).

In effect, water property rights developed in the Great Lakes Basin so that private and state riparian rights coexisted and were largely unmodified until well into the 20th century. Particularly over the last twenty-five years, though, state and provincial governments have introduced a number of statutory and regulatory limitations on the exercise of riparian rights, primarily in response to incidences of local water scarcity and emerging basin-wide concerns about the diversion and export of water out of the

ii Actually, the first European settlers in the Great Lakes Basin were French and they came from the civil law tradition rather than the common law tradition. These settlers set up civil law institutions and these institutions are still preserved today, but only in the province of Quebec. However, in the civil law, the riparian principle also exists, although these rights are subject to greater restrictions if the riparian water source is one that is deemed navigable. Nevertheless, riparianism still predominantly characterizes water rights in Quebec, despite its different legal tradition.

Great Lakes Basin. These legislative actions have not replaced riparianism with state allocation but have only modified the riparian principle so that a small number of riparian uses were designated as requiring state/provincial approval before they can be undertaken. The case of Ontario is illustrative, in this regard.

Until 1961, the appropriation of water in Ontario was governed solely by the riparian principle. However, as more industrial processes demanded larger volumes of water, local water rivalries started to develop and the riparian principle came to be viewed as an inadequate means of managing these conflicts. Conflict resolution under riparianism was centered in the courts and based on common law precedents defining reasonable uses. This judicial process was somewhat unpredictable and gave the Ontario government little discretion in managing water uses within its borders, so statutory modifications to riparian rights were eventually introduced in the *Ontario Water Resource Act* to give the government a degree of regulatory control. Under the original act, anybody withdrawing more than 50,000 litres of water per day was required to obtain a government permit, notwithstanding a whole range of exceptions for domestic and agricultural use. In a practical sense, this limitation applied to few water users and most riparian rights were unaffected by this limited statutory intervention (Percy 1988, 76-77).

Among the Great Lakes jurisdictions, Ontario was actually a leader in introducing statutory limitations to riparian rights. By the mid 1980s, only Ontario and Minnesota had introduced statutory permitting systems for large-volume water withdrawals, and Minnesota's permitting system had only been in place since 1975 (Rueggeberg and Thompson 1984). In the early 1980s, however, governmental attitudes began to change. At this time, politicians from the American southwest revived some previously discarded proposals to divert Great Lakes water to their home states through either an expansion of the existing Chicago diversionⁱⁱⁱ or the construction of an entirely new pipeline or canal. Studies were undertaken to this effect at both the state and federal levels, and, suddenly, politicians in the Great Lakes were confronted with a new group of potential water users, located outside of the basin. This threat was regarded as quite credible and it did not take long for the Great Lakes jurisdictions to close ranks in an effort to protect the Great Lakes water supply from extra-basin interlopers (Heinmiller 2004, 88).

The first intergovernmental effort in this regard was the negotiation of the Great Lakes Charter in 1985. Signed by all of the basin's provincial and state governments, the Charter sought to protect Great Lakes water through

iii A canal diverting water from Lake Michigan into the Mississippi river system has existed at Chicago since the middle of the 19th century. This diversion is discussed in more detail at the end of this section.

the creation of an intergovernmental "Prior Notice and Consultation Process" for proposed water withdrawals greater than 19 million litres per day and the introduction of statutory permitting systems for water withdrawals greater than 7.6 million litres per day (Council of Great Lakes Governors 1985). Like the earlier permitting systems introduced in Ontario and Minnesota, these regulations would have the effect of modifying the traditional riparian rights regime, but only for large-volume uses. However, implementation of the Charter at the state/provincial level has been sporadic, at best. The intergovernmental Prior Notice and Consultation Process has only been initiated once and most governments were disappointed with it as the Government of Michigan proceeded with an irrigation project in Huron County, over the objections of a number of other Great Lakes governments. Furthermore, the pledged permitting systems have not been introduced in all of the Great Lakes jurisdictions, and some jurisdictions, such as Pennsylvania and New York, continue to maintain unmodified regimes of riparian rights (Heinmiller 2004, 116-128).

The second effort to protect Great Lakes water from extra-basin usurpation came in the form of an act of the US Congress, the *Water Resources Development Act* (WRDA) of 1986. Introduced and pushed by some entrepreneurial Great Lakes congressmen, WRDA takes advantage of the US federal government's constitutional jurisdiction over interstate water issues by introducing procedural barriers to the inter-basin diversion of Great Lakes water. As a result of WRDA, each Great Lakes governor was given a veto over any inter-basin diversion anywhere in the US portion of the Great Lakes Basin. This has effectively modified riparian rights in all of the Great Lakes states (but not in the provinces) by placing procedural restrictions on the exercise of riparian rights if the right is being used to remove water from the basin. Thus far, WRDA has been activated on three occasions, with mixed results: inter-basin diversions were approved for Pleasant Prairie, Wisconsin and Akron, Ohio on the promise of full returns to the basin, while an inter-basin diversion was rejected for Lowell, Indiana (Heinmiller 2004, 134-147). As with the Great Lakes Charter, WRDA's modification of riparian rights is notable, but applies to a very narrow range of uses.

Finally, the most recent extra-basin threat to the security of Great Lakes water, proposals for bulk water exports using tanker ships or other large containers, has also resulted in a modification to riparian rights in most jurisdictions. In March 1998, the Government of Ontario granted a water-taking permit to a private company called Nova Group, who planned to export Lake Superior water by tanker to undisclosed markets in Asia. The permit was granted under the *Ontario Water Resources Act* and, at a volume of 14 million litres per day, was not subject to the Prior Notice and Consultation Process of the Great Lakes Charter. Nevertheless, the other

Great Lakes governments became very alarmed and increased public concern prompted politicians to take action to restrict riparian removals for export. In Ontario, the Nova permit was rescinded and a regulation was introduced to ban water removals in containers larger than 20 litres. A similar statutory rule was also introduced in Quebec (Heinmiller 2003). In the US portion of the basin, WRDA was amended in 2000 to include water exports as a water appropriation requiring unanimous gubernatorial consent. Once again, riparian rights in the Great Lakes Basin were modified, but the basic structure of the riparian regime was left intact.

Although it seems as though a substantial amount of regulation has been introduced concerning Great Lakes water use since 1985, a close examination reveals that this regulation is quite narrow in scope and was developed on an ad hoc basis in response to various perceived crises in the security of Great Lakes water. Thus, a situation exists where riparian rights remain largely unmodified, excepting certain statutory limitations concerning large-volume removals, inter-basin diversions, and bulk export removals. For most water users, such uses are never even contemplated and riparianism remains the basis of their water rights. As a result, water users in the Great Lakes Basin generally exercise their water rights independently of each other with little regard for their interdependence and no regulatory mechanism to limit their collective impact on the resource. Such a water rights regime is only possible in a situation of water abundance, but this is not to say that this regime is sustainable in the long-term.

The only exception to this pattern is in the state of Illinois, and the water rights regime in this jurisdiction provides a revealing contrast with those of its Great Lakes brethren. Illinois shares only a small portion of the Great Lakes Basin, but a canal at Chicago has diverted water from Lake Michigan to the Mississippi River system since the mid 19th century. After decades of court battles between Illinois and its neighbouring states, the US Supreme Court issued a consent decree in 1967 limiting the Chicago diversion to no more than 3,200 cubic feet per second (Changnon and Harper 1994). Forced to work within this fixed state water allocation, the Government of Illinois has replaced riparianism with state allocation, ensuring that its total permitted withdrawals from Lake Michigan do not exceed 3,200 cubic feet per second. While Illinois has not always remained within the established limit, its permitting system has created a nested relationship between private water allocations (permit holders) and the state allocation (as defined by the Supreme Court) (Injerd 1993). This institutionalizes the interdependence of Illinois water users and has much more in common with the property rights regimes of the Murray-Darling than those in the other Great Lakes jurisdictions.

STATE ALLOCATION AND NESTED GOVERNANCE IN THE MURRAY-DARLING BASIN

The state allocation of water rights in the Murray-Darling Basin is a practice that predates the Australian federation and remains the predominant feature of water governance in this area. While the states allocate water to local water users through the issuance of licenced entitlements, the state themselves have water entitlements that are based in intergovernmental agreements. This has created a nested system of water governance that intimately connects water users at the local, state, and basin scales. The nested approach has effectively institutionalized the interdependence of water users in the basin and can be mostly attributed to the condition of water scarcity that generally prevails in much of the Murray-Darling.

Like their North American counterparts, the early British settlers of the Australian continent brought with them the riparian principle and relied on it in their efforts to establish secure water access rights in the early 19th century. Though the Australian colonial governments and courts recognized these rights, it soon became apparent that the riparian doctrine was not as practicable in the semi-arid Australian interior as it had been in the temperate British Isles. Water access was limited in most of Australia and riparianism inadvertently acted as a barrier to development by limiting the number of landowners who could obtain secure access to water (Clark and Renard 1970, 477-478). Much of the potentially usable land was non-riparian, and, by the 1850s, many non-riparian landowners in the colonies of New South Wales, Victoria and South Australia were calling for water rights reform to facilitate their development ambitions. The colonial governments shared in these ambitions and a number of ad hoc modifications to riparian rights were introduced over the next few decades (Clark and Renard 1970).

By the 1880s, colonial politicians had embraced the idea of full development of water resources and it seemed apparent that a modified riparian rights regime would not achieve this objective. Comprehensive water rights reform was deemed necessary and a considerable degree of study was put into the matter. In Victoria, for instance, a Royal Commission was created in 1883 that traversed the world and gathered information on various water property rights regimes including the state allocation regime in the Canadian northwest and the prior allocation regimes of the American southwest. Ultimately, the Commission recommended that ownership of water be vested in the state so it "...may be distributed under well-considered government control for the benefit of the greatest possible number" (Clark and Renard 1970, 487). Similar recommendations came from a New South Wales Royal Commission, and legislation to replace riparianism with state

allocation soon followed. The first was Victoria's *Irrigation Act 1887*, and, by the early 20th century, state allocation regimes were in place in all four Murray-Darling states (Clark and Renard 1970).

As the states took control of water allocation within their respective boundaries, they also quickly realized their rivalry for their shared waters, particularly the River Murray. In the negotiations leading to federation in 1900, interstate allocation of the Murray was a central issue, proving so controversial that it was eventually set aside for future resolution so as not to derail the federation project. After fourteen more years of sporadic interstate negotiation, the River Murray Waters Agreement (RMWA) was finally signed in 1914, effectively dividing up the river among the three Murray states.^{iv} In addition, a program of new storage and diversion projects was planned for the Murray, and the new infrastructure was to be operated by an intergovernmental organization – the River Murray Commission – to ensure that the designated state entitlements could be consistently met (Wright 1975; Wright 1978; Pigram 1986). The overall effect of the RMWA was to create state entitlements to the waters of the Murray, while the existing private water entitlements, created through state allocation regimes, became nested within the state entitlements. Thus, already by the second decade of the 20th century, the interdependence of Murray water users was institutionalized in a multi-level, nested governance system.

Over the next fifty years, the RMWA served the dual purpose of securing state water rights without inhibiting full development of the basin's water resources. Still driven by a desire to expand their agricultural development, the state and Commonwealth governments heavily subsidized the expansion of irrigation farming and much of the infrastructure that goes along with it. Accordingly, from 1920 to 1980, water diversions in the Murray-Darling Basin increased from just over 2,000 GL per year to almost 10,000 GL per year. This is even more remarkable considering that the average annual flow in the Murray-Darling Basin is only about 14,000 GL per year and tends to fluctuate widely around this average (Murray-Darling Basin Ministerial Council 1995, 13). Evidently, the basin governments were nearing their longstanding vision of full development of the basin's water resources, but the closer they came to full development, the more problems started to emerge.

The two major problems that became increasingly evident were over-appropriation and salinization, and both seemed to emerge first in South

iv Under the RMWA, South Australia, the downstream state, was guaranteed a minimum annual flow of 1.254 million acre-feet (1,850 GL) in specified monthly amounts. New South Wales and Victoria, who share the Murray along their mutual border, were each given entitlement to half of the Murray's flow at Albury and all of the tributary waters below Albury.

Australia before working their way upstream to encompass all of the basin states. By the late 1960s, diminished flows and high salinity levels threatened the security of water rights in South Australia, and the state government realized that its state allocation regime would have to be significantly reformed. As in the other Murray states, the Government of South Australia had perennially issued water permits in excess of the 1,850 GL it was guaranteed in the RMWA. However, the excess river flows that had traditionally supported this over-permitting had dwindled in the 1960s and the government was forced, in 1967, to clawback its total permitted volume to the guaranteed 1,850 GL (Cooper 1985). Only then could the private water entitlements allocated by the South Australian government be guaranteed as secure. Similar problems were later encountered in Victoria and New South Wales and these states also began limiting their total permitted allocations starting in the mid 1970s (Alvarez 2002; Fitzpatrick 2002).

The problem of water scarcity that had initially been encountered in the distribution of private water rights and was later encountered in the allocation of state water rights was, by the 1980s, finally being confronted at the highest scale possible, the basin level. Managing scarcity at the basin level required an unprecedented level of intergovernmental cooperation between the Commonwealth and Murray-Darling state governments, and new intergovernmental institutions were created for this purpose. In 1985, a ministerial council for the basin was created, and through this council the Murray-Darling Basin Agreement (MDBA) was signed in 1992. The MDBA retains the interstate water allocation of the RMWA, but also contains a number of provisions to help address the problem of water scarcity at the basin level (Crabb 1992; Powell 1993).

Chief among these is the Cap on Diversions, added as Schedule F to the MDBA in 1995. The Cap established a basin-wide ceiling on total yearly water diversions, defined as the total volume of diversions correspondent with 1993-94 levels of development.^v This makes the Cap a flexible ceiling, varying from year to year according to climatic conditions, and each Murray-Darling state has a defined share of the available water in any year (Independent Audit Group 1996). Though the Cap limits are not always followed by the states, and compliance is an ongoing concern, most state governments have made a significant effort to reform their water allocation

v The definition of the Cap is, perhaps, best described by Australian economist John Quiggin: "The Cap is not the volume of water that was used in 1993-94. Rather, the Cap in any year is the volume of water that would have been used with the infrastructure (pumps, dams, channels, areas developed for irrigation, management rules and so on) that existed in 1993-94, assuming similar climatic and hydrologic conditions to those experienced in the year in question. Thus, the Cap provides scope for greater water use in certain years and lower use in other years."

systems to bring them in line with the Cap. Most states now have allocation regimes in which private water rights are comprised of a combination of high security entitlements and low security entitlements, with high security entitlements being available in most years and low security entitlements being available in only some years, when water is available. Consequently, most private water entitlements are now nested within the yearly Cap level for the basin, and their respective states' share of this Cap. This has institutionalized the interdependence of Murray-Darling water users to such a degree, that yearly fluctuations in Cap levels now affect almost all water rights holders in the Murray-Darling.

When the Cap level was set at 1993-94 levels of development, this definition was the result of political compromise rather than a scientifically-based assessment of ecosystem water needs. Nevertheless, it was assumed that any water above Cap levels would be reserved for environmental preservation and restoration purposes. This was a first step toward the creation of an environmental allocation for the basin, held in common by the basin's residents. In 2001, a second step was taken with the introduction of the Living Murray Initiative, a program intended to create an environmental allocation to enhance the riverine environment of the River Murray. Essentially, this involved a reduction of the Cap to a level below 1993-94 levels of development, reducing state and private entitlements and allocating the recovered water to the environment (Murray-Darling Basin Ministerial Council 2002). The proposal has been fiercely resisted by many irrigators, most of whom had already suffered a reduction in entitlements from the introduction of the Cap, and the final outcome of the Living Murray Initiative remains uncertain. Nevertheless, it represents an effort to institutionalize further the interdependence of those who rely on Murray-Darling water, by creating a large-scale common property water right shared by the basin's citizens.

Though the creation of this common property right remains uncertain, the interdependence of Murray-Darling water users is clearly institutionalized in the nested governance system that has developed since the introduction of the Cap. Both the Cap and the state water allocation regimes nested within the Cap were instituted as responses to the perennial problem of water scarcity. Thus, as suggested at the outset, the condition of water scarcity in the Murray-Darling Basin has resulted in the development of a water rights regime that effectively institutionalizes water user interdependence at multiple social scales.

CONCLUSION

This paper has shown how the relative abundance or scarcity of water in an environment can significantly affect the development of water rights.

In situations of water abundance, like the Great Lakes, there was relatively little rivalry for the access and use of water resources, facilitating the development of water rights regimes that allow water users to act relatively independent of each other. In contrast, water scarcity in the Murray-Darling highlighted problems of user rivalry at a relatively early stage and prompted the development of water rights regimes that institutionalized water user interdependence between private rights holders and between states. Furthermore, as water scarcity became more pressing over time, the institutionalization of user interdependence was made even tighter, in a nested governance system spanning the entire basin.

As the demands on water resources in most parts of the world continue to grow, and situations of water scarcity become increasingly common, this paper suggests that more nested, multi-level governance systems are also likely to emerge. With this in mind, it may be important for academics and practitioners to study more closely the political-economy and institutional architecture of the Murray-Darling, and similar nested governance systems, as a window into the future of water management. Scholars such as Elinor Ostrom, Oran Young and Graham Marshall have already commented on the crucial role of nested governance in effective resource management, but much more remains to be done (Ostrom 1990; Young 2002; Marshall 2005).

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GAPs in the Dialogue of Governance: Conflicting Ideologies of Development in Turkey

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INTRODUCTION

In the last 20 years, Turkey has built a network of 22 dams, 19 hydroelectric plants, and extensive irrigation systems on the Tigris and Euphrates Rivers, together called the Southeastern Anatolia Project (GAP).

The South eastern Anatolian Project is Turkey's largest and most multifaceted development project, and also, one of the largest development projects in the world. The project includes active farming with extensive irrigation systems and electricity production; following these are tourism, mining, petrol, education, health, communication, industry and transport sectors.

In short, GAP is a multi-sectoral and integrated regional development project based on the concept of sustainable development. Its basic aim is to eliminate regional development disparities by raising people's income level and living standards; and to contribute to such national development targets as social stability and economic growth by enhancing the productive and employment generating capacity of the rural sector. The project area covers nine provinces in the Euphrates-Tigris basins and Upper Mesopotamia plains.

But more significantly and less obviously than the engineering feats of the project itself, the GAP is a means through which the Turkish government is strategically reformatting the process of governance on a national level.

The social effects of the development project are interpreted very differently by governmental, environmental, and minority interest groups, and the actual effects generally point to increased government control rather than increased development.

This chapter evaluates the conceptions and arguments of different actors engaged in decision-making vis-à-vis development projects. It focuses on the following questions regarding the social construction and governance of GAP in Turkey: How are development projects perceived, and what is the language used to describe them? How does this construction affect the structure of governance? How do historical trends augment socio-political relationships in the development process? These questions are designed to direct research towards the processes through which development is planned, accepted, and incorporated into certain ways of organizing and controlling society. Answers to these questions uncover changing knowledge systems as they are embedded within geographical, historical and social frameworks. The dialogue among interest groups is, in essence, a power struggle over ideological systems. It is manifested in different types of projects at different scales and with different moral arguments. Turkey's plan to fill the dams will drown 155 villages in Turkey, change the entire environment in the watershed and reduce the shares of Syria and Iraq in a fundamental way. When Turkey decided to divert the Euphrates to fill the Ataturk Dam, shutting totally its flow to Syria and Iraq in 1990 despite an informal agreement with Syria to maintain the flow at 500 cubic meters per second at Karkamis, both Syria and Iraq realized the kind of difficulties the Turks could cause them. Despite major political difficulties between Damascus and Baghdad at that time, the two leaderships quickly came together, threatening war over protecting their shares. Turkey discovered that it had overestimated the rift between the two neighbors and opened the flow to its normal course. Water conflicts between the parties have never subsided. They are partly related to water, but they have a lot to do with strategic posturing.

The GAP project is also touted as transforming the area into a vibrant economy that can countervail and dilute the threat of the Kurds' Workers Party (PKK) in that region. There are strong reasons to believe that the project is intended to change the demography of the region by dwarfing the Kurds and flooding the region with other ethnic groups. Syria's preoccupation with the perpetual Israeli threat to its southern flank, its military presence in Lebanon, and Iraq's vacuum after the third Gulf War with large contingents of American troops at its borders have combined to weaken Syria's bargaining position vis-à-vis its neighbors. But these same forces, and particularly the latter, have created a commonality of interest with Turkey. Both Syria and Turkey have discovered that they have a wide room to project their strategic interests in the region as long as the Americans

are bogged down in Iraq. Even water difficulties have taken a backseat to their newly developed shared interests in curtailing Kurdish separatism and control of oil.

Kurdish people are disadvantaged in part because they do not have access to the data and knowledge systems involved in successful technical arguments, nor do they have direct access to publicity and media which could project their cause. Large media conglomerates in Turkey are "increasingly disinclined to bite the hands that may now or in the future feed them" because they are dependent on government contracts and funding. "And since today's opposition may well be tomorrow's government, the media moguls have little incentive to take unnecessary risks or to serve as a serious watchdog on government" (Lowry 2000). Without access to the media, Kurds in Turkey have trouble overcoming historical oppression (Lazier 1991).

Ironically, while the Turkish government refuses to recognize NGOs which supported 'Kurdish minority rights,' many American and international funding agencies refuse to give funding to those which do not (Orhun 2003). In this way, NGOs are caught having to make a decision to ally with one or the other to get any funding at all. This created friction among different NGOs; groups which ignored the 'Kurdish issue' received governmental funding and were allowed access to the GAP region while similar groups who did claim to support Kurdish rights received a greater share of international funding but were restricted to working abroad or in Istanbul, and each criticized the other for 'selling out' to the larger power (Orhun 2003).

Turkey defies clear-cut labels or categories: East or West, European or Middle Eastern, North or South, secular or religious, developing or developed. The often conflicting ideologies inherent in each of these categories highlight the debate among differing world views and expose an identity crisis of what it means to be Turkish. "Whenever we Turks decide, we seem to injure ourselves. We hurt each other... Indecision, not ideology; that's the whole point of being Turkish" (Seal 1996). In the debate about the GAP project, paradigms which are reflections of world ideologies, (for instance, environmentalism), come to the forefront.

This research differs from most studies of natural resources because the actors involved are not necessarily competing with each other for rights or access to what is typically seen as a scarce resource. Rather than competing over the resource itself, they are competing over the righteousness and influence of different knowledge systems. It is not the resource which is contended but the ideologies as they pertain to that resource. The fight is not overtly over water; it is about notions of sustainability, security, identity, human rights and equity. These are arguments which hold a 'higher' moral

ground than competition over a resource; they are used to further a group's legitimacy on the water issue.

Unearthing institutional relationships and revealing political motivations has the effect of deconstructing and questioning the established order. This study is not intended to suggest policies that would solve Turkey's water resource problems. Rather, it might encourage actors who do not have access to resources to question established political relationships. Actors should realize that existing paradigms are not inevitable or intrinsic; they are a result of the changing social constructs. Access to and interpretation of technological and political discourses dynamically shapes the relationship of humans with each other and with the environment.

Despite plans for participatory approaches and increased local prosperity, the way in which development rhetoric is constructed and reinforced has the effect of increasing the dominant perspective (in this case, of the government) and facilitating that group's capacity to further its goals. The construction of the GAP is a process through which the government promotes 'Turification' of the GAP region while simultaneously sidestepping political and social ramifications associated with an exclusively Turkish national identity. Turkey must find creative solutions to reach its development goals. But realizing the human and environmental consequences of such projects, as well as the technical benefits, is essential to creating successful governance mechanisms. Although some of the following arguments may seem critical of the Turkish government, they do not fault government officials for bad intentions or negligence. The term 'good governance' usually implies transparency, accountability, equity, efficiency and inclusiveness. But even under a governance system that conforms to international standards, certain groups effectively work within the given framework and express themselves, while other groups are left unheard.

Language of the Damming: An All-Purpose Project to Serve All Turkish Identities

Turkey's central government is using dams as the catch-all solution to economic stability through job creation and irrigation while attempting to rid themselves of historic human rights violations in Southeast Anatolia. In the West, broad demands for political participation and social equality arose only after productive capacity and national income had increased enough to satisfy them (Bianchi 1984). Turkey's dilemma is that it is trying to simultaneously achieve rapid economic development and a western-style democracy. The separate goals of optimizing natural resource use and encouraging public participation often have contradictory agendas that ignore localized cultural and political differences. In the GAP, democratic ideals such as public participation, equalization of resources, and maximizing efficient use of natural resources are used as a the 'public face' of resource exploitation.

The same description of the GAP is reproduced in almost all government documents, press articles, and publications on the subject. The figures, examples and ideas are remarkably uniform, establishing what seems to be a unanimous consensus on what the GAP 'is.' The following description serves as the most often-used definition for the project in its current state:

"GAP is the biggest development project ever undertaken by Turkey, and one of the biggest of its kind in the world. The integrated, multi-sectoral project includes 13 major projects which are primarily for irrigation and hydropower generation. The project envisages the construction of 22 dams and 19 hydroelectric power plants on the Euphrates and Tigris rivers and their tributaries. It is planned that at full development over 1.7 million ha of land will be irrigated and 27 billion kWh of electricity will be generated annually, with an installed capacity of over 7,500 MW. By the time all 22 dams and connected irrigation channels are finished by the year 2010, the nation's irrigated lands will have increased by fifty percent. In addition to the irrigation and hydropower schemes, all the related social and economic sectors including industry, transportation, mining, telecommunications, health, education, tourism, and infrastructure. GAP covers 32,000 square miles of land and will cost \$32 billion. The project plans to develop the long ignored Southeastern Turkey, where a major outflow of population has been combined with high levels of unemployment and political instability" (GAP 2003).

The uniformity of the definition of the GAP sets the tone of technical and rational language used by the project planners and their critics alike. It limits the debate about the project to what Bill Lord would call 'cognitive conflict' that is 'rooted in different understandings' of the technical probabilities of success or failure that are only resolved through data acquisition (Lord 1979). The technical language used in these descriptions leads to the dangerous perception of the project as apolitical, sterile and straightforward.

Quantitative references to power output and total cost in the above excerpt, for example, cannot be questioned without scientific qualifications and access to fluvial and economic data guarded by government institutions. Technical language proves a project's 'success' in terms of quantitative increases in hectares of irrigated land, kWh of energy produced, percentage in per capita income, employment, GDP, or agricultural output. These figures are effective because of the perception that numbers themselves are apolitical and depict the 'true nature' of the region.

Even if scientists who collect data are not political themselves, the very use of this language automatically leaves groups without access to data out of the debate. Those who are most directly affected by dams often "lack the professional resources necessary even to read and evaluate the water agencies' technical planning reports, to say nothing of preparing rival technical reports which can buttress their own positions" (Lord 1979). There is a direct correlation between groups with the most power and

those which are able to produce, project and replicate technical arguments. Kurds generally do not have access to legal, economic or scientific knowledge systems; they rely on cultural ties and political arguments to politicize wide-sweeping, externally-motivated changes. In this way, using technical language in the development rhetoric disables and silences groups which cannot effectively use this same language.

The established description of the GAP, as quoted above, forms a starting point from which outside actors judge the project on its own, simplified terms. Rather than questioning the project itself, they can only analyze how accurate the optimization models were. This routes critics around the major ideas – dams for development in the first place – and limits them to smaller sub-sets of the project which can be ‘fixed’ without major structural changes to the original plan. Water resource planners mitigate criticism from environmental groups using “distributive politics and conflict avoidance... It is possible to add one extra mile of wildlife corridor or some extra storage for recreational use” without dramatically changing the planned infrastructure or the actual effects of the project (Lord 1979).

The GAP Authority oversees virtually every listable problem of the region. The Decree No. 388 Force of Law sets out the tasks of the GAP Administration, and just *one* of the ten duties assigned to this Administration is to:

“conduct and coordinate all activities to ensure the rapid development of the region within the framework of long term plans and programs including those related to public investments in agriculture, mining, manufacturing, industry, energy, transportation, communication, construction and tourism, as well as other activities of research, implementation and investment in the fields of human resources, sociology, economics, scientific research, development and technology, environment and urban planning, regional development and culture...” (GAP 2000).

In response to, and in anticipation of, critics who see holes which need to be filled and problems which need to be solved in the region, the GAP planners have incorporated virtually every problem imaginable into the development scheme. On paper, at least, there is a description and action plan for every preconceived social or environmental issue. Yet the general terms used to describe so many problems raises logistical questions and skepticism about the real priorities of the government (Lustgarten 2003). Indeed, “support is justified by magnifying the need and benefits of water projects... Economic and social advantage is promised to all sorts of groups, even if their interests conflict” (Ingram 1990). The fact that the GAP has addressed so many problems does not mean that it is more effective in solving regional differences; instead, the very act of acknowledging concerns and taking control of solutions gives the GAP Administration more legitimacy and a wider jurisdiction.

NGOs working in the region must get permission from, and are often financially dependent on, the Administration and are not willing to express many negative opinions about it (Goksel 2003). The GAP is efficient because it has a highly centralized structure, employs approachable experts, and actively advertises their projects to validate their activities. With its glossy brochures and friendly, English-speaking employees, the GAP Administration is as much of a public relations agency as it is an actor in the region (Oruc 2003). Though GAP employees may be genuinely concerned about environmental and social problems, their capabilities are diminished because of confusing overlap with Agriculture, Forestry, Tourism and Culture Ministries. Overlapping responsibilities make change in the region politically charged even within competing government agencies.

Evolving History of the GAP: 'Moral' Paradigms Supporting Nationalism

"Multiple distinct incarnations of Atatürk seem to exist in the Turkish mind... Everything from the doughty fighter, the national father, the great educator, to champion of women, of panama hats, and of Western coattails. As such, every Turkish constituency can find something in the man of which they approve. It may be imagined that further manifestations of his personality and achievements will be manufactured to soak up other constituencies as they emerge so that if existing versions of Atatürk do not fit to his world view then the Turk can tailor-make him in other images until one does."
(Seal 1996)

Just as Atatürk's icon is integrated into changing political views, the GAP has been designed to suit evolving purposes, with the ultimate effect of enhancing a unified Turkish identity. The GAP rhetoric and public image have been through numerous evolutions as officials respond to changing international influences. To maintain control over resources in Southeast Anatolia, the government has adjusted to changing knowledge systems by increasing the size, scope, and ambitions of the GAP, ultimately to an enormous scale. In this way the institutional and ideological aspects of dam projects, rather than the engineering plans themselves, have been radically adjusted to meet new international agendas (Brismar 2002). Such changes resulted from top-down, external influences rather than from the locals who are most affected by the projects.

Riding on nationalistic sentiment to support the dam construction, it is not surprising that, as far as the GAP Administration is concerned, the history of development in Turkey starts with Mustafa Kemal Atatürk, the founder of the Turkish State. Atatürk is used as a modern symbol for the GAP: the name of the largest dam, which is the mainstay of the project, bears his name. This is the irony of nationalism, where, in a region with the longest human history and oldest archaeological remains, Turkish history begins in the 1920s with Atatürk. It is a "Turkish paradox which enshrines the nation's commitment to the modern in the memory of a man who died

fifty-five years ago, before space travel, before the last war, before even the Beatles" (Seal 1996). Atatürk's sweeping reforms were externally motivated, forcing a transition from traditional Ottoman to modern European. Kemalism, by which Atatürk tried to establish a "Turkish society as a unified, solidaristic totality devoid of [racial] divisions and conflicts," disempowered ethnic minorities (Koker 1997).

The popularity of the Aswan High Dam in Egypt was the stimulus for Turkey, Syria, and Iraq to build dams in a 'race for regional leadership,' without fully considering their individual water needs (Chalabi 1995). The State Hydraulic Works (DSI) was formed in 1954 to "plan, design, construct and operate dams, hydroelectric power plants, domestic water and irrigation schemes" (DSI 2003). DSI today includes engineers and planners responsible for water-related projects in Turkey. DSI's first proposal in 1970 included a series of four dams and irrigation facilities on the lower parts of the Tigris and Euphrates Rivers in Turkey. The project was intended to "[transmit] large amounts of power" from the eastern rivers to the western cities of Turkey (Brismar 2002). At this time, the term 'multipurpose' was limited to hydropower, agricultural production, and economic growth (DSI 1970).

In the 1980s Turkish planners merged these four dams with nine additional dam projects and incorporated the concept of 'integrated multi-sectoral development project' by including industry, infrastructure and transportation fields. At this time, the emphasis of the project was on the dams; increasing other sectors was only intended to accelerate the dam-building process (Brismar 2002). The GAP Administration increased the proposed number of dams to 22 in 1990, despite warnings from environmentalists that this over-ambitious project serves political purposes at the cost of sustainability. International literature in the 1990s focused on 'adverse social and environmental impacts of large dam projects' and their failure to achieve expected results (Brismar 2002; McCully 1996). Partially in response to international criticism of dams, the government drafted a master plan whose goals became reducing economic disparities, increasing political stability and supporting urban and industrial development in Eastern Turkey (SPO 1990).

The GAP was directly affected by the next major shift in political priorities: a desire to join the European Union (Kibaroglu 2003). The EU scorned human rights violations of minorities in Turkey and pressurized for social reform. EU funding for the GAP goes exclusively to human rights projects and civil society initiatives rather than to government-planned construction projects or public institutions (Lustgarten 1997). The 1992 United Nations Conference on Environment and Development in Rio de Janeiro emphasized "the need for community participation, improved basic education, health and social services, the advancement of women, the creation of more employment opportunities, efficient use of resources,

and environmental preservation" (Brismar 2002). These terms have since been injected into every GAP proposal with references of 'sustainability' that are 'fluid' enough to be used in different contexts and for different meanings (Oruc 2003; Fisher 1995). Throughout so many ideological shifts, the basic construction of the GAP has not changed since the 1970s: the primary goal of building dams in specific locations has remained the constant prerequisite to all the other changes. Ideological changes were necessary to legitimize development projects, keep skeptical NGOs at bay, secure foreign loans and consultants, and increase government participation in Southeast Anatolia.

Creating an Environmental Consciousness

There has been extensive scientific study of ecological, social and financial problems associated with dam construction, including decreased water quality and quantity, failed resettlement policies, and growing foreign debt (Barrow 1988; Goldsmith 1984; McCully 1996). After seeing these problems in developed countries, interest groups and NGOs form 'epistemic communities' and diligent lobbies to prevent additional dam construction (Haas 1990). They are able to communicate quickly over the internet and articulate political attitudes which often judge governments in developing countries as corrupt and uninformed (Anderson 1983). But environmental and scientific pleas to stop dam construction are not entirely convincing for politicians who are desperate to boost national economies and maintain security in a competitive scramble to catch-up with the West. Faced with frustrating objections to their projects, politicians who are trying to pursue dam-building strategies view some environmental rhetoric as a foreign impediment to the modernization process (Seth 2002; Rende 2003).

Hajer argues that "the developments in environmental politics critically depend on the specific social construction of environmental problems. It is important to analyze not only "what is being said but also to include the institutional context in which this is being done and which co-determines what can be said meaningfully" (Hajer 1995). The environmental argument is an example of how NGOs have to work within the government's framework and within the limits of its development processes, which often ignore, discredit and reinterpret to environmentalism to fit other agendas.

A frequently cited problem associated with dams in Turkey is salinization accompanying irrigation in arid areas with improper drainage, leaving soil infertile for further agricultural activity (Yazgan 2000). Soil is also eroded and transported to stream channels where increased sediment affects albedo, temperature, and dissolved oxygen content, favoring different plant and animal species. Sediment is then trapped in the dam's reservoir, decreasing its capacity and energy efficiency. Stagnant water in dammed reservoirs can increase disease (especially malaria) and trigger algae growth. Dams impede fish migration and change flood cycles, destroying estuary

ecosystems and preventing nutrients from replenishing the floodplain (McCully 1996).

Environmental issues transcend national and political boundaries, requiring different groups to cooperate in order to protect and retain access to natural resources. In the case of dams on the Tigris and Euphrates, Turkey's government has had to negotiate with international environmental groups who are not riparians to the rivers. Friends of the Earth and World Wildlife Fund, based in the United Kingdom and Washington, D.C., have been the most active environmental groups against GAP. The idea that environmental conservation is a global rather than local problem has legitimized and motivated international groups to activism in developing countries. Their "appeals to conservation can mask deep economic and social inequalities" (Sullivan 2001).

The Turkish government now takes environmental concerns seriously because adequate environmental laws and protection are key components of admittance to the European Union. But the attitude of many Turkish officials is that "they have to do it, but they really don't understand what they have to do." Understanding what conservation is and what protection means "is a foreign language they are realizing they have to learn" (Welch 2003). Through either the EU or international NGOs, the environmental rhetoric in Turkey is externally motivated. The Turkish government contends that people are only able to develop environmental sentiments and awareness after they have the resources and technology to have higher standards of living. This argument holds that only after people are able to provide adequately for themselves are they able to understand and respect environmental initiatives and concerns. The government uses this argument because it implies that the sooner they are able to complete their development projects, the sooner Turkish people will be able to take environmental concerns seriously.

Southeastern Anatolia had not, until very recently, been studied in terms of its biodiversity and natural plant and animal resources, so environmental scientists are not yet able to recommend policies which would then protect those species. Biodiversity surveys are being conducted only after many of the dams have been constructed and plans for other dams have been finalized, so it will be almost impossible to compare the effects of the dams on biodiversity in the area. "These studies should have been conducted twenty or thirty years ago" (Welch 2003). Such surveys had not been conducted in the past because of security problems and lack of transportation infrastructure, especially in the winter when the roads are impassable. Again governance is closely tied to technology and information: environmentalists do not have a powerful argument for policy change without the scientific data and surveys supporting their claims of what needs to be protected in the first place.

Environmental Arguments Diverted

Arguments based in environmental rhetoric can be used by dam-builders for their own purposes. Sediment load was a highly publicized environmental problem in the Keban Dam, which was the first to be built on the Euphrates. But the government asserts that as more dams are built on the tributaries to the Tigris and Euphrates, more of the sediment will be caught upstream and sedimentation will be less problematic (Altinbilek 2003). This is a rational argument which asserts that the solution to the problem that a dam causes is simply building more dams.

Environmental groups describe the river banks to be teeming with biodiversity, but the Environmental Impact Assessment conducted by the government for the Ilusu Dam states that the shoreline along the river banks is presently "scarce and not diversified." The species which are displaced "should find sufficient replacement habitats around the reservoir. No mammals appear to be in danger of drowning during impoundment" (Environmental Impact Assessment 2001). In the same vein, the Environmental Impact Assessment states that "the reservoir will blend into the regional landscapes and will become one of its major landmarks... the river panorama will offer a much wider, unobstructed view." The government's analysis of the scenery is superficial to the environmentalists' concern with complicated systems of habitat and chains of life.

Many dams have been exempted from Environmental impact assessments "on the grounds that impact assessments were only required for projects formulated after 1993." Since many of the GAP dams were planned prior to this date, they are largely exempted unless pressured to do so from foreign companies (Lustgarten 2003). And even recommendations of assessments that are made are often not heeded. In 1996, an Atatürk Dam Reservoir development plan was completed, proposing a set of environmental policies to control hillside and shoreline erosion and reservoir sedimentation, to prevent degradation of the reservoir water quality, and to monitor the affected groundwater table. However, in 2001, "no measures had yet been presented that would adjust the design or operation of the Atatürk Dam to minimize potential adverse effects on the river ecology downstream of the dam" (Brismar 2002).

The government agrees with the environmental argument as long as it contributes to Turkey's pre-conceived development of dams. One of Turkey's strongest arguments for constructing water projects is that it can get more 'beneficial use of the water because land in Syria and Iraq is flatter, necessitating wider reservoirs with more surface area and more potential for evaporation and salinization (Bilen 2000; Lorenz 2003). Turkey's government acknowledges the environmental problems associated with dams only because it has favorable climatic and topographic features for dams than do its downstream neighbors. The logic of this argument implies

that Turkey uses the water most beneficially, and therefore should have more rights to its use. This argument has been used to combat international criticism which has targeted Turkey as an aggressive upstream country. Turkey's claim that it is entitled to full river access because it can use them more beneficially leads its politicians to the often-quoted conclusion that Turkey could become the 'breadbasket of the Middle East' (Bilen 2000; Rende 2003). Rather than have water flow downstream, they could irrigate their soil and export agricultural products to these downstream riparians.

Another aspect of the beneficial-use argument is the idea that water which is not entirely used for human benefit, or water which flows downstream, is 'wasted:'

Turkey has built hundreds of dams and hydroelectric power plants, and it has carried out other water-related projects to harness water, produce energy, and irrigate arid lands, but this still does not mean that Turkey has fully benefited from these resources. About 37/110 Gm³ of usable water is actually used. Almost 33% of economically usable water can actually be used at present. The remaining 67% of economically usable water, which Turkey desperately needs for economic development, still flows freely to the sea. Despite its own growing need for water, Turkey is still willing to export some of its water to neighboring countries to relieve their shortages (Tomanbay 2000).

This passage demonstrates how an argument based in technical-rational descriptions can have the effect of promoting a nationalist, apolitical perspective on water use. The idea that water which flows 'freely to the sea' is not used for maximum benefit ignores the effect of fresh water on ecosystems and water quality at the river mouth. This argument also ignores the water uses and needs of other riparians to the Tigris and Euphrates Rivers, treating water as an economic resource which, by flowing downstream, is 'exported' rather than legitimately claimed by Syria and Iraq. As this argument is based in technical-rational language, it depoliticizes river flows while at the same time promoting Turkey's sovereignty and maximizing its control over water resources, both of which are intensely political.

The Development of Problems

"Policy-making is in fact to be analyzed as the creation of problems, that is to say, policy-making can be analyzed as a set of practices that are meant to process fragmented and contradictory statements to be able to create the sort of problems that institutions can handle and for which solutions can be found. Hence policies are not only devised to solve problems, problems also have to be devised to be able to create policies" (Hajer 1995, p.15).

"Even the mention of the eastern provinces gave visions of ignorance and poverty" (Nestor 1995). The perception, and then reproduction of

Southeast Anatolia as an 'other' place that is far away, backward, traditional and dangerous implies specific constraints of what activities can and should be done in that space, and who should have access to those activities. The description of Southeast Anatolia as 'traditional' implies that traditions are "constraints" that stand "in the way of change... Achieving 'development' is thus largely a matter of changing values and attitudes" (Ferguson 1959). The government asserts that traditional nomadic and tribal ways of life "constitute serious obstacles to the development and modernization of the region... Local functions need to be reassigned to contemporary organizations and institutions" (Sencer 1996). This argument follows a rational mindset that increasing government interference is the solution to 'problems' of tradition.

Characterizing the region as traditional has the effect of blaming local people themselves for failures of certain projects. When asked about an increase in water-borne diseases after the reservoirs were filled, a former president of the DSI said the problem had nothing to do with the reservoirs themselves and everything to do with traditional food which included raw meat dishes (Altinbilek 2003). Similarly, soil salinization and environmental degradation are not results of the dams themselves but rather caused by farmers who are not "aware of proper irrigation techniques" (Brismar 2002; Demirci 2003). Public opinion holds that people who were involuntarily resettled during reservoir flooding are poor because they were irresponsible and spent government compensation "extravagantly" (GAP 1998). Implying that the projects fail because the people are not 'smart' or 'modern' enough to use them avoids questioning dams as the solution to economic problems.

The extent to which 'security threats' are associated with the Southeast has become a sort of paranoia that encourages the domination of security-conscious regimes and sensitizes the rhetoric of development projects in the region. The GAP Administration repeatedly emphasizes that "it is essential to reestablish security conditions by urgently eradicating the atmosphere of anarchy" (Sencer 1996). The result of security fears is that the government, as the institution responsible for maintaining stability and gathering information, is allowed free reign in that area. The Turkish military is the largest and most powerful institution in Turkey and holds an impressive sway over civil affairs.

There are two major security threats involved in the discussion of the Tigris and Euphrates Rivers: retaliation from downstream neighbors and terrorism of the Workers' Party of Kurdistan (PKK). Syrian and Iraqi officials are irate that Turkish dams and irrigation have significantly decreased water quality and quantity (Beschoner 1992). Extensive research focuses on the potential for military clashes over essential and limited water resources (Schulz 1994; Lorenz 1999; Carkoglu 2001; Bulloch 1993).

The Turkish response to this speculated violent conflict has been to downplay costs of decreased water quality and instead to highlight downstream benefits of flood control and regulation of water flows (Rende 2003). The international community's priority on speculation of conflict with Syria and Iraq narrows the development framework and "unduly privileges state scales and actors, ignoring the complex relationships of water-related development to other sociopolitical conflicts – past, present, and future" (Harris 2002).

The second major security issue is domestic: war with the PKK raged in the southeastern region of Turkey for the greater part of the 1980s (Ahmad 1993). The PKK has made "threats against Turkey's hydraulic installations, especially the Atatürk Dam" (Bilen 2000). Continued military intervention in this region is the result of such terrorist fears; paradoxically, the Kurdish desire for autonomy has instead led to increased military control. Some theorists argue that the military's goal in the region isn't to actually solve the terrorist problem; terrorist threats actually work to the government's advantage because as a mask of legitimacy that can be used "at any moment to seize power" (Ahmad 1994). The hype of the GAP's security concerns has even entered the realm of popular literature, including Tom Clancy's thrilling fiction *Acts of War* which dramatizes Syrian Kurdish terrorists who blow up the Atatürk Dam (Clancy 1997).

For the purposes of this chapter, it is not the security issues themselves which are significant but the way in which insecurity is propagated and institutionalized by different groups involved in the GAP. As security is the top regional priority, each group contextualizes the security debate in ways that legitimize its activities. The Turkish Professor of International Relations Ilter Turan emphasizes this point, suggesting that "water disputes may be handy to politicians in personifying real or perceived outside threats in the domestic context, and in this way serve to unite the society against foreign enemies and mobilize support for the government" (Carkoglu 2001). Information is, of course, power, and the state has a monopoly on gathering and analyzing fluvial records. Justification for data secrecy is security issues; as such, no further explanation is necessary. The GAP is offered as a solution to the security dilemma by eliminating poverty and thereby decreasing public support for terrorist organizations. "GAP will accelerate the whole economy of the region and will greatly contribute to the solution of the backwardness and unemployment problems of the region, and in turn will dry up the economic and social sources of terrorist activities" (GAP 1995). This idea that the lack of access to 'development' is the basis for terrorism is widely accepted by public opinion (Demirci 2003; Kara 2003).

"Spaces are both arenas and outcomes of politics, and it is because they so frequently are taken for granted as being 'just there' that they are such

fertile ground for implementing, reproducing, and challenging systems of power/knowledge" (Steinberg 2001). Social attitudes and institutions have marked Southeast Anatolia as a space of economic dependence, exploitable resources and military domain. Propagating this space as backward and empty negates institutions and norms intrinsic to people who live there and emphasizes the need for a predetermined set of development solutions. Balance between different regional constructions tends to "shift from time to time, as the power of the actors varied and the need for certain [resources] waxes and wanes, but the overall competition among the various actors serves to reproduce the [region] as a uniquely constructed space with a complex regime designated to serve a multiplicity of functions" (Steinberg 2001).

The Kurdish Question

The 'Kurdish issue' has been the most politically sensitive, internationally recognized and potentially destructive issue in Southeastern Turkey. It has been so problematic for so long that even mentioning the name of the ethnic group raises suspicion and tension. Unlike governmental and environmental groups that use technical language in an attempt to depoliticize their priorities for either development or conservation, Kurdish people largely do not have access to such technical knowledge systems and are left without a strong voice in the development process. The interplay between Kurdish minorities and GAP planners demonstrates problems and uncertainties associated with increased governmental activity in the Southeast. While the previous sections of this chapter have shown that the GAP is a means through which government power is increased, this section addresses potentially negative effects of that power.

Supporters of the 'Kurdish cause' do not have technical language to depoliticize development but rather use historic examples and personal experiences to make the government's activity in the region outwardly political. The Kurds make up the largest of several minority groups in Turkey and the one which reveals the most conflict over issues of racism and human rights violations in the last few decades. There is no clear distinction of what it means to be 'Kurdish.' It is a group that is composed of individuals who speak at least four different languages, live in many countries of the Middle East, are members of different cultural and political groups, and even practice different religious traditions (White 2000). Estimates of the size of the Kurdish population in Turkey range from 12 to 20 million people, and many claim that it is the largest ethnic group without its own nation-state (Kirisci 1997). Despite the wide variations in cultural identities in Southeastern Anatolia, governmental intervention has influenced, and even precipitated, the creation of a Kurdish identity at odds with the state.

In an attempt to strengthen Turkish identity and allegiance with the state, Atatürk abolished cultural and linguistic practices of minorities.

Kurdish language, education, organizations, and later television, were declared illegal. Governmental policy was to derecognize anything Kurdish, calling the people "mountain-Turks who had forgotten their native language" (Bulloch 1993). By referring to them as 'mountain-Turks,' the government attempted to depoliticize their references to Kurdish people and forcibly assimilate them into a 'unified' Turkish culture. In this way, "national identity, either as invented tradition or as imagined community, is used by the political actors dominating the state apparatuses to justify oppressive political practices... National identity is an important pillar of legitimization for state-centered oppression" (Koker 1997). Nationalism and development became mobilizing forces of Atatürk's party, but despite his lasting legacy, a Turkish 'identity crisis' remains between the "glorification of everything Turkish, carried to the point of xenophobia, and an open admiration for the technical and social achievements of the West," which later became embodied in the GAP (Stirling 1965).

One of the many strategies the military used to combat Kurdish terrorism, which arose with the Workers' Party of Kurdistan (PKK) in the 1980s, included a controversial policy of forcefully evacuating rural villages. In the last decade, "at least 2 million Kurds have been forced out of villages by the Turkish military... which increasingly regards Turkish Kurds as either the enemy or at least a potential enemy" (White 1998). By mandating that Kurds move out of traditional village networks and then by burning the remains of many villages, the military intended to wipe out hiding areas and resources which fueled the PKK (Kirisci 1997). From cities and state-constructed housing units, the government can better monitor and control the population than in distant mountain villages (Bulloch 1993). The majority of those displaced decided to move to cities, where they become unskilled laborers either in urban areas of Southeastern Anatolia or in Istanbul or Ankara.

The resulting rapid urban growth has led to other infrastructural and economic problems from the failure of many of these families to gain adequate housing or employment, which then reinforces the conceptions of Kurdish people as poor and expendable within the Turkish state (White 1998). The Turkish government's strategies for 'dealing with' the Kurdish region have included depoliticizing their actions under the blanket of 'security issues' and relocating entire villages for the very purpose of disrupting social networks. This second policy in particular has led to local peoples' suspicion and mistrust of the real political intentions underlying dam constructions under the GAP.

Effects of the GAP on the Local Population

The GAP dams have driven rural people off their land with little or no compensation and no place for resettlement except the slums of cities of western Turkey, in which the process of assimilation gradually absorbs

them. They lose not just their land but all their social networks and solidarities, the links to others that helped them make sense of and survive in the world" (Lustgarten 2003). The GAP was envisioned within the same nationalist discourse that tried to create a Turkish national identity out of the fragments of Ottoman ideologies while submerging Kurdish influences. This historical context has raised suspicion among inhabitants living in the region towards the central government in Ankara, and it has tremendous impact on the perception and acceptance of the GAP by the local farmers and workers who are supposed to benefit from the economic outcomes of the project. Although the dams are just now nearing completion, there are many indications that the most fundamental effect of the project is increased governmental control over the people in the region.

Identity conflicts are directly manifested in and perpetuated by the GAP – not only in its ideological descriptions but also in its physical constructions. The side of one of the GAP dams reads in bold letters, "ne mutlu Turkum diyne," or 'happy is one who can say one is a Turk' (Kirisci 1997). This direct statement imposing Turkish unity and nationality on the GAP project in the Kurdish region emphasizes the government's priority and focus on integrating the Kurdish population into Turkish institutions and culture.

Yet this picture of integration is not so simple; the vast majority of people who are relocated from the flood zone say they are 'very unhappy' with their new situation. However, members of the DSI – which is responsible for the relocation process – do not understand why these families are so upset (Lustgarten 2003). DSI administrators believe that the "benefits of resettlement for the affected population are overwhelming compared with the cost" (Altinbilek 2003). There is a complicated, technical process of determining how much compensation each person is given depending on the size of their family, the amount of land they own, and how many trees are on that land. Weighing the costs and benefits of relocation in numeric and technical terms effectively ignores unquantifiable assets. Equations do not take into account psychological trauma and cultural shock which often accompany the moves. Using a systematic equation to determine monetary compensation for people who are involuntarily relocated appears to be apolitical because it is based on numbers, but the equations themselves and the numeric system of valuation are embedded with political effects that empower educated landowners.

Ninety percent of those who receive compensation for relocation have to take the government to court to get adequate funding (Environmental Impact Assessment 2001). Only those who own land are given compensation in the first place. This has definite political effects in a region where most of the land is owned by large landowners, and those who work the land are 'squatters' and are not taken into the government's budget for relocation even though they also lose their homes and jobs when the dams are filled.

Even among the landowners, most of the payments come months late and are tied up in a complicated banking system which requires an understanding of financial management. Money that is left in the bank is quickly devalued due to extremely high inflation rates (Environmental Impact Assessment 2001). Only those who understand the legal system enough to know their rights and their ability to challenge it, and who are patient enough to go through the slow litigation process before receiving their money, are able to receive adequate payments. The judicial system requires that those challenging it speak Turkish, which is not the case for almost all men over fifty and women of all ages in the region. This again limits the population to those who are educated in the judicial and financial systems of central Turkey.

Another component of the relocation process is mistrust of the government's policies and relocation strategies because the village evacuations carried out during the government's war with the PKK, as explained earlier. There is a fine distinction between evacuating villages as a technique to fight a war in the last decade and evacuating villages as a technique to promote prosperity for those same people in the current decade. The dams effectively disrupted the cultural and political fabric of the region and opened the way for increasing governmental power and dependency (Kirisci 1997). Kurdish sympathizers link the creation of the dams directly to a political agenda of disrupting the Kurdish homelands. In a note which was leaked to the press, President Turgut Ozal outlined his solution to the 'Kurdish Question':

"With the evacuation of the mountain settlements, the terrorist organization will have been isolated. Security forces should immediately move in and establish complete control in such areas. To prevent the locals' return to the region, the building of a large number of dams in appropriate places is an alternative" (Lustgarten 2001).

Through leaked evidence such as the above passage, Kurdish groups politicize the GAP, trying to prove that the intensions and objectives behind the GAP are secretly to "disengage Turkish Kurdistan" (Chalabi 1995).

One of the most enticing aspects of the GAP is the government's claim that the construction projects and increased economic investments in the region will create a few million more job opportunities (GAP 2000). These opportunities, however, have not gone to the poor people in the region who worked as sharecroppers on land owned by large landowners. Most of the workers employed on GAP construction projects are not from the local Kurdish regions but are more skilled laborers from other regions of Turkey (White 2000). In addition, the loss of land which was flooded has increased the demand, and therefore the price, of other cultivable lands in the region. With an understanding of economics and information detailing

the GAP plans, several “financially powerful companies and individuals” purchased land in the region “to sell later for large profits” (Tomanbay 2000). Although the GAP can potentially bring more economic resources to Southeastern Anatolia, the existing socio-political structure of the region increases the disparity between the wealthy landowners and the poor Kurdish workers.

Even farmers whose lands were not flooded are dramatically affected by the new irrigation institutions created by the GAP, forcing them to work within a more bureaucratic and technical system of water dispersion. In this new system, farmers must first make claims to GAP technicians about how much water is needed. This technician then passes these requests on to another technician in charge of secondary canals, who then passes them on to another technician for the main canals. If they do not follow formal and technical procedures by set deadlines, the farmers are fined (Unver 1993). The fact that each farmer has to go through agencies of the central government to receive water for irrigation increasingly enforces a system of dependence on and submission to the development apparatus.

The Kurds’ last and strongest weapon is their sense of identity: their language, traditions, culture, and pride (Laizer 1991). However, with the overwhelming incentives for development and legitimacy of information-based arguments, the Kurdish people who are most directly affected by the dam constructions are also those who are marginalized from any ability to prosper from them. As a group, the Kurds “have become the worst casualties of Turkey’s problematic attempts at integration and economic reform” (White 1998). The institutions of landownership in the region, together with the formation of a racially-based Turkish identity and a history of terrorism and security issues, have given the GAP’s supposedly apolitical constructions distinctly political effects.

Conclusion

“The notion that one can reduce motivations of states to a simpleminded pursuit of resources leads to an unrealistic disregard of the fact that resources are merely means that can be used to accomplish desirable ends or to prevent undesirable ones from occurring; they are not ends in and of themselves. Actors have preferences for certain outcomes; hence, their choice of resources should really be seen in the context of which outcomes can be secured by certain resources... Weak actors do not willingly submit to strong ones simply because they know they are weak; strong actors do not simply swallow up weak ones simply because they are strong” (Maoz 1989).

Development projects, constructed in a technical-rational language, appear to be apolitical by ignoring local nuances while facilitating governmental control and nationalist identity. They are not simply solutions to certain problems: development policies themselves indicate other social and political phenomenon. Indeed, by “reducing poverty to a technical

problem, and by promising technical solutions to the sufferings of powerless and oppressed people," the development process depoliticizes poverty while "performing extremely sensitive political operations involving the entrenchment and expansion of institutional state power almost invisibly, under cover of a neutral, technical mission to which no one can object" (Ferguson 1990). This conclusion resulted from specific research questions addressed at the beginning of this study: How are development projects perceived, and what is the language used to describe them? How does this construction affect the structure of governance? How do historical trends augment socio-political relationships in the development process?

These are important questions given the tremendous magnitude to which development projects are pursued and accelerated in the current age. Development as a goal is almost unanimously accepted as right and good, just as civilization was in the last century (Ferguson 1990). But the benefits of such ideas cannot only be measured through analysis of increased crop yields, increased consumerism, or even increased GDP per capita. The underlying goal to relieve suffering and empower individuals to take control of their lives is often obscured by such technological and mathematical tools and arguments; technology itself is a social phenomenon.

Through political participation, lobbying, publicity and advocacy, governmental officials, environmental advocates and ethnic minorities each had roles in the changing discussion, perception, presentation, and implementation of the GAP project. Each group has vastly different interpretations of the region and priorities that should be pursued in it. Analyzing specific interest groups' interactions with the government and with each other is an effective tool to unearth conflicts over conceptions of power, 'truth,' and 'nature.' To change the way of life of a certain group of people, one needs to change the ideas by which that group and their problems are perceived, reproduced and reiterated in society. The institutions are products of certain idea systems.

Historical analysis shows the different theories and priorities that have taken hold, based on who is in power and which resources are important and which groups need to be controlled to pursue those purposes. And the future will be no different. There is no one perfect worldview or organizational scheme that will be best for humankind for the rest of existence. We are not tumbling towards some sort of final perfect state – in fact there is none, even if we could learn from all of our mistakes. This study is less about humans' relationship with nature as it is about humans' relationship with their own ideas.

Technical-rational assessments, security threats, publicity – these are effective tools in the information and knowledge-centered post-industrial world to enact change and impose a sense of order on the 'natural' world. Countries that are still trying to industrialize are continuously adopting

new arguments for doing so. In Turkey's case, historical trends, power structures and political frameworks result in the government's overwhelming power over the water resources and their uses. But the very fact that these debates are ideological indicates that there are possibilities for further shifts of power and, following that, shifts in priorities of natural resource management. This poses a "continuing challenge to an increasingly complex and interrelated society; How can we plan for the unknown future based on mindsets and paradigms of the Present?" (Olsenius 1987).

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19

Integrated Water Resources Management: A Catalyst for Regional Cooperation?

The Case of Palestine and Israel

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1. INTRODUCTION

Conflict over water is integrally related to many factors. At the domestic level, water can cause or contribute to internal conflict, which generally manifests itself at the community level, between individual users and water-use sectors. Additionally, water can lead to political instability and increase external tensions. Poor government water management schemes, the lack of a social safety measures in times of crisis, can all produce conflict.¹ Equity between and among the various interest groups, stakeholders, and consumers needs to be carefully monitored throughout the process of policy development and implementation. In transboundary contexts, where water crosses political borders, these factors concern the equity in the utilization between the states sharing the water. Equity is determined through the operationalization of equitable and reasonable utilization principle, which is unanimously agreed to be a rule of customary international law, thus binding to all nations.

¹ Church, C. *Water: A Threat of War or an Opportunity for Peace?* Conflict Trends No. 2/2000, found at <http://www.accord.org.za/web.nsf/0/50c67884a05b59ce42256a10004018de?OpenDocument> (last visited March 2004).

A proper response by governments to water resources management has potential to eliminate conflicts both at the national and international levels. The challenge lies in the design and implementation of regulatory and institutional frameworks that respond to the multidisciplinary and limited nature of water, and operate in a democratic and participatory manner reflecting the needs of the current and future generations. Such frameworks have to be transparent, integrative, equitable, accountable and above all ethical. If genuinely and collectively designed and implemented, these frameworks have the potential to challenge and overcome existing conflicts.

The Palestinian/Israeli case is the best example where water conflict is still prevalent. At the international level, the politicization of the water issue continues to outpace any serious effort to resolve the conflict. The imbalance in the power structures between the two parties, which appears to be in favour of Israel, continues to hinder the attaining of a fair and equitable binding arrangement concerning the shared water resources. On the one hand, the Palestinians—being the weak party—find no support to their demands for an equitable and reasonable utilization of the shared resources. This has consequently weakened their position and contributed to the continuation of *status quo*. On the other hand, Israel continues to ignore the alarming situation arising from the lack of cooperation and coordination concerning the utilization, development and protection of these resources. The current water situation and management practices by both parties are indeed threatening the sustainability of the water resources and the general welfare of both nations. With the construction of the 'Separation Wall', even the most secular people on both sides started to doubt the viability of the two state solution and the potential for resolving the water conflict peacefully and amicably.

In addition to their responsibility to utilize and protect the shared resources in accordance to the principles of customary international law,ⁱⁱ both governments have a national duty towards the water resources and the people each within their territory. This duty encompasses the enactment of national policies and institutional reform which are a prerequisite to the success of regional cooperation. In order to pave the way for a sustainable and equitable resolution of the current water conflict at the international

ⁱⁱ Customary International Law are: certain 'unwritten' rules generally accepted by states as legally binding; a general practice of states accepted as law. Customary rules/laws may be 'codified' in a multilateral convention. However, these rules are legally binding for all states regardless of whether or not they are parties to such a 'codification' treaty. Those customary rules which govern the conduct of transboundary watercourse states vis-à-vis each other include: the principle of equitable and reasonable utilization; the duty to give notice of a planned measure (use) that may cause significant adverse effects; the duty to take measures aimed at preventing significant harm to or within the territory of another co-basin state; the duty to cooperate; and the duty to peacefully settle international disputes.

level, prodigious efforts are required at the national level to properly manage and administer the scarce resources in an integrated manner. This will eventually contribute to the establishment of an authoritative, effective and coordinated system of uniformly managing water resources that integrates river basin management with regional management. To that end, it is recommended to follow an innovative approach that draws lessons from international law and best state practice in order to systematically address the hydrological, legal and institutional challenges in a stepwise manner.ⁱⁱⁱ This approach is advisable for many reasons, including the fact that it has the potential to aid the decision-making process by clarifying the various steps that states must undertake before committing themselves to implementing international law.

This chapter attempts to present an important step forward in formulating a national and regional water policy based on cooperation for transboundary water management. It introduces in a nutshell the concept of “Integrated Water Resources Management” (IWRM) and what policy decisions and structural changes are needed by the Palestinians and Israelis for the implementation of this concept at the national and regional levels.

1.1 Background—What is IWRM

Due to the increasing awareness regarding the interdisciplinary nature of the water resources, recent international initiatives call for establishing a clear connection between social and economic development and land and water uses within the context of river basins, groundwater basins, and estuaries. The IWRM is an approach initiated by the Global Water Partnership (GWP) that seeks to balance human, industrial, agricultural and environmental needs. In 2000, the Technical Advisory Committee of the GWP has identified IWRM as:

“a process, which promotes the coordinated development and management of water, land and related resources in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems”^{iv}

ⁱⁱⁱ The efforts that were facilitated by the United States and the EU in the Water Working Group on Water followed a project-based approach which appeared not to have genuine intentions for cooperation and lacked the concept of equity as far as the Palestinians were concerned. The core parties in the WWG are Jordan Palestine and Israel. Original plans included Syria and Lebanon as well but their participation did not materialize. The projects undertaken within the WWG cover (i) Enhancement of data availability, (ii) Enhancement of water supply, (iii) Water management and conservation, (iv) Concepts of regional cooperation. These projects are presently semi frozen due to the unstable political situation. See generally <http://www.us-israel.org/jsource/Peace/water.html> (last visited January 2004).

^{iv} See generally the GWP Website, found at www.gwpforum.org (last visited April 2003).

Piecemeal approaches to river or drainage basin development and management may not fully recognize the interactions and interdependencies among components of a water system.^v The alternative strategic approach is an operational framework centred on a set of guiding principles that enables water related activities to be developed and managed in an organized, integrated and sustainable manner.^{vi} The units of management should be river basins,^{vii} sub-basins, aquifers, lakes, within whose boundaries resources can be quantified and allocated and secure systems of water rights developed. Population growth and urbanization are key factors underlying the enormous growth in the demand of water and the increase of environmental degradation. The management of freshwater resources, and of the services drawing upon water for functions central to human life, is of critical importance to healthy social, economic and political well-being.^{viii}

IWRM is based on the perception of water as an integral part of the ecosystem, a natural resource and a social and economic good whose quantity and quality determine the nature of its utilization^{ix}. IWRM includes the integration of land and water related aspects. Population growth, limited water management capacity, fragmented organizational structures, and inadequate water planning, management, and conservation are among the contributing factors. The impacts of climate changes and increasing threats from natural hazards, such as floods, droughts, and sea level rise. IWRM is conceptually simple, however, in practice it is very difficult. IWRM as an approach requires holistic thinking, including integration with non-water sectors.^x

^v A. Dinar and Donna Lee, Review of Integrated Approaches to River Basin Planning Development, and Management, www.worldbank.org/html/dec/Publications (*last visited* March 2004).

^{vi} The European Commission Guideline for Water Resources Development Cooperation: Towards Sustainable Water Resources, A Strategic Approach *found at* http://europa.eu.int/comm/development/sector/intro_en.htm (*last visited* March 2003).

^{vii} In arid and semi arid countries this is replaced by the concept of drainage basin or catchment area.

^{viii} Guidelines for water resources development cooperation *found at* http://europa.eu.int/comm/development/sector/intro_en.htm (*last visited* March 2003).

^{ix} Agenda 21 Chapter 18: Programme Areas 18.6-18.11 *found at* <http://www.icg.apc.org/habitat/agenda21/ch-18.html> (*last visited* March 2003).

^x Clemett, A., Soussan, J. and Mitchell, G., *Making Integrated Water Resources Management (IWRM) Work: Lessons from the Evaluation of Water Sector Programmes*, (University of Leeds) Working Document/ October 2000, <http://www.euforic.org/iob/publ/workdocs/iwrw.pdf> (*last visited* March 2004).

1.2 Elements of IWRM

Integration in the context of water resources management includes the following key elements:^{xi}

- The integration of ground- and surface-water sources;
- Connecting social and economic development and land and water uses within the context of river basins, groundwater basins, and estuaries;
- Development of the appropriate institutional structure with emphasis on decentralization to facilitate the necessary coordination within the water management sector and between the water sector and other sectors;^{xii}
- Public participation and empowerment in the process of decision-making and involvement in project planning and implementation;
- Consideration of the needs of aquatic ecosystems for water; coastal-zone management; recognition of water as a social, ecological and economic good;
- Integrated management of water demands; contingency planning to mitigate the social and economic effects of natural disasters;
- Conservation of soil and water; and prevention and reduction of pollutant discharges.

These approaches take into account the intersectoral linkages among economic sectors especially agriculture. Agricultural water pollution is becoming a major concern in both developed and developing countries. The intensification of agricultural practices—in particular, the growing use of fertilizers and pesticides, and the specialization and concentration of crop and livestock production—has had an increasing impact on water quality. Pollution control measures must rely heavily on approaches that affect farmers' land use and production decisions.

1.3 Why IWRM—A Mutual Benefit?

Palestine and Israel being semi-arid countries are characterized by large variations in rainfall and limited surface resources which have led to widespread scarcity of the water resources. Population growth, socio-economic development, urbanization and industrial and agricultural activities have exhausted the water resources. The competition between different users and uses without proper planning and coordination could lead to the depletion of the water resources.

^{xi} See *supra* note 4.

^{xii} Recommendations and Guidelines on Sustainable River Basin Management; Workshop Report "International Workshop on River Basin Management, the Hague, October 1999 found in: www.ct.tudelft.nl/rba/recommendations.html (last visited February 2004).

From time immemorial, rain falling on the West Bank mountains has fed Israel's major water sources and storage resources. In international law absolute sovereignty by any of the parties has little if any backing. Nor would it make economic sense for the Palestinians to divert the water before it infiltrates and seeps westwards to replenish Israel's underground aquifers. Thus, Palestine's water problems are inevitably bound with those of Israel. Having agreed to that, it is essential to base strategies for sustainable management of the water resources on cooperation and collaboration.

IWRM involves understanding the characteristics of a basin, in all of its bio-physical, socio-economic, and geo-political complexity. This is expected to allow the parties to foresee the benefits derived from the integrative. The operationalization of IWRM at the national level by each country is expected to be the catalyst for efficient water resources management leading to integrated regional cooperation. The challenge is that despite the demonstrable gains that can be obtained through IWRM elsewhere in the world,^{xiii} in most situations these incentives fail to rapidly induce the cooperative mechanisms. A common obstacle in that endeavour appears to exist where traditional forces manage to delay the establishment of the appropriate institutions. Moreover, the current scarcity and deficiency in water resources management systems seem to be used as arguments to further strengthen traditional centralized or mono-sectoral management arrangements, rather than make a shift towards integrated water management.

2. UNDERSTANDING THE CURRENT SITUATION OF WATER RESOURCES-THE CASE OF ISRAEL AND PALESTINE

2.1 Water Availability and Utilizations

2.1.1 Groundwater

Since 1967, Palestine's main water supply comes from the mountain aquifer, the majority of which lies in the Palestinian territory. Virtually all renewable water filling the mountain aquifer system falls on the West Bank. The

^{xiii} The Australian Murray-Darling Commission, took almost 80 years and several environmental crises to be established as an effective institution, as the riparian states refused to relinquish power over their share of the water resources. Similarly, the Rhine river had to become Europe's sewer, endangering health and economy, before agreements were concluded between the riparian nations. In the US, it also took 50 years of intervention of Congress to have an agreement concluded in 1997 on the joint management of the Appalachicola-Coosa-Tallapoosa-Alabama-Chattahoochee-Flint (ACT-ACF) complex in the south east US. See generally Sherk, G.W., *Dividing the Water: The Resolution of Interstate Conflicts in the United States* (Kluwer Law International, the Netherlands, 2000).

annual rainfall in the West Bank is an estimated 3,000 mcm. 600-650 mcm of this rainfall is estimated to replenish the aquifers each year. Currently, Israel and Palestine jointly use the mountain aquifer, however looking at the actual utilizations, Israeli use of this system is drastically greater than that of Palestinian.

The Western aquifer mountain basin is transboundary with Israel. It is located in the western part of the West Bank. The recharge area is 1,800 km² of which 1,400 km² lie in the West Bank. The storage area of 2,500 km² lies in Israel. Two major natural outlets are Rash Al-Ein (Rosh Ha'ayn) and the Tamaseeh Springs. The Western aquifer basin is estimated to have a recharge of 362 mcm/yr. Israel utilizes 95% of this aquifer. The Northeastern mountain aquifer basin is also transboundary with Israel. It covers the areas of Nablus and Jenin in the West Bank; its waters flow northwards to their major outlets in the Bet Shean Springs in northern Israel. The feeding and storage area of 700 km² lies almost completely in the WB (650 km²). The NEAB starts near Nablus and flows towards the Gilboa Mountains, Jezreel, and Bet Shean valley to the northeast. In the Oslo II Agreement, the recharge of this aquifer was estimated to yield 145 mcm/yr.

The Eastern aquifer is located and recharged almost entirely in the WB, with the feeding and storage area spread over 2,200 km² mostly in the West Bank. A small part of recharge is located west of the Green Line, including West Jerusalem. The Oslo II Agreement estimated the recharge of the EAB at 172 mcm/yr. This aquifer feeds the lower Jordan River and it is therefore considered to be the Palestinian contribution to the waters of the Jordan River Basin.

Table 19.1. Israeli vs. Palestinian utilization of the WB aquifer basins (mcm/yr)

Aquifer basin	Annual recharge	Israeli water use	Settlement water use	Palestinian water use	Total water use
Western	362	340	10	22	372
Northeastern	145	103	5	42	150
Eastern	172	40 from wells	50	54	144
Total	679				

2.1.2 Surface Water

Apart from the water resources in the Jordan River system, the only surface water available is the runoff in the wadis, which for most wadis is intermittent. An exception is the spring-fed wadis – for instance Wadi Qilt and Wadi Far'ia, but these are already heavily utilized. To a large extent, the wadis are also overloaded by raw sewerage in the headwater areas.

Further utilization of the wadi runoff will depend on the construction of reservoirs, either for irrigation or for increasing the reinfiltration of the wadi flood water. It should be kept in mind that the wadi flood water is a relatively small volume, a few percent of the rainfall. A significant amount of the potential wadi runoff is already utilized by the wadi agriculture in the headwater areas.

The main underground catchment area on the mountainous backbone of the West Bank divides the West Bank into a western drainage basin, an eastern drainage basin, and a northern drainage basin. The western section of the drainage basin includes catchment areas of the Kishon, Alexander, Hadera, Yarkon, Lachish, Sorek, Shikma, and Besor streams. The largest of these catchment basins is the Yarkon, which drains an area in the West Bank extending from the hills of Beit El to the environs of Nablus. Runoff in the western drainage area from Kishon in the north, to Besor in the south arrive from the area of West Bank into the Israeli territory. On the eastern side of the watershed, the streams drain into the Jordan Valley or the Dead Sea. The total upper run-off of all of the drainage basins in the West Bank is estimated at 50 million cubic meters annually (multi-year average).^{xiv}

2.2 Present Water Supply

At present, there are 375 abstraction wells in the West Bank, 359 of which solely serve the Palestinians. The Palestinian wells extract approximately 62 mcm/yr on average as follows: 31 municipal wells yielding approximately 16 mcm/yr; 13 West Bank Water Department wells yielding 12 mcm/yr; and 315 agricultural wells abstracting 34.5 mcm/yr. The remaining 36 abstraction wells are under Israeli control and they extract approximately 42 mcm/yr.^{xv} Table 19.2 shows the Palestinian and Israeli abstractions from wells in the West Bank classified by aquifer basin.^{xvi}

There are approximately 300 springs in the West Bank, of which 112 are considered major freshwater springs. The total discharge of the major springs is approximately 60 mcm/yr. However, 50% of the spring discharges are of brackish quality and 50% are of freshwater quality. Approximately 49 mcm/yr of the spring discharges are used for irrigation and 4 mcm/yr for municipal and domestic purposes. The average amount of discharge is

^{xiv} Compiled from various sources mainly the editions of the Israeli Annual Hydrological Year Book.

^{xv} See note 1.

^{xvi} A. Jayyousi, *Water Supply and Demand Development in Palestine*, found in F. Daibes (editor), *Water in Palestine: Problems, Politics, Prospects* (PASSIA, Jerusalem, 2003).



Map 19.1. Transboundary groundwater aquifers shared between Israel and Palestine

estimated at 103 mcm/yr (including Ein Gedi Springs, outside the Green Line).

Table 19.2. Abstraction (mcm/year) of the Palestinian and Israeli wells in the West Bank

Basin	Palestinian wells		Israeli wells	
	No. of wells	Abstraction	No. of wells	Abstraction
Eastern	129	25.12	28	29.85
Northeastern	85	16.48	4	9.82
Western	145	20.78	4	2.10
Total	359	62.32	36	41.77

2.3 Policy and Institutional Frameworks

2.3.1 Background

Palestine's legal, policy and institutional frameworks in the water sector are emerging. In theory the philosophy of IWRM has been adopted in the national water policy of 1995, the Water Management Strategy of 1998 and in the Water Law No. 3 of 2002. However, it must be recognized that the overall capacity shortfalls for the comprehensive operationalization of this concept. The following sections present an analysis of the existing policies, laws and regulations in Palestine including an assessment of their adequacy to operationalise the IWRM. The outcome of this analysis lays the ground for decision making concerning the needed reforms and policy changes for the successful implementation of IWRM. Palestine is currently undertaking reform in the water and sanitation sector through management contracts with performance targets. There is decision concerning the establishment of water supply and sanitation utilities in the West Bank and Gaza Strip. These utilities are planned to take over the responsibility for water and sanitation operations. The proposed utilities are divided according to the administrative/governorate lines and not according to the lines of catchment areas.

2.3.2 Palestinian National Water Policy of September 1995

After the signing of the Interim Agreement of 1995, the need for a comprehensive survey of water resources and their development strategies became a top priority as far as the PA was concerned. The adoption of the elements of the National Water Policy (NWP) in September 1995 represented the first step in addressing the important issues of water resources management and planning. The NWP establishes the foundation for decisions regarding the structure and tasks of water sector institutions as well as water sector legislation. It also underpins the necessity of the sustainable development of all water resources and establishes the principle that water resources are a public property of the State. Clearly, the development of the water resources of Palestine must be coordinated on a national level and carried out on the appropriate local level.

2.3.3 Water Resources Management Strategy of May 1998

The overall development objective of the Water Management Strategy is to translate the messages from the NWP into strategic imperatives. The strategy emphasizes the necessary aspects of water development as the establishment of a comprehensive framework for the sustainable management of Palestine's water resources, in addition to the development of an appropriate institutional set-up for reforming and strengthening the water sector in coordination with relevant stakeholders. This long-term and coordinated strategy for the water sector will be used as an overall basis for further planning relating to the activities and tasks associated with the water sector, with the main objective being the securing of an environmentally sound and sustainable development of the water resources through efficient and equitable water management. The eight key elements of the Water Resources Management Strategy are as follows:

- Secure the Palestinian water rights
- Strengthen national policies and regulations
- Develop institutional capacity and human resources
- Improve information services and assessment of water resources
- Regulate and coordinate integrated water and wastewater investments and operations
- Enforce water pollution control and protection of water resources
- Develop public awareness and participation
- Promote regional and international cooperation

2.3.4 Water Law No. 3 for 2002

The objective of this particular law, as stated in Article 2, is to "develop and manage the water resources, increasing their capacity, improving their quality and preserving and protecting them from pollution and depletion. This objective is fulfilled through: i) The sustainable development of water resources based on environmentally sound and enabling bases; ii) The provision and satisfaction of societal and individual needs for water in an optimal and equitable way; and iii) The protection of all water resources from pollution to secure water quality, an environment not harmful to human health or well-being, and sufficient water for production and self-renewal."

2.4 Water Stakeholders

2.4.1 Background

At present there are 359 abstraction wells in the West Bank, most of which are for private users. The Palestinian wells extract approximately 62 mcm/yr on average as following: 28 mcm/yr for domestic purposes (a figure that includes industrial and commercial uses), and 34.5 for irrigation. In

addition to groundwater wells the Palestinians have 300 springs of which 112 are considered major freshwater springs. The total discharge of these springs is 62 mcm/yr. Approximately 49 of the spring discharge are used for irrigation and 4 mcm/yr for domestic purposes.

Except at the regulatory and political levels, the present organization of the water sector is mainly as it has been under the occupation period, and this again has not changed much since pre-1997. The end user suppliers are mainly municipal water works, independent utilities, and village councils and committees. The West Bank Water Department is operating mainly as a bulk utility, supplying the distribution utilities, but also has some directly connected end users. On the other hand, it does not supply all the distribution utilities.

2.4.2 Service Provision Institutions

2.4.2.1 MUNICIPAL WATER DEPARTMENTS

Most existing utilities were established before 1967. These departments dealt with the planning, development, operation and maintenance of domestic supply networks, sewerage networks and other water resources development. Since the occupation, the role of these departments was limited to the operation and maintenance of the water and sewerage networks. Thus they do not possess up to date competence in planning and design. These departments suffer from a multitude of constraints which render their service inefficient and limits the possibilities for improvements. The municipal water department is an integral part of the organizational structure of the municipalities and has a common economy with the municipality administration. This subjects these departments to all the bureaucratic deficiencies integral in the existing municipal system, and subsequently limits their efficiency.

2.4.2.2 SEMI-GOVERNMENTAL UTILITIES

Two independent utilities were established before 1967: Jerusalem Water Undertaking (JWU) and Bethlehem Water Supply and Sewerage Authority (WSSA). JWU serves Ramallah district. The WSSA serves the towns of Bethlehem, Beit Jala, Beit Sahour and a number of villages and refugee camps. These utilities are administratively and financially independent and each has its own board of directors. JWU runs with cost recovery, has a sound technical and financial operation, and offers good services to its customers.

2.4.2.3 LOCAL COMMUNITIES AND VILLAGE COUNCILS

About one quarter of the villages has village councils. These local bodies manage and develop public services in the village including the supply of domestic water, energy and sanitary services. Local committees are formed where there are no councils. The councils and committees generally do not have access to the necessary technical and administrative competence for developing and operating efficient water and sewerage systems.

2.4.3 Regulatory Institutions

The Palestinian Water Authority (PWA) was established by the Presidential Order No. 90 for 1995. By-Law No. 2 for 1996 empowered PWA with the mandate to regulate and manage all water resources of Palestine. The Palestinian National Authority has established the Palestinian Water Authority, as a statutory institution with its own budget, and under the authority of the Palestinian Cabinet of Ministers. The Palestinian Legislative Council adopted the Water Law No. 3 for 2002 whose objective, as stated in Article 2: "is to develop and manage the water resources, increasing their capacity, improving their quality and preserving and protecting them from pollution and depletion. The PWA is responsible for the enforcement and implementation of the provisions of the law in addition to their responsibility to enact directives and regulations and management procedures to put this law into practice. Chapter three of the Water Law establishes the National Water Council (NWC), whose chairman is the Chairman of the PA, whose secretary is the PWA, and whose members include the main Palestinian ministries and other relevant stakeholders. As to the main task of the NWC, it is to ratify policies, plans, and programmes pertaining to the water resources of Palestine.

2.4.4 Plans for Water Sector Reform

As a basis for decisions regarding the structure and tasks of water sector institutions, and the water sector legislation, the Palestinian Authority (PA) has adopted the main principles for a National Water Policy. This policy stresses the necessity of a sustainable development of all water resources and establishes the principle that water resources are public property. The development of the water resources of Palestine must be coordinated on a national level and carried out on the appropriate local level.

The water sector shall be regulated by one responsible body, with the separation of its institutional responsibility for policy and regulatory functions from the service delivery functions. This management should ensure that domestic, industrial and agricultural development and investments must be compatible with water resources quantity available. At the service delivery level the strategy is to establish three regional utilities in the West Bank and one utility in Gaza. These utilities will have a lean management set-up where water supply and adequate sewage disposal are regionally provided on a cost recovery basis and ecologically sound. This strategy will in the long term encourage the involvement of the private sector in the implementation of certain projects that could be contracted out by the utilities. Coordinating mechanisms among line agencies and between line agencies and local governments have not been fully established yet.

2.4.5 *Joint Management Institutions*

In 1995, Israel signed with the PLO the Oslo II agreement on the interim arrangement for Gaza and the West Bank. This agreement deals with the issue of water in a separate section. Appendix I of Annex III, Article 40 is the section dealing with water and wastewater. The two parties agreed to establish a Joint Water Committee (JWC) as an institutional mechanism for the interim period, to be responsible for implementing Article 40. It was further agreed that decisions of the JWC should be reached by consensus, including the agenda, the procedures, and other matters.

2.5 **The Hydrological Challenges**

2.5.1 *Overpumping*

The main problem connected with the utilization of the Mountain Aquifer is overpumping. Israel claims that the waters of the aquifer basins are fully exploited. The consequences of over pumping are: (i) increased salinity in the Jordan valley; (ii) springs and shallow wells drying up; (iii) increasingly higher pumping costs as the water table lowers; (iv) aquifer depletion – the aquifer will eventually be depleted. In the best case it will be possible to go back to sustainable pumping – in the worst case, the aquifer will be out of use for a shorter or longer period while it recovers.

2.5.2 *Water Quality and Pollution Problems*

On the West Bank, the quality of water from deep groundwater aquifers is generally good, although there are indications of increasing salinity in the Jordan Valley area. Surface water supply and water from shallow springs can be of much more variable quality, mainly due to mixing of sewage. Again, poor infrastructure might also cause problems. Raw sewage is usually discharged to the wadis, where it is partly reinfiltrated, and partly used in irrigation. The seriousness of these discharges on the deep groundwater has not yet been investigated. However, due to the long transport time, only conservative constituents are expected to be a problem. As for the impact on irrigation, it is known that bacteria is a serious problem especially in vegetable cultures. If the quality of the irrigation water is not controlled, export to markets outside Palestine can be difficult. In addition to sewage water, the water resources of Palestine is also threatened by other pollutants, like oil spills from industry and garages, leaking tanks and landfills, and accidental or deliberate discharge of pesticides and chemicals. As the potential risk zones mainly are in the headwater areas of the aquifers, a massive spill of a conservative pollutant could have a delayed, but large scale impact on the aquifers. Again, the vulnerability of the deep aquifers to such impacts is not much investigated – the shallow aquifers are certainly at risk.

2.5.3 Lack of Information and Knowledge

For long years the Palestinians were denied access to hydrological investigations and data regarding the transboundary groundwater resources. At the one end; it is an abundance of data and information on the Israeli side, and at the other, a paucity of data and information on the Palestinian side. By and large the Palestinians were and are still recipients of data from the various Israeli or international organizations, due to the unilateral control over research and development in the field of hydrology water resources development. This fact is serious, and would require prodigious efforts in order to verify existing information and reproduce national Palestinian figures and statistics.

2.6 Legal and Institutional Challenges

As a starting point, there is an urgent need to put existing policies which serve the objectives of IWRM into practice. Policy reforms are often seen as an end in themselves, rather than as a means to improving water resources management, which in turn depends on the policies being put into practice. There is a need to raise levels of awareness amongst governments and other parties at the national level on the challenges facing them and the need for and direction of reform. The need for carefully targeted and realistic new laws and policies and well structured institutional reforms that create the environment within which changes to water resources management at sub-national levels can take place.

2.6.1 Inadequate Access to Water Resources and Proper Sanitation

Whilst around 2 million Palestinians have access to 16% of the mountain aquifer's renewable waters, Israel – besides all the other surface and groundwater resources available for its use – has control over the remaining 84% of these waters. A deficient domestic water supply, in quantity as well as quality, is not only detrimental to general welfare, but also a direct economic liability to society, through increased load on the health and social services, and through prolonged absence from work. Generally, it is not possible to achieve high quality water supply without proper handling of sewage. The economic development is also to a large extent dependent on adequate water supply. A wide range of industries depends on water in processing. For some uses, the quality of the water is of less importance, but for some, like food processing, the adherence to high standards is vital for access to national and international markets.

2.6.2 Deteriorated Infrastructure and Services

The level of development in the field of water infrastructure and services is far less developed in the Palestine Territories compared with Israel. After the establishment of the PA and especially after the takeover by the PWA many projects have been implemented to construct new water networks or

to rehabilitate existing ones. This is considered to be a time consuming task that requires commitments from the Palestinians and Israelis supported by the international community. There are very few sewage treatment plants in Palestine, and the few existing do not operate satisfactorily. With the relatively high percentage of the population connected to a sewerage network, this gives a high amount of raw sewage being returned to the natural environment.

2.6.3 Lack of Cooperation and Coordination and Weakness of Existing Joint Management Institutions

Coordination between Israel and Palestine on the transboundary groundwater resources has been absent so far because the magnitude of the problems has outpaced efforts for comprehensive management. In effect during the period of occupation the Palestinian have had limited -if any- control over these resources. Any further delays in taking serious steps towards genuine cooperation will lead to a more deteriorated water situation and to inflation in the water crises thus causing harm for the present and future generations and to the groundwater resources themselves. The current situation of no cooperation has widened the gap between the parties and deepened the mistrust in all matters and at all levels. It is evident that the continuation of the *status quo* in relation to the imbalance in utilization and the uncoordinated management of transboundary groundwater are not in the interest of both parties.

2.6.4 Lack of Financial Resources and Donor Coordination

The requirements of efficient water resources management cannot be accomplished unless there is a strong commitment from the multilateral institutions and governmental donor agencies to fund such activities. This commitment must derive from the government's genuine intention to end the conflict between the parties peacefully and amicably. It is true that current investments in the water sector in Palestine and Israel are huge, it is however believed that these investments are improperly planned. The reason for that is obvious since as of today there is no unified donor coordination policy towards the water conflict and the means for its resolution and accordingly projects are not planned procedures that ensures no duplications and overinvestment. There is a need for the harmonization of donor policies and strategies towards the water problems and more intensified efforts.

3. THE REQUIRED RESPONSE

3.1 Strengthen Regulatory and Environmental Frameworks

Although the Water Law No. 3 for 2002 presents an adequate framework for managing and conserving the water resources, there is a need to draft

regulations, outline the new operating license, and train staff, among other activities. There is a need to review, coordinate, and update national water policies, legislation, and institutions to guide the preparation of water-resources assessments and management plans; and to promote the use of sustainable management practices to meet the growing needs for drinking water and access to sanitary services, especially in rural areas. There is an urgent need to activate the work of the NWC to ensure that the conditions of intersectoral planning and coordination are fulfilled.

3.2 Reassess the Objectives of Water Sector Reform

The pace of institutional and structural reforms in the water sector of Palestine is very slow. In the last few years a number of political, financial and technical factors have contributed to significant changes in the way this reform is proposed, designed and implemented. An important factor influencing the water sector reform in Palestine has a lot to do with a general reluctance on the part of the PA to move towards transactions. Uncertainty about their options and the impact these have both on their own roles and on their constituencies, entrenched interests. The other important factor relates to the donors' and private sector's uncertainty of the viability of such arrangements given the unstable political situations. There is a need for greater analysis to understand how, within this environment, corporate incentives to serve the poor are affected, the public sector's oversight function is enhanced, and ultimately how poor communities are impacted. There is a need to understand the impacts of certain contract types, tariff structures and sector reforms in order to propose the most appropriate implementation models. There is as well need for a multi-stakeholder dialogue on the issue of Private Sector Participation (PSP) in developing countries. Though civil society organizations are demanding more of a say in decision-making, clearly some capacity building needs to occur to allow them to engage productively. Similarly issues around NGOs' own accountability, incentives and drives are increasingly being challenged.

3.3 Strengthen the Management and Technical Capacities

At the national level the particular strengths and weaknesses with respect to technical personnel and equipment must be identified. This will enable the design of programme that captures the training and capacity building needs. Technical assistance can be sought from outside the region. Parallel to that some studies relating to enhancing and strengthening the knowledge on the shared water resources could be undertaken these include (i) an inventory of shared water resources; (ii) inventory of wells and other water

related infrastructure; (iii) inventory of existing monitoring stations; (iv) design and creation of a joint monitoring and assessment systems; (vi) institutional mechanism.

3.4 Improve Knowledge on Transboundary Water

The Palestinians need to improve their level of knowledge concerning the mountain aquifer. The current desk studies of the drainage basins by the Palestinians need to be complemented by hydrological, geophysical and hydrogeological investigations and modelling. Understanding the features of water namely the interaction between groundwater, surface water and the environment, is essential for the choice of planning, management and regulatory decisions at the national and international levels. Such a step is a prerequisite for the establishment of physical and legal frameworks essential to view the entire drainage system.

3.5 Harmonize National Laws Pertaining to Transboundary Water

National water legislation concerning the utilization development management and protection of shared water should be harmonized. Only those general policies and specific provisions that inhibit and obstruct the desired development need to be harmonized. The removal of legal conflicts and the enactment of needed provisions in the respective state codes are essential to water-use optimization and to the promotion of regional development generally. Preparatory studies for such harmonization would be

- (i) the conduction a comparative studies of water laws of some countries.
- (ii) a manual for the drafting of a water code based on the principles and considerations outlined in the recommendations of the comparative study.

3.6 Create Drainage Basin Authorities/Boards

The river/drainage basin is the logical unit for water resources management. In many cases this has led to the decentralisation of management to river basin level. The creation of these bodies does not conflict with the role of the central government; PWA and the NWC in the case of Palestine. A drainage authority must be designed as an operational body, whereby water allocation, water quality management, cost recovery and stakeholder involvement are essential components. However, such authority is not a legislator and not responsible for policymaking and the setting of objectives and constraints to operational management. The PWA and the NWC have an important role in IWRM in policymaking, legislation, strategic planning,

establishment of the appropriate legal and institutional framework, capacity building, and supervision of decentralized and privatized institutions in water resources management. In addition, government should provide the protocols for information exchange (on water resources, water use and infrastructure), should provide adequate databases required for strategic planning and should prepare integrated river basins plans in response to its policy guidelines and constraints.

3.7 Achieve Sustainability

Under normal conditions, four potential sources of funds exist for water supply development programme. These are government budget, international assistance, institutional funding within the country and the communities themselves. Only the international assistance is currently available. The Palestinian authority is far from being self sufficient as it actually depend on international funding to survive. The institutions and communities have the same problem as the current political situation they are totally dependent on foreign funding. There is an urgent need for a source of funds that would be a revolving fund, sustained exclusively by the contributions of beneficiary communities at a level adequate to ensure reapplication of investments for expanding coverage and for operating and maintaining existing facilities. Policies and strategies at the national and by the donor community must ensure this financial sustainability. Inadequate cost recovery procedures have, sometimes, hampered the ability of water supply agencies to become self-financing. The establishment of an adequate tariff structure and of effective mechanisms for assessing and collecting charges is a prerequisite to reverse the trend. Water tariffs should ideally be established on an incremental basis, where the initial quantity of water to be consumed for basic needs is charged at a nominal rate, but the rate increases with the overall quantity consumed.

3.8 Reinforce the Role of International Institutions

Multilateral and bilateral financing institutions, have a great deal to offer to Palestine and Israel in terms of encouragement to choose policies that address the economic, environmental and social in an integrated and holistic manner. The encouragement could be in the form of intellectual sharing, institutional capacity building, and even in financing of appropriate institutions. The support should not, however, be short term, for as the cases demonstrate it takes a long time for the policies to be implemented and the consequences felt. (a) Donors/partners should also make every effort to provide the requested information to governments in a timely, complete and accurate manner. (b) Governments should undertake a review

monitoring and evaluation of their on-going technical assistance programmes and projects for purposes of accountability and cost effectiveness and to determine whether those could be realised within own resources. (c) Governments should strengthen their capacities on the basis of their assessed needs and priorities and take concrete action in terms of training, financial and equipment requirements. (d) A rigorous follow-up technical and financial assistance should be undertaken through an established co-ordinating mechanism.

3.9 Joint Assessment of the Legal Entitlements from the Transboundary Groundwater Resources

There are enough evidence that the current water utilizations is not based on agreement between the Palestinians and Israelis. The current imbalance in must be corrected through the implementation of rules and principles of international law; namely the equitable and reasonable utilization principle. There is a urgent need for a joint assessment of legal entitlement from the Mountain Aquifer. The agreement among the Parties to conduct such a study would indicate good intentions, which contributes to building confidence between them. It is recommended to follow a systematic approach in identifying the factors that affect and are affected by the existing transboundary groundwater recourses and their distribution. The recent research efforts conducted in this field by the International Water Law Research Institute (IWLRI), are very relevant. Within this research the transboundary groundwater in Palestine was one of the three case studies. One of the major outputs of the IWLRI Project was the development of a methodology to help States assess their legal entitlements and obligations with respect to their shared water resources. The methodology is supported by certain tools created for the purpose including: the "Glossary of Terms", the "Relevant Factors Matrix", the "Legal Audit Scheme", geographic, hydrographic hydrologic/hydrogeologic, climatic, population dependence, economic and social factors that must be jointly collected compiled and analyzed in a consistent manner. The impact of the existing and planned uses of one State on the other, the efficiency and available alternatives including the potential for conjunctive use of the available waters are also factors that must as well be jointly studied and analyzed. The success of such evaluation depends mainly on the availability of accurate and reliable information to be shared by the parties. The study addresses the questions of how to operationalise the rule of customary international law "equitable and reasonable utilization" in the case of transboundary groundwater and how to best inform and influence decision-making. This will be done through examining the type of data is needed to incorporate legal, technical and social science existing requirements and needs of the future. What is

the format for data collection and presentation to allow exchange and easy access? How dynamic the process? What are the triggers for the reassessment? Is there a generic model that could be implemented in cases of transboundary groundwater aquifers?

The conclusions from the IWLRI Palestine Case Study revealed that as groundwater is the major resource of supply for the Palestinians and Israelis, the increase in population and the demands of development are putting increasing strain on resources. Of fundamental importance the legal and institutional frameworks within each watercourse States and their impacts on the allocation decisions of the transboundary groundwaters among the legitimate users. Vital Human Needs (VHN) were considered on the top of priorities for the assessment. This was an essential exercise to demonstrate that needs that are vital for human survival within the same environmental context must be the same if discrimination is considered illegal. Additionally, the justification of current and future sectoral water uses and demands have to be assessed based on criteria that are acceptable to all parties. The results of the evaluation demonstrate that major changes in the current practices and allocation have to take place in order to achieve and equitable and reasonable use of the shared groundwater resources.

3.10 Collaboration and Joint Projects

Regardless the details of the permanent political solution on water between Israel and Palestine, there is a need to pave the way for such solution to materialize. This is envisioned to be done through collaboration and joint projects that have mutual benefits to the Parties and to the water resources themselves. Types of collaboration may include technical economic, financial administrative and political fields. There need at this stage to implement projects and undertake programmes that might have an influence on the existing utilizations. Water officials from each Party have to be alerted on plans and the various options that can be made to need the need of any stage of development of their shared groundwater system. Each of these projects must provide a specific contribution to this multidisciplinary initiative aiming to improve understanding of scientific, socio-economic, legal, institutional and environmental issues surrounding the management of transboundary aquifers. These include conducting transboundary groundwater surveys, and the development of monitoring and assessment guidelines. The integral basin area approach must be used as the basic concept for structuring the guidelines on monitoring and assessment. Also essential for the transboundary groundwater assessment is to develop and evaluate strategic policies for groundwater management in a harmonized way.

3.11 Treaty Formulation

The Parties are recommended to recognize and accept their common responsibility in ensuring the reasonable and equitable development and management of groundwaters in the border region for the well being of their peoples. In the treaty formulation process, attention must be paid to the fact that international water resources development is an undertaking involving policy decisions and complex technical assignments the current state require the knowledgeable and persistent support of political forces. The basis for treaty formulation is the Parties' common objective concerning the need to attain optimum utilization and conservation of transboundary groundwaters and to protect the underground environment. Essential to the success of cooperation decisions is the operationalization of the equitable and reasonable utilization principle. This type of understanding requires the Parties to develop and maintain reliable data and information concerning transboundary aquifers and their waters in order to use and protect these waters in a rational and informed manner.

3.12 Development of the Proper Joint Institutions

The foregoing proposal for treaty governing the utilization and development of transboundary groundwaters between Israel and Palestine cannot be realistic and achievable unless there is an authorized joint institution responsible for the implementation. The JWC that was established under the Interim Agreement between Israel and Palestine can assume the role of such institution. However, the mandate, structure and objectives of this institution must be modified. It is recommended not to limit the authorities of such institution to oversight and supervision rather expand it to include enforcement.

4. CONCLUSIONS AND RECOMMENDATIONS

Israel's water problems and the key for their solutions are bound with those of Palestine. This fact implies that future cooperation between the parties over the utilization, development and protection of their shared water resources is inevitable. Increasing population growth continues to set a heavy demand on land and other natural resources and induce conflicting and competing water uses because of changing needs. Environmental degradation is becoming increasingly visible. Basically, the emphasis should focus on the management of land and water as finite resources and on the coordination and integration of water, land-use, and population policies for sustainable development.

The provision and expansion of domestic and municipal water supplies, together with hygiene education is considered to be one of the contributors to the social well being of a community. In Palestine, 50% are without water supply service and proper sanitation. To improve this, efforts in the water supply development in both rural and urban areas should be accelerated and complemented with effluent treatment and disposal services particularly in the urban centres.

Closely linked to the economic difficulties, is a common problem of maintaining water systems in a state matching design criteria and meeting operational and efficiency requirements. This applies to all sectors in particular to drinking water and irrigation infrastructures. Emphasis on rehabilitation of inefficient systems, reduction in wastage and unaccounted for water, recycling and reuse of water, and improved operation and maintenance can be more cost-effective approaches than investing in new services.

This chapter confirms that national and international efforts concerning the operationalization of an IWRM system intertwine. Some preconditions have to be present at the national level for international cooperation to take place. In the case of Palestine and Israel, each party needs to prepare the grounds and create commitment at the national level to develop relevant water policies and strategies. However, as Palestine and Israel are at different levels of development it would neither be possible nor desirable to recommend a single national water development strategy as a comprehensive model.

The integrated approach takes into consideration surface and groundwater, quality and quantity, with appropriate inter-linkages established between social, economic and political factors. IWRM is a dynamic process, which can be implemented at the national level, and when circumstances allow, can be expanded at the international level.

In Palestine, water legislation and institutional frameworks are emerging. There is, however, a need to review the existing policies and regulation in line with the requirements of IWRM at the national and international levels. The Palestinian water sector is not restructured yet. This is for the good of Palestine. There is a need to review the institutional strategies for the efficient and integrated management of all water resources within Palestine. PWA in its capacity as the regulator and administrator of the water resources cannot accomplish the whole range of mandated tasks without the support of local decentralized management institutions at the drainage basin level. This research recommends the establishment of drainage basin authorities or boards which have operational functions to allocate, monitor and manage water resources and public participation at the drainage basin level.

IWRM requires the mobilization of human and financial resources. Adequate human resources, with training, skills and experience in the scientific, technical, managerial and administrative functions is essential for the development, conservation and management of water resources. There is need for training in planning, project identification and preparation, project implementation, project monitoring and evaluation. A cost-effective way to train technicians on a continuous basis may be to set up training schools that can train technicians for the various sub-sectors of water.

Water has an economic value and the cost of providing water services to users must be met by the beneficiary communities. In applying the principle of cost recovery or a degree of financial autonomy in a scheme, two important points need consideration. The first is the guaranteeing of reliability of the supply system for users to accept the principle, and secondly the ability to adjust charges to meet the cost of supply.

The international community has been closely following and supporting activities geared to the use and development of water resources in Palestine and more so to its implication on the nexus issues of population, environment and food security. The establishment of a collaborative mechanism to maintain close linkages by means of strengthening the capacity for the management of water resources through the national coordinating bodies and the corresponding regional and global arrangements and programmes in support of these efforts is central.

20

Water Scarcity and Water Wars in the Middle East?

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INTRODUCTION

Throughout the Middle East, water shortages, asymmetries in political-military power and water control, consumption and demand interplay form a complex hydro political web. The current allocation arrangements of the region's three major river basins – the Nile, the Euphrates–Tigris and the Jordan – are nascent sources of tension, and potential sources of conflict and violence. Turkish relations with both Iraq and Syria are strained over Turkey's South East Anatolia Project. Egypt is concerned about the water development activities of the upstream users of the Nile. Of all the Middle East's river basins, however, it is the Jordan River that hosts the most violent fraught and inflammable dispute.

This chapter focuses on the region's hydrological conflicts recognizing that water is a particularly critical, as well as an emotional point of dispute for all parties to these water disputes. There is, however, no alternative to an honest and forthright discussion of the water issues to expose the current unsustainable and unstable reality. Finding a common understanding of water issues in the Middle East would go far to enhance the possibilities of achieving stability in the region. It is only then that neighbors can negotiate long term regional arrangements. Agreements concluded under duress cannot be expected to last.

The Middle East is one of the most water poor and water stressed regions of the globe. While the region is home to 5% of the people of the world, it has less than 1% of its renewable freshwater. Today's annual per capita availability of freshwater in the region is only one third of its

1960 level (World Bank, 1996), falling from 3,300 cubic meters per person in 1960 to less than 1,250 cubic meters in 1995. This is the lowest per capita water availability in the world. However, some of the Arab Gulf countries and the Palestinians have per capita availability averages that are even below 10% of the regional average of 1250 cubic meters, and even a country that is considered to be relatively water endowed like Lebanon shows an average of 1,200 cubic meters (Gleick, 1993).

The growth of population and industry are responsible for increasing the demand for water everywhere. This is, however, only one aspect of the problem. Actual physical scarcity, even in the Middle East region, is not the only key issue. Conditions of economic scarcity seem to be more pressing: there is enough water to meet the society's needs, but there are few incentives for wise and efficient use of this critical resource. Water shortages can be dealt with in a number of ways—increasing supplies and the water system efficiencies and/or through conservation and demand management. The latter are more recent in nature and less used. They are increasingly becoming more urgent and more dependent on using economic instruments such as efficiency prices and conservation compatible incentive regimes. But for these economic instruments to work there should exist an understanding of how these instruments work and why? A clear set of objectives and strategies that co-ordinate their use and institutions to monitor, guide and implement incentives for their application are necessary. Equally important is to provide a macroeconomic context which is compatible with micro efficiency while also being consistent with standard notions of equity and justice. A number of questions arise and these need to be answered clearly and conclusively.

Is water different from other commodities? Is its value infinite and 'thicker than blood?' Can a price for water be determined much like any other commodity? Can water be traded and shared? Are water wars inevitable? Can reasonable arrangements among riparians be negotiated? What constitutes an equitable distribution of shared resources? These are some of the complex questions that arise about water and arouse passion. There is no area of the world where these passions are stronger or more pressing than in the Middle East, where severe water scarcity is compounded by historical suspicions, asymmetries of power, and the exploitation of strategic advantages by the powerful countries of the region.

A lot has been written about water in the Middle East especially during the last few years. Most of the writings focused on hydro-politics and tended to create a hydrophobic environment towards the subject. Some analysts have even suggested that the region's next war will be fought over water. Others, stressing a more somber tone, tried to establish explicit and implicit links between water scarcity and regional security. Few went beyond that and offered a wide array of solutions to solve the water 'crisis'

ranging from multi-billion dollar peace pipelines from Turkey, Lebanon, or Egypt to Medusa Bags (a Canadian idea) ferrying water from countries with water surplus to those in short supply, to tugging icebergs from northern areas, to mega-desalination projects. Regional parties met, in both official and unofficial capacities, in an attempt to solve or moderate the water crisis in the region. Their plans included joint management proposals, fixed quotas, data exchanges, human resource development, technology transfer, strategies for enhancing water supplies, water conservation programmes, equitable utilization schemes, water banking, cross-border storage projects, water diversion plans and programs for the prevention of environmental degradation.

After many years of meetings, agreements, treaties and endless negotiations, the gap in the positions among regional parties is still as wide as ever. The region's hydrologists, economists and politicians are still talking at different wavelengths. This chapter will focus on two of the three major areas of open water conflicts in the region—the Arab-Israeli water disputes over the groundwater aquifers and the Jordan Water Basin and the conflicts of Syria, and Iraq with Turkey in the Euphrates/Tigris Basin. The aim is to expose bluntly and objectively the water issues and to underline the current unsustainable reality of mismanagement, inequities, and denials of inalienable rights of people to their resources.

Water Crisis in the Middle East: The Issues

The water crisis in the Middle East has a lot to do with some general characteristics of water and their peculiarities in the region and still more with the underlying asymmetries in the power structure of the state system within the region. But the crisis need not lead to conflict and rational solutions abound.

Among the many especially complicated characteristics of water that contribute to the crisis, the following are perhaps the major ones:

- Water is a scarce resource whose availability is far below the compelling demands for it. This scarcity is more pronounced in some specific areas of the region and within even the same state. It is not uncommon to find areas and groups of people with abundant water and others with no or little amounts. The scarcity issue is about *relative scarcity* and not *absolute scarcity*.
- Water scarcity is also about *physical scarcity* that is complicated by *economic scarcity* where actual prices for water are fractions of the true scarcity price (shadow). When prices are below scarcity prices, waste and over use are quickly observed. There are many examples in the Middle East, particularly in Israel where subsidies have engendered

a culture of excessive use, irrational production structures and ultimately waste.

- Water is fugitive, reusable, stochastically supplied resource and whose production can be subject to economies of scale. In this respect water has many of the characteristics of a common property resource and a quasi public good. The secure supply of water in much of the region, where security is defined as the probability of its availability 9 out of 10 years, is less than 5%. It is rarely recycled, and variability in rain fall is significantly higher than what it is in other regions.
- Water is typically a non-traded commodity that is rarely sold in a competitive market. There are few overt water markets where suppliers and demanders exchange water. Recently markets in water rights have emerged in several parts of the world; the most notable examples are in Colorado, California and Argentina. But most of these markets are within national entities and often represent simulated market solutions. There are only few international examples of water trade, but it is not difficult to conceive schemes that would involve this trade. There is now a lot of literature on this subject that can help in designing efficient markets.
- Water values generally differ from the price that could be obtained in a free and competitive market. It is often the case that water has a social value that is above what private users are willing to pay for. The allocation of water often reflects national and social policies and priorities towards agriculture, the environment and national security that go beyond promoting the interests of profitable private farmers. Social and policy considerations apart, the diversion of actual prices from their scarcity values imposes social costs on the domestic economy as well as on neighboring countries.
- Water is not only a desirable commodity, its availability is also critical for life. There are little or no substitutes for it. Furthermore, it is a well entrenched principle that no matter how scarce water is, every person is entitled to a minimum quantity that is considered consistent with human dignity.
- Very few countries have water supplies that they have to themselves alone, that they do not share with others. It is often the case that surface water (rivers) passes through several countries and aquifers are shared. More than 85% of the water available to the respective countries of the region originate outside their borders or is shared in a common aquifer with others. It comes as no surprise that there are no well defined sharing agreements among riparian parties and that history is rife with water conflicts. Water is part of the tragedy of the commons.

- While the total water supply may be limited and, few if any, substitutes exit for it, there exist substantial possibilities for intersectoral and interregional substitutions. As well, there are a number of technologies and conservation packages that rationalize demand and raise the efficiency of its use. Part of the water scarcity crisis in the region is the fact that agriculture uses over 70-80% of the total available domestic supply. It is typically the case that other needs are suppressed, but this leaves a wide room for intersectoral reallocations. Besides, water is transported from one part of the country to another (Israel transports water from the northern part of the country to the desert-like south). This regional reallocation to make the 'desert bloom' is at the heart of the water problems of the region, but it is suggestive of the possibility and capacity to effect interregional allocations, should such changes become necessary or acceptable.
- While the quantity of water is in short supply in the region, concern for preserving its quality is perhaps more pressing. Syria is more worried about the quality of water that will be left for it after the irrigation schemes that Turkey is contemplating in the South-East Anatolia Project than about the total quantity. Pollution and saline intrusion of the aquifers are being increasingly recognized as critical factors in planning for the future.
- The current allocation of the shared water resources in the region are not the outcome of agreements, negotiations or equitable principles. Rather they reflect the asymmetries of power in existence and the abilities of the strong to impose their preferences and needs on the weak. Turkey and Israel, even though one is a downstream riparian and the other is an upstream one, have both managed to monopolize and utilize water shares far beyond those of an equitable, efficient or rational allocation system consistent with basic international law governing transboundary resources would entitle them to.

The areas of conflict are wide and real. The case studies below will outline some of salient features of these disputes and their implications for peace and stability.

Israeli-Palestinian Water Conflict

The headwaters of the River Jordan, located in northern Israel, the occupied Golan Heights and southern Lebanon, feed Lake Tiberius; Syrian and Jordanian waters (most importantly the Yarmouk River), meanwhile, West Bank and Israeli springs feed the Jordan River below Lake Tiberius. As a whole, these elements constitute the Jordan international drainage basin, a naturally-defined area that cannot be artificially sub-sectioned.

As a result of Israel's occupation of the Golan Heights and at one time its control over southern Lebanon (which ended in the year 2000), Israel controlled the headwaters of the Jordan River. Also, in its pre-1967 borders, Israel accounted for only 3% of the Jordan basin area; yet it currently has control of the greater part of this basin's waters. At present, Israel is drawing an annual 70-100 million cubic meters (mcm) from the Yarmouk, and is piping 1.5 mcm per day from Lake Tiberius in its National Water Carrier (Rudge 1992). Consequently, the River Jordan, which, in 1953, had an average flow of 1250 mcm per year at the Allenby Bridge (Main 1953), now records annual flows of just 152-203 mcm (Soffer 1994).

Israel has restricted Palestinian water usage and extracted Palestinian water resources for its use. Presently, more than 85% of the Palestinian water from the West Bank aquifers is taken by Israel, accounting for 25.3% of Israel's total water consumption. Palestinians are also denied their right to utilize water resources from the Jordan and Yarmouk Rivers, to which both Israel and Palestine are riparians. West Bank farmers historically used the waters of the Jordan River to irrigate their fields, but this source has become quite polluted as Israel is diverting saline water flows from around Lake Tiberius into the lower Jordan River. Moreover, Israeli diversions from Lake Tiberius into the National Water Carrier have reduced the flow considerably, leaving Palestinians downstream with only effluent.

In Gaza, the coastal aquifer serves as its main water resource. Other Gazan water sources, such as runoff from the Hebron hills, have been diverted for Israeli purposes. The Gaza Strip, which housed only 50,000 people before 1948, is now one of the most densely populated regions in the world. This is the result of the high levels of forced immigration following the 1948 and 1967 conflicts, and the high rate of natural population increase. Gaza's coastal aquifer is now suffering from severe saltwater intrusion (Table 20.1).

With regard to total water consumption, an Israeli uses 370 cubic meters per year (CM/year), compared to an average Palestinian use of 107-156 CM/year, while a Jewish settler uses 640-1,480 CM/year (Table 20.2).

Israeli restrictions have drastically limited the irrigation of Palestinian land so that today only 5.5% of the West Bank land cultivated by Palestinians is under irrigation, the same proportion as in 1967. By contrast, about 70% of the area cultivated by Jewish settlers is irrigated.

The per capita water consumption among Palestinians, in sectors other than agriculture, is approximately 25 CM/year in the West Bank, and 50 CM/year in the Gaza Strip, while it is 100 CM/year in Israel. This outlines the suppressed demand of Palestinians. The unsuppressed Palestinian demand is estimated at 125 CM/year per capita and therefore consumption would most likely increase if restrictions were lifted (Isaac et al., 1994).

Table 20.1. Water availability and usage in the arab world and neighbouring countries

Country	Annual renewable resources (MCM)	Annual withdrawals		Per capita ARR 1995 CM	Water usage (%)		
		(MCM)	As % of ARR		Domestic	Industry	Agriculture
Algeria	18400	3000	16	655	22	4	74
Egypt	58000	56300	97	1005	7	5	88
Bahrain	N/A	200	N/A	N/A	60	36	4
Iraq	104,000	43,900	42	4,952	3	5	92
Jordan	800	1,000	125	213	20	5	75
Kuwait	N/A	N/A	N/A	N/A	64	32	4
Lebanon	4,800	800	17	1,200	11	4	85
Libya	700	2,800	400	130	15	10	75
Morocco	30,000	11,000	37	1,083	6	3	91
Oman	2,000	1,300	65	1,053	3	3	94
Qatar	200	150	750	N/A	36	26	38
Saudi Arabia	2,200	3,600	164	118	45	8	47
Syria	5,500	3,300	60	385	7	10	83
Tunisia	4,400	3,000	68	489	13	7	80
UAE	300	400	133	167	11	9	80
Yemen	3,000	3,900	130	176	5	2	93
Palestine	200	200	100	105	12	13	75
Iran	118,300	46,500	39	1,826	4	9	87
Israel	2,100	1,900	90	375	16	5	79
MENA avg.	355	183	52	1,250	6	7	87

Source: World Resources 1992-1993; Pacific Institute for Studies in Development, Environment and Security, Stockholm Environment Institute, and World Bank Estimates, 1990-1995.

The prospect of substantial increases in water demand in the coming years renders it absolutely imperative to find a solution to Palestine’s water shortage. Demand projections for Palestine are shown in Table 20.3. The calculations are premised upon population growth projections given above, and upon the lifting of current restrictions on water supplies.

Water shortages in the region are expected to become more acute and critical as a result of over population, economic development and global warming. We cannot, therefore, count on natural trends to moderate the increase in demand. Rational policies are required to supplement any price adjustment to restrict and rationalize consumption.

Table 20.2. Fresh groundwater balance of the Gaza Governate (1995)

Inflow component	MCM/Year	Outflow component	MCM/Year
Average recharge by rain	21	Domestic abstraction	32
Recharge from wadis	0	Irrigation abstraction	40
Groundwater from Israel	7	Industrial abstraction	1
Return flow (domestic)	13	Settlements abstraction	6
Return flow (irrigation)	18	Groundwater outflow	2
Brackish water inflow	20	Evaporation in Mawasy area	0
		Drop in groundwater table	-2
Total	79	Total	79

Source: Ministry of Planning and International Cooperation, 1996

Table 20.3. Projected sectoral demand for Palestine

Year	Domestic	Agricultural	Industrial	Total
1990	78	140	7	225
2000	263	217	18	495
2010	484	305	37	826
2020	787	415	61	1,263

Source: Isaac and Selby, 1996

Use of water in agriculture is perhaps at the heart of the water scarcity problem. It is here that one can make the most significant and meaningful adjustments. As was mentioned earlier more than 70% of the water resources in the region are used in agriculture. A large percentage of the agricultural areas in the region is irrigated, especially in Israel where its portion of irrigated agriculture exceeds other relatively water-rich countries as Lebanon and Syria. Such extravagant dependency on irrigated agriculture is imposing an additional unsupportable demand on the scarce and limited water resources of the region. Proper water management is therefore essential to ensure optimum utilization of this valuable resource. Optimization of water use for irrigation, development of rain-fed farming, cultivating low-water consuming crops, and reducing water subsidies may provide effective instruments for proper use of water in the water-scarce areas of the Middle East.

Promoting rain-fed farming in the region may save thousands of million cubic meters of water, especially in countries where agriculture is minimally contributing to GDP, as is the case in Israel. Despite the immense quantities of water that are used by Israel for agriculture, this sector contributes less than 2.4% to the GNP while in Palestine agriculture contributes 30% to the

GNP. Furthermore, the agricultural sector employs 3.3% of the working force in Israel compared to 25% of the working force in Palestine. These asymmetries suggest that there are opportunities for bargaining and restitution.

Water in the Peace Process

It is now almost fifteen years since the initial peace conference at Madrid was inaugurated. Upon Israel's insistence, the peace process was divided into two tracks namely the bilateral negotiations and the multilateral tracks. The bilateral meetings were intended to lead to peace treaties between Israel on the one hand and each of the regional parties, namely Jordan, Lebanon, Palestine and Syria on the other. The multilateral track was intended to complement and support the bilateral track by promoting regional cooperation. A special working group was established for water resources in the multilateral negotiations.

So far, a peace treaty has been reached between Israel and Jordan in which the water dispute between the two states was resolved based on mutual recognition of the 'rightful allocations' of both parties to the Jordan and Yarmouk Rivers as well as the Araba/Arava ground waters. The agreement allows for the use of Lake Tiberius for storing Jordanian surplus rain flows from the Yarmouk to be redrawn during the summer. It also maintained the right of Israeli farmers to draw water from the Nubian sandstone aquifers from the Jordanian territory in the Araba Valley. Israel and Jordan are now working on constructing two dams in the lower Jordan River Basin. There is no doubt that this bilateral agreement will not be a substitute for an integrated and comprehensive agreement among all riparians to the Jordan River Basin.

On the Israeli-Palestinian track, water was one of the major sticking points in the negotiations leading to the signing of the Interim Agreement (Oslo II) in Washington September 1996. Water is referred to under article 40 of Annex 3 'Protocol concerning Civil Affairs' of the Agreement. The first principle in the article dealing with water and sewage states that "Israel recognizes the Palestinian water rights in the West Bank. These will be negotiated in the permanent status negotiations and settled in the Permanent Status Agreement relating to the various water resources." There is no doubt that this may be considered as an important breakthrough as it is the first time that Israel has recognized the Palestinian water rights. While the Agreement did not go into the details of the Palestinian water rights, the use of the term 'various water resources' in the second sentence is very significant. For the Palestinians, define their water rights as follows:

- a fair share of their riparian rights in the Jordan River Basin
- a fair share of the Western and North eastern aquifer

- full rights in the eastern aquifer
- storage and fishing rights in the Lake Tiberius
- full right to the Gaza Coastal aquifer

While this recognition is a very important step forward, the second and third principles in the Agreement attempt to undermine the significance of this issue. They do so by talking about maintaining existing utilization rates and recognizing the necessity to develop new resources, tacitly accepting that more water is needed to satisfy the needs of both populations. The Agreement stated that all powers currently held by the civil administration and military government relating to water and sewage will be transferred to the Palestinians, except for those specified as issues for the "Final Status Negotiations. Nevertheless, the Israeli authorities have not transferred the authority of the West Bank Water Department to the Palestinian Water Authority until now. Work on drilling new wells, agreed to by Israel to meet the needs of the Palestinian community is still stalled. So far, the Palestinians in the West Bank and Gaza Strip have not seen the translation of this agreement to water in their taps. They continue to experience severe water shortages.

The bilateral negotiations between Israel and Syria on one hand, and Israel and Lebanon on the other hand, have been lagging behind. This led both Lebanon and Syria to boycott the multilateral talks. The liberation of South Lebanon in 2000 has reduced the Israeli control of the entire Jordan Basin. Lebanon has moved quickly to reutilize Lebanese tributaries of the Jordan River such as the Wazani River that flows into the Hasbani River for domestic and agricultural uses. Israel quickly threatened the use of force to thwart Lebanon's plans. The situation escalated very quickly but quieted down as the United States mediated an interim solution where the Lebanese could use their water without reducing the natural flow of the river to the Jordan River. This is at best an interim solution but does not resolve the problem. Lebanon believes that it is entitled to its historical use of all the waters of the Wazani that it considers for all practical purposes a totally Lebanese river.

Syria has teamed with Jordan on a project to utilize more fully the waters of the Yarmouk. They have planned a dam known as the Wahda Dam (Unity Dam) that would allow them to irrigate larger tracts of land in Jordan and Syria. Israel has again threatened the use of force if the dam was built for fear that it would reduce the flow of water into Lake Tiberius.

There is no doubt that the present system of water allocations of the Yarmouk River and those of the Wazani and Hasbani rivers remain flash points for an impending crisis – a crisis that again need not degenerate into conflict. But this calls on the parties to balance the asymmetries and resolve their differences rationally.

Conflicts Over the Euphrates and the Tigris

On July 25, 1992 Turkey inaugurated the Ataturk Dam near Bozova in South-East Anatolia. The dam is part of a large integrated multi-billion dollar irrigation and power generation complex that comprises 22 dams on both the Tigris and Euphrates rivers. By the year 2015, the new dams would help generate about 20% more electricity (more than 27 billion kilowatt-hours) and could irrigate 20,000 square kilometers of land (twice the size of Lebanon) which could theoretically double Turkey's farm output. While the Euphrates and Tigris account for 28% of Turkey's water supply, the two rivers represent over 40% of Syria's and 80% of Iraq's available water.

Turkey's plan to fill the dams will drown 155 villages in Turkey, change the entire environment in the watershed and reduce the shares of Syria and Iraq in a fundamental way. When Turkey decided to divert the Euphrates to fill the Ataturk Dam shutting totally its flow to Syria and Iraq in 1990, despite an informal agreement with Syria to maintain the flow at 500 cubic meters per second at Karkamis, both Syria and Iraq realized the kind of difficulties Turkey could cause them. Despite major political difficulties between Damascus and Baghdad at that time, the two leaderships quickly came together threatening war over protecting their shares. Turkey, discovered that it overestimated the rift between the two neighbors, opened the flow to its normal course. Water conflicts between the parties have never subsided. They are partly related to water, but they have a lot to do with strategic posturing.

After the dissolution of the Soviet Union in 1991, Turkey started looking for an alternative direction to project its power and interests. It has lost its advanced western post on the border of the 'evil empire' and has been practically shut out of Europe. Turkey has abundant water but not much oil which its neighbors in Iraq, Iran and Syria have in different proportions. Water gives Turkey the instrument and pretext to project itself southward, and to offer its abundant water for the scarce oil that is available in abundance in neighboring countries.

The GAP project is also touted as transforming the area into a vibrant economy that can countervail and dilute the threat of the Kurds' Workers Party (PKK) in that region. There are strong reasons to believe that the project is intended to change the demography of the region by dwarfing the Kurds and flooding the region with other ethnic groups. Syria's preoccupation with the perpetual Israeli threat to its southern flank, its military presence in Lebanon (which ended in April 2005) and Iraq's vacuum after the third Gulf War with large contingents of American troops at its borders, have combined to give weakened Syria's a bargaining

position vis-à-vis its neighbors. But these same forces and particularly the latter have created a commonality of interest with Turkey. Both Syria and Turkey have discovered that they have a wide room to project their strategic interests in the region as long as the Americans are bogged down in Iraq. Even water difficulties have taken a backseat to their newly developed shared interests in curtailing Kurdish separatism and control of Iraqi oil in the North.

The precariousness of the political situation in the Euphrates-Tigris Basin is only matched by the variability of the flow of the Euphrates' waters. The velocity of the Euphrates may fall as low as 100 cubic meters per second as it enters Syria at Karkamis in the summer and as high as 7000 cubic meters per second in April when the snow melts, the existence of the dams should theoretically allow Turkey to provide Syria with an even flow of 500 cubic meters per second throughout the year. This it actually did during the three drought years of 1989, 1990 and 1991. Turkey in the early 1990s exerted pressures on Syria through the variability of the water flow of the Euphrates as part of a political strategy to extract concessions from it with regards to the presumed support Syria were extending then to the PKK. Turkey has gone as far as promulgating a military agreement with Israel that extended Turkey's air space to Israeli planes. The American occupation of Iraq and Israeli flirtations with the Kurds has narrowed quickly the differences between Turkey and Syria. For now, water disputes are not likely. But the objective reality of water scarcity and ambitious Turkish plans will not disappear. The crisis is at best postponed and not resolved and it is here that the problem lies.

Equally important and critical is the fact that even when the water flow is kept evenly at 500 cubic meters per second, is it of the same quality that it was in the past. There is considerable evidence that Iraq has already experienced a rise in the salinity of the water it gets from Turkey directly or through Syria, so much so that at Basra much of the irrigated lands are lost due to excessive salinity. The quality of water passing to Syria and Iraq from Turkey is perhaps more important than its quantity. Both Syria and Iraq are adamant about protecting not only their quantitative shares, but also the quality of those shares. This issue will not disappear. It will emerge again. Its impacts and severity will clearly depend on the shape of the future Iraqi entity that would emerge after the Americans leave Iraq, and Turkey's entry into the European Union.

It is now abundantly clear that the Euphrates and Tigris waters are tied to the waters of the Jordan. The links are not physical, but strategic. Equitable shares among the riparians are falling prey to the imperatives of power, strategic alliances, and political agencies.

The Nile Waters

In the late 1970s President Sadat of Egypt suggested that he would be willing to provide Israel with water from the Nile. This prompted hostile reactions from the Egyptians, Ethiopians, and Israelis. With the population explosion Egypt has been witnessing, local planners asserted that the Nile's waters would hardly be sufficient for the country's future needs. Israeli officials stated that the taps to such a vital resource should not be under the control of their former enemy and untried friend. Ethiopia reacted by declaring its intention to build a number of dams on the Blue Nile (the Nile's largest tributary, which springs from there), to which Sadat threatened military intervention. In 1997 relations between the two countries were tested once more when it was rumored that Ethiopia, with Israel's help, was planning to build dams on the Blue Nile. Sudan's chronic droughts have spurred concern over the Egyptian plans and have prompted the Sudanese to exert pressure on Egypt to renegotiate their water sharing plans. New plans are emerging to redirect the flow of Lake Victoria's water away from the Nile. Egypt is very worried about these plans by Uganda and Kenya that can affect the availability of water to its growing population and economy. It has not taken any overt action, but it has quickly confirmed its preparedness to go to war to protect its water needs. Water again is treated as a strategic resource over which strategic posturing is evident and can be dangerous. The Nile emerges as another crisis flash point in the Middle East. Conflict can easily become violent. Alternatives to conflict need to be contemplated quickly. Time is running out.

The Way Ahead

Are conflict and violence the only options to deal with impending shortages and increased water scarcity in the region? Peace offers a special opportunity for all nations in the Middle East to abandon the existing states of belligerency, confrontation, non-cooperation and polarization. It is possible to arrive at a comprehensive, just and lasting peace in the whole region where all the peoples of the area can join their efforts to develop the area and promote progress and prosperity in the region. Water will be a major issue that can catalyze the peace process or inhibit it. Unfortunately, the recent political changes in Israel and Iraq have brought into power regimes that are obsessed with power and military solutions to difficult political and ethnic conflicts. Water security can easily be transformed into plans to retain and control the neighbors' water.

While in principle, the resolution of the Middle East water allocations and disputes will be based on the principles of international law, there is no mechanism for this issue to be institutionalized. If the issue of water allocation continues to be addressed with an eye for might rather than

justice, Arabs will remain the thirsty partner to an unjust peace. And, as is so often pointed out, an unjust peace is no peace at all. Words, however, are not sufficient: declarations alone, no matter how detailed, cannot solve the problems of Gaza Palestinians who have no access to clean water. No Gaza Palestinian will be impressed by the recognition of intangible rights, by the consideration of proposals or by the establishment of a regional water data bank. Concrete action is needed.

First, Israel needs to ascertain unequivocally the property rights of the Palestinians, Lebanese, Syrians and Jordanians over their waters. It should instigate some confidence-building measures to show that it is committed to resolving the allocation problem. Israel should immediately provide Gaza with 50 MCM through the National Water Carrier. Such a move is urgently needed, and would serve as a practical recognition of Palestine's riparian rights. Gaza Palestinians should not be charged the full cost of this allocation, as is the case within the terms of the Oslo Agreement; instead they should be offered this amount of water free of charge in partial recognition of Palestinian water rights. Additionally, Israel should immediately make more water available for domestic consumption in the West Bank. The 35 CM per capita annually consumed for domestic purposes in Palestinian towns is simply insufficient, with shortages being critical during the summer. Seventy CM per capita/annum should be made available to those Palestinians who are connected to piped water supplies and Israel should facilitate the work of the Palestinian Water Authority in providing water networks to the 25% of the Palestinian villages in the West Bank who have no piped supplies.

Such confidence-building measures would clearly demonstrate that Israel desires a just and equitable solution to the riparian dispute. It is not fanciful to envisage a resolution, rather than a settlement, to the region's riparian dispute. On the contrary, the only way that peace can be meaningful is if agreements are sustainable. And the potential does exist for cooperative solutions to the water crisis. A third party should perhaps be invited, but a thoroughly independent body at that, not simply a subscriber to one party's agenda. The 'honest broker' would fulfill the following functions. First, it would be responsible for verifying data, for establishing the facts which would form the basis of negotiation, and for clarifying misleading assertions. Secondly, it would act as a clearing house, as an incubator for positions. And thirdly, it would be in close contact with international financial institutions, and would attempt to guide the dispute by holding the right to sanctions against one or other of the parties.

Perhaps the most relevant mechanism here for a sustainable solution is the institution of demand management and 'correct' prices for water resources. Surely, the property right question is crucial for any equitable and sustainable solution, but it is not sufficient. Water prices are too low

and do not reflect the marginal cost of their extraction and delivery. This has engendered a 'culture of waste' and excessive use of water. It is ironic that the region, particularly Israel produces and exports agricultural products and exports them to water-rich countries in Europe. A correct price regime would certainly help in constraining the irrational and inefficient use of this scarce resource. Water management regimes that capitalize on political stability and good will among neighbors could provide credible incentives to conserve and share cementing peace and stability.

Turkey should commit itself to the riparian rights of the Syrians and Iraqis and to a specific and agreed upon quantity and quality water passing at Karkamis. The Ataturk Dam cannot operate at the expense of the Syrians and Iraqis water needs. On this front, the interest of peace requires an immediate delinking of the two basins (Jordan, and Euphrates/Tigris). The existing Tripartite Commission should be convened immediately to settle any water disputes and to define these equitable shares quantitatively and qualitatively for all of the respective parties. The sooner water is lifted from the strategic posturing of the parties, the sooner and the more likely that a peaceful resolution to the water crisis will emerge.

Egypt should work a tripartite agreement with Sudan and Ethiopia on an equitable distribution of water rights and the three parties have to work together to thwart plans for diversion of Nile waters and tributaries in the opposite direction towards Lake Victoria.

Until this happens, there are several small steps that can be initiated at the national, regional and international levels to facilitate the work of the political leaders of the region including:

1. Make all available water data in the region accessible through improved communication networks and web sites (e.g. an On-Line Water Information Network);
2. Encourage open forums (workshops, conferences, meetings) to discuss all aspects of the Middle East water issues at national, regional and international levels;
3. Promote the capacity building of the regional parties in the area of integrated water management;
4. Develop simulation models that could assist decision makers in the region in policy formulation, planning and negotiations;
5. Promote the participation of water planners, distributors and users in decision making;
6. Invite the private sector to assume a leading role in the water services;
7. Promote R&D in the region aimed at transferring new water technologies;

8. Train a number of economists in the region in the fields of water and environmental economics;
9. Restructure the water policies at the national level;
10. Introduce conflict resolution mechanisms and options at different levels within the region; and
11. Share with the regional parties the international experience in water dispute resolution and joint management of international river basins and groundwater aquifers.

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Section 3

Best Practices Management

21

Community-based Watersheds: A Novel Approach to Sustainable Freshwater Management

Case Study of the Rajiv Gandhi Mission for Watershed Management, Madhya Pradesh, India

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Water is essential for human survival. We use it extensively for drinking and farming. In developing countries like India, where 70% of the people are dependent on agriculture, water plays a crucial role in the livelihood of people. It has been widely acknowledged that water is a critical element of poverty in its many dimensions (Biltonen and Dalton, 2003). But, in the last couple of decades the increasing population has skyrocketed the exploitation of water. An example of the overexploitation of groundwater can be cited from the case of Rajasthan where out of 237 Panchayat Samitis 82 have been declared as dark zone, 34 as gray zone and only 121 as white zone, indicating further exploitation of groundwater would be dangerous (Singh, 2003). Groundwater exploitation has been a common phenomenon across all the states of India. The last few decades have also faced erratic rainfall pattern leading surface water availability to the most critical situation.

People from rainfed areas have been the worst victims of water resource. The situation in these areas has been compounded by the continuous occurrence of drought and the erratic nature of rainfall that resulted in highly fluctuating productivity of dryland regions (Mukhopadhyaya, 2003). The efforts of the government on increasing production in the 60's and 70's, known as "Green Revolution", brought good results. But the benefits of 'green revolution' were limited to the resource-rich farmers and to the irrigated areas. The inequitable distribution of benefits has resulted in widening the gap between the rich and poor. This widening of gap has created social unrest culminating in naxalism in many places of India (Maheswari, 1985; Chambers et al. 1989; Beteille, 1974).

To counter water scarcity that has an wholesome effect on the society, many approaches have been followed. Amongst all approaches, integrated watershed management has emerged as an effective strategy of addressing the problem of natural resource degradation (Singh, 1994) that includes land, water and forests. In fact, the watershed approach has become the sole approach for all the rural development programmes funded by the government having a component of natural resource management.

This chapter tries to catch the evolution of the watershed concept over a period of time and in light of the case of Rajiv Gandhi Mission for Watershed Management analyses the approach followed at present. The chapter discusses how the Indian Government, in the early 50's and 60's, addressed the issue of water scarcity and how over a period of time the watershed concept was embraced. It then gives details of the Rajiv Gandhi Mission for Watershed Management and finally, enlists the main achievements of the programme. Throughout the chapter short caselets or stories are dispersed of watershed driven local successes that dot the landscape of Madhya Pradesh.

EVOLUTION OF THE WATERSHED CONCEPT

The problem of water scarcity is not a result of any single or generic factor. A complex array of issues like unsustainable methods of resource use, mismanagement of common pool resources (CPR), exploitation without replenishment, poor policy framework has brought about this situation. Verghese (1990) attributes the degradation of environmental resources to faulty landuse planning, while several authors say that natural resource degradation is a result of improper policy measures (Gadgil and Guha, 1992; Chambers et al. 1989).

Soon after independence, the Indian policymakers realized the importance of water resource development. But initially the approach was focussed on creation of large river valley projects. In 1947, India had about 293 large dams, now the number has increased to more than 4000 (Goswami

2003). Water resource development was addressed in an isolated manner without considering the complex integrated nature of the natural resource systems. This approach helped in ushering an era of green revolution, but at the same time led to imbalanced growth. It also augmented large-scale deforestation resulting in heavy soil erosion in upstreams, accelerated the sedimentation of reservoirs and drastically shortening its life (Doolette and Magrath 1990). It also encouraged the practice of agriculture intensification, monocropping and withered away the traditional farming system which was based on integrated land use and sustainable methods of farming (Jules 2000). The complementarity between uncultivated and cultivated land was not understood, especially in the case of upland agriculture (Rao 1999).

The understanding of the issue at the policy level was no less responsible for depletion of this valuable resource. The problem of degeneration of village lands was seen as arising from people's demands for fuelwood and fodder, resulting in overexploitation. However, the loss of soil from such land was due to a lack of control of rainwater runoff. Without controlling runoff, it was not possible to stabilize water regimes even for croplands, and thus it was a mistake in rainfed areas to look at the degradation of commonlands in isolation from the other issues of low cropland productivity (Rao, 1999). Another policy discrepancy was in the method of implementation of the programmes, which were mainly done by the line departments of state government. People's participation was negligible and the programme interventions did not create any sense of belongingness in the community, tempting them to exploit the commons (particularly) for their individual benefits.

There were a good number of programmes that focussed on the resource poor farmers in rainfed areas, like the Drought Prone Area Programme (DPAP), Small Farmers Development Agency (SFDA), National Rural Employment Programme (NREP), Rural Landless Employment Guarantee Programme (RLEGP) etc. All these programmes had some basic flaws, some described above, summarized as follows:

1. Development plans were made in a compartmentalized way. The systemic linkages were not considered.
2. People's participation was not ensured.
3. The positive features of traditional system was not incorporated in the programmes.
4. Another important reason was that the programmes were planned without considering the natural geographical boundaries. This made any intervention incomplete.

Realizing this trend of resource degradation, in the 1980s, the concept of 'watershed based development' was accepted. Watersheds being a natural

geographical unit became the ideal model in scientific terms. The USDA has been traditionally applying the concept for its soil conservation and landuse planning efforts. But here in India, the watershed programme included all the features of an integrated programme.

Operationally, the watershed approach was first adopted in 1974 when the Government of India (GOI) enforced its implementation under the Centrally Sponsored ‘Scheme of Soil Conservation in the Catchments of River Valley Projects’ (Bali, 1988). Some special projects for watershed development were commissioned during the 1970s and early 1980s (Turton, 2000). During the Sixth Five-Year Plan, the Department of Agriculture and Cooperation (DoAC) launched a

Watershed Management in India: A Timeline	
1970-85	: Special Projects with the help of ICAR Agencies
1980-85	: 19 watersheds in 15 states by DoAC, 23 watersheds by MoRD in drought-prone areas during Sixth Plan
1983-84	: Two World Bank aided projects
1986-87	: NWDPRa programme launched in 99 dist. of 16 states
1990	: Restructured NWDPRa, launched in 25 states and 2 UTs during Eighth plan
Early 90's	: NGO Projects
1994	: Hanumantha Rao Committee's Recommendations made
1995	: Integrated Watershed Projects with People's Participation, New Guidelines, NGO participation
2001	: Revised Guidelines issued

pilot project for propagation of water conservation/harvesting in rainfed areas in 19 watersheds located in 15 states. The main objectives were water harvesting and water conservation. Besides, the Ministry of Rural Development selected 23 watersheds in drought-prone areas for soil and water conservation. In 1983-84, two World Bank aided projects were started in Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra and the Garhwal region of Uttar Pradesh. These projects showed the potentials of vegetative conservation measures to support bio-mass production (Hashim, 1999).

The first major programme ‘National Watershed Development Project for Rainfed Areas’ (NWDPRa) was launched in 99 districts of 16 states in the country in July 1986. The principal objective of the project was to optimally utilize the available rainwater and minimize the risk of crop failure. Districts were selected on the criteria that annual rainfall should be more than 750 mm and irrigated area should be less than 30% of cultivated area. It was financed by Government of India. Funds under this programme were provided for treatment of arable land only. For non-arable land of the identified watersheds, funds were to come from other State and Central schemes such as RLEGP, NREP, DPAP and DDP (Singh 1994, Hashim 1999, Lok Sabha debates, 1992).

The NWDPRRA was restructured and launched in 1990 in 25 states and two UTs covering all districts having less than 30% of its cultivated area in irrigated condition. It was aimed at achieving the twin objective of sustainable production of biomass and restoration of ecological balance in the vast tracts of rainfed areas. It focussed on conservation, upgradation and utilization of natural endowments like land, water, plant, animal and human resources in a harmonious and integrated manner and generation of massive employment during the project period and regular employment after the project completion. All three spatial components of watershed namely, arable land, non-arable land and drainage lines were treated as part of this programme (Lok Sabha debates, 1992). In the Eighth Plan period the programme covered 42.97 million ha area against a target of 2.8 million ha (Hashim, 1999). But, being implemented by the line agencies, the programme focussed mainly on the delivery and technical inputs through government machinery on agriculture lands, and people's participation was less emphasized. The benefits were not sustainable in the long term (Rao, 1999). There was an absence of a robust institutional set up, resulting in poor coordination between line agencies. The programme was also strangled by the rigid norms and its inherent technical bias, which could not include local need-specific and area-specific interventions.

In the 1980s and early 1990s, we had the rich experience of leading Non Government Organisations (NGOs) and community initiatives that exemplified how the watershed approach can tackle problems. The experience of MYRADA, a Karnataka-based organization can be cited in this regard. There were also the experience of Ralegan Sidhi of Maharashtra and Sukhomajari of Haryana which are examples of community level initiatives; how a member of the community took the leadership and set an example of grand success. There were several NGOs which also had experience that shaped up the future strategy; among them was the Aga Khan Rural Support Programme (India) based at Ahmedabad.

In 1994-95, a High Level Committeeⁱ was set up to review the Drought Prone Area Programme (DPAP) and the Desert Development Programme (DDP) and suggest measures for improving these programmes. The Committee observed that the programmes in the past two decades had made very little impact. The Committee recommended a holistic approach to develop these areas through a process of micro watershed planning by preparing integrated land development plans. The plans would take into consideration the land capability, site condition and local needs of the people. The watershed development plans, it was suggested, should be prepared with the involvement of the people of the area and the plans should include programmes for soil and moisture conservation, water harvesting structures, afforestation/horticulture/pasture development and

ⁱ Hanumanth Rao Committee

upgradation of common property resources. A multi-disciplinary team of experts was to give technical assistance to Programme Implementing Agencies (PIAs) which could be a Line Department, an NGO, Panchayat or a User Group. A well-designed training programme would create awareness among functionaries. The Ministry of Rural Development issued guidelines to put the Committee's recommendations into operation. (Planning Commission, 1997). The guidelines were effective on all the major programmes of Ministry of Rural Development of Government of India from 1st April 1995 to undertake integrated land development based on micro-watershed plans.

The change was revolutionary in the field of management of water conservation programmes in the rainfed areas. It not only brought homogeneity across the nation for approaching rural development, but also accommodated the flexibility of developing need-specific plans. The components like people's participation, microplanning, capacity building and self help groups helped to build the institutional base. The assistance of Geographic Information System (GIS) was also taken that helped in mapping the whole area. Involvement of NGOs and village institutions, added to the dynamism and broadened the overall mindset in the strategy. Moreover, the programme maintained its dynamism by making required changes from time to time on the basis of feedback from field. The revised guidelines issued in 2001, has been a milestone in this regard, further in 2002 the Hariyali guidelines went for implementation through PRIsⁱⁱ. For NWDPR programme also a revised guideline was issued in 2001 that has made it more open. Though, many of the decisions have been criticized from time to time the beauty of the programme lies in its changing nature. It has not only inculcated the remedies for shortcomings observed earlier, but has tried to make the programme more effective by institutional reforms and innovative approaches.

IN MADHYA PRADESH

The State of Madhya Pradesh (MP), in spite of being endowed with abundant natural resources, remains a state of developmental paradoxes. The state is the source of all major river systems of Central India, and receives an annual rainfall of 1150 mm. Only 30% agricultural land of Madhya Pradesh has assured irrigation facilities, while a majority of the remaining cropped area being rainfed and drought prone. In fact, all 313 developmental blocks in the state are categorized as either drought prone or requiring seasonal employment.

ⁱⁱ Panchayati Raj Institutions – refers to the elected local governments

Watershed development in MP dates back to 1950s. MP was one of the states chosen immediately after Independence for centrally sponsored programmes for the River Valley Project (RVP) and ravine reclamation. Later, programmes such as the Drought Prone Area Programme (DPAP), Integrated Wasteland Development Programme (IWDP) and National Watershed Development Project for Rain-fed Areas (NWDPR) were also initiated in the state (Source: MPHDR). Till the 1990s, these programmes were taken up as departmental works with limited community participation. Given the focus on water and land treatment and degraded ravine lands, programme activities were typically concentrated at constructing structures to arrest soil and water erosion, water harvesting and reducing biotic pressure to enhance land productivity. People's stake and their inclusion in planning and management of watershed development activities were not on the agenda.

It was during this period that GOI programmes like DPAP, IWDP and Employment Assurance Scheme (EAS) were combined under one umbrella in MP and implemented in mission mode through the Rajiv Gandhi Mission for Watershed Management (RGMWSM). RGMWSM was started in August 1994. The mission represented an attempt to address the agenda of basic needs centring around rural livelihood through people-oriented approaches. The unprecedented devolution of powers to panchayats was intended to complement the mission's agenda. The mission mode of operation was selected for it entailed clarity of strategies and objectives, action within a definite time-frame, fast-track procedures, committed teams, inter-sectoral effort, collective action, close monitoring and transparent evaluation.

RGMWSM-ORIGIN, OBJECTIVES AND STRATEGY

In the late 1980s and early 1990s, the success of NGO-led projects based on watershed approach in the states of Maharashtra, Haryana and Karnataka that led to the development of rainfed areas did not go unnoticed in MP. The State Government of Madhya Pradesh was convinced that it is possible to raise living standards in rainfed agriculture areas by conservation and optimal use of soil and water resources, with a view to regenerate natural vegetation and increase agricultural productivity. Community-based planning and labor intensive implementation of such initiatives was expected to increase local involvement and enhance household incomes, thus imparting sustainability to the entire programme. Thus was born the Rajiv Gandhi Mission for Watershed Management (RGMWSM).

The programme aims at reducing the vulnerability of people to droughts, improving their incomes and providing them with short-term employment opportunities, especially in the agricultural lean season. A unique feature

of the watershed programme in MP is its mission mode that helps in accomplishment of tasks within a definite time frame and as per the pre-defined objectives. The specific *objectives* of the mission are:

- Augmentation, conservation and optimum utilization of soil and water resources in rainfed areas;
- Reducing vulnerability of people to droughts and fluctuations in agricultural production;
- Restoration of ecological balance and improvement in the environmental resource base;
- Developing an accessible repository of scientific and technological inputs for detailed and area specific planning to the field level implementing agencies;
- Maximize people's participation in planning, implementation and maintenance of soil and water conservation activities in the watershed area, to make the entire scheme more effective and transparent;
- Equitable distribution of resources and sharing of benefits so as to improve the lot of the disadvantaged communities.

The mission mode of programme functioning means that the watershed program is not to be implemented through any particular line department of the government or by any particular agency but through village level institutions known as Watershed Associations. They are guided and facilitated in their efforts by several local agencies including line departments, NGOs and Panchayati Raj Institutions. At the district level, Zila Panchayats have been entrusted the responsibility of programme execution. The Department of Rural Development (DoRD), GoMP is the nodal Department for RGMWSM implementation. The organizational structure of the RGMWSM is shown in the Annexure to this chapter.

At the heart of the mission's strategy lies the understanding that the watershed programme is not just for soil and water conservation. The mission has been constituted for an overall improvement in the availability and access to natural resources of the poor and weaker sections of the society living in the rainfed and drought-prone areas of the state. Thus, the most important element of the RGMWSM is that it is people centered – people are the hub of all developmental activities. This is more simply said than done, with the diversity of rural community in MP stratified (and often divided) along the lines of several socio-economic and cultural parameters, like caste, ethnicity, religion, sex, class, asset-based, occupation, literacy and so on. The daunting task set by the mission for itself is to bring these diverse groups together, encourage them to voice their needs and aspirations and convert this community demand into organized action. This *participatory strategy* has been built into the RGMWSM programme through the following components:

- Multidisciplinary co-ordinating structures established at the block and district levels for facilitating community organization, capacity building, and streamlining community action processes;
- Participatory and need-based planning, implementation, management, maintenance and monitoring of the physical structures developed under the project;
- Harnessing the available scientific and technical resources (individuals, institutions and technology) for supporting participatory decision-making processes;
- Dovetailing efforts of various other related developmental programmes and schemes with the mission's activities to synergize efforts and prevent duplication;
- Integrating area development programmes, beneficiary-oriented initiatives and institutional lending, so as to optimize sustainable utilization of the resource based at the grassroots;
- Giving preference to low cost, locally available and appropriate technology and recognizing local skills for meeting the technical and soft skill requirements of the program;
- Adopting a *cascade* approach while designing physical structures for soil and water conservation whereby isolated water harvesting structures would knit together into a larger soil conservation and water impounding structure for cumulatively increasing the scale of impact and ensuring equitable benefit sharing;

Since the mission envisages integrated natural resource development, it is considered as an umbrella for receiving funds for programme implementation from a number of existing and related schemes and development programmes of the government. The sources of funds include the DPAP, EAS, and IWDP.

PROGRAMME IMPLEMENTATION MECHANISM UNDER RGMWSM

The entire programme under RGMWSM is implemented in eight chronologically overlapping and inter-dependent stages, namely:

- I. Establishment of co-ordination structures and selection of watersheds
- II. Establishing rapport with the community and baseline assessment of resources found in the selected watershed
- III. Problem identification and selection of watershed management activities
- IV. Community organization into various affinity/interest groups
- V. Enhancing community capacities

- VI. Community action
- VII. Programme evaluation
- VIII. Follow-up and maintenance

The chief features and activities undertaken in each of the above stages are briefly described in this section.

I. Establishment of Coordination Structures and Selection of Watersheds

A multi-tier organizational and coordination structure is established to meet the objectives of the mission, and fulfil the aspirations of the communities in the selected watershed. The structure is depicted in *Box 1* and the roles that each tier/responsibility center performs has been presented in Table 21.1. The Government of India has laid down the criteria for selection of watersheds to be taken up for treatment. The District Watershed Management Advisory Committee deploys those criteria for watershed selection.

II. Establishing Rapport with the Community and Baseline Assessment of Resources Found in the Selected Watershed

In this phase, the PIA establishes rapport with the community and thus, begins a long-term relationship built upon trust and principles of co-operative functioning. The PIA also collects the baseline information on the community (constitution, needs, aspirations, skills, etc.) and the resource (components/types, extent, status and potential) as required for formulation of site-specific watershed development plans in this phase.

III. Problem Identification and Selection of Watershed Management Activities

Once the PIA has developed an in-depth understanding of the resource at hand, and established rapport with the community, attention is paid to participatory identification of problems and issues related to soil, water, and overall natural resource degradation. Relevant studies, appraisals and surveys are conducted and the linkages between resource degradation and poverty in the area are dissected and a list prioritizing problems and community needs is generated in a participatory manner. Based on this list, location specific, watershed management activities are selected in the zones of recharge, transition and discharge of the watershed. Available avenues (utilized or otherwise) for generating income and supporting livelihoods of the local community are also identified in this phase. An important feature of this phase is the stress on incorporating learning from indigenous technical knowledge and application of locally available skills

Table 21.1. The roles of various coordinating structures of the mission in MP

Level	Nodal organization/ individual	Chief responsibilities
State	Mission housed in the DoRD, GoMP	<ul style="list-style-type: none"> • Chief information node • Facilitation of other structures • Assists in capacity building of the community in the long-term • Monitors programme implementation by the Zila Parishads
District	District Collector Zila Panchayat District Watershed Management Advisory Committee (DWMAC) with NGO and people’s representatives as members Technical Advisory Committee (TAC) Minister-in-charge of District	<p>Mission Leader</p> <ul style="list-style-type: none"> • Key agency for programme implementation • Monitoring of the programme • Programme coordination in the district • Selection of watersheds for treatment • Sanctioning watershed management action plans • Monitors programme implementation <p>Techno-scientific support and guidance for programme implementation</p> <p>Functions as chairman of DWMAC</p>
Block	Project Implementation Agency (PIA) for each milli-watershed PIA consist of: <ul style="list-style-type: none"> • Project Officer • Watershed Development Team (WDT – a multi-disciplinary team, with specialists from various fields and government departments) 	<ul style="list-style-type: none"> • Facilitating planning, implementation, monitoring and review of the watershed programme • Conducting baseline surveys to generate information for planning • Carry out need-based research for selection of low cost and appropriate technology and for community organization • Selection of useful, technically feasible and financially viable watershed management activities • Community capacity building • System support for organized functioning of and record keeping by community groups
Village	Village Watershed Committee headed by a chairman, with a secretary and representatives of: <ul style="list-style-type: none"> • Self-help groups; • User groups; • Credit and thrift groups of women; as members 	<ul style="list-style-type: none"> • Actual implementation of watershed development plans on field • Assistance to agencies functioning at various levels in collecting information and provide inputs for developing need-based plans • Contribute to monitoring and review of programme • Ensure equitable sharing of programme benefits • Conflict resolution at village-level

and resources, to increase ownership of the proposed interventions among the community in the area.

IV. Community Organization into Various Affinity/Interest Groups

As is evident from the name, this phase involves organizing the community into various interest -and/or affinity groups that would be ready to take over the baton of the programme and feel ownership about its constituent initiatives and resulting products. Besides organizing people for future action, the village level groups also function as platforms for conflict resolution and as vehicles for resource support. Formulating and establishing the modalities of group functioning, responsibility allocation among the members and equitable sharing of benefits are the other important tasks that these organizations are called on to perform in a phased manner as the group matures. Various groups that are formed during this stage, their constitution and responsibilities are indicated in Table 21.2.

Conflict resolution is crucial to group formation and functioning. As the different interest/affinity groups start interacting and working together differences and biases emerge. Any latent conflict among different groups emerges as also an understanding that the resources available for planning and implementation are limited. After considerable empathy has been built among the conflicting groups, prioritization of interventions is done to ensure equitable sharing of benefits and responsibilities for maintenance of the assets are fixed.

V. Enhancing Community Capacities

Once the priority activities are decided and the roles and responsibilities of various actors (individuals and institutions) fixed, capacity assessment of various stakeholders is undertaken. This helps the PIA to determine capacity gaps and accordingly design capacity enhancement packages for the community members/groups. Training programme, exposure visits, demonstration area development and workshops are planned and delivered to enable the community to perform the following roles efficiently:

- Community organization and group functioning;
- Articulation of needs, demands and their prioritization for development of action plans;
- Participatory planning and implementation of watershed management activities;
- Develop and establish a mechanism for equitable benefit sharing; and
- Maintenance of assets created during the programme.

Table 21.2. Composition and responsibilities of village level groups formed under RGMWSM

S.No.	Type of groups	Composition	Responsibilities
1	User Groups (for each type of activity, like soil conservation, water conservation, horticulture development, etc.)	Landowners who would directly benefit from watershed management activities	<ul style="list-style-type: none"> • Responsible for implementation of watershed management activities on field; • Assist the PIA in need identification and planning of activities; • Play an active role in management and monitoring of resulting physical structures; and • Responsible for conflict resolution and equitable sharing of benefits.
2	Self-Help Groups	Community members (may/may not be land-owners) who may indirectly benefit from watershed management activities through income generating activities	<ul style="list-style-type: none"> • Organize to carry out income generation activities in a collective manner; and • With PIA's assistance, work on the backward and forward linkages to make the income generating activities sustainable.
3	Women's Groups	Self-help groups of womenfolk in the village	<ul style="list-style-type: none"> • Thrift and credit activities; • Take up nursery raising and other plantation related work as per the Watershed Plan; and • Engage in income generation activities (individual as well as group based).
4	Watershed Committee	Composed of representatives from all user groups, self-help groups, Panchayat members, women and PIA representatives	<ul style="list-style-type: none"> • Acts as an executive committee to look after the day-to-day affairs of the watershed at the village level; • Facilitates participation of community members in watershed management activities and ensures contribution of community members in cash/kind; • Responsible for implementation of plans; • Responsible for financial and physical progress reporting to the Zila Panchayat; • Management of project funds; • Acts as a vehicle for watershed management planning, execution, maintenance of records and accounts, fund distribution for program implementation; and • Oversees structure maintenance in the post-project phase, utilizing development funds.

MANDSAUR

People's movement to conserve water

In June 1999, at a *Jal Sammelan* held at Mandsaur, where an appeal was made to all Panchayat and other public representatives to take up water conservation works on a priority basis. The district Mandsaur, though richly endowed in terms of rainfall and fertile agricultural land is currently in the throes of a grave water crisis, having resulted from overexploitation of groundwater resources.

The people got together to contribute nearly Rs.10 million in cash and as Shramdaan out of a total expenditure of Rs. 40 million to undertake rejuvenation of tanks and other structures.

In the month of May and June 2001, rejuvenation of 3 large tanks, construction of 28 new tanks, desilting and deepening of 19 tanks, recharging of 800 tubewells and dugwells, 1400 ha. area enclosed by *nala bandhan*, and construction of 450 farm ponds was taken up under this massive water conservation effort.

VI. Community Action

This is the phase in which community's skills, capacities and physical energy are utilized for development and implementation of site-specific and need-based watershed management plans and simultaneous efficient management is attempted through Log Frame Analysis (LFA). The outcome planning based on LFA technique helps in implementation of watershed activities within a definite time frame to bring about desired impact. The PIA works closely with various community groups to develop the programme phases and component activities. Wherever possible, local indigenous knowledge and existing community capacities are put to use, for optimal resource utilization for sustained benefits from the watershed management activities. Each group prepares its own plan complete with the technical design and cost estimates for taking up the proposed activity. All these plans are consolidated to prepare a 5-year action plan for the entire micro-watershed that is based on the *ridge to valley* approach of watershed management. This plan, once approved by the watershed committee, is submitted to the Zila Panchayat for sanction and release of funds. Funds are directly released to the project account of the watershed committee. The funds in these accounts are used for day-to-day programme implementation activities. The watershed committee has another account – the development fund account—which is like a fixed deposit/interest based account where funds for post-project asset management and maintenance are parked.

SON-CHIRAIYA: A UNIQUE CONVERGENCE SCHEME IN CHATTARPUR

Son-Chiraiya is a scheme designed keeping in mind the natural proclivity of tribals for rearing coloured birds. The scheme provides additional income to them through poultry activity.

Mother units were established at Bhaikunthpur, Sonhat and Khadgavan villages under the watershed mission. Groups of five women were formed and were responsible for running these units. Special care was taken to use only the locally available material

and resources. In the first phase around 9000 chicks were distributed to these women SHGs. They looked after the chicks for 15 days and then they were distributed onwards to other beneficiaries in the watershed areas.

The villagers displayed great enthusiasm as a result of which the survival rate was as high as 95%. The profit after keeping the chicks for 15 days works out to Rs.5.60 per chick. If 20.5-day-old chicks are distributed to beneficiaries at a cost of Rs.12.50 each then assuming a mortality of 10%, the beneficiary would still have earned Rs.55 at the end of 90 days.

This scheme has generated a large demand for chicks and is being implemented in a large way in Chhatarpur.

Not all implementation takes place using government funds. There is a provision for the community to contribute labor (in kind) or cash during program implementation. The funds so collected are deposited in the Development Fund Account of the Watershed Committee, for use in the post-project phase for asset management and maintenance.

During this phase, continuous monitoring of programme implementation is done by the PIA. In order to ensure transparency in fund utilization, the expenditure statements related to each activity are presented to the *Gram Sabha*. The watershed committee also submits a monthly narrative and financial progress report to the *Zila Panchayat* through the PIA.

The activities taken up in this phase of RGMWSM are multiple and varied; they include:

- Land development, including *in situ* soil and water conservation measures, like construction of gully plugs, contour bunds, broad based furrows, etc.;
- Drainage line treatment using a combination of vegetative and physical measures like construction of check dams, percolation tanks, ponds, diversion drains, soak pits, etc.;
- Development of new, small, low-cost water harvesting structures like ponds, and revival of old water harvesting structures;
- Raising nurseries of planting stock of fodder-, timber-, and fuelwood-yielding plants and for horticultural species;
- Afforestation including block plantations and shelterbelts, pasture development to meet local fodder needs; bund stabilization through grasses, agroforestry combinations that include horticultural species, etc.;
- Repair, restoration and upgradation of existing facilities for soil and water harvesting, for obtaining sustained benefits from earlier public investments;
- Assisting self help groups of marginal farmers, and the landless in utilization of existing and newly emerging options for local income generation;
- Encouraging thrift and credit activities among the women groups.

**ENVIRONMENTAL REGENERATION THROUGH SOCIAL FENCING IN SHAADI,
DISTRICT DHAR, MADHYA PRADESH**

The villagers of Shaadi micro watersheds have shown considerable initiative and awareness for protection and conservation of forest after the initiation of watershed programme in their village. The result of efforts made by villagers to protect 60 ha of forest adjoining their village is remarkable. The area is flush with vegetation. The uniformity of medium height shoots growing from the rootstock clearly shows that protection for the past 2 to 3 years has resulted in this bounty of nature. The dominant species in the area is Teak. In addition, on completely degraded patches staggered contour trenches have been dug and species like Ratanjyot have been planted. The enthusiasm of the villagers continues unabated as they move on to treating other areas.

VII. Programme Evaluation

In this phase impact evaluation is carried out to judge the progress of the programme towards the goal of sustainable development. It is a regular and integral activity rather than a sporadic and separate event. The evaluation is carried out with reference to base line information of resources and socio-economic status. It is effective in encouraging participants to modify mechanisms, rethink priorities, reset development options and rechart their course of action and for preparing the recommendations for improving the strategies. Evaluation covers:

- Operational success or failure of adopted strategies.
- Resource awareness among the community.
- Extent to which participation has been achieved in planning and implementation of programme.
- Growth of capability of community to take up the task of planning and implementation.
- Technical feasibility and sustainability of implemented activities.
- Equitable sharing of benefits.
- Impact of income generating activities.
- Overall impact of the programme on restoring ecological balance and socio-economic condition of the community.
- Achievement of programme as compared to objectives, targets and success criteria laid down in project guidelines.
- Optimum utilization of resources.
- Capacity of community to undertake follow up maintenance of assets created during the project.

Nirakh Parakh

The discussion on the evaluation methods and approaches adopted by the RGMWSM will not be complete without mentioning about *Nirakh Parakh*, that is a rapid participatory evaluation technique adopted by the mission.

In consonance with mission philosophy, this methodology of participatory evaluation is undertaken in the village by the community itself thus ensuring transparency. The activities undertaken and the processes adopted are identified and assessed by the stakeholders in the presence of the entire village and facilitators. This exercise has led to increased ownership of the community for the activities carried out, identified gaps and made review of the action plan possible and has also brought to the fore success stories.

A detailed *khasra* map indicating each field (along with the name of the owner) and habitation is made at a public meeting place. All the activities (inputs and outputs) are marked on this map for verification and review. This multidimensional evaluation technique is uniquely positioned to be able to highlight and verify the interventions taken up according to decisions of the watershed committee.

- Validation of the claims made by the village level watershed committee.
- Satisfaction level of beneficiaries.
- Identification of members of the village community who have not benefited.
- Identification of areas, which need interventions.
- Preparation of action plan for future action and identifying the processes through which implementation is to be carried out.

IX. Follow-up Maintenance

This phase is envisaged for participatory maintenance of the assets created. It is done by the community through their own contributions, which they have collected during the project. In this phase the watershed committee decides procedures of maintenance, role and responsibility of different group members.

PRESENT STATUS AND ACHIEVEMENTS OF RGMWSM

Today, the RGMWSM has grown to cover all 45 districts, 313 blocks, 6799 watersheds and 9809 villages of MP, to become India's largest watershed management programme currently in operation with 120846 User Groups, 32148 Self Help Groups and 12986 Women's Thrift and Credit Groups. The total area selected for treatment is 41.98 million ha. Of this, an area of 24.21 million ha has already been treated. Of the total fund of Rs. 1946 million received for the mission's activities, Rs.1898 million has been spent.

Changing their Destiny: Village Kotvariyaamal, District Khandwa

Village Kotvariyaamal is located in Khalava tribal block in Khandwa District. In this village, people realized how important water is for their sustenance and in order to conserve it they carried out rejuvenation and desiltation of tanks and deepening of wells on a large scale. All this was done through community action.

This has enhanced the percolation rate of surface water to groundwater reservoirs leading to increase in water level in dug wells and tubewells. In the same season previous year there used to be only 5 feet of water in the wells, which are now filled upto the top. One of the farmers of this village, Sr. Punia, owns 5 acres of farmland. Earlier, he could take only one crop of *Kharif*, yielding 8 quintals of maize and no *Rabi* crop. But now he getting a yield of 16 quintals of maize in *Kharif* season and 20 quintals of wheat in *Rabi* season.

Realizing the importance of conservation of water farmers in this village are determined to continue their effort for the betterment of their future generations.

The project endeavors in the state have led to an increase in the total *Kharif* area by over 20% and the *Rabi* area by 49% of the pre-project figures. The biggest increase has been seen in the area under summer crop – an increase by over 90% of the pre-project area was obtained. The double-cropped area has increased by over 55% of the pre-project period figure, while fodder production has increased by 56%.

The mission has also carried out extensive work on local institutional development and the following figures say it all:

- Assistance provided to SHGs: Rs. 948.39 million
- Income generated by SHGs: Rs. 596.38 million
- Savings by women thrift and credit groups: Rs. 498.26 million

To conclude, RGMWSM represents a community-based programme that has put in place in paradigms and practices of natural resource management, for all to follow. The fact that it is a government initiative and is inclusive to contributions from voluntary agencies, individuals and totally based on community needs and aspirations, adds to the uniqueness of this programme. Today, this flagship programme of the state of MP is being replicated in other states of India. But, its relevance and applicability holds for other developing countries as well, that have large rainfed areas reeling under frequent droughts. The programme represents an idea that cannot be restricted within politico-geographical boundaries of a single state or country, but can be applied with local variations to improve the lives and livelihoods of millions of rural poor. Given the traditional roots of the watershed concept, we can also say that we owe it all to them.

Vriksha Mitra Award 1997

The watershed committee, Jamunia district, Sagar, Madhya Pradesh was constituted in 1996 with the objective of conserving water and soil in the area. Before formation of this committee there was no afforestation or social forestry work in this village or

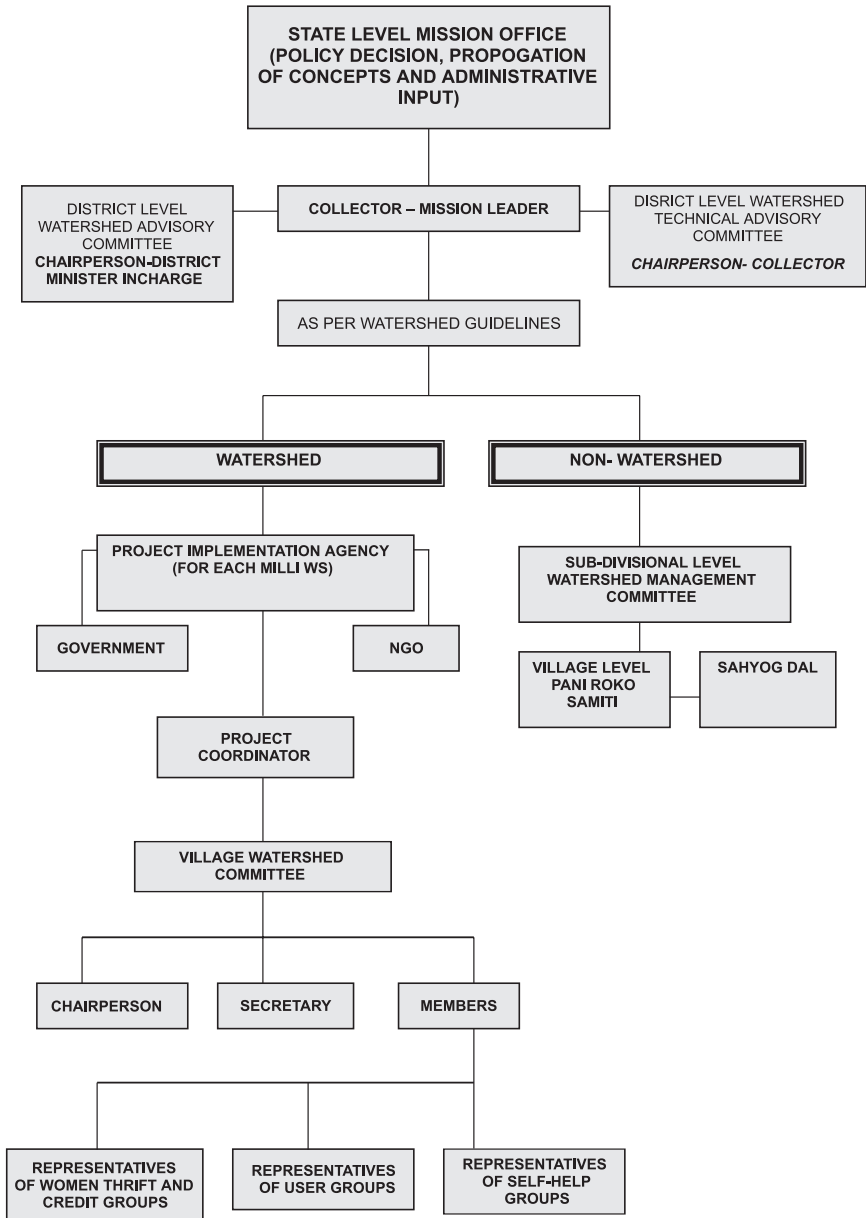
the surrounding area. The area had hilly and undulating terrain and was completely devoid of natural vegetation. The soil cover was shallow and stony.

The committee established 3 decentralizing nurseries, raising about 27000 seedlings and distributed about 17000 seedlings. Structures to conserve and protect the plantation were constructed. Due to these well-designed structures the area had become green. The rural poor in the village are fully involved in the work of the forest department. The programme has specially benefited the women in the area.

Indira Priyadarshni Vriksha Mitra Awards are given to individuals and institutions, who have done pioneering and exemplary works in the field of afforestation and wasteland development by Government of India, Ministry of Environment and Forest. In recognition of the outstanding afforestation work in difficult terrain though the involvement of the people, the watershed committee, Jamunia was awarded the India *Priyadarshini Vikasmitra Award*, by the Government of India, for the year 1997, in the "Panchayat" category.

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Annexure: Organisational structure of RGMWSM

Freshwater Management in Industrialized Urban Areas: The Role of Water Conservation

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INTRODUCTION

Access to safe drinking water is a serious concern in developing countries, where 1.1 billion people lack access (WHO, 2000).ⁱ But access to water is also inadequate in many urban areas of industrial countries, especially during periods of drought (NDMC, 1997). The situation may worsen in industrial urban areas due to:

- Increased water demand for economic development and population growth (Wolff and Gleick, 2002);
- Impacts of changes in both global and regional climate on water

ⁱ Specifically important is the way in which drought impacts local societies by reducing access to safe drinking water in places that currently enjoy only marginal water quantity and quality, and endure severe seasonal shifts in precipitation. In these regions, even a slight drop off in water availability will result in severe outcomes. The impact of arid conditions and extreme poverty impedes the ability of local populations to secure consistent supplies of safe drinking water.

supply systems (Alliance to Save Energy, 2003; Blake et al. 2000; Morehouse, 2000); and

- Reduced percolation due to high levels of impervious surfaces resulting from urbanization of basins (EPA, 1997; Cahill et al. 1996; Schueler, 1994).

On a global level, annual freshwater availability per person decreased from 16,800 m³ to 6,800 m³ per year between 1950 and 2000 (WRI, 2000). When drought conditions persist, urban centers in many industrialized regions are prone to experience a severe freshwater supply-demand gap. A traditional method of attempting to resolve this gap is to increase supply vis-à-vis, large reservoirs, desalination plants, and inter-basin transfers. While such techniques can provide a definite source to offset water demand, costs and environmental impacts are major concerns.ⁱⁱ However, through demand-side management, the gap can be closed without large construction costs and negative environmental consequences. In fact, as will be shown, efficiency can be increased, and environmental conservation enhanced.

Prolonged periods of dry conditions in several U.S. regions over the past 25 years resulted in coordinated national and state policies and programs.ⁱⁱⁱ California state law, for example, requires water purveyors to prepare plans to respond to cutbacks of up to 50% in their supplies in the event of drought or natural disasters (Deister, 2001). The potential of demand-side management is significant. According to Vickers (2001), system-wide demand reductions of at least 25% are possible from conservation for many North American water utilities.

This chapter explores how demand-side management can be applied to help close the expanding freshwater supply gap in industrialized urban centers, especially in drought conditions. The authors provide a U.S. case study that serves as a model for mitigating drought in such settings in which demand-side options are cost effective, environmentally benign, less energy intensive, and often more socially equitable^{iv} when compared to supply options.

ⁱⁱ As a supply option, desalination of sea or brackish water can provide virtually unlimited supplies of freshwater. But higher energy costs have limited its use to specialized applications such as military outposts on small islands, and to energy-rich, freshwater-poor coastal areas like the states of the Arabian Gulf. The substantial energy needs of desalination mean that it has a heavy environmental impact. Another concern sometimes raised is the brine left over from the process (McCully, 2001).

ⁱⁱⁱ The United States Congress passed the National Drought Policy Act (NDPA) of 1998, creating the National Drought Policy Commission to review strategies and solutions to successfully mitigate damages caused by drought.

^{iv} The "scarce" resource may be divided in an inequitable manner as a reflection of the political and economic systems that govern it. In such cases it is likely that the poor and ecosystems will suffer the most (Smith Jr., 2003b).

The Demand-Supply Gap

At the global scale, there appears to be an under-appreciation for the manner in which droughts threaten access to adequate levels of water supply in urban areas within wealthy countries.^v Such threats from drought are made more alarming by the fact that demand for water is rapidly expanding due to increased population growth and urban development, while supply is diminishing due to contamination^{vi} and increased impervious cover.^{vii} In addition, minimum stream flow requirements also reduce the volume of water available for domestic and industrial consumption.

This gap in supply and demand can significantly harm economic activities and ecological processes in urban areas, especially during periods of severe drought. Water shortages resulting from drought restrict urban activities in the commercial and industrial sectors, and also the agricultural sector in its surrounding areas, leading to unemployment and loss of tax revenue for local, state, and federal governments (CEEP, 2001).^{viii} The 1996 drought in Texas alone resulted in an estimated \$5 billion dollars in damage (Wilhite et al. 2000).

When drought lowers urban stream flow levels, wetlands can be impacted, multiple scales of ecosystems disturbed, and water-related environmental and recreational environmental amenities lost to residents (NDMC, 1998). Reduced quality and quantity of drinking water associated with upstream development and/or heavy withdraws during drought cause public safety and health concerns, user conflicts, reduced quality of life, and equity concerns for downstream city residents (CEEP, 2001; NDMC, 1998). In addition, reduced generation of hydro electricity

^v Several chapters in this volume have discussed the condition mentioned above at great length, suggesting methods and practices to overcome freshwater shortages in less-wealthy regions. While this problem is certainly a major concern for the global community, it is important to consider the impact of freshwater shortages in industrialized urban areas during droughts.

^{vi} All surface water systems are considered highly vulnerable to contamination. Drinking water is at risk from surface runoff because of poor air quality, spills, wastewater discharges, sewer overflows and storm water runoff, etc. (Byrne, et al. 2003).

^{vii} A one-acre parking lot can produce 16 times more storm water runoff than a one-acre meadow each year (Schueler and Holland, 2000). It is this increase in storm water runoff that negatively affects water quality, water quantity, public health, flooding, and aesthetics of waterways (Wozniak, 2004).

^{viii} The growing demand for water in the cities is often satisfied by diverting irrigation water from agriculture. With every country facing irrigation water shortages, grain imports are climbing (Brown, 2000).

resulting from droughts negatively affects energy required to support urban activities.^{ix}

Droughts in the western region of the U.S. provide a good example in terms of how drought affects economy, energy, environment and equity. As this region suffers through yet another year of drought, a western newspaper prints the following from drought's 'front line:'

[Lake] Powell's water levels could sink below Glen Canyon Dam's turbines, which supply part of the West's power... A water court ruling in 2002 shut down 800 wells and several thousand other farmers face a protracted legal battle to keep their wells pumping to irrigate corn, wheat and other grains ... Crop losses due to the drought have sapped savings, sending farmers to banks for operating loans and money for water court costs... Many of the farmers' court fights include multiple objectors, usually cities, including water-short communities in Arapahoe and Douglas counties, that want to buy the water to use in subdivisions... But there's more at stake for Colorado than just water. Revenue from the sale of electricity generated at Glen Canyon Dam at Lake Powell pays for Colorado's endangered-fish recovery programs and helps repay federal water project costs (Frazier, 2004).

The reduction of the water supply-demand gap in industrialized urban areas is therefore necessary to ensure sustainable water resource management for urban residents in industrialized countries. The primary concern is that cities secure consistent supplies of safe drinking water for all residents at reasonable rates. If supplies of freshwater are limited to the extent that residential demand cannot be met, the well-being of citizens will be sacrificed. By moving to reduce the supply-demand gap through the efficient use of freshwater, the gap can be closed, and urban health can be ensured. Other communities, including ecological ones, will also benefit from the wise use of water. Demand-side management should be at the core of this endeavor.

Demand-side Drought Management

By mitigating urban-industrial drought through the efficient use of water, the gap in supply and demand can be closed in an environmentally sustainable manner. Many ways of conserving water in an urban setting have been considered and applied as shown in Table 22.1.

^{ix} Concerns regarding drought have captured the attention of many Americans in recent years. In fact, scientists at the U.S. Geological Survey have stated that the drought in the western U.S. could be the greatest in 500 years, with impact in the Colorado River Basin significantly worse than during the Dust Bowl years (Associated Press, 2004).

Table 22.1. Major facets of water conservation mechanisms

Conservation mechanism	Investigator	Year published
Curtailment and ordinances	Tippett and O'Hare	1999
	Aitken, McMahon, Wearing and Finlayson	1994
	Agras, Jacob and Lebedeck	1980
	Bruvold	1979
Technological efficiency improvement	Irvine Ranch Water District	2004
	Vickers	2001
	Wang, Song, Byrne and Yun	1999
	Gleick et al.	1995
	Postel	1986
Information campaign	Irvine Ranch Water District	2004
	Peckumn	2003
	Wang, Song, Byrne and Yun	1999
	Abu-Taleb and Murad	1999
	Moore, Murphy and Watson	1994
	Nieswiadomy	1992
	Billings and Day	1989
Recycling and reuse	U.S. Environmental Protection Agency	2004
	Guendert and Jordan	2004
	Water Reuse Association	2004
	Williams and Safrit	2003
	Nolde	2000
	Jefferson, Laine, Parsons, Stephenson and Judd	2000
	Marks	2000
	Roseland	1998
Land use modifications	Wozniak	2004
	Center for Watershed Protection	2004
	Rushton and Hastings	2001
	U.S. Environmental Protection Agency	1999
	Prince George's County	1999
	Miller	1998
Conservation-oriented pricing	Wang, Smith and Byrne	2004
	Center for Energy and Environmental Policy	2002
	Wang, Song, Byrne and Yun	1999
	Renwick and Archibald	1998
	Hewitt and Henemann	1995
	Rhodes, Miller and MacDonnell	1992
	Nieswiadomy	1992

Curtailment and Ordinances

Curtailment or reasoned response is responsible for considerable success in certain water campaigns (Aitken et al. 1994). Bruvold (1979) and Agras et al. (1980) identified the tendency of people to conserve during a crisis situation like severe drought. When citizens feared a community crisis or viewed the drought as an indicator of a long-term problem, more involvement in conservation efforts was apparent. According to our interviews, another concern is how long such reductions persist – which is a reason that a long-term outreach strategy in both periods of crisis and non-crisis has been noted in places such as Corpus Christi and Tucson as being key to sustaining any necessary changes in behavior.

Municipalities use ordinances as part of demand-side management initiative. Use of ordinances that promote water conservation and efficiency include water rate, lawn watering, plumbing fixture, mandatory retrofit of water fixture, and restrictions on specific users such as golf courses (de Loe et al. 2001). Of these, water rate ordinances and lawn watering ordinances are most frequently used.

For example, the City of Santa Fe adopted the Emergency Water Regulation Ordinance in March 1996 to control water use in response to a twelve-month long drought. Commercial and residential water users were required to reduce their use by 25% as measured against the water bills during the same month of the previous year.^x In August 1996, 91% of the residential water users used less than 12,500 gallons a month as compared with 75% in August 1995. Residential water use dropped by 28% as a result of the adoption of the ordinance, surpassing the goal of a 25% reduction (Tippett and O'Hare, 1999). Obviously this can wreck havoc with utility revenues, and this concern is addressed later in this chapter.

Efficiency Improvement

Engineering estimates (Vickers, 2001, 1993, 1991, 1989; Postel, 1986) generally indicate that efficient water appliances can significantly reduce water consumption. The Pacific Institute, a California water-research NGO, calculates that using only existing technologies, average residential water use per person in the state could be almost halved between 1995 and 2020 (Gleick et al. 1995).

In the area of the Irvine Ranch Water District in California, 51% of all residential water is used for landscape irrigation. Smart sprinkler technologies that adjust the amount of water sprayed on the daily basis of evapotranspiration rates resulted in water savings of 41 gallons per day (gpd) in typical residential settings. The observed reduction in runoff from

^x The 25% reduction goal gave each water user a "Conservation Target." A \$10 "Target Exceedance Surcharge" was assessed for each 1,000 gallons a customer used in excess of his or her target. In addition, a "High Use Surcharge" was levied on single-family residential customers that used over 12,500 gallons per month. The "High Use Surcharge" ranged from \$15 to \$50 per 1,000 gallons for use over 12,500 gallons.

the test area was 49% when comparing pre- and post-intervention periods, and 71% in comparison to the control group (IRWD, 2004).

Wang et al. (1999) also show that those customers who received conservation kits (including faucet aerators, low-flow shower heads, and toilet dams) as part of voluntary conservation programs had a significant reduction in water consumption compared to those who did not (16%).^{xi} However, the percentage of customers using conservation devices is small.

A high penetration program could be adopted to increase participation in the delivery of water conservation devices, be it for free, or for a fee. To illustrate, the Santa Monica Energy Fitness Program used new techniques designed to increase participation in the Residential Conservation Service (RCS) program by utility customers. The technique was to complete a direct-service-home-energy audit, which included the actual on-site installation of energy saving devices in the participant's home (Egel, 1986). This type of energy program could clearly be applied to water conservation as well, especially since several of the Santa Monica measures were for hot water savings. This approach resulted in participation among the highest ever achieved by an RCS Program.^{xii}

Information Campaign and Audits

Information and educational campaigns are common tools used to promote water conservation. Educational campaigns involve the use of the radio, television, and written media such as pamphlets and programs in the school systems. However, as counterintuitive as it may seem, Abu-Taleb and Murad (1999) found a very poor correlation between knowledge and action.^{xiii} This study's most important observation on behavior was primary school children directly reflect their parents' views towards conservation. This is significant because it identifies an important pathway to influence younger attitudes towards conservation behavior (Peckumn, 2003).

Water utilities, in collaboration with state and local governments, could play an active role in the dissemination of quality information on the water supply situation and conservation needs. From a policy standpoint, the amount of information the residents have is not that important. The most critical matter is to get them to take the message seriously enough to change their behavior in a timely manner. The information should be clear

^{xi} In a typical single family home, by installing water efficient ultra low-flush toilets that use 1.6 gallons per flush, toilet use declined to 19.3% (AWWA, 1999). Low-flow showerheads are the most commonly used devices in voluntary conservation programs.

^{xii} Since program costs and energy savings per household were comparable to those associated with most traditional RCS Programs, far more total conservation was achieved at similar cost per unit saved.

^{xiii} Moore, Murphy and Watson (1994) observed the largest conservation came from people who had been subject to at least one water conservation campaign earlier in their life, but a follow up survey (1999) three years later found the minute correlation had disappeared and people were not conserving.

and understandable to residents and motivate them to take actual conservation measures. The information campaign should also be persistent to be most effective. Billings and Day indicate that “the effect of publicity exists only as long as the publicity continues” (1989: 63).

Using the American Water Works Association survey of 430 U.S. water utilities, Nieswiadomy (1992) estimated the impacts of public education programs on water conservation for four different regions and showed that the program, which urge people to conserve water, significantly reduce water demand only in the West region. A study of southern Arizona’s campaign showed that publicity about water problems had an impact on water conservation, with an average elasticity of -0.05 (Billings and Day, 1989). A residential group which received only educational materials and a suggested irrigation schedule saw reductions in outdoor water use of 28 gpd per residence and a 36% decreased in runoff following intervention. Relative to the control group, the education program resulted in a 21% reduction in runoff (IRWD, 2004).

Water audits can be an important tool of information campaign. Many municipalities use water audits of homes and businesses to save water through retrofitting or changing practices of water use. Water audits are subsidized in several municipalities as their responsibilities have been increased, while general revenues have decreased. Water conservation is bolstered by programs that provide free leak detection via audit and which may be supported via rebate programs to promote consumer choice of low-flow toilets and other high efficiency water service technologies.

Water Recycling and Reuse

Water recycling can be an effective method of reducing urban water consumption. A gray water recycling system exclusively used for toilet flushing can save 34% to 40% of household consumption, with a payback period of 8 years in a four-person household (Jefferson, 2000; Nolde, 2000; CMHC, 2000). A more expansive system that also uses recycled water for irrigation can save between 50% and 70% (EPA, 2004; Marks, 2000).

Recycled water can come from homes, rainwater storage tanks and storm drains. There are many potential applications for recycled water in the home and throughout the community. Individual homes can use recycled water to flush toilets, water gardens, and wash cars, while communities can irrigate public areas and create artificial lakes or fountains. Household gray water is transported through a dual reticulation system of pipes. This system involves collecting wastewater from a residence, treating it off-site, then returning the recycled water to the community.^{xiv} It is

^{xiv} Although the majority of recycling projects involve entire communities, not all systems require the development of large infrastructure. There are systems available for purchase by individuals that involve the recycling of their personal gray water. Specific products

noteworthy that major metropolitan areas such as the city of Denver uses recycled water for display in its zoo and on local golf courses.^{xv}

A number of different water recycling projects are currently in place in the U.S., especially in southern areas and California. In St. Petersburg, Florida, water reclamation efforts have been underway since the 1970's. 8,000 people were already being served in 1995, and the system is expected to expand to up to 17,000 residents (Water Reuse Association, 2004). There is also a dual reticulation system planned for Brunswick County, North Carolina. New developments will be constructed with the pipe infrastructure needed to make use of recycled water for lawn irrigation, while older communities will be retrofitted when economically efficient (Williams, 2003).^{xvi} In Los Angeles, 500 homes rerouted gray water to their washing machines and saved approximately 4 million gallons of water per year (Roseland, 1998).

The satellite reuse plant^{xvii} alleviates the need to expand old, centralized wastewater systems in an urban location, where expansion can be disruptive and costly. In Woods Valley, California the high-quality effluent produced from the satellite facility irrigates the community's golf course as well as fill the course's water features (Guendert and Jordan, 2004). This remote treatment of wastewater for reuse provides a reliable, drought-proof supply water that can benefit urban communities by reducing the reliance on overstressed existing supplies, increasing availability of potable water and improving the environment by decreasing discharges of wastewater to oceans, lakes, rivers, streams, and creeks (Guendert and Jordan, 2004).

Land Use Modification

Conventional urban development can create many problems due to traditional construction practices. Water that previously ponded in natural depressions, infiltrated into the soil and provided groundwater recharge, or evaporated and transpired into the atmosphere, is now converted into surface runoff (U.S. EPA, 1999). As groups such as the Center for Watershed

sold in the United States include the Envirosink and the Cloudy Water Recycling System. These two devices offer the choice of a low-tech option and much higher tech option.

^{xv} The San Antonio Water System has a gold course program named "Golf Fore" that certifies four levels of environmental achievement based upon the four criteria of: 1) Water conservation; 2) Water quality; 3) Wildlife habitat and open space; and 4) Community outreach.

^{xvi} Recycled water has been used in the service area of the Irvine Ranch Water District in California (IRWD) since 1967. Recycled water is used for landscape irrigation, agriculture, in large commercial building's toilets, and (as a pilot study) in cooling towers. The full array of recycling services can be viewed on the corresponding website.

^{xvii} The new technology used for these types of applications is the membrane bioreactor (MBR) which allows it to be easily sited; operates reliably with minimal operator attention; contains microorganisms in the process; and provides a high-quality effluent (Guendert and Jordan, 2004).

Protection (2004) note, increases in impervious surfaces such as rooftops, roads, parking lots, and driveways reduce percolation and filtration. As a consequence, a lot of rainfall is converted into stormwater runoff, negatively affecting water quality and quantity, habitat, biological resources, and public health, and often enhancing flood hazards.

A two-year study by the Southwest Florida Water Management District (Rushton and Hastings, 2001) has shown that permeable pavement can produce both water quantity and water quality effects that far exceed that of other types of conventional pavement. Also, the implementation of a rooftop garden in Philadelphia has shown decreased stormwater runoff flows (Miller, 1998).

Low impact development (LID) is a technique brought to the forefront by the staff working for Prince George's County, Maryland. Based on eight sustainability goals, LID practices can be employed to retrofit urban communities, making them more hydrologically sustainable by increasing water quality, preventing flooding and protecting biological resources (Prince George's County, 1999). Specific examples of structural procedures include rooftop gardens, rain barrels, rain gardens, bioretention areas in parking lots and along roadsides, permeable pavement, and infiltration basins (Wozniak, 2004).

These urban practices have been shown to provide many benefits including enhanced property values and redevelopment potential, greater marketability, improved wildlife habitat, thermal pollution reduction, energy savings, smog reduction, enhanced wetlands protection, and decreased flooding (U.S. EPA: 2000, 1999). Of course, in cities where vector-borne diseases are a concern, one must be cautious in utilizing technologies such as rain barrels in order not to dramatically increase the number of potentially disease causing vectors near homes.

Water Conservation Pricing

A conservation-oriented pricing policy is essential for ensuring that water utilities and customers alike weigh efficiency alternatives properly in their water supply and demand decisions.^{xviii} The most serious water supply problem faced by water utilities is peak summer demand that occurs when capacity is limited. In this case, utilities satisfy demand through such options as purchasing expensive water from other utilities, reactivating old wells currently not in use or expanding storage capacities. These supply-side actions impose high costs on the utilities (higher marginal costs). Consumers who are the principal source of peak demand should shoulder higher costs. Thus, seasonal water conservation pricing reflects these higher costs (Wang et al. 2004).

^{xviii} Pricing policy is essential for a demand-side management in combination with metering to provide an incentive for customers to reduce water use. Metering is a prerequisite for conservation-oriented rate structures (De Loe et al. 2001).

Since pricing is a significant policy variable influencing water conservation, water utilities need to continue considering pricing as a water DSM alternative to conventional supply options (Wang et al., 1998). To be most effective, pricing structure should be designed in such a way that discretionary water users in the summer months are given signals to reduce consumption. Indeed, outdoor water use has been found in the literature to be particularly sensitive to price increases, especially during the high-demand summer months (Hewitt and Hanemann, 1995; Rhodes et al. 1992).

Price responsiveness varies by the income group. According to Renwick and Archibald (1998), lower income households were more price-responsive because their water bill typically constitutes a larger share of their household budgets. This implies that price policy will achieve a larger reduction in residential demand in a lower income community than in a higher income community. The Center for Energy and Environmental Policy (2002) shows, however, that during summer months the upper-income groups have a much higher price responsiveness than low-income groups because their discretionary uses are more easily altered than those corresponding to basic needs for which demand more readily 'hardens.'

Impacts of Demand-side Drought Management

The impacts of the efficient use of water on economy, environment, energy and equity (E^4) are positive. Water conservation improves the E^4 balance, enhancing urban sustainability, especially during droughts in urban areas. Previous responses to drought have been mostly reactive, representing a crisis management approach that has been largely ineffective (Wilhite et al. 2000), whereas conservation programs can be effective to reduce the risks associated with drought in a more systematic manner.

Economy

Customers enjoy immediate economic benefits through lowered bills, but the more important element is long-term societal benefits from lessening or eliminating needs for costly supply-side facilities or wastewater and sewage treatment facilities (Wang et al. 2004; U.S. EPA, 1998; Featherstone, 1996). In Santa Barbara, CA, a large desalination plant brought in the late 1970s due to a severe drought is in the process of being 'mothballed' because reductions in demand occurred from the high costs passed on to consumers (Gleick, 2002). The three examples below further attest proven measures of water savings.

An important reason for the suspension of the Two Forks Dam, planned to supply water to Denver, Colorado, was that installing meter and water-saving devices in Denver households could save more water than the dam would supply – and at about one-fifth of the dam's \$1 billion cost. After

the U.S. EPA vetoed Two Forks in 1990, the Denver Water Department actively promoted water use efficiency, helping to cut average household consumption by 9% in just two years (Haberman, 1993).

The Town of Cary, NC, has found that a carefully planned water conservation program can offer a 'new' source of water and enabled the town to delay two future plant expansions by 10 years (Platt and Delforge, 2001). Its Water Conservation Program (WCP) recommended seven programs that have a combined benefit-cost ratio of 4.44. The programs reduce retail water production of 4.6 mgd by 2028, representing a savings in retail water production of 16%.

Since the early 1990s, New York City has saved more than 250 million gallons per day in water through a conservation program that included an aggressive low-volume toilet rebate program involving more than 1 million fixture replacements. These savings allowed the city to avoid spending more than \$1 billion to expand a wastewater treatment plant and have indefinitely postponed development of new water supply sources (Vickers, 2001).

Environment

Reduced water consumption lowers needs for withdrawal from surface and groundwater and treatment of wastewater, mitigates saltwater intrusion in certain cities near coastal areas,^{xix} and mitigates or eliminates environmentally questionable water supply augmentation solutions (CEEP, 2001; U.S. EPA, 1999).

The burning of fossil fuels to generate the energy used to supply water (including treatment) affects air quality. Emissions from power plants contribute to already high levels of pollutants in the urban environment. In addition, millions of tons of carbon dioxide are emitted every year, contributing to global climate change. Global climate change has the potential to alter water tables and disrupt water supplies in many areas, making water even more costly (and energy intensive) to obtain in the future (Alliance to Save Energy, 2003).

Excessive ground and surface water withdrawals can be avoided vis-à-vis conservation. Aquifer depletion can cause the land above to subside, with serious consequences for the stability of buildings. In fact, Beijing is sinking at an annual rate of around 10 centimeters, and its water table dropping by up to 2 meters a year. The ground under Houston, Texas has subsided by more than 2 meters over the last four decades (Panel on Land Subsidence and National Research Council, 1991).

Altered flows are a concern as well. More than 20% of all freshwater fish species are now threatened or endangered because dams and water

^{xix} Sinking water tables in coastal areas can cause saline water to seep into aquifers, ultimately making them useless for either drinking water or irrigation. Drinking water supplied by groundwater under a number of cities and towns along the eastern and southern coasts of the US has been contaminated by saline ingress.

withdrawals have destroyed the free-flowing river ecosystems where they thrive (Gleick, 2002).

Energy

Energy consumption is directly reduced when residents adopt water efficient appliances, and water utilities use less energy for surface and groundwater withdrawal and wastewater treatment and discharge (Cohen et al. 2004; U.S. EPA, 1998). Specially, reductions in peak water system loads reduce peak energy demands by less water pumping, treatment, and heating so that energy utilities avoid or reduce capital expenses (Gleick, 2002).

Sullivan et al. (2001) show in their Oregon study that the mean electricity savings from the new clothes washer was 0.9 kWh/cycle, for a 68% reduction in use over the baseline electric water heater, while the mean water savings was 15.2 gallons/cycle, for a 38% reduction in use over the baseline. In the case of the new dishwasher, compared with the baseline equipment, the mean water savings was 3.7 gallons/cycle, for a 39% reduction in use, whereas the mean electricity savings was 0.6 kWh/cycle, for a 39% reduction in use.^{xx}

The worldwide energy consumption to pump and treat water for urban residents and industry is between 2 and 3% of total global energy consumption (Alliance to Save Energy, 2003). Unfortunately, relatively little attention has been given to reducing energy use in urban water systems. Energy costs draw precious budgetary resources from other important urban functions such as education, public transportation, and health care. In the developing world, the cost of energy to supply water may easily consume half of a municipality's total budget. Even in developed countries, energy is typically the second largest cost after labor in urban water systems (Alliance to Save Energy, 2003).

Equity

Conserving water makes it easier to optimize water allocation between competing users, this is due to increased water availability. Given the Earth's limited water budget, conservation is essential to build a 'water trust,' an endowment that generations to come can rely on for their own security and prosperity (Vickers, 2001). As we will demonstrate later, compared to supply-side options, conservation can be achieved without over-burdening under-privileged residents, and also enhances opportunities for participation by residents and localized communities in water decision processes (Newman, 1999).

^{xx} Sullivan et al. also show that the energy savings from reduced water distribution and water/wastewater treatment from the water and energy-efficient devices (including clothes washers, clothes dryers, dishwashers, toilets, showerheads, and faucet aerators) were calculated to be 55 kWh per home per year. These savings are realized by the community through reduced electricity use by supply pumps and other water/wastewater treatment equipment.

Successful urban conservation efforts will reduce conflicts over in-stream flow rights and competing uses of water that are occurring with increasing frequency (Vickers, 2000). Improved efficiency of water use will result in additional water to share among competing users and with the natural environment. Getting more from each gallon of water extracted from nature is the key to meeting future human needs and at the same time protecting the environment (Postel, 2000).

A Case Study: Wilmington Metropolitan Area

Delaware has a history of periodic water ‘shortages’ due to droughts. The portion of the state most affected by drought has typically been the city of Wilmington and its metropolitan perimeter. Approximately 70% of metropolitan Wilmington’s drinking water is drawn from the Christina River Basin – mainly composed of the White Clay Creek (WCC) and the Brandywine Creek (BC). During droughts, water supply in the area can be severely strained. Water quality has also been threatened (Wang et al. 2001; WSTF, 1999).

Withdrawals of water from the Christina River Basin is regulated by the 7Q10 Minimum Flow Standard, which is based on a statistically computed lowest flow rates occurring once every 10 years for a 7-day period. This standard prescribes the minimum flow that must be maintained in the streams so that human health, riparian ecosystems and aquatic life are not significantly impacted. According to the Second Report by WSTF submitted to the state’s Governor and General Assembly, the demand in the Wilmington metropolitan area for 2010 is projected to reach 88 mgd (DWSCC, 2001). When demand for water is compared with supply availability, it becomes evident that the adequacy of the water supply system depends on the adoption of the 7Q10 system. Table 22.2 indicates the water balance for the metropolitan area in 2000 and 2010.

Expanding the 7Q10 standard to include both BC and WCC could result in a projected supply deficit of nearly 15 million gallons per day (mgd), or, 17% of the demand during droughts in 2010. The solution to meeting this

Table 22.2. Water supply and demand scenarios in the Wilmington Metropolitan Area: 2000 and 2010

Scenario	Supply (mgd)	Demand (mgd)	Balance (mgd)
No 7Q10	93	86 (for 2000)	7 (8%)
7Q10 in WCC, not in BC	85	86 (for 2000)	-1 (-1.2%)
7Q10 in both WCC and BC	73	86 (for 2000)	-13 (-15%)
7Q10 in both WCC and BC	73	88 (for 2010)	-15 (-17%)

shortfall could lie either in increasing supply or in reducing demand— or some combination of the two. Water conservation efforts can play a crucial part in achieving the goal of reducing demand by 17% in the Wilmington metropolitan area. This reduction can enhance the E⁴ balance, helping city residents to flourish into the indefinite future without unnecessarily undermining the integrity of the hydrological cycle or ecological systems that depend on it (Malkina-Pykh and Pykh, 2003; Gleick et al. 1995).

As previously discussed, in an urban setting, many strategies for conserving water have been considered and applied (Wang et al. 1999). They include curtailment, conservation-oriented pricing, information campaign, technological efficiency improvements, recycling and reuse, and land use modifications. In our analysis, we consider conservation-oriented pricing and conservation technology programs in the residential sector to meet the gap between water supply and demand during droughts modeled for the target year of 2010, while achieving revenue neutrality for utilities and equity for low-income groups.

Water Conservation-oriented Rates (WCORs)

In the design of WCORs, it is important to account for revenue volatility and address possible distributional effects (Chesnutt and Beecher, 1998 and Chesnutt et al. 1996). WCORs are usually justified as a form of marginal cost pricing that can often be at odds with a goal of revenue neutrality (Pint et al. 1999). Results suggest that if pricing is the primary conservation instrument, lower income households could bear a larger share of the conservation burden (Renwick and Archibald, 1998). Researchers have also found that marginal pricing can be regressive to low-income customers when compared with high-income customers (Pint et al. 1999; Agthe and Billings, 1997). These concerns are addressed below.

Water Conservation and Price Elasticity

A series of analyses were conducted by the Center for Energy and Environmental Policy at the University of Delaware utilizing a panel of 500 households for the period 1992-1997. The panel households were randomly drawn from the service area of Artesian Water Company, Inc., an investor-owned water utility serving a portion of the Wilmington metropolitan area. The dataset contains not only water consumption and bill information for the sample households during the summer quarters, but also information on their socio-economic characteristics that were obtained from surveys conducted in 1992 and 1994 (Wang et al. 1998). In the sensitivity analyses, the 500 households are assumed to represent residential customers in the Wilmington metropolitan area.

As a means of evaluating conservation, revenue, and equity implications of WCORs, we first classified the sample households into four income

groups. The price elasticity of each income group was next estimated based on the model CEEP had developed for the Artesian Water Company. This is based on a regression model that is built using a proportional change measure of price and consumption between 1992 and 1997, instead of a single-year cross-sectional model. Before estimating the proportional change regression model, preliminary analyses were first conducted using the t-test (for dichotomous independent variables) and Pearson’s correlation (for numerical independent variables) to identify variables that were significantly influence change in water consumption. The general form of the equation (1) used here is as follows (Wang et al. 1999):

$$[(Q_1 - Q_0) / Q_0] = \beta_0 + \beta_1 [(P_1 - P_0) / P_0] + \beta_2 \text{INFORM} + \beta_3 \text{DEVICE} + e \quad (1)$$

- where, $[(Q_1 - Q_0) / Q_0]$: Proportional changes in day- and weather-adjusted water consumption during the summer months between two periods
- $[(P_1 - P_0) / P_0]$: Proportional changes in inflation-adjusted average prices of water during the summer months between two periods
- INFORM : Consumers with higher levels of water conservation information provided by Artesian = 1 and consumers with lower levels of information = 0
- DEVICE : Customer who used water conservation devices provided by Artesian = 1 and customers who did not = 0
- e : Error term

The overall price elasticity of water demand for residential customers in this utility derived from the above equation is -0.82, which is comparable with other studies. According to a study for the eastern U.S., winter elasticity is relatively low at -0.15, and summer elasticity is at -0.57, but the elasticity of outdoor sprinkling is quite elastic at -1.57 (Billings and Jones, 1996). A 5-year panel study for 121 households in Texas shows elastic price elasticity during summer, ranging from -1.57 to -1.63 (Hewitt and Hanemann, 1995). Using the income classification, separate regression analyses for households in each income bracket were performed to estimate elasticity for each income group (Table 22.3).

A series of scenario analyses were conducted to examine the level of changes in utility revenue and water consumption for each income group. As a reference case, both 15% and 20% price hikes were applied to all residential customers irrespective of their consumption levels and different elasticities as shown in Table 22.4. As expected, they lead to violation of

Table 22.3. Price elasticity for different income groups

Income group	Price elasticity
Group 1: Low-Income	-0.688 (-7.15)
Group 2: Low-Middle Income	-0.738 (-8.53)
Group 3: High-Income	-1.028 (-4.87)
Group 4: Upper-Income	-1.686 (-8.47)
Total residential customers	-0.816 (-13.56)

Note : The values in the parentheses denote t statistics. The estimated price elasticities are statistically significant because the observed t values are greater than the critical t values of -1.96 with significant level of 5%.

Table 22.4. Summary of the sensitivity analysis

Sensitivity scenarios	Equity to the low-income group	Revenue neutrality to utility	Utility-wide water conservation
Reference Scenario			
• Rate 15%↑ Entire Consumption	No	No	S (17% ↓)
• Rate 20%↑ Entire Consumption	No	No	S (23% ↓)
Marginal Consumption Scenarios			
• Rate 20%↑ Consumption>12,000 gals	Yes	Yes	S (10% ↓)
• Rate 20%↑ Consumption>13,000 gals	Yes	Yes	S (9% ↓)
• Rate 35%↑ Consumption>15,000 gals	Yes	Yes	S (13% ↓)
• Rate 25%↑ Consumption>10,000 gals	Yes	No	S (14% ↓)
• Rate 20%↑ Consumption>20,000 gals	Yes	Yes	NS (4% ↓)
• Rate 20%↑ Consumption>30,000 gals	Yes	Yes	NS (2% ↓)

the equity principle to the low-income group. The low-income group is expected to pay more, even with their lowered consumption. The reference cases meet a conservation criterion (significant reductions by 17% and 23%, respectively), but falls short of meeting the other two criteria: revenue neutrality to utility and equity to low-income customers.

In our alternative scenario analyses, water consumption on the amount exceeding the critical cut-off level from 10,000 gallons to 30,000 gallons (Pint et al. 1999; Tippett and O’Hare, 1999) per a summer quarter is only subjected to the higher rates from 20% to 50% (Wang et al. 2001). No rate change is assumed in the consumption below the level. Based on a series of scenario analyses, we identified a sound WCOR option that meets all the three requirements: 1) Water conservation; 2) Revenue neutrality to utility; and 3) Equity to customers.

The scenarios that meet all the three requirements are the cases where water rates were assumed to increase by 20%-35% on consumption above 12,000-15,000 gallons during the summer quarter. The most significant water savings come from the 35% rate hike and the 15,000 gallons cut-off level. In the case of a 35%-15,000 gallon scenario, statistically, no significant changes before and after the implementation are incurred in utility's revenue and low-income customers' bills. Overall conservation impact is statistically significant, reducing 13% of utility-wide residential water consumption (a 20%-12,000 gallon scenario is estimated to achieve a 10% reduction).

Table 22.5 shows in detail the results of the most significant water savings scenario (35% -15,000 gallons) that meets all the requirements of a sound WCOR option. Statistically, no significant changes before and after the implementation of a WCOR are incurred in utility's revenue (reduction in average bills from \$68.9 to \$65.9) and low-income customers' bills (from \$51.3 to \$50.7 in the low-income group and \$63.0 to \$61.9 in the low-middle income group). Overall conservation impact is statistically significant, reducing 13% of utility-wide residential water consumption (from 17.2 thousand gallons to 15.0 thousand gallons per quarter).

Table 22.5. Mean changes in revenue and consumption in various income groups: 35% marginal price increase on consumption above 15,000 gallons

Income groups	Revenue per customer (cutoff 15,000 gallons)			Consumption per customer (cutoff 15,000 gallons)		
	Before (\$)	After (\$)	Statistical significance*	Before (1,000 Gal.)	After (1,000 Gal.)	Statistical significance*
Group 1	51.27	50.68	NS	10.69	10.23	NS
Group 2	63.04	61.91	NS	15.08	14.17	NS
Group 3	77.19	71.96	S	19.67	17.57	NS
Group 4	83.41	70.21	S	22.38	17.18	S
Utility	68.85	65.91	NS	17.18	14.96	S (13% ↓)

* Note: 'S' denotes statistically significant difference in the before and after values, while 'NS' denotes statistically no significant difference based on one-tailed test with the 95% confidence level.

Our scenario results also show that a DDR option could enhance efficiency of water resource allocation among customers. Upper-income customers usually use much more water vis-a-vis discretionary uses than low-income customers, as reflected in their high price elasticity (-1.686 compared to -0.688 of the low-income group). As shown in Table 22.6, with the cut-off consumption level of 15,000 gallons, the marginal prices for the low-income and low-middle income groups are not changed, but in cases of high income (assumed consumption of 25,000 gallons per a summer

Table 22.6. Efficiency implications of a WCOR implementation: based on artesian’s WCOR residential tariff (1997)

Inclining rates	Income group	Before*	After*
1 st Block	Low Income (Consumption 10,000 gals)	\$ 2.45	\$ 2.45
2 nd Block	Low-Middle Income (Consumption 15,000 gals)	\$ 2.61	\$ 2.61
2 nd Block	High Income (Consumption 25,000 gals)	\$ 2.61	\$ 3.22
3 rd Block	Upper Income (Consumption 35,000 gals)	\$ 3.04	\$ 4.47

Note: * Inclining block rates per 1,000 gallons.

quarter) and upper income customers (assumed summer quarter consumption of 35,000 gallons), their marginal prices are increased by 23% (from \$2.61 to \$3.22) and 47 percent (from \$3.04 to \$4.47), respectively. The price hikes target discretionary water uses by large consumers.

Conservation Implications of WCORs

Assuming all the utilities in the metropolitan area adopt a WCOR option as suggested above, residential water consumption is expected to reduce by 13% during drought events. The proportion of residential water consumption to the total consumption during the summer months is expected to be 48.8% in 2010 (WSTF, 1999), which is equivalent to a 6.3% reduction in total water consumption in 2010. As around 12% of water produced is unaccounted in the city (Song, 2001), total water savings from the case scenario would amount to 7.1%, equivalent to 6.3 mgd (in a 20% -12,000 gallon scenario, it would be 5.5%, equivalent to 4.8 mgd).

In 2010, water demand in northern New Castle County is projected to reach 88 mgd, but its supply is expected to be 85 mgd, based on the current condition where a 7Q10 exists only on WCC (but not on BC), meaning a negative balance of 3 mgd. But due to a WCOR option, water demand could be reduced to 81.7 mgd, and no water shortage problem would surface. In the case where 7Q10 is applied to both WCC and BC, the area is projected to need 88 mgd in 2010, but its supply is only 73 mgd, a deficit of nearly 15 mgd or 17%. Residential water savings through the above WCOR option would reduce 6.3 mgd, leaving 8.7 mgd short.

Conservation Technology Programs (CTPs)

The state, in collaboration with water utilities, can encourage adoption of more efficient water-consuming appliances by residential customers. On January 13, 1988, the Delaware River Basin Commission (DRBC) passed Resolution 88-2, setting standards for toilets, showerheads, faucets and urinals. It applied to all fixtures and fittings in new or renovated homes

throughout the Delaware valley.^{xxi} This resolution went into effect July 1, 1991. By January 1, 1992, three of the four states—Delaware, New Jersey, New York—had adapted statewide standards that met the DRBC standards (Featherstone, 1996).

In this study we have only considered five indoor appliances and one outdoor lawn sprinkler. The indoor appliances include clothes washers, dishwashers, faucets, toilets, and showerheads. Assuming that the homes built after 1991 will adopt the state plumbing code, our estimation of conservation potentials for faucets, toilets and showerheads are applied only to the housing units already existed in 1992. For clothes washers and dishwashers, both new and existing housing units are applied in the estimation of water savings potentials. Water savings potential for lawn sprinklers is estimated on the basis of the size of lawn areas regardless of the age of housing units.^{xxii}

Data, Assumptions and Procedures

As part of estimating water savings potential, we used the census data regarding number of households in the Wilmington metropolitan area in 1990 and in 2000, and a forecasted number of households in 2010 by the Delaware Population Consortium. For the participation rate of CTPs by residential customers, we take after those commonly used in the evaluation analysis of energy efficiency programs (IWG, 2000), assuming to be 65% in 2010. For the automatic energy efficiency improvements (AEEL) in water-consuming appliances, even without any policy interventions they are assumed to be 2% for those fixtures subject to the plumbing code and 1% for regular appliances such as clothes washers and dishwashers due to their slow turnover rates compared to toilets, showerheads or faucets.

For each indoor appliance, we first estimate the percentage of households that had inefficient appliances in 1992 based on our survey result. The percentage figure is adjusted to estimate those in 2010 by applying its automatic annual efficiency improvement rate. Once the number of households who would participate in CTP in 2010 is identified, potential water savings are estimated through multiplying it by an engineering and/or empirical savings figure (identified through literature review). The savings figure is usually expressed as gallon per capita per day (gpcd).

For outdoor water savings from lawn sprinklers, our target is total acreage of lawn areas in 2010, rather than total number of households or housing units. To produce the total lawn acres, remote sensing with a tie-in to a geographic information system (GIS) can be utilized by overlaying

^{xxi} It required a maximum flow of 1.6 gallons per flush (gpf) for toilets and 1.5 (gpf) for urinals.

^{xxii} Although it should be noted, however, that new houses need more water for gardens and lawns because of higher evapotranspiration rates due to lack of mature trees, but data do not allow for the distinction.

the parcel layers to residential properties. Using the percentage of lawn areas out of residential acres and potential reduced water consumption per acre, we estimated water savings from sprinkling per acre per day under a certain percentage of program participation assumption.

Estimation of Water Savings

Clothes washers and dishwashers are not subject to the State Plumbing Code regulation. Based on the CEEP survey, it was identified that 99% of households have clothes washers, and among them only 20% have efficient clothes washers. Potential water savings from efficient clothes washers range from 4.0 to 6.5 gallons per capita per day (gpcd) (FEMP, 2002; PNNL, 2002). Seventy-seven percent of households owned dishwashers, and only 20% of them have efficient dishwashers. Potential water savings from efficient dishwashers range from 0.4 to 1.0 gpcd (DRBC, 2002; Vickers, 2001). As an example, Table 22.7 summarizes procedures and estimates of potential water savings from CTP with respect to clothes washers.

Table 22.7. Potential water savings from clothes washers program (2010)

Estimation procedures	Estimates
Number of households in 2000: 2000 Census	189,017
Number of households in 2010: Delaware Population Consortium	207,988
Number of persons in a household in 2010: Delaware Population Consortium	2.65
Number of households with CW in 2000 (eligible households): 99%	187,127
Percentage of households with efficient CWs in 1992: CEEP survey	20.0%
Percentage of households with efficient CWs in 2010: a 1% annual improvement	24.2%
Number of households with inefficient CWs in 2010 (target households)	141,842
Number of households with potential program participation: 65% in 2010	92,197
Potential water savings (mg/yr.): 5.6 gpcd (DeOreo, 2001)	499.4
Potential water savings (mg/yr.): 4.0 gpcd (FEMP, 2002)	354.9
Potential water savings (mg/yr.): 6.5 gpcd (PNNL, 2002)	577.9
Potential water savings (mg/yr.): 5.9 gpcd (Vickers, 2001)	526.1
Potential water savings (million gallons per day)	0.97-1.58

Since faucets, toilets and showerheads are all subject to the State Plumbing Code regulation, their estimation procedures of water savings are different from those of clothes washers and dishwashers. New residential housing units built or renovated after 1991 are supposed to have efficient plumbing facilities because of the regulation. Our target units in 2010 are based on the 1992 housing stocks (with inefficient faucets, toilets and showerheads) minus those housing units to install efficient plumbing fixtures according to an annual 2% AEEI. In case of faucets, those households with efficient faucets were only 23% in 1991 (based on the CEEP survey) and are expected

to increase to 27.8% in 2010 due to a 2% automatic annual efficiency improvement. Potential water savings from efficient faucets range from 1.2 to 2.7 gpcd (DeOreo, 2001 and Vickers, 2001). Using the same approach, water savings from low-consumption toilets and low-flow showerheads are estimated.

In the case of lawn sprinklers, a completely different approach was used. Instead of housing units as a basic unit of analysis, outdoor water savings are estimated on the basis of lawn acreage and potential water savings per acre (McCann, 1994). According to Robbins et al. 2002, lawn area is usually 60% of residentially-zoned land area. This figure was adjusted by both the CEEP survey result and a 2% automatic efficiency improvement. The survey shows that one-quarter of those households who have a lawn and/or gardens did not water at all during the summer. Using this adjusted figure, potential water savings from sprinkling management are estimated to be 1.63 mgd (Table 22.8).

Table 22.8. Potential water savings from sprinkling management during peak seasons

Estimation procedures	Estimates
Residentially-zoned land area in 2000 (acres)	200,732
Proportion of lawn area in 2000 (acres): Robbins	60.0%
Estimated size of lawn area in 2000	120,439
Estimated size of lawn area in 2010: Assuming the same proportion of lawn acre to household size as the 2000 case	132,527
Program participation rate	3%
Participating lawn acreage	3,976
Potential water savings from sprinkling management (mg/yr.): 450 g/acre (McCann, 1994)	595.0
Potential water savings (million gallons per day)	1.63

Potential water savings from the above selected indoor and outdoor conservation technologies are shown in Table 22.9. Due to the significant variations in estimated savings, the median estimate of each technology is also used in the analysis. The following summary table shows both range and median. The effective water savings become in the range from 6 to 11 mgd with median of 8 mgd by reducing 12% water losses.

Major Barriers to WCOR and CTP

Given the potentially powerful effects of WCOR and CTP in the Wilmington metropolitan area as discussed above, care should be taken in implementing them. Successful implementation of these programs is contingent upon a

Table 22.9. Summary of potential water savings from CTPs (mgd)

Conservation technologies	Water savings	
	Range	Median
Clothes Washers	0.97~1.58	1.37
Dishwashers	0.08~0.19	0.13
Faucet Restrictors	0.23~0.51	0.26
Ultra Low-Consumption Toilets	1.89~2.92	2.36
Low-Flow Showerheads	0.04~0.72	0.24
Sprinkling Management	2.16~3.60	2.88
Indoor and Outdoor Water Savings	5.37~9.52	7.24
Effective Water Savings (Including unaccounted for water rate of 12%)	6.01~10.66	8.11

utility’s current rate structure, conservation programs, awareness of consumers, system operating characteristics, potentially adverse impacts on customers, billing and implementation issues, the state’s current regulatory supports, etc. The following are some implementation strategies to address major barriers to the WCOR and/or the CTP adoption.

- WCOR can be implemented during the drought emergency period declared by state or local government;
- Price hikes need to be significant enough to affect their water consumption behavior;
- Public awareness of WCOR and CTP is critically important. Changes need to be publicized in advance via media and also bill inserts to customers. These programs are only effective if they are known to customers in an appropriate time frame and are also simple enough to be broadly understood;
- Potential adverse impacts on customers need to be considered. Price hikes usually generate revenue surplus for a given utility because water demand is relatively inelastic, but they are regressive to the low-income group. A minimal amount of necessary water needs to be designated in order to address negative impacts on the low-income group and provide for equity in basic water needs;
- CTP may raise prices for customers due to reduced revenue from its implementation. CTP may discriminate low-income customers because they are less likely to take advantage of CTP, but pay higher prices. Revenue surplus possibly from WCOR is less of a concern in comparison to shortfalls. The excess utility revenues can be captured by several adjustment mechanisms, including taxes to improve low-income equity issue (Merrifield and Collinge, 1999);

- A close review of the rate structures and conservation programs of the unregulated utilities should be undertaken to determine if WCOR and CTP would help reduce significant water consumption in their systems during the summer droughts;
- Revenue volatility always exists in the implementation of WCOR and CTP. Implementing WCOR and CTP programs are learning experiences, requiring certain mechanisms to address volatility. They include the creation of a contingency fund, inclusion of a risk margin in calculation of revenue requirements, an automatic rate adjustment, and frequent rate adjustments (Chesnutt et al. 1996);
- The state needs to coordinate water utilities regarding implementation of WCOR and CTP programs. Monitoring, data collection, and evaluation of these programs also need to be also coordinated by the state. Governor Gary Locke of the state of Washington has signed into law a water reform measure that offers, among other benefits, a tax incentive for water utilities to conserve and reuse water. Under this measure, the tax rate would be reduced to about 1.25% from about 5% in cases where the water is conserved or reused;
- The State Public Service or Utility Commissions are one vehicle to advance implementation of WCOR and CTP programs, since sometimes they are asked to look at a number of types of WCOR and/or CTP programs and select appropriate alternative(s) for those under their jurisdiction by their State General Assembly. Currently, most municipal water systems are not regulated by Public Service Commission; and
- Unless there is the legislative resolution or governor's 'executive order' to adopt a WCOR and CTP option county- or state-wide, WCOR and CTP will be limited if adopted only by PSC. Otherwise, it may appear that some customers of investor-owned water utilities are subject to paying penalties for excess water usage, whereas customers of municipal water systems are not. WCOR and CTP programs need to be applied on a non-discriminatory basis.

Water Savings: Reduced Withdrawal

Water savings potential from both residential WCOR and CTP programs in the Wilmington metropolitan area are estimated to be in the range of 11~17 mgd (4.8~6.3 mgd from WCOR and 6.0~10.7 mgd from CTP).^{xxiii} The estimated minimum savings are less than what is forecasted to be needed during drought seasons in 2010 (15 mgd), but the maximum savings

^{xxiii} It can be argued that water savings may be underestimated because synergic effects of both programs are not considered. Utility revenue issues associated with CTP is not fully considered due to limited information on program costs and additional investment costs incurred during summer peak.

exceed the target. Considering the fact that these savings are only from the residential sector, any gap between supply and demand can be easily resolved through water conservation programs if they include the other sectors. Some studies show that the commercial and industrial sectors may have higher potentials for water savings than the residential sector (Vista et al. 1997).

Reduced Intakes from Stream Flows

As a means of exploring impacts of WCORs and CTPs on stream flows in the Christina River Basin, a scenario approach is adopted to estimate potential reduction in water intakes from three utilities that withdraw water from BC or WCC.^{xxiv} Stream flows are also affected by heavy use of groundwater sources because a lot of groundwater comes from shallower aquifers that draw from the same runoff that feeds freshwater ecosystems – but that is not in this model.^{xxv} In order to estimate potential reduction in water intake from the streams, water savings from WCORs and CTPs by each utility were first estimated.

For Scenarios I and II, we used two saving figures (10% and 13%) that are revenue neutral and equitable WCORs for use during drought summer months. These saving percentages are derived from the cases where the 20% marginal price increase is applied to consumption above 12,000 gallons and the 35% marginal price increase above 15,000 gallons during the summer quarter. A 20% -12,000 gallon scenario is estimated to achieve a 10% reduction in residential water consumption, whereas a 35%-15,000 gallon scenario represents a 13% reduction. Daily water savings per utility were estimated by the following formula:

$$DDR = RPD * SR * (1 + UR)$$

where, DDR : Residential daily peak water savings from the WCOR
 RPD : Residential daily peak water demand
 SR : Water savings rate from the WCOR
 UR : Unaccounted-for-water rates

The results of the estimate are shown in Table 22.10. The city of Wilmington is expected to reduce water intake from the Brandywine Creek

^{xxiv} Scenarios I and II are solely based on WCOR in the residential sector, and another two Scenarios (III and IV) are derived from residential CTP. Scenarios V and VI include both WCOR and CTP.

^{xxv} Over-drafting of groundwater can rob streams and rivers of a significant fraction of their flow, whereas pollution can render aquifers unfit for human use and degrade water quality in adjacent freshwater ecosystems (Johnson et al. 2001). In a study of 54 streams in different parts of the country, the U.S. Geological Survey (USGS) found that groundwater is the source for more than half the flow (on average). While providing surface bodies with enough water to keep them stable, aquifers also help prevent them from flooding (Sampat, 2000).

Table 22.10. Daily water savings of residential peak consumption: WCORs

Utility	Peak daily (mgd)	Savings rate (%)	Unaccounted-for-water rates (%)	Daily savings (mgd)
		10		0.94
City of Wilmington	8.31	13	13.0	1.22
		10		0.78
United Water Delaware	7.08	13	9.05	1.00
		10		0.05
City of Newark	0.46	13	13.0	0.07
		10		1.77
Total/Average	15.85	13	11.2	2.29

by 0.94 mgd in Scenario I and 1.22 mgd in Scenario II. United Water Delaware and the city of Newark are expected to withdraw less water from the White Clay Creek by 0.78 mgd (1.00 mgd in Scenario II) and 0.05 mgd (0.07 mgd in Scenario II), respectively, during summer droughts. Total daily peak savings in the residential sector are expected to range from 1.77 mgd to 2.29 mgd.

CTPs are estimated to contribute to effective water savings in the residential sector by 6.0 to 10.7 mgd with a median of 8.1 mgd as shown in Table 22.9. As the residential peak water demand is estimated at 42.9 mgd in 2010, this leads to water savings ranging from 14 to 25%, with median savings of 16%. Based on the following formula, potential water savings from the CTP are estimated and shown in Table 22.11. Water savings from CTPs for all three utility areas that withdraw water from both streams are expected to range from 2.47 mgd to 4.41 mgd. The city of Newark has the smallest impact among three utilities because of a small population.

Table 22.11. Daily water savings of residential peak consumption: CTPs

Utility	Peak daily (mgd)	Savings rate (%)	Unaccounted-for-water rates (%)	Daily savings (mgd)
		14		1.31
City of Wilmington	8.31	25	13.0	2.35
		14		1.08
United Water Delaware	7.08	25	9.05	1.93
		14		0.07
City of Newark	0.46	25	13.0	0.13
		14		2.47
Total/Average	15.85	25	11.2	4.41

$$CTP = RPD * (1 + UR)$$

where, CTP : Residential daily peak water savings from the CTP
 RPD : Residential daily peak water demand
 UR : Unaccounted-for-water rates

Table 22.12 summarizes expected daily peak water savings for three utilities by each scenario. The city of Wilmington shows the largest savings, ranging from 0.94 mgd to 3.57 mgd, whereas the city of Newark is expected to reduce withdraws of water during the summer months, ranging from 0.05 mgd to 0.20 mgd. Overall, Scenario IV, which combines high residential peak savings from the WCOR (Scenario II) with CTP peak savings (Scenario IV), conserves the most at 6.70 mgd during the drought summer.

Table 22.12. Expected daily peak water savings by utilities

(Unit: mgd)				
Scenario	City of wilmington	United water delaware	City of newark	Total impact
• Scenario I: 35%-12,000 gal	0.94	0.78	0.05	1.77
• Scenario II: 35%-15,000 gal	1.22	1.00	0.07	2.29
• Scenario III: min. CTP	1.31	1.08	0.07	2.47
• Scenario IV: max. CTP	2.35	1.93	0.13	4.41
• Scenario V: Scn. I + Scn. III	2.25	1.86	0.12	4.24
• Scenario VI: Scn.II +Scn.IV	3.57	2.93	0.20	6.70

Impacts on Stream Flows

During July of 1999, the Wilmington metropolitan area experienced a record drought. Using the month of July as a baseline, our analysis explores how conservation can reduce water intakes by the utilities to reduce the number of days spent below 7Q10 low-flow standards.

The results of our Scenarios IV, V and VI are displayed in Table 22.13. The savings figures are added to July 1999 stream flow records (provided by Delaware’s Water Resources Agency) at each utility intake site to calculate the additional daily stream flow achieved under each conservation scenario. The augmented daily stream flows are then juxtaposed against 7Q10 levels to determine the number of days spent below critical levels. Especially significant is the case of the United Water Delaware intake at Smalley’s Pond, where applying any conservation scenario would reduce the number of days below 7Q10 from 16 to 1. The United Water intake on WCC also achieved significant savings, where Scenarios IV and V result in 1 day below 7Q10, and no days are below in Scenario VI. For the basin as a whole, we see that by implementing the scenarios, the number of days below 7Q10 can be reduced by 26 days from the basin total of 57 days.

Table 22.13. Number of days spent below critical 7Q10 levels, July 1999

Scenario	BC Wilmington	WCC Newark	WCC UWD	Christina UWD	Basin totals
Observed	7	29	5	16	57
Scenario IV	4	26	1	1	32
Scenario V	4	26	1	1	32
Scenario VI	4	23	0	1	31

CONCLUSIONS

A few general conclusions can be reached as a result of the analysis considered above. It is evident that WCOR and CTP programs that promote water conservation can produce an effective reduction in water consumption in urban areas during drought. This analysis shows conclusively that future water demand for the Wilmington metropolitan area can be met through the introduction of a WCOR option. The analysis also shows that the combined WCOR and CTP programs could meet the 15 mgd gap in 2010 – even with the condition of 7Q10 applied to both WCC and BC. Furthermore, the lower income group need not be subjected to an inequitable fiscal burden.

An indirect, but significant advantage of the combined conservation option is its positive E^4 consequence. The reduction in the consumption of water allows for an increased amount of water to remain in the natural environment, thus supporting ecology, potentially mitigating saltwater intrusion in coastal cities, and perhaps even eliminating need for environmentally and socially questionable water supply augmentation options. Water conservation also leads to energy and economic savings. Energy consumption is reduced vis-à-vis utilization of water efficient appliances, and lowered energy needs associated with withdrawal from surface and groundwater and discharge of wastewater. Customers also enjoy immediate economic benefits through lowered bills. Compared to supply-side options, conservation can be achieved without seriously burdening under-privileged residents or downstream residents, and also enhances opportunity for participation by residents and localized communities in water management processes (Smith Jr., 2003a, b). The efficient use of water improves the E^4 balance, enhancing urban sustainability, especially during the course of droughts in urban areas.

Overall, adopting the combined conservation program is a viable option. It has been established in this chapter that by employing the conservation options, and it is possible to achieve an efficient outcome without sacrificing equity requirements. The advantages of this program are that it satisfies

with minimal regulation the quadruple objectives of water conservation, namely:

- Improving efficiency;
- Providing revenue neutrality;
- Assuring distributional equity; and
- Enhancing stream ecology.

Even though there are stellar examples of benefits of water conservation as indicated above, most utilities in urban areas have only scratched the surface of what is possible in their service areas. Even where some of the best funded and most promising water conservation programs exist, the majority of urban water agencies rely on voluntary practices and programs that are not comprehensive are incompletely implemented, and are inadequately monitored (Gleick, 2001). As Vickers (2001) indicates, to achieve impressive water savings, we need a combination of elements: leadership; political will; commitment to more sustainable water supply and wastewater systems; and concern about long-term costs to consumers. Most important is an understanding of, and strategic investment in, large-scale, innovative, yet dependable, water-efficiency technologies and pricing policies.

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Section 4
Human Rights

Introduction to Human Rights Section

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As has been discussed so far in the book, water is seen differently by different people. It can be seen a commodity, a global common, as a basic human right or a sacred resource divinity.

Water as a global common (as oceans, lakes), or common resource pool such as lake and pond means it is owned by the community. The concept of commons is more easily acceptable when it is a small body and shared by local people together, but as the size of the water body gets bigger the complexities increase and conflicts arise (especially if water is shared between states or countries). The problems get more complex in the case of a river because of upstream vs downstream communities – water gets polluted when the water flows downstream if the users upstream are not considerate (especially if there are a lot of industries located upstream or proper sewage system is not available). Water can be seen as a global common, a natural resource which supports the humanity as a whole but it raises certain questions and dilemmas such as if it is a community resource an individual's rights would be decided by the community as a whole. The problem then becomes complicated when in urban water supply where an agency (private or public) supplies water to the citizens – then who decides how much does the water cost?

Water as a commodity

Water can be described as an economic and social good. Although, not everyone agrees to this point of view, but technically water can be considered as a commodity when used in large quantities in commercial agriculture,

industries, hotels, for recreational purposes like swimming pools and maintaining big gardens, golf parks in deserts.

Water as a basic right

Water is the basic necessity to sustain life, which means it is not only a basic right but also a human right. This is further discussed by Rosseman in his chapter in this section. Water is essential for life – not only for human beings but for all the living species. When the term ‘human right’ is used – will it be the duty of the community or of some level of the Government (municipal, provincial or national) to supply safe drinking water to all? Who would enforce it? Can the Government licence it to a private company and let them charge for water for full recovery of cost or should water be free? It can be argued that like water, food is also a basic necessity of life but no one has ever argued that food should be made available free to all, however, the counter argument can then be that water occurs naturally while food needs to be grown (which means growing food needs investment while water is available in nature like fruits in forests. Though, with the decreasing quality of water, it needs to be purified, pumped and supplied which also means maintenance of the supply system). Rosemman in his second chapter puts forward some ways on how to finance water for all – considering it a basic human right.

Water as a sacred resource divinity

At some places rivers (and water bodies) are seen as sacred and divine. According to Eastern philosophy nature must be preserved and conserved, some philosophers have even written that nature must be worshiped. For example, Koran mentions the fact that the natural world is loaned from God. Sages of Atharva Veda used to chant in their hymn to earth, “What of thee I dig out, let that quickly grow over, let me not hit thy vitals, or thy heart”—because as Brishspati said, the bodies of living beings are created with fire fundamental elements: earth, water, fire, sky and air. So if human race has to survive we must preserve the nature (including water) and live in harmony with it. Even T.S. Eliot in a passage in his third quartet of the *Four Quartets* has written:

*I do not know much about gods; but I think that the river
Is a strong brown god—sullen, untamed and intractable,
Patient to some degree, at first recognised as a frontier;
Useful, untrustworthy, as a conveyor of commerce;
Then only a problem confronting the builder of bridges.
The problem once solved, the brown god is almost forgotten
By the dwellers in cities—ever, however, implacable.
Keeping his seasons and rages, destroyer, reminder
Of what men choose to forget. Unhonoured, unpropitiated
By worshippers of the machine, but waiting, watching and waiting.*

*His rhythm was present in the nursery bedroom,
In the rank ailanthus of the April dooryard,
In the smell of grapes on the autumn table,
And the evening circle in the winter gaslight.
The river is within us, the sea is all about us;
The sea is the land's edge also, the granite
Into which it reaches, the beaches where it tosses
Its hints of earlier and other creation:
The starfish, the horseshoe crab, the whale's backbone;
The pools where it offers to our curiosity
The more delicate algae and the sea anemone.
It tosses up our losses, the torn seine,
The shattered lobsterpot, the broken oar
And the gear of foreign dead men. The sea has many voices,
Many gods and many voices.*

Source: <http://www.tristan.icom43.net/quartets/salvages.html>

In his chapter, Roseman argues why water should be considered as a human right and what implications and obligations it would have for Governments, corporations and civil society. The last chapter in this section by Roseman discusses different financing options for funding water infrastructure – while still arguing that is water a human right and an obligation for the Governments to provide safe and sufficient drinking water to all.

Water: A Human Right

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The United Nations Committee on Economic, Social and Cultural Rights stated in 2002: “Water is a limited natural resource and a public good fundamental for life and health. The human right to water is indispensable for leading a life in human dignity.”ⁱ This chapter will outline how the definition of a sustainable access to water as a human right can help to challenge the global lack of safe, clean and affordable water. In order to explain this role, the description will focus on two predominant levels and scopes of action: the normative provisions of the United Nations with respect to the Millennium Development Goal and the demand to consider water supply and wastewater disposal a human right.

Water – A Rare but Basic Need

Water is essential for human beings to survive and develop. At the same time water is a scarce resource, sometimes the shortage is acute enough to cause crises. Both facts lead to the simple conclusion that lack of water hinders development and the right to live in dignity. According to figures published by the United Nations, subsidiary organizations and other international organizations (United Nations, 2003), 1.1 billion people are without sufficient access to water and 2.4 billion people have to live without adequate sanitation. Estimated 2.4 billion people are suffering from water-related diseases and the World Health Organization reckons that 80% of all diseases can be contributed to poor water conditions. Under these trends the prognosis is that by 2025, of a total population of 8.5 billion

ⁱ Committee on ESCR, General Comment No. 15, E/C.12/2002/11 (November 26, 2002)

about 3 billion people will suffer from water shortage. Eighty-three per cent of them will be in developing countries, mostly in rural areas where even today about 20% of the population have access to a sufficient water supply.

This actual lack of water is opposed by the theoretical fact that there is enough groundwater in all regions of the world to guarantee an adequate water supply for all people. According to the international law in the case of concurring water users the socioeconomic priorities depend on human development and social interests of the people.ⁱⁱ Freshwater is mainly used by agriculture farms (70%) followed by industrial use (20%) and only 6% of it is used by households. This leads to the conclusion that water shortage and the unequal distribution of water are global problems rather than regional problems and therefore require international solutions.

Water – a basic need becomes a Millennium Development Goal

International conferences dealing with water and related issues such as health, environment and development can be traced back to the late 1970s. Some of the milestone international developments are the Water Conference in Mar del Plata 1977, which declared the access to water as a basic needⁱⁱⁱ; the International Decade of Water and Sanitation (1981-1990), that developed the goal to provide access to safe drinking water to everyone by 2000^{iv}; and the declaration of March 21 as the World Day for Water.^v Although these international efforts missed the goal of giving access to safe water to everyone, they did mobilize the resources to provide additional 600-800 million people with access to water.

It can be stated that, after decades of international debates, conferences and political declarations on the improvement of water supply, very limited action has happened on the ground with a very little improvement of water supplies. Therefore, at the end of the Global Consultation on Safe Water and Sanitation it was concluded, that some water for all is better than enough water for few.^{vi}

The main shift in the perspective came with the Millennium Assembly in 2000 and its declaration of access to water and sanitation as a Millennium

ⁱⁱ Article 5, 10 of Convention on the Law of the Non-navigational Uses of International Watercourses, adopted by UN General Assembly Resolution 51/229 of May 21, 1997, U.N. Doc. A/RES/51/869

ⁱⁱⁱ Mar del Plata (March 14-25, 1977) Programme of Action, U.C. Doc. E/CONF.70/29

^{iv} General Assembly Resolution 35/18 "Proclamation of the International Drinking Water Supply and Sanitation Decade" of November 10, 1980, U.N. Doc. A/RES/35/18

^v General Assembly Resolution 47/193 "Observance of World Day for Water" of December 22, 1992, U.N. Doc. A/RES/47/193

^{vi} New Delhi Statement, Global Consultation on Safe Water and Sanitation for the 1990's on file with author.

Development Goal^{vii}. Adopting the Millennium Declaration, the international community committed itself to halve the number of people without sufficient access to safe water and to sanitation by 2015. The Millennium Development Goals share a common motivation and constitute a new and ongoing commitment to sustainable and balanced development (UNDP, 2003). While in the 1990s some nations developed at a faster rate than others, Millennium Development Goals try to leave no nation behind. But considering the recent development and progress into account (UNDP, 2004), the prognoses after the first five out of fifteen years is that the goal to provide access to safe drinking water will be met only in South Asia, Latin America and the Caribbean. It is expected that by 2100 there would be access to safe drinking water and sanitation in East Asia, the Pacific region, South Asia and Latin America. In Sub-Sahara Africa no prognosis can be made for sanitation because the situation is worsening instead of improving.

Water – A Basic Beed Becomes a Human Right

Although the great number of world conferences, declarations and action programmes have had little practical impact, these have helped in sensitizing governments and international actors with respect to the issue of water shortage and the human right to water. Due to this sensitization the institutions, bodies and agencies of the United Nations are increasingly discussing the issue of water shortage from the standpoint of other endangered human rights, such as the right to food, health, shelter, education and development.

A human right can be seen as a universal and indivisible standard that provides equality and outlaws discrimination. Human rights call for participation and inclusion, guided by accountability and the rule of law. The protection of a human right, such as the human right to water, starts with the definition of the normative demand of the right by setting of international agreed standards. These norms have to be implemented nationally and might be overseen and guided internationally. This international monitoring and implementation functions either within the treaty based quasi-judicial proceedings and guidance throughout international treaties bodies such as the UN Committee on Economic, Social and Cultural Rights^{viii} or by the Charter-based general mandate of the United Nations for human rights protection. Within the latter the General Assembly and its subsidiaries, such

^{vii} United Nations Millennium Declaration, General Assembly Resolution 55/2 of September 8, 2000, U.N.Doc. A/RES/55/2

^{viii} Set up by Economic and Social Council Resolution 1985/17 of May 28, 1985, U.N. Doc. E/RES/1985/17; approved by General Assembly Resolution 40/114 of December 13, 1985, U.N. Doc. A/RES/40/144

as the Economic and Social Council, Commission on Human Rights and the Sub-Commission on the Promotion and Protection of Human Rights, are able to make recommendations^{ix} and to encourage the progressive development of international law as part of the Charta-based human rights protection mechanisms.^x

The advantage of the human rights approach is that the needs must be satisfied and the human rights must be respected, protected and implemented. It is not absolutely necessary for needs to be satisfied by means of legal (human) rights. However, by recognizing the human right to water, decision makers and actors whose decisions have an impact on the access and accessibility of water are responsible for satisfying the needs to the greatest possible extent. The benefit of access to water and sanitation as a human right is that one enlarges the political and economical debates about needs to an international discourse of standard setting, national and international implementation as well as monitoring.

This socio-economic priority of individual use of water for development and human dignity becomes even more important if different water uses stand in competition. The human right to water lays the decision about rival water users in the hand of the people who need an access to water and sanitation most. In other words, the human right to water shifts the participation from a merely political decision about socioeconomic priorities to an economic democracy with the human being in its centre. The human rights approach is deconstructing power relationships, such as economic and political interests, that hinder the satisfaction of basic needs. By recognizing a basic need as a human right exercised political power becomes legitimized if its objective is the fulfilment of human rights and economic power is legitimized as long as it does not obstruct the individual or collective satisfaction of human rights.

The human right approach to basic needs urges public authorities to provide a legal framework that serves economic interests as well as socioeconomic priorities for human development. In order to enable concerned people to participate in decision-making processes about water issues the human rights approach, linked with the notion of democracy, calls for certain information about objectives and means of public and private water policies. Furthermore people have to be empowered to practically participate in public and economic affairs on equal footing. In addition the human rights approach also introduces the concept of accountability and responsibility – thus holding actors with power to influence the access to water and sanitation accountable.

^{ix} Article 62, Para. 2 Charter of the United Nations (adopted on June 26, 1945 and entered into force on October 24, 1945) 557 U.N.T.S 143

^x Article 13 lit. (a) Charter of the United Nations (adopted on June 26, 1945 and entered into force on October 24, 1945) 557 U.N.T.S 143

Finally, the human rights approach to basic needs brings out that the core obligations of the human right to water – which is a basic framework that is necessary to provide a minimum standard of living – are regarded as compulsory norms (*jus cogens*) of the international law. This means that provisions of human rights become inalienable components of the law which apply to everyone (*erga omnes*). Thus, any violating provisions are null and void.

The Human Right to Water and its Relation to Other Human Rights

The normative demand for the Human Right to Water is derived from the Universal Declaration of Human Rights, which has arguably recognized implicitly the right to drinking water and sanitation in article 25 (1), which states that “everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care ...”. It is restated in article 11 of the International Convention on Economic, Social and Cultural Rights as part of the right of everyone to an adequate standard of living for himself and his family.^{xi} In previous comments by the UN Committee on Economic, Social and Cultural Rights^{xii} as well as in various human rights protection mechanisms the human right to water is recognized as a precondition for other human rights – such as the human right to live, to appropriate nutrition and sufficient medical care.

Apart from being the precondition for other human rights, the human right to water has its own contents and protective duty. As outlined in General Comment Number 15 by the UN Committee on Economic, Social and Cultural Rights^{xiii}, the Human Right to Water aims at guaranteeing that all people have the right to non-discriminatory and fair access to safe, sufficient and affordable drinking water in order to satisfy their personal needs (such as the preparation of food, the use of water for sanitary facilities and for domestic consumption). Safe drinking water means that the water quality must not jeopardize peoples’ health. Affordable water means that the expenditure for water must not jeopardize the fulfilment of other basic needs that are guaranteed by human rights – such as the right to education and food.

In addition to the function of a precondition for other human rights and its own content, further rights are derived from the human right to water, which are considered a prerequisite to actually implement the right to

^{xi} Adopted by General Assembly Resolution 2200 A (XXI) of December 16, 1966; ICESCR entered into force on January 03, 1976 U.N. Doc. A/RES/2200 A (XXI)

^{xii} See among other the General Comment No. 12 (1999) with regard to the right to food and No. 15 (2000) with regard to the right to health; U.N. Doc. HRI/GEN/1/Rev.5

^{xiii} Adopted on November 26, 2002, U.N. Doc. E/C.12/2002/11

water. These are, among others: the right to have access to existing water supply systems without being discriminated against, the ban on destroying or separating existing water supply systems, the right to have priority over industrial or agro-industrial water use, the right to be supported in case of financial problems, and the right to information and participation in national and local water policies. If water is supplied by private companies, there is also the right to governmental regulation in order to guarantee that these private companies comply with the duties stipulated by the human right to water.

Core Obligations Under the Human Right to Water

The benefit of defining the basic need for sufficient water as a human right is that general obligations and particular duties ensue from such a qualification. These duties comprise among others:

- the duty of a state to respect, protect and implement the human right to water;
- the duty of a state to respect the human right to water in other countries, i.e. not to interfere with the fulfilment of other governments' duties to respect the right to water;
- the duty of a state to contribute to the fulfilment of the human right to water in other countries by means of international cooperation;
- the duty of a state to prevent and stop violations of the human right to water and to make no decisions that jeopardize the fulfilment of the human right to water in one's own country or in other countries. This can be done within the framework of affiliation in international organizations;
- the duty of international organizations to respect the human right to water and to contribute to its fulfilment by means of international cooperation;
- the duty of non-state actors, such as companies or individual persons, to respect the human right to water and to support its implementation within their own scope of action.

These duties should all be stipulated in a national water strategy. This strategy ought to be based on human rights in general and on the human right to water in particular. It should assign governmental and institutional responsibilities to the duties mentioned above.

With respect to the government's fundamental freedom of choice when to take steps or to develop political approaches, the human right to water has core obligations which are not subject to this principle of free choice. These core obligations must be ensured even in times of scarce resources or in a state of emergency. Core obligations include the most basic forms of the Human Right to Water such as:

- non-discriminatory and regular access to a minimum of safe drinking water for personal and domestic use and
- access to simple – yet hygienically acceptable – wastewater disposal and sanitary infrastructure.

Violation of the Human Right to Water

As described above, a benefit for describing the basic need of access to safe water and sufficient sanitation as a human right is the relationship between the rights holder and the duty bearer. The rights of the one correlate with the obligations of the other. If the specific duties which arise of the general obligations are not fulfilled, the clear definition of the rights and the duties under the human right to water makes it easy to describe violations of the human right as holding the relevant actors responsible.

From this perspective those countries who violate the human right to water do not act in good faith and fail to explain why they do not comply with their core obligations. A decisive factor to determine whether such a violation has taken place or not is to assess the resources deployed by the state. If a state has not deployed a maximum of available resources to guarantee a basic supply of drinking water and sanitation to ensure that access to the existing systems is non-discriminatory, or to prevent companies from establishing an unfair price system and excessive charges, the human right to water is violated.

Violations of the human right to water on part of the state may also be manifested indirectly. Among these indirect violations are: the lack of laws to regulate water companies, the insufficient enforcement of existing laws or the lack of a national water strategy. The state violates its protective duties if it fails to stop individual persons, groups, companies or other non-state actors from interfering.

The duty to respect the human rights in other countries is violated if there are no regulations concerning the use of water resources and, as a result, these resources are used to one's own benefit. The duty to international cooperation is violated if developed countries do not aim at reducing the developing countries' debt burden in order to improve their water supply and sanitary infrastructure.

The Human Right to Water as a Framework for Privatization

As described above, government's interference with exercising the human right to water possibly causes a violation of the human right. This might be the case when formerly public-owned water facilities are privatized, privatization as such may represent a violation when no mechanisms of fair pricing, affordable services and participation are introduced during

the process of privatizing water supply and wastewater disposal systems. Although certain risks are involved with privatization, the privatization per se is not a human rights violation, nor is the recognition of water as an economic commodity.

Governments are free to decide whether they want to have public or private water supply in order to implement the human right to water. However the kind of water supply has to be from the commodification of water. This means that water is a basic need and as such a social and public commodity which also has an environmental value and must therefore be used in such a way that these values are linked to one another in a sensible and sustainable way. One should not undermine the economic value of water for a commercial use.

If water and wastewater services are supplied by private companies, governments are obliged to give priority to the protection of human rights over economic policy and international trade treaties. More concretely, they are obliged to regulate and control water consumption and water supply. This control should be based on the understanding that water may have an economic value, but it cannot be considered a commodity that can be left to self-regulation in the markets. This is the difference between economic value and commercial use of water resources. In addition to that, water can only be supplied by a monopoly due to the fact that it is liquid. In contrast to other goods that can be counted, mixed or separated, such as power supply or telecommunications, competitive water supply structures are both technically and financially impossible. Thus, water demands monopolistic supply structures. This does not restrict the profit motive of water suppliers in the sense of the market, but rather in an ethical, normative and legal sense as expressed in the human right to water.

If water privatization deteriorates the exercise of the human right to water, e.g. because supply costs have risen and water is not affordable any more, the government has the duty to justify the privatization by giving good reasons and weighing the different options. Even after privatization processes, governments are obliged to make sure that the poor have access to a basic water supply and sanitation.

The Human Right to Water as Guidance for Corporate Behaviour

Beside the indirect protection from corporate human rights abuses throughout official activities such as regulation and prosecution, another benefit of defining a basic need such as the access to water as a human right lies in the fact, that human rights put direct normative standards on corporations. Corporate behaviour might have different motivations. First and foremost the objective for all the corporations is to make profit. Due to the risk management it observes the law and because of market forces it

obeys the costumers demands. Since water is a natural resource there are almost no market forces that could lead to access to water and sanitation except that either a pipeline or access to water exists or not, and if so it will served by one provider.

The human right to water constitutes the framework for corporate behaviour in absence of market forces and law-based objectives. The human right to water goes far beyond the mere philanthropic behaviour for doing something good with profit. In addition the human rights approach to corporate accountability goes beyond the general principles of corporate social responsibility, by which corporations voluntarily accept standards for their conduct. The human rights approach constitutes the direct obligation that corporations within their respective spheres of activity and influence have the obligation to promote, secure the fulfilment of, respect, ensure respect of and protect human rights recognized in international as well as national law.^{xiv}

Under the general standard of the human right to water non-state actors, such as a private water providers, violate the human right to water if they make it physically or financially impossible to get access to water. Furthermore a corporation violates the human right to water if it pollutes the existing water supplies.

Satisfaction of Access to Water and Sanitation as a Basic Need

The access to water and sanitation, recognized in various international documents, such as the Rio Declaration and Agenda 21, Programme of Action of the World Summit on Sustainable Development or within the Millennium Declaration, strives for global efforts to satisfy this basic need. Global awareness building is necessary, but only the first step. Since political will is still lacking new approaches and innovative concepts have to be developed for implementation of ideas. One of these concepts is the idea of a World Water Contract (Petrella, 2001), which takes the state sovereignty of the ownership and use of water resources as a point of departure. In order to face the three global problems, such as no access to and degradation of water, as well as lack of international rules the World Water Contract calls for domestic constitutional changes in order to introduce greater accountability of public officials and more democratic participation via so called 'water parliaments'.

The idea of the World Water Contract has many innovative ideas but its state centred approach fails to address the main problem of unwilling and corrupt governments and corporate power. The idea of having public-

^{xiv} Para 1 of Norms on the responsibilities of transnational corporations and other business enterprises with regard to human rights approved by the Sub-Commission on the Promotion and Protection of Human Rights, U.N. Doc. E/CN.4/Sub.2/2003/12/Rev.2

private-society partnerships fails when the corrupt public-private partnership sets the civil society aside. Furthermore the role of civil society is over estimated. Civil society and its main actors, NGOs and Unions are watchdogs of political and economic power, but danger lies in the idea of blurring this monitoring function with the exercise of power and direct influence. Civil society serves to hold political and economic actors responsible. But if the civil society decides on its own, to whom will it be accountable? Therefore the proposal should be, to introduce a participatory process of concerned people with their right to organize themselves. Different interests have to be contested and it is not the role of the civil society to take the decision but to make proposals of which the most convincing one will be taken as well as to hold relevant actors accountable.

Implementation of the Human Right to Water

As outlined above the human rights approach to access to water and sanitation constitutes a framework for an individual or organized participation and for holding the relevant actors accountable. Since human rights have to be first of all implemented on a national level the main objective has to be the strengthening of the rule of law and the incorporation of basic standards of access, safety and sufficiency of water and sanitation into law. Therefore, the international formulation of framework laws and model legislations for domestic guidance is needed (Guissé, 2004). Such guidelines could assist the states to incorporate the human rights to water in their domestic legislation in order to assist service providers, regulatory bodies and individuals to recognize their rights and duties. Furthermore such standards will be able to clarify indicators for the violation of the human right to water.

Firstly, the General Comment on the right to water by the United Nations Committee on Economic, Social and Cultural Rights should serve as the point of departure. The definition of the duties, obligations and responsibilities under the human right to water should provide the foundation of further clarifications. Secondly, these clarifications should be developed in a consecutive and participatory process, which starts on an expert level, continues at the governmental and international level. With regard to the clarification of the work of the United Nations Sub-Commission on the Promotion and Protection of Human Rights is a helpful tool. This expert body focused recently on the human right to water and elaborated the need of guidelines for the implementation of the human right to water and affirmed that the access of everyone to drinking water supply is an individual and collective human right which must not be subject to any restriction but has to be subject to regulation and control by

the public authorities.^{xv} With view to the governmental and international level the United Nations Commission on Human Rights – a sub-body of the General Assembly that consists of elected member states of the United Nations and is monitored by all members, sub-organizations and accredited NGOs – is able to provide the right forum for introduction and discussion about human rights obligation.

Finally, this discourse might be able to be finalized in an International Convention. Such a Convention – as already demanded by an international coalition of NGOs (Baer, 2004) – will collect existing obligations under international law with regard to water in general and the human right to water in particular into one international treaty. Just like the Kyoto Protocol for climate change issues, an International Water Convention might assist and mobilize all relevant actors, set up a framework by international law and authorize sanctions for non-compliance.

Until these future but necessary steps are not taken, existing international human rights protection mechanism, such as the United Nations Committee on Economic, Social and Cultural Rights or the United Nations Committee on the Rights of the Child^{xvi}, should focus on the human right of water when reviewing states reports or adopting general comments and recommendations. Beside this treaty based human rights protection mechanism, the United Nations charter based human rights protection mechanism – among others the Commission on Human Rights, the Office of the High Commissioner of Human Rights and the various Special Rapporteurs – are able to focus more on the importance of the right to water within their specific mandates.

Lastly, the service provider – whether public or private – are obliged to incorporate the normative objectives of the human right to water as the right of every individual to have access to the amount of water required to meet his or her basic needs. This can be done by single adoption of corporate codes of conduct or joint efforts to formulate a common principle of corporate responsibility. International institutions, like the Global Compact Initiative of the United Nations^{xvii} or Business Leaders Initiative on Human Rights^{xviii} of former United Nations High Commissioner for Human Rights, Mary Robinson, should provide room for exchanging best practices and elaborate together with governments and civil society a common meaning of corporate responsibilities with regard to the human right to water.

^{xv} Resolution of the Sub-Commission “promotion of the realization of the right to drinking water and sanitation” of August 9, 2004, U.N. Doc. E/CN.4/Sub.2/2004/L.20

^{xvi} United Nations Committee on the Rights of the Child, established under article 43 of International Convention on the Rights of the Child, adopted by General Assembly Resolution 44/25 of November 20, 1989 and entered into force on September 2, 1990; U.N. Doc. A/RES/44/25

^{xvii} www.globalcompact.org

^{xviii} more information under www.respecteurope.com

CONCLUSION

While the basic need for safe, secure and sufficient access to water is still not fulfilled for approximately 1.1 billion people and circa 1.4 billion people lack sanitation, the normative demand of the human right to water is not the magic solution. But the human right approach elaborates duties, which call for remedy in the case of their breach. Human rights as part of the international law shifts the moral or philanthropic commitment to the legal basis of responsibilities. As Hans Corell said in his Lunchtime Lecture on the eve of his departure as Under Secretary General for Legal Affairs and Legal Counsel of the United Nations: "Sometimes international law is violated because of lack of resources. But all too often violations are intentional and committed with contempt. However, today there is also a threat to our common endeavour of a different kind: the attempts by some to belittle our efforts at the international level. There are those who even maintain that international law does not exist unless it suits their interests to invoke it in a particular situation. [If] they [these opinions – remark by the author] are not emphatically rebutted, they risk damaging all that the United Nations stands for."^{xix}

The definition of the human right to water reflects a common standard of obligations, both for states and for corporations that have to be implemented at a national and international level. This implementation needs awareness of the rights and duties under the human right to water, recognition of the obligations by the relevant actors with influence to the human right, empowerment of the rights holders to hold these actors accountable and a law-based participatory system, where this is possible.

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Financing the Human Right to Water as a Millennium Development Goal

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As elaborated in the previous chapter the human right to water aims at guaranteeing that all people have the non-discriminatory right to and fair access of safe, sufficient and affordable drinking water in order to satisfy their personal needs (such as the preparation of food, the use of water for sanitary facilities and for domestic consumption). Safe drinking water means that the water quality must not risk peoples' health. Affordable water means that the expenditure for water must not jeopardize the fulfilment of other basic needs that are guaranteed by human rights – such as the right to education and food. But these normative objectives are far from being attained. One billion people still lack access to sufficient water supply and about 2.4 billion people lack access to adequate sanitation. Lack of access to safe water and sanitation is mainly a problem of the developing countries. Within these countries, rural and disadvantaged urban areas are of the most concern as they have minimum number of people with access to water and lack sanitation. From these staggering figures, it is obvious that the implementation of the human right to water and the fulfilment of internationally agreed targets aimed at to improving access to drinking water and sanitation requires considerable funds.

With the world population growing and the already existing problem of lack of access to water and sanitation services to everyone and the ever shrinking public budgets on the other hand, there is a need for alternative solutions to raise the required investment. This chapter addresses among others the questions, if privatization, public-private-partnership and foreign

direct investment in the water sector can deliver the solution? Or does the Human Right to Water run the risk of being commercialized in a way that it becomes a luxury product, affordable just to those who can pay for an adequate water and sanitation service? In addition to the discussion on the risks of a pure commercial perspective this chapter will also focus on other solutions like cross subsidizing.

Water – Issue for Public Funding

From a historical perspective central governments and local authorities have played the major role in financing the water system. In developing countries – where the major need for investment lies – 90% of water and wastewater treatment infrastructure has public ownership of which 65-70% investment comes from public funding, 10-15% from development assistance as well as transnational corporations and 5% from local business (UNDP, 2003).

To reach the Agenda 21 objective of integrated international water policy additional costs of USD 20 billion per year is required. But in reality international development assistance in water and wastewater projects stagnated by 3 billion per year in the 1990s. Although this sum rose up to USD 3.5 billion between 1996-1998 it dropped again to USD 3.1 billion between 1999-2001. Compared to all development assistance – whether or not water was an international priority – the share of water and wastewater projects in national development budgets kept stable by 4-5% of the total funds.

Recent studies (Office of the High Commissioner for Human Rights, 2003) ascertained that between 1990 and 2000 a total of only 6% of households without water service worldwide got access to a water supply system. In sanitation, the figure stands at only 4%. Until now only 12% of multilateral and bilateral development assistance has flown into the projects in regions where 60% of the people have access to water and 40% of multilateral and bilateral development assistance is directed into projects where 70% have access to water. This shows that development assistance mainly goes into areas and sectors where infrastructure already exists instead of directing it for the poor and needy. Furthermore, bilateral development aid dropped by 12% since 1996, whereas the share of water and wastewater projects in national development budgets remained at 4-5%. Therefore the investment in projects concerning water and sanitation via bilateral development assistance is decreasing instead of increasing.

These observations are in contrast to the commitments of the Millennium Development Goals and the human right to water. Through the Millennium Declaration the international community pledged to half the number of people without access to safe drinking water and sanitation by 2015.

Considering that the world population could increase by 2015, an additional 100 million people will have to be provided with access to safe water per year and another 125 million people will need access to sanitation (United Nation 2003).

The funds required for investment in water infrastructure and sanitation differ with different agencies. According to the UN agencies additional USD 50 billion are required to meet MDG in general and from this USD 12.6 billion are required for water and sanitation (United Nation, 2003; UNDP, 2003). The *World Panel on Financing Water Infrastructure* submitted its final report at the 3rd *World Water Forum* in Kyoto 2003. This *Camdessus Report*, established that an additional investment of USD 10 billion per year is required to meet minimum standards and USD 17 billion per year are required to supply water access to urban areas. Furthermore an additional USD 32 billion per year would be needed for urban standard of sanitation (World Panel on Financing Water Infrastructure, 2003).

The question that arose from this difference between needed and allocated resources is, where should the difference in amount come from? Different approaches have been developed to respond to this question. The first possibility is to acquire further national money via cross subsidizing the water sector with tax-payers money. The second possibility is to acquire additional money by raising the cost of water. Another possibility at the national level is part privatization of water and sanitation services at the local level (Cooperatives) or at the national level to private business. All these possibilities lie within the national water strategy as well as socio-economic priorities of a country.

But the precondition for all the above-mentioned possibilities is that needed resources are available at the national level. In many cases either states are highly indebted or GDP is so low that socio-economic priorities cannot be served without foreign assistance. This assistance comes by either bilateral or multilateral development assistance or from private sector participation. The preconditions for these possibilities are (partial) privatization of public suppliers, a safe climate for investment, risk improvement for private companies, and the economic approach that considers water a commodity. Due to these preconditions, the governments are subject to international credit terms, investment treaties and private sector agreements, all of which reduce the national socio-economic scope of action.

Defining Development Standards as a Precondition for Investment

Another question that can be raised is, who is defining development goals and investment objectives? It is unfortunately common that within bilateral and multilateral development assistance there is less participation of

concerned people and local communities. It is very seldom that policies are defined from bottom up. Usually development goals and standards are agreed among governments and/or governments and corporations. This top down approach leads to the problem that the local and traditional knowledge about water treatment and use is not included into water strategies.

The Problem of Foreign Direct Investment / Private Sector Participation

Public resources on the national and international level are not able to meet the demand of investment and lack of political will to provide more resources is camouflaged by the call for private sector participation. The two main concepts of private sector participation are privatization and Public-Private-Partnerships (PPP). In the latter case, the state (or another public body) still remains a stakeholder with a certain degree of control. The involvement of the private sector ranges from management, concessions to build, operate or transfer a certain infrastructure to long lasting concession agreements. In the water and sanitation sector, concession agreements to private businesses are the usual PPP-form. Within these contracts the level of influence by the state or a regulatory office decides the fulfilment of the human rights obligations. But since PPP focuses on the micro-level it should be contested whether it is the appropriate form to meet the objectives of development cooperation which necessarily needs to focus on both the macro- and micro-level.

In addition to the conceptual and structural arguments on PPP, private international capital flows, particularly foreign direct investment (FDI) is seen as a vital complement to national and international development efforts. FDI should contribute towards financing sustained economic growth. To attract and enhance inflows of productive capital a transparent, stable and predictable investment climate, including proper contract enforcement and respect for property rights is required.ⁱ This means that the right of business to seek profit will have an impact on sustainable development and poverty reduction.

UNCTAD has indicated that the stock of outward FDI alone increased from USD 1.7 trillion to USD 6.6 trillion from 1990 to 2001 (Office of the High Commissioner for Human Rights, 2003). On the other hand, Africa remains a marginal recipient of FDI, although inflows did rise from USD 9 billion in 2000 to more than USD 17 billion in 2001, the majority of this increase was concentrated in large projects in Morocco and South Africa. Similarly, FDI in the 49 least developed countries (LDCs) was small in absolute terms. While levels did rise to USD 3.8 billion over 2002 in spite

ⁱ See: Monterrey Consensus, A/ CONF/189/11

of an overall economic slowdown, LDCs remained marginal recipients of FDI, accounting for only 2% of all FDI to developing countries or 0.5% of the global total. Finally only 5% of all investments in the water and sanitation sector were made by the private sector.

This conclusion leads to the question (Guissé, 2002), if private sector participation and FDI is an adequate approach of financing water infrastructure and wastewater treatment. In 2025 3 billion of 8.5 billion people on earth will suffer from water shortages, and of this 83% will be in developing countries (whereas today partly 80% are without sustainable and sufficient access to water).

Another issue is that private sector participation via FDI requires certain property rights for private investors. It has been observed that in public services, such as water, electricity or telecommunication FDI led to partly privatization of these services. Via privatization states – which are continue as the main bearer of human rights obligations – are limiting opportunities to meet its human rights duties to respect, protect and fulfil human rights.

Furthermore privatization causes a shift of burden for investment. The responsibility for investment is moved away from the public sector to private business and therefore can be easily transferred from the (water) service company to the customer. As the FDI is generally in foreign currency the costumer holds the risk of the fluctuating currency exchange rate, which might cause rate increases like in Manila (Rosemann, 2003). Examples such as Manila demonstrate that the burden of devaluation risk is shifted from the public sector to the private sector. Within the private sector the private water provider transfers the risk of the investment in a foreign currency to the customer who pays the bills in domestic currency. The increased water prices clearly shows this. Since privatization in 1997 the water price, calculated in Philippine Peso, rose up to 525% in the West-Zone (*Maynilad Water*) and 560% in the East-Zone (*Manila Water*) in 2003. But taking into account the exchange rate and calculating the water prices in USD the water price rose in the West-Zone up to 290% and in the East-Zone up to 310%. These features are quite common within a period of seven years service and are in fact within the price increase rates when Manila was serviced by the public sector. But nevertheless the FDI caused the high risk that the improved water service becomes less affordable and the satisfaction of the basic need to water endangers other human rights like health, food or education. With examples like this privatization becomes a threat to the human right to water.

Risks in Attracting PPP and FDI by Deregulation

Another dilemma evolves if the private sector participation is attached with deregulation. Many international or bilateral investment agreements

require certain corporate rights, such as the right to property, and public risk management, like investment securities. Corporate freedom, guided by deregulation, confronts the individual right to a regulation of water issues under the human right to water. Furthermore the concept of deregulation can theoretically only work where market forces can balance corporate power. But due to the natural monopoly of water supply these lacking market forces call for a strong regulation of corporate conduct. The increasing FDI in tantamount with private sector involvement could therefore lead to a private monopoly as the outcome of a privatization process. In order to avoid this, firstly a partial privatization of public companies and other options which range from full privatization of services to PPPs, concession contracts, build operate transfer contracts, outsourcing should be given priority.

Secondly, it should be tested if PPP-model will work or not for water provision, day-to-day management, extension of pipelines, monitoring of the water quality and to run the administration. The same criteria should be used for FDI where it is allocated to substitute public investment. In order to meet the normative demand of the human right to water the precondition for involving FDI, the decision should be taken in an open and transparent way with the involvement of affected stakeholders.

Thirdly, the human right to water should be incorporated in any International Investment Agreement (IIA). In past few years, many countries have signed IIAs whether they are bilateral, regional or covered by investment aspects in Foreign Trade Agreements. Many of these also cover service by this FDI, because such services are run by private investors. But when considering IIAs as a tool to meet the challenge of lack of finances, the outcome might not be the demanded FDI. First, IIAs are only one determinant in an investor's decision to make an investment. Others are economic and local determinants such as infrastructure, human resources, market, export market, political stability and also a country's attitude towards FDI. Opening up markets and signing IIAs can have an important signaling effect for an investor decision but, it does not always bring about FDI. Second, the overall goal of IIA is not uniquely to only attract (or to attract more) FDI but rather also benefit from it and address concerns. UNCTAD (UNCTAD, 2003) addressed these concerns by referring to the need of government regulation to benefit from investment. This is particularly important in light of the human right to water where governments have the obligation to put in place the necessary domestic policy framework and a regulatory framework that ensures that the human right to water is progressively fulfilled. The human rights framework does not give specific policy suggestions, but gives general recommendations.

The challenge is to use the signalling effect of IIAs in terms of attracting investment, but keep the regulatory freedom to put in place the necessary

policy measures at the national level that ensures a country and, most important, its citizens, benefit from FDI and so that other related concerns may be addressed.

Tradeable Water Services

Beside the additional allocation of resources throughout private sector participation another notion in order to meet the challenges of lack of local water supply is the globalization of water business. Forced by the European Union water services should be recognized as a new sub-sector “water for human use and wastewater management” under environmental service within the General Agreement on Trade and Services.ⁱⁱ

If the European Union would be successful with these efforts, services in water and sanitation would become tradeable commodities and hence will fall into the category of issues that can be taken into the World Trade Organization for dispute settlement. Furthermore the national treatment provision would hinder a regulatory office to prefer local or domestic water suppliers. This would benefit the transnational water corporations and they would be able to break through in the functioning of profitable domestic markets without the regulation to invest in non-profitable sectors.

Financing the Human Right to Water is a Question of Cross Subsidizing

As discussed above, its mainly the Least Developed Countries and rural areas, with almost no potential for economic growth that are mostly affected by water shortage. In addition these regions are less attractive for private sector participation. It is estimated (Smets, 2004 I) that an increased investment of 5-8% is needed to meet the challenge, although the estimated global economic growth rate is 1.3%. The reference to Sub-Saharan Africa, the region with the most difficulties to meet the Millennium Development Goals (UNDP, 2004) will illustrate that difference. Smets (Smets, 2004 II) suggests that the poor users themselves could – in addition to the running costs – provide 1% of their low income in order to finance 18% of the needed investments. Other citizens who are already connected to the water system should agree to pay an additional 30% of the cost of the water they consume in order to subsidize water for the poor. Additional grants from abroad would serve to subsidize 35% of the investment for the poor but as a matter of fact there is still 17% of investment which cannot come from private investors, banks and multinational corporations.

Calculating for the investment for water supply and sanitation in Africa this has to be doubled from USD 3 billion per annum to USD 6 billion per

ⁱⁱ WTO: EC-Communication S/CSC/25 of September 28, 1999

annum in order to meet the Millennium Development Goals. Another calculation by Smets (Smets, 2004 II) suggests that users who are already connected to the public or private water supply have to provide an additional 57% by cross-subsidizing from USD 2.3 billion to USD 3.6 billion. In addition foreign support has to be increased by 200% from USD 0.6 billion to USD 1.8 billion and the revenue by newly connected users has to be increased by 500% from USD 0.1 billion to USD 0.6 billion. It is recommended that instead of depending on private investors, banks and multinational corporations as a source for investment the enhancement of grants from foreign governments, multinational bodies, gifts from charitable bodies, NGOs, municipalities and the money which is sent home by migrant workers in industrialized countries should be utilized. In theory, the needed investment can be shouldered by the citizens in 15 Western European countries if everyone would spend USD 4.8 per year only. This contribution is comparable with 3 cent per cubic meter of water or by saving 4.4 liters of water per day – which is less than one water toilet flush. In other words the Millennium Development Goals and the human right to water can be broken down from a normative ideal to a practical tool for human development, if people with access to water are willing to subsidize the water access for people without water. This aim could be guided by an International Water Convention.

Conclusion

The definition of the basic need to water and sanitation as a human right is one thing, but to allocate sufficient resources to meet the global challenge of local water shortages is other. These are both sides of the same coin and depend on political will. The acceptance of a human right and the distribution of satisfactory resources are a question of accountability of the actors who influence the global financial architecture as well as the local and domestic water and sanitation systems. Since the Millennium Development Goal to halve the number of people without sufficient access to safe water and to wastewater treatment by 2015 is a political declaration it is in citizen's hands to hold Governments accountable for their commitment. Moreover this request for accountability should be guided by the request of a national and international framework that enables a clear pledge from people with access to water and sanitation to people without. The political will to face this challenge is especially needed from people in Europe who spend the yearly as much on ice-cream or people in Northern America who pay yearly as much for pets as is needed in order to meet the Millennium Development Goal on water and sanitation (Ziegler, 2001).

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