Rob Roggema

Adaptation to Climate Change: A Spatial Challenge

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Foreword

I had the privilege to be invited for a Learning Journey to Greenland in May 2009, organized by the Tällberg Foundation. We stayed at Illulisat, one of the places where the Icefjord Glacier comes into the ocean. We learned and observed how the glacier withdrew 60 kilometres since the beginning of the industrial revolution in the second half of the 19th century. In the last year, not less than 15 kilometres were added to it! This large and alarming withdrawal is just one of the indications that the rise of the average world temperature, the melting of the ice at the North Pole, the size of the dark blue deserts in the oceans, and the increase in CO_2 concentration in the atmosphere are larger than predicted in the computer simulations that are the basis of the IPCC reports. These alarming empirical data about climate change and its effects were the starting points for the Greenland journey presentations of the climatologists Dorthe Dahl-Jensen (University of Copenhagen, Denmark) and Johan Rockström (Stockholm Environment Institute). One of the explanations is the fact that the IPCC models do not include interaction effects between different environmental effects of climate change and consequently predict a rather linear increase of temperature with increased CO_2 emissions and a gradual decrease in temperature when we reduce CO_2 emissions. This results in too positive predictions in the near future and the false belief that a large increase in temperature can be corrected by simply reducing CO_2 emissions. Instead, we will experience much larger, shock wise increases of temperatures in the near future, resulting in for us and other living organisms very unfavourable new equilibrium that may well remain stable for 100,000 years, as Lovelock predicts in his fascinating book *The Vanishing Face of Gaia. A last Warning* (London: Penguin Books 2009).

Starting from the same premise that climate change will be quicker and more dramatic, the present book has four great merits. First, it shows in a very concrete way how climate change will affect almost all aspects of our physical and social environment, and as a consequence, of human life. Second, starting from the adaptation approaches of several countries, it shows that still a long path has to be followed before the adaptation strategies can be implemented into spatial planning, in spatial projects, programmes and plans. Third, the book shows that we have to eliminate sectoral thinking in order to come to proactive and integrative solutions for the challenges we face. As Lovelock arrived at his conclusions by bridging disciplinary boundaries between Earth and Life sciences, thise book shows how solutions can and should bridge different disciplines and sectors. We all have separate departments for Economic Affairs, Agriculture, Environmental Affairs, Social Affairs etc, but living in harmony with each other and with nature requires integrated solutions that are simultaneously sustainable, economically, ecologically, and socially. Sustainable well*being* is only created if economic and financial goals are instrumental to and serve sustainable environmental and social solutions, rather than are focused on our welfare *wealth* as a goal in itself. Fourth, the book shows that integrative cross-sectoral creative thinking is at least as important in the planning stage as in the strategy phase, but even more difficult to realize as diverging interests will strongly defend their vested interests.

This book, and consequently also the author, deserves a very large audience. *We really have to act now and this book really helps to translate ambitious plans into concrete spatial actions!*

Frans N. Stokman between the huge amounts of melting ice, broken from the large Greenland Icefjord Glacier

University of Groningen and c8Foundation — Frans N. Stokman
July 2009

Preface

In designs for cities and landscapes climate change is not integrated yet. However, the spatial lay out will be affected strongly by the changes in climate. The adaptation of cities and the landscape to climate change is dominantly a spatial matter. Landscapes need to become more resilient and cities less vulnerable for climate change. This book takes spatial design and planning as the starting point. It shows international adaptation strategies and design examples on how adaptation to climate change can be used in spatial planning projects and programmes. The rich variety of images, ideas and drawings illustrate that the issue is included in practice more and more. It is inspiring to include adaptation-issues in designs, it challenges the creativity of designers and it creates new images of future living environments, which are beautiful, safe and prepared.

Climate change is influencing our future. A long period of climatic stabilisation lies behind us. The changes are researched and knowledge on the content of these changes is being developed. But in practice this knowledge is not yet implemented in spatial planning. The first examples and projects become visible around the world, but the general practice faces a major challenge.

Many countries already have formulated an adaptation strategy, as described in Chapter 1. Most of the strategies are generally formulated and contain policy statements and objectives. The role spatial planning and design plays in the strategies, is mostly small.

The way adaptation to climate change can be integrated in design is described in Chapter 2. The Dutch and Chinese examples illustrate that if the natural system of the site is taken as a base for the design the adaptive capacity of the area can be increased. The future changes in climate need to be combined with the local characteristics of the natural system: ecological, relief, soil and water. Human interference often transforms the natural system into a controlled and artificial system. This results in difficulties to adapt to unforeseen changes. If, however, the natural system functions naturally, with its own dynamics, its flexibility, its normal internal changes and succession, the adaptability of the system increases. This needs to be included in spatial designs.

In Chapter 3 a gallery of possible solutions for the improvement of the coastal defence is presented. There are many ideas available, but in the end technical solution prevail: the technical standards, budget limitations, sectoral thinking and juridical impossibilities lead to suboptimal results. In order to increase the resilience in the coastal zone multifunctional and flexible solutions are to be preferred instead of fixed and fierce dikes.

In Chapter 4 some tools and examples are described on the way water management can be organised. The focus in water management lies on risk management and the protection measures to decrease the chance at a flood. The standards on strengths of dikes and the periodicity of dike breeches are more in the spotlight than the question to design the area behind the dike in a way that a flood can be dealt with and water is a profitable element instead of a threat. The fact that a flexible system is less vulnerable for the effects of a flood is not yet prominently apparent in the debate.

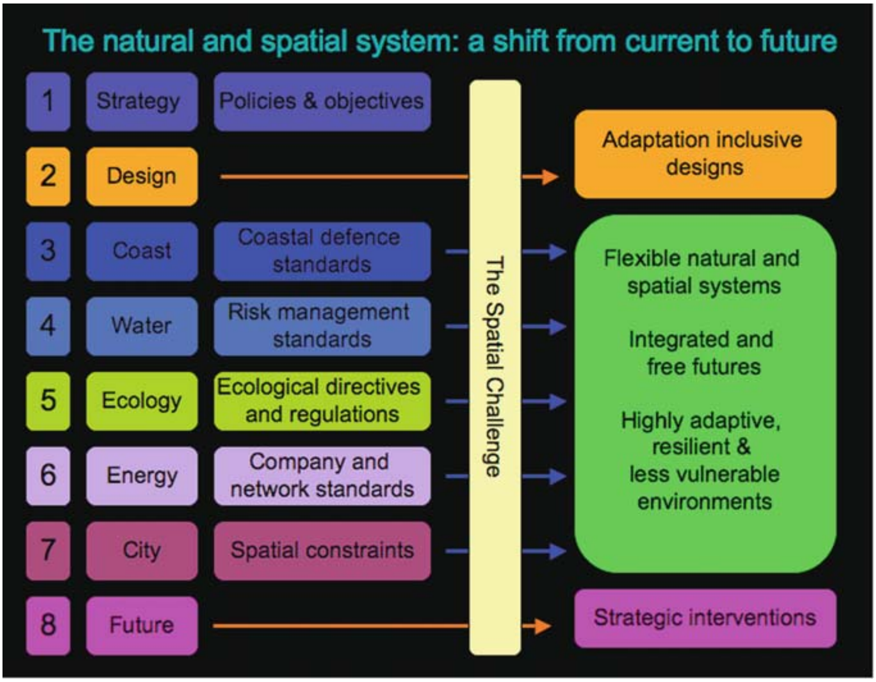
The same remark can be made for ecology. It seems to be more important that general policies, like directives and the status of ecological areas, are carried out instead of the realisation of a robust and well functioning ecological system, which is capable of adapting climate changes (Chapter 5).

The market dominance results also in standards in the energy sector. The centrally and hierarchical organised energy sector sets the standards, which are a given for local situations. It seems that the network and regulations cannot be changed, even if circumstances ask for it. This makes it very difficult to create a more flexible energy network, in which deliverance of local produced energy to the grid is easy. In Chapter 6 is described how the local energy potentials can be mapped in order to provide information on the possibilities to provide the grid with local produced and sustainable energy.

In the seventh chapter the effects of climate change in urban environments are described. Excessive heat stress and water annoyances in dense urban areas cause major problems. The existing spatial boundaries of city patterns in combination with the high square meter prices in the city are a constraint to find space for public green and water, which is necessary to adapt the city to increased temperatures and extreme weather events. The city needs to increase its internal flexibility. Public spaces need to be able to change their function if climate circumstances ask for it and extra space needs to be generated for green in order to moderate climate changes.

Planning for a climate proof future, as described in Chapter 8, is impossible if current processes and practices are sustained. The long-term changes are to a certain extent unpredictable and trying to define a predictable future through spatial planning leads to mismatches. A fixed and detailed image of the future layout of an area needs to be replaced by a rough image of the future, which can be adjusted anytime if needed. Here, an increased role of spatial planning and design is at stake, because the creation of these rough images needs to be done by creative people, who are capable to think out of the box. Designers are able to stimulate spatial imagination, which provides the required spatial flexibility to constantly adjust the spatial future.

A general conclusion can be drawn that in existing practice the standards are the standard. An existing conglomerate of standardised thinking withstands an innovative development, which is needed to anticipate on fundamental and long-term changes.



The spatial challenge or spatial task is to implement and initiate a shift from this sectoral standardised thinking, with higher risks, towards multifunctional and flexible thinking based on the dynamics of the natural system. Spatial planning and design should not only implement the shift, but also needs to play a leading role in the transition. The key characteristics needed in such a transition are creativity and innovative thinking without boundaries. New pathways need to be discovered and the future needs to be visualised. Cross-sectoral thinking and integrated design needs to be enhanced. The required innovative capacity is available in designers' brains. A highly adaptive, resilient and less vulnerable environment can be designed if the pressure to fulfil all kinds of standards is minimised. This will result in a new paradigm: adaptation inclusive planning.

Ten Boer R. Roggema

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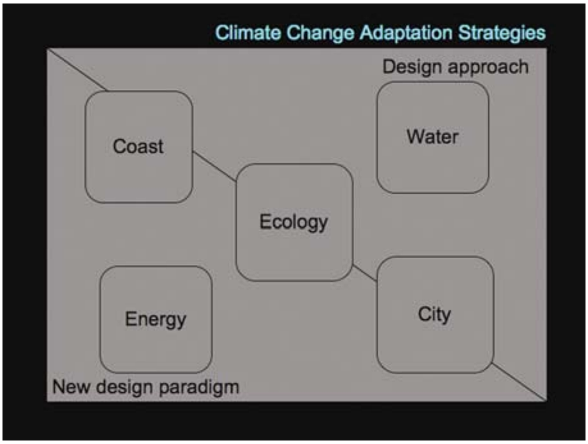
About the Author

Ir. R.E. (Rob) Roggema (1964) is Landscape Architect (Wageningen, 1990) and is an expert on the issues of sustainable development, sustainable energy supply and adaptation to climate change. He developed and used this expertise with several governmental organisations and consultants. Recent years he works for the province of Groningen on strategic questions and complex projects in the field of sustainability and spatial planning. Among his special interests are the research on the spatial planning of a sustainable energy system in Northern Netherlands – Grounds for Change – and design of a climate proof regional plan for the province of Groningen. Additionally he conducts a PhD-research on the relation between a sustainable energy system, the adaptation to climate change and the spatial impact on the regional lay out at the Technical University in Delft as well as at the Wageningen University and Research Centre. The central question is which new planning concepts are able to connect long-term problems and challenges, like climate change and energy depletion, with short-term spatial planning practice. He has written his first volume on adaptation to climate change and spatial planning: 'Tegenhouden of Meebewegen' (in Dutch). He has won the award for the best theoretical paper during the World Sustainable Building conference in Melbourne, 2008.

Introduction

Probably the most urgent problem of this century is the change the climate on earth will undergo. Therefore it is of the highest importance to reduce human impact on these emerging changes. Mitigation of climate change should stay high on the political agendas for the rest of the century. However, despite all efforts to minimise the changes in climate, the world needs to adapt to the upcoming changes as well. This adaptation to climate change is necessary to prevent societies from disasters and disruption. The most important field where adaptation can be realised is the spatial lay out of the area. Spatial adaptations are from all times. Therefore, theoretically, it must be easy to adjust the spatial planning practice and make it ready for the required climate change adaptations. However, in spatial planning practice of today the focus lies on facilitating economic developments like agriculture, infrastructure, living areas and enterprises as well as creating the necessary space for water management and nature. Because the attention lies on these aspects, there are not many good examples of climate proof spatial lay out. Spatial designs and planning needs to orientate its adaptation on the one hand side on the incorporation of the spatial consequences of climate change and on the other hand on those spatial measurements, which are minimising climate change, i.e. the spatial requirements of local energy production. The most important issues to incorporate in the spatial lay out of areas contain the way the coast is defended, how the lay out of the water system is organised, how the space is created for the production of energy, in which way the ecological structures can survive and the way how the urban areas are capable to adapt to higher temperatures and periodically large amounts of rain water. These aspects, when integrated in a spatial design, are capable of making a society more resilient for future long-term changes. In order to do so the aspects do not on need to be integrated in spatial designs, but they are also need to create the specific spatial interventions that will ensure an adaptation of the society on the long term. Today's spatial planning system is mostly short term oriented and is therefore not capable of anticipating on long-term developments. Thus, not only the individual thematic issues require adaptation to climate change, the planning practice does as well. If the planning system is optimised for adaptation, i.e. long-term oriented, integrated and area specific, a new planning paradigm will emerge. The characteristics of this new paradigm are a focus of planning on strategic interventions and measures, which start developments that result in desired future instead of defining an end-image of the far future.

Chapter 1
Create Space for Climate!



Abstract The predictions on climate change are more than once overtaken by reality. Climate change seems to accelerate: sooner, faster, stronger. This means that the uncertainties on future changes are large. What is agreed on is the fact that even if the World succeeds in minimising CO_2 emissions of today, the effects of the changes will continue to affect communities, ecologies and economies all over the world. Therefore, one way or another adaptation of societies to the changes is necessary. Because of the regular surprises in the pace of climate change, and always at the top-line of predicted scenarios, the question is if mankind is aware of the urgency to adapt. Probably the best strategy is to be prepared in a worse case scenario and organise land-use and spatial functions in a way that they are capable of withstanding big changes. This requires transformation of climate change knowledge into spatial planning. Many countries, of which the Netherlands, United Kingdom, Spain, Denmark, Japan and Finland are analysed, have developed an adaptation strategy, but only few of them incorporate the field of spatial planning in it. The focus on

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adaptation as a part of regular policies is creating a cloud curtain for the real urgencies. A shift is necessary towards using knowledge on the adaptation to climate change in spatial projects, programmes and plans. The role spatial planning can play in creating a more resilient society is underestimated.

1.1 Climate Change

Global warming develops slowly, continuously and is accelerating. In the recent 150 years temperatures on earth have clearly increased. It takes a long time to stop this process, decades or more. The warming process reacts very slowly, because warming of the atmosphere indicates a slow warming of oceans and they are, with their large warming-capacity, not able to react fast. The emissions of greenhouse gases of recent decennia, combined with current emissions, lead to a continued global warming for at least the next decades (IPCC, 2007a; b). The second development is that climate changes at a continuous faster pace. It seems that predictions on expected changes are reached sooner and that the climate changes are going faster and the changes are stronger than expected (Tin, 2008). Global warming is accelerating at times far beyond forecasts outlined in, amongst others, IPCC IV. Important aspects of climate change have been underestimated and are being felt sooner. For example the less than 1°C warming the world has experienced to date may have triggered the first tipping point of Earth's climate system: the disappearance of Arctic summer sea ice (Fig. 1.1), which causes at its turn rapid and abrupt climate change. This implies that mitigation and adaptation responses need to be even more rapid and ambitious.

Today, several processes are happening faster and sooner than projected (Tin, 2008):

1. The melt of sea ice in the Arctic Ocean happens 30 year or more ahead of projections;
2. The Antarctic Peninsula is losing faster ice than expected;
3. Since 1990 global sea level rises one and a half time faster than the forecast of IPCC III. This century sea level rise is expected to double the projected maximum of 59 centimetres;
4. The growth rate of CO_2 emissions has increased from 1.1% per year from 1990–1999 to 3% per year from 2000–2004. The latter rate is higher than use in any scenario in IPCC III or IV;
5. Land and oceans absorb 50% of the emissions. The capacity of these 'sinks' is declining at a greater rate than expected;
6. A cut of 80% greenhouse gases at a global level is needed to stay below the, as acceptable declared temperature rise of 2°C in 2100. Which means tat developed countries should achieve even higher levels

The scientific research conducted after the publication of IPCC IV illustrates that the speed and scale of changes that affect the global climate is much greater

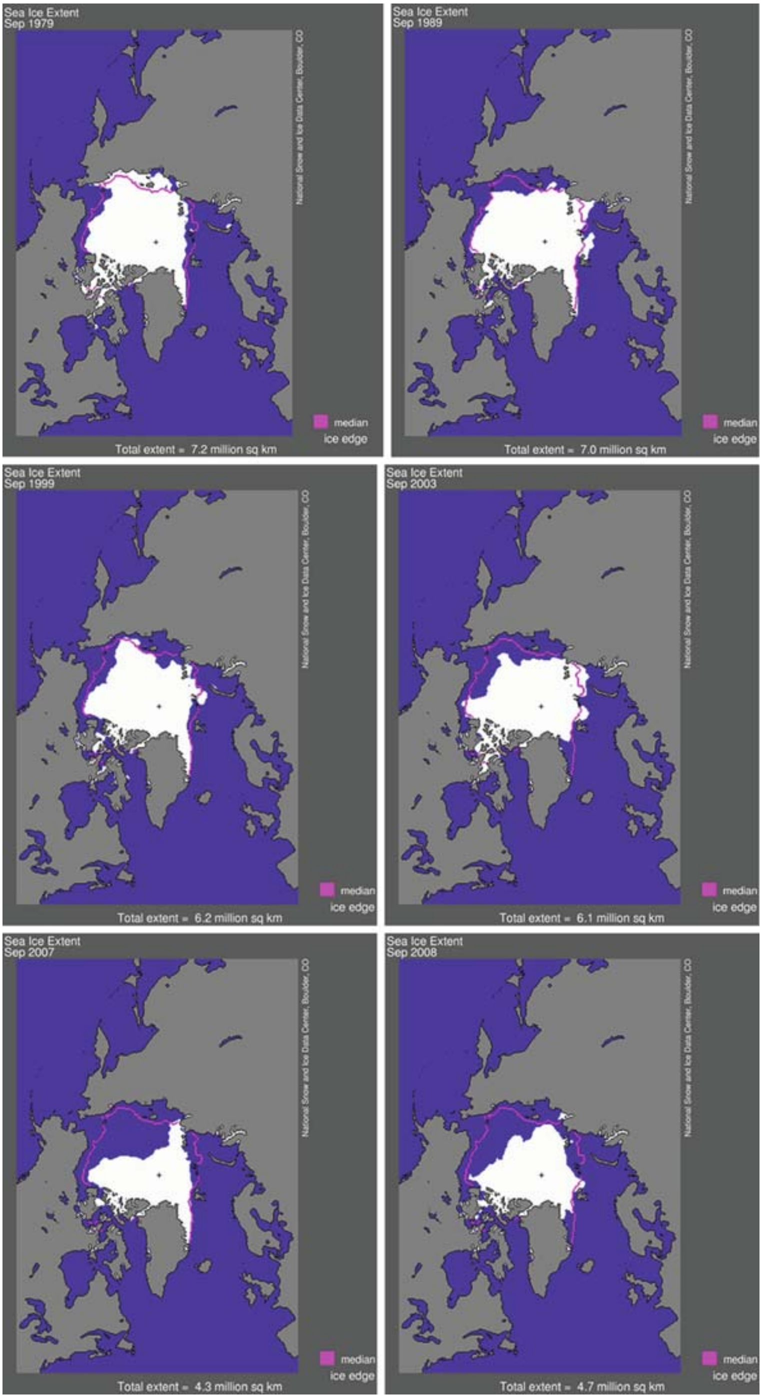


Fig. 1.1 Arctic sea ice extent in September 1979, 1989, 1999, 2003, 2007, 2008 (Source: Fetterer et al., 2008; Image credit: Image/photo courtesy of the National Snow and Ice Data Center, University of Colorado, Boulder)

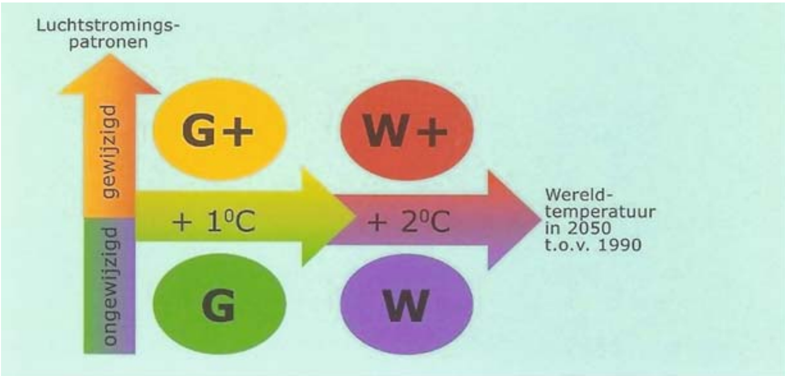
than predicted and it will affect all functions of society: food production, health, ecosystems, water and storm damage.

Because of the long lasting impact of global warming as well as the pace warming takes place, emissions needs to be decreased urgently and it is inevitable for mankind to adapt to climate change as soon as possible. In many countries around the world adaptation strategies are being developed, in every country in different ways.

1.2 The Dutch Approach

1.2.1 Dutch Climate Scenarios

The Dutch Meteorological Institute developed four climate scenarios for the Netherlands (KNMI, 2006). The scenarios for 2050 are based on two variables, which influence the Dutch weather in particular: changing air patterns and temperature rise. Thus, four scenarios are defined (Fig. 1.2): G (no change in air patterns and 1°C rise of temperature), G+ (changed air patterns and 1°C rise), W (no change



G	Gematigd	1°C temperatuurstijging op aarde in 2050 ten opzichte van 1990 geen verandering in luchtstromingspatronen in West Europa
G+	Gematigd +	1°C temperatuurstijging op aarde in 2050 ten opzichte van 1990 + winters zachter en natter door meer westenwind + zomers warmer en droger door meer oostenwind
W	Warm	2°C temperatuurstijging op aarde in 2050 ten opzichte van 1990 geen verandering in luchtstromingspatronen in West Europa
W+	Warm +	2°C temperatuurstijging op aarde in 2050 ten opzichte van 1990 + winters zachter en natter door meer westenwind + zomers warmer en droger door meer oostenwind

Fig. 1.2 Climate scenarios for the Netherlands (KNMI, 2006)

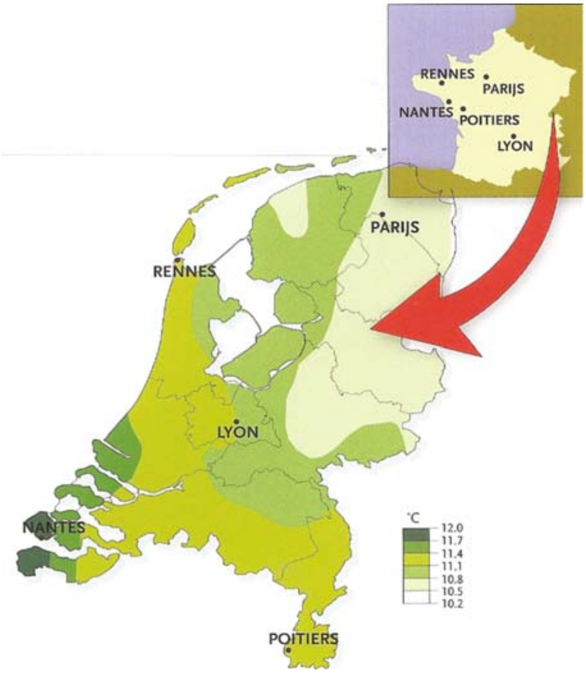


Fig. 1.3 Average temperatures French cities equal 2006 and 2007 temperatures in the Netherlands (Source: KNMI, 2008)

in air patterns and 2°C rise) and W+ (changed air patterns and 2°C temperature rise). The changed air patterns imply a more moderate and wet winter caused by a dominant western wind as well as increased dry and warm summers, caused by a dominant eastern wind.

Recent climate in the Netherlands has been analysed by KNMI (2008). In 5 recent years warming continued. 2006 and 2007 are the warmest years since the Dutch started to measure temperature. These years represent the temperatures in the Netherlands can be compared with average temperatures in French cities, about 600–800 kilometres southward (Fig. 1.3). It is perfectly clear that the last 10–15 years most of the seasons are much warmer than normal (Fig. 1.4).

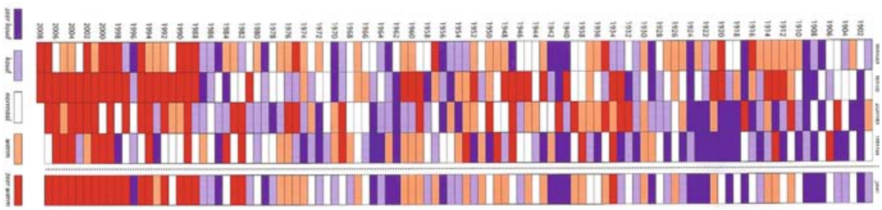


Fig. 1.4 Relative seasonal warmth since 1900 (Source: KNMI, 2008)

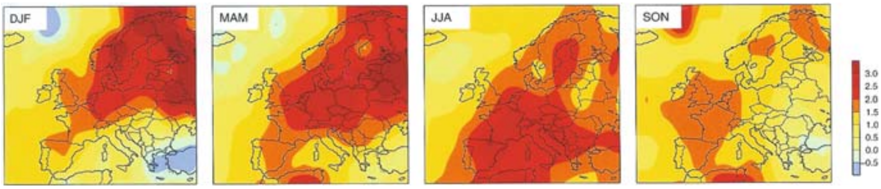


Fig. 1.5 Recorded trends in temperature rise between 1950 and 2007 (local temperature rise per centigrade rise of world average) (Source: KNMI, 2008)

The warming of the Netherlands takes place at a faster pace than expected. Since 1950 the Netherlands heated up twice as fast as the global average. Even if this is taken into account, 2006 (autumn) and 2007 (winter and spring) show extraordinary results. And if we compare the recorded trend in temperature in four seasons with the world average, the rise of temperature above North-Western Europe is evident in all seasons (Fig. 1.5).

The Dutch coast is in (late) summer wetter than the rest of the country. This is caused by the warming of the North Sea, resulting in heavy precipitation and water annoyance in the coastal provinces.

1.2.2 The Dutch Adaptation Strategy

The Dutch national program 'Adaptation of the Spatial lay out and Climate' (ARK) is a cooperation between the central government, provinces, municipalities and water boards.[1] Within this program a national adaptation strategy and – agenda is developed. The cooperation of all involved partners illustrates that adaptation is important in several policy-fields and on different levels of scale. This is the key factor in the national strategy: cooperation is essential to become successful.

The national program focuses on those measures that are necessary to adapt to climate change. Needless to state here that in both the policy document (VROM, 2007a) as well as in the political report (VROM, 2007b) on adaptation the necessity to mitigate climate change by reduction of the emissions of greenhouse gases is underpinned. However, some changes in the global climate are unavoidable and thus, the world needs to focus on adaptation also. The National Program on Spatial lay out and Climate offers the building stones in the form of a national adaptation strategy as well as an adaptation agenda.

The national adaptation strategy is essential, because:

- The room for solutions decreases:
- In the future the necessary measures will require more and more efforts;

[1] Cooperating governemnts include four ministries (Housing, Spatial Affairs and Environment, Traffic and Water, Agriculture, Nature and Food, and Economic Affairs), the IPO (Interprovincial Board), the VNG (Unified Dutch Municipalities) and the UvW (Union of Waterboards).

- Cooperation between governments, enterprises and societal organisations needs to be encouraged in order to generate inter-sectoral and integral solutions;
- A safe and attractive environment needs to be created and guaranteed for an international business environment.

Not undertake any action is not an option. The climate proofing of the Netherlands is seen as the most important task of this century. It shall steer investment decisions and shall provide a balanced – social, economical and ecological – development of society.

1.2.2.1 Economic Driver

Adaptation to climate change is not only desired from a sustainable or environmental point of view. There are also economical motives to undertake action now. Keeping track of things is relatively simple in case nothing goes wrong, but under pressure it is needed to stay keep and behold the overview. In order to minimise economic, material and personal damage especially in a disaster situation the right measures must be taken.

If climate change is taken into account in current investment decisions future far more costly investments in inevitable adjustments can be avoided. If spatial investments in a certain area increase, the value in that area increases as well. The possible damage in that area in case of a disaster will increase in that situation. This is why specifically these areas with the highest economical value adapt to climate change. Here, the damage is highest in case of a disaster. To find out which areas are most vulnerable not only the economic values must be added, but the possibility of failure of one crucial function – in itself probably not extreme economical valuable – must also be included in the analysis, because failure might imply a domino of effects, which lead to even higher damage for other functions. For example, if the data centre of Google is flooded, the damage on the building and machines are nothing compared with the worldwide damage as a result of failing networks, safety systems etcetera. The safety-level of the data-centre needs to be very high, while the added economic values in the area could be satisfied with a more moderate level of protection.

If functions are intensified, the physical space for adaptation decreases. Therefore, the room for adjustments needs to be created and reserved now. Taking action now, it is still possible to keep up with spatial development projects. Waiting for several years leads to decreased space for adaptation measures and increased difficulties to adapt to climate change.

1.2.2.2 Three Demands for a Climate Proof Lay Out

The Dutch adaptation strategy states that a climate proof spatial lay out requires a high resistance, resilience and adaptability.

Resistance is the ability to resist extreme circumstances. A change in attitude is not necessary. If the dikes are maintained well, the resistance of an area stays intact.

Resilience is the quality to recover from an event fast when circumstances return normal again. The area changes temporarily and after a – as short as possible – period everything functions as normal again.

Adaptability is the capability to deal with the uncertainties, both in size as pace, of climate change. As time goes by the problems of climate change increase and the adaptation requires more intense efforts. Therefore, the capability of the society to realise adaptation measures needs to increase as well. This is only possible if the realisation of the adaptation measures will be easier in increasing difficult circumstances.

If areas are developed, realised and maintained these three elements need to be kept in mind consequently and explicitly.

1.2.2.3 Risk Management and Natural Processes

According the Dutch national adaptation strategy two principles are leading in dealing with a changing climate: risk management and natural processes. Because of the uncertainties of future circumstances in the Netherlands, risk management focuses on both the possibilities to prevent a disaster (Fig. 1.6) as well as reducing the damage and casualties in case a disaster happens. The right spatial choices can make the difference here. For example, the creation of compartments in the defence against flooding reduces the chance on damage and casualties. And vital and vulnerable functions should be placed at locations, where the chance on a disaster is minimal or at locations, which are safe, even if a dike breaks through (VROM, 2007b).

Fig. 1.6 Increasing chance on flooding (Source: Ministerie van VROM et al., 2007a, Illustration by: Beeldleveranciers Amsterdam)

The use of natural processes increases the resilience and adaptability of an area. For example, if a river is able to flow in a natural way, it is better equipped to deal with extreme circumstances. If new urban areas are planned the natural system, like the soil, the relief and the water system, needs to play a decisive role in decisions on size and nature of new building areas.

1.2.2.4 Spatial Tasks

The Dutch adaptation strategy focuses on a number of spatial tasks. On the one hand side the tasks, which prevent society from collapsing and on the other hand tasks, which minimise undesirable effects.

Prevention of Societal Collapse

A sustainable coastal defence (Fig. 1.7) should be realised, where space can be created for nature, recreation and urban functions. Extension of the coast is one of the options.

The river system needs to be robust also. Enough storage- and discharge capacity should be created within the riverbed (Fig. 1.8). Beside this, the river system needs to prevent navigation passage problems from happening during long dry periods (Fig. 1.9). On top of that, the natural dynamic of the river system should be taken into account (Fig. 1.10).

Future lay out of cities and the countryside should be robust. Vital functions should be protected by creating compartments and by creating safe spots in the landscape. Large concentrations of people should be protected against disasters through safeguarding the functioning of main-ports and energy and transport networks, even in the most difficult circumstances. Beside that quick assistance must be guaranteed.

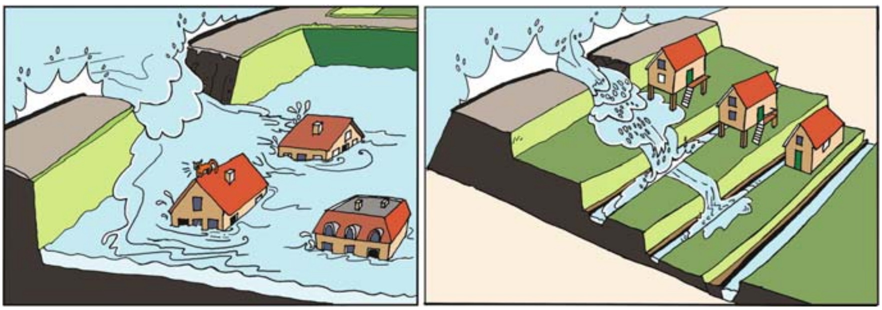


Fig. 1.7 Strategy to deal with floods (Source: Ministerie van VROM et al., 2007a, Illustration by: Beeldleveranciers Amsterdam)

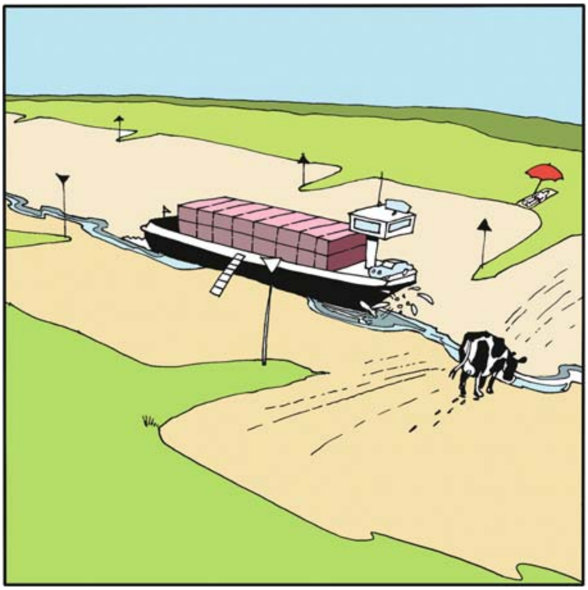


Fig. 1.8 Strategy to deal with drainage peaks in the river (Source: Ministerie van VROM et al., 2007a, Illustration by: Beeldleveranciers Amsterdam)

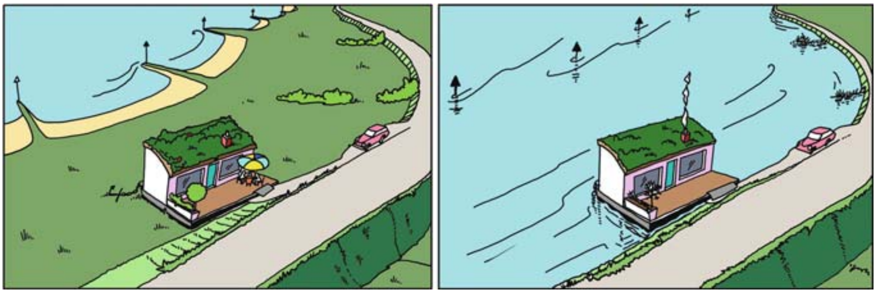


Fig. 1.9 Water shortages in summer (Source: Ministerie van VROM et al., 2007a, Illustration by: Beeldleveranciers Amsterdam)

Minimising Undesirable Effects

The lay out of a sustainable water system is very important. It should be capable to deal with extreme differences in precipitation and droughts, it should secure a good ecological water quality and it should supply the drinking water resources. Besides a sustainable water system, a robust ecological main structure is very important. This structure needs to be extensive in size, but requires also good connections in order to optimise migration of (new) species. Moreover, a living environment of good quality needs to be realised in cities. The environment needs to moderate the heat island effect when temperatures are high (Fig. 1.11) and deal with water surpluses if precipitation is extreme (Fig. 1.12).

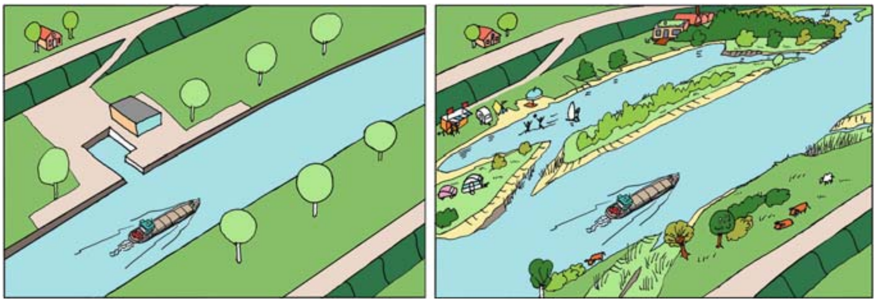


Fig. 1.10 Increasing the flexibility of the river system. 'Space for the river' (Source: Ministerie van VROM et al., 2007a, Illustration by: Beeldleveranciers Amsterdam)

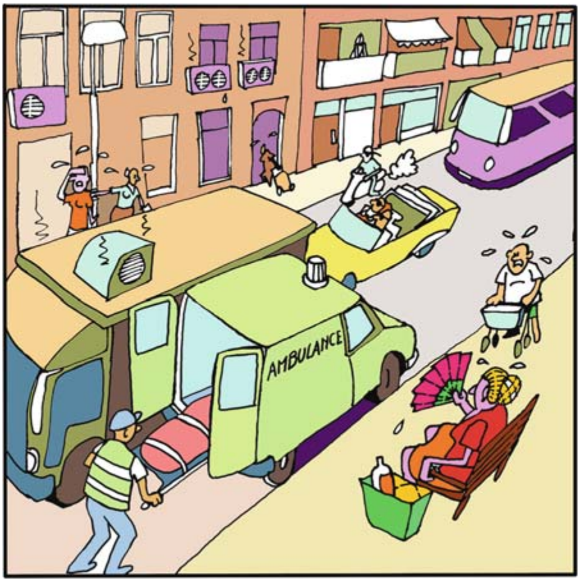


Fig. 1.11 Heat island effect in the city (Source: Ministerie van VROM et al., 2007a, Illustration by: Beeldleveranciers Amsterdam)

Buildings and neighbourhoods should be designed in a climate proof way (Figs. 1.13 and 1.14). These neighbourhoods and buildings need to be able to withstand floods and inundations, but evacuation routes and evacuation plans should be incorporated in the design. Finally, the structures need to be designed in a way that recovering after a disaster is easy.

The lay out of urban green and ecological structures must be designed in a climate proof way (Fig. 1.15), which means that enough space is reserved for green, good connections between different green spaces and coherence between the green and water systems.

There are changes to develop the recreational infrastructure, because of rising temperatures. In order to develop these infrastructures it needs to be based on future changes (Fig. 1.16).

Fig. 1.12 Water annoyance in urban areas (Source: Ministerie van VROM et al., 2007a, Illustration by: Beeldleveranciers Amsterdam)

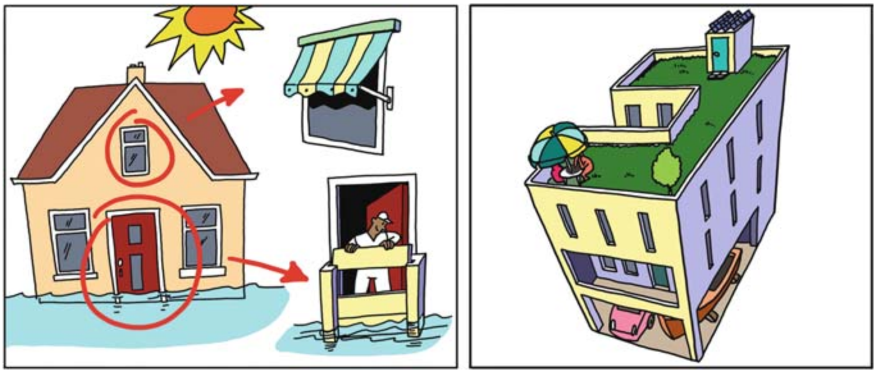


Fig. 1.13 Adjustments in buildings (Source: Ministerie van VROM et al., 2007a, Illustration by: Beeldleveranciers Amsterdam)

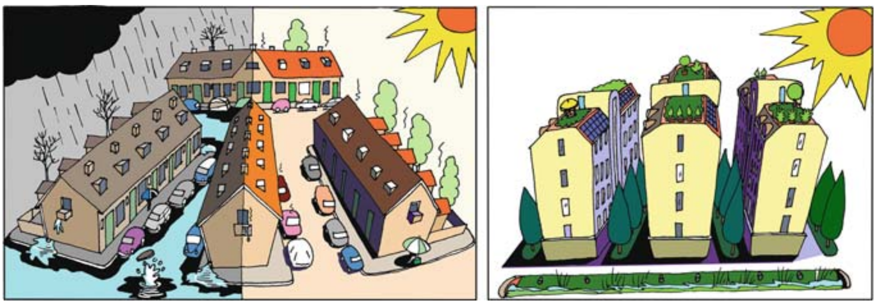


Fig. 1.14 Climate proof lay out of urban areas (Source: Ministerie van VROM et al., 2007a, Illustration by: Beeldleveranciers Amsterdam)

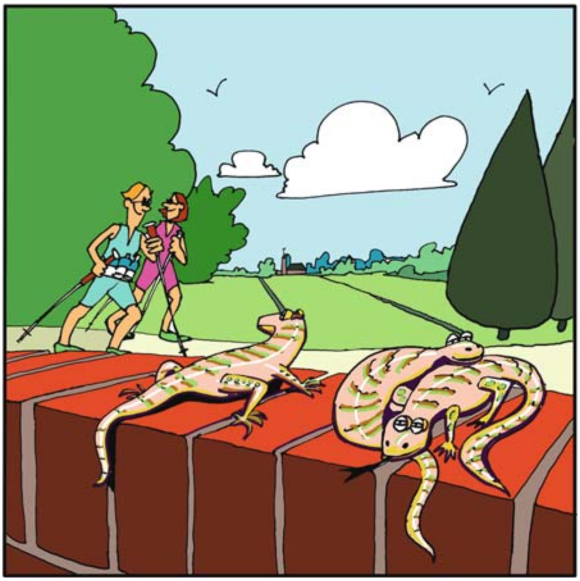


Fig. 1.15 Changing nature and recreation (Source: Ministerie van VROM et al., 2007a; Illustration by: Beeldleveranciers Amsterdam)

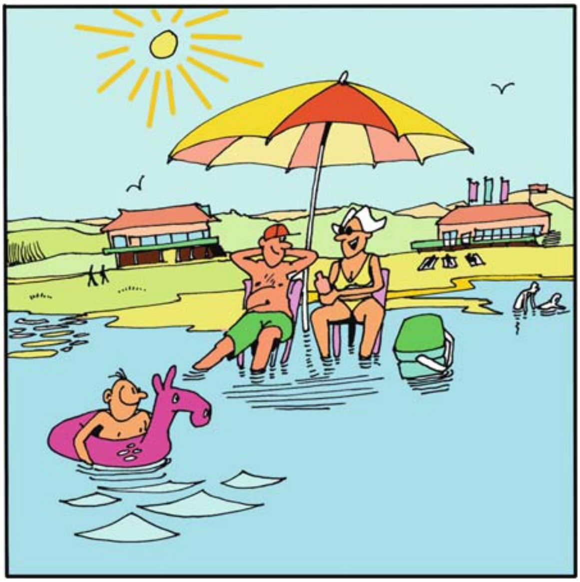


Fig. 1.16 Increasing chances for tourism and recreation (Source: Ministerie van VROM et al., 2007a, Illustration by: Beeldleveranciers Amsterdam)

Agriculture needs to become climate proof as well (Fig. 1.17). Agriculture needs to adapt to weather extremes, become resistant against plagues and needs to deal with salination.

Health risks (Fig. 1.18), which occur with a changing climate, need to be minimised and treated well.

Utilise Market Chances

If the tasks are approached in a design-oriented way, not only the possible threats are treated, but it offers market chances and chances to improve the spatial quality in the Netherlands also. The national ecological aims can be reached, the country can be made more attractive and the national economical development can be stimulated if can be anticipated on future developments and if combinations of different functions can be made. In concrete, the delivery of green–blue services in the agricultural and tourist sector, thanks to a longer growing season is an example of this. Above that, knowledge, which is developed in water-related innovations, can be exported worldwide. The Netherlands stays, as a result of a climate proof lay out, internationally an attractive business place and the extensions of international nature reserves and ecological connections contribute to an attractive and valuable landscape.

Fig. 1.17 New chances for agriculture (Source: Ministerie van VROM et al., 2007a, Illustration by: Beeldleveranciers Amsterdam)

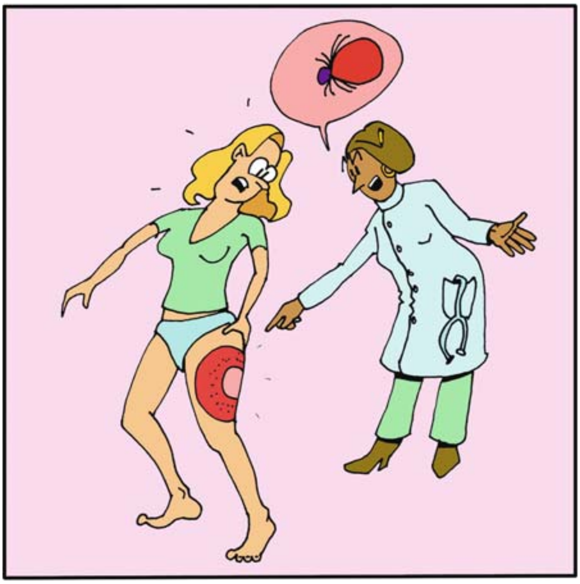


Fig. 1.18 Health risks (Source: Ministerie van VROM et al., 2007a, Illustration by: Beeldleveranciers Amsterdam)

1.2.2.5 Important Issues

The national strategy addresses strategic and important issues, which require a supra-sectoral and quick decision.

1. How to make it possible that the big rivers flow freely into the see, on the very long-term also?
2. What means climate proof planning and building? Which risks are acceptable? How should flood risk be minimised? Is it necessary to reconsider the existing building plans? Should vulnerable and less vulnerable areas be protected at different safety levels?
3. How can the Netherlands stay safe? How can the country be protected against the sea? By creating compartments, by heightening the dikes or by the introduction of an offensive and flexible coastal defence?
4. What is the role of climate scenarios in formal planning procedures?
5. Is Natura 2000 defined broadly enough to deal with the increasing dynamics resulting from climate change?
6. How can be dealt with increasing salination? Should fresh water be used to minimise the effects or should new crops be introduced?
7. How can space be reserved, which is required over a period of 20, 40 or even 100 years?
8. How can space be created inside dense cities for water and green space, while the pressure increases on the city to use free space in order to keep vulnerable area outside the city free of developments?

9. How can finance be arranged for measures, which benefits and debts are spread out over time and have different results for many involved partners?

1.2.2.6 Ambition of the Dutch Strategy

The Dutch strategy focuses on making many parties responsible by increasing consciousness and preparedness for action within businesses, societal organisations and the scientific world. Spatial plans will be tested on the level of climate proofing by defining a checking framework. Innovation and knowledge development will be stimulated in cooperation with business partners. A future oriented government will be developed, which takes the long-term into account while making decisions for the short term.

The central government shall, in cooperation with other partners, develop a communication strategy and reconsider large-scale investments and spatial development projects. An area-oriented and integrated approach will be stimulated and the realisation of projects, which add to the climate proof level of an area, shall take place mainly on a regional level. At this level knowledge and experience of several partners is connected best and the effectiveness is highest.

1.2.3 The Dutch Adaptation Agenda

The national Adaptation Agenda is the second part of the Dutch policy on adaptation. The most important projects, which need to make the Netherlands climate proof, are placed on the agenda. The projects are chosen because they improve the climate proofing of the Netherlands and the agenda accelerates the realisation of the projects. Beside projects of national importance, projects, which have a regional value, are placed on the agenda as well. The projects need to contribute o the ambitions of the national strategy. These ambitions focus on different issues:

1. Societal themes: safety, economy, quality of the environment and biodiversity;
2. Objectives: prevent societal collapse, minimise undesired effects and utilise chances;
3. Desired changes: increase resistance, increase resilience and increase adaptability;
4. Leading principles: risk management and use of natural processes

In order to be effective the agenda needs to be selective as well. Only guiding projects, which are able to inspire and which are innovative are offered a place in the show-window and gain extra attention. The agenda is the starting point of the transition towards a climate proof Netherlands. Therefore regional partners are encouraged to define their shared ambitions to increase the climate proof quality of the entire Netherlands. The final aim of agenda is that in the future all projects in the Netherlands become climate proof, without extra attention: climate proof projects are the state of the art. The agenda is therefore seen as a temporary impulse. The input or the agenda is done partially by the central government, but is filled for the other part by the regional partners. In five regions of the Netherlands policy makers and decision-makers from business, science, societal organisations and government came up with project-ideas, which meet the ambitions of the strategy.

A selection of projects, which are placed on the Agenda, is presented here (VROM, 2007b):

- Improve the international image of the Netherlands as 'Holland Wetland';
- Development of a framework to judge choices for spatial developments;
- Integration of the climate objectives in the Dutch Water-vision;
- Research the possible adaptation strategies for the coastal zone (Delta commission);
- Start of the national research program 'Knowledge for Climate';
- Support the realisation of so-called climate buffers, which are aimed to increase the climate proofing of natural systems;
- Creation of spatial reservations alongside rivers and the coast;
- Integration of climate adaptation in regional plans, on the basis of climate-atlases;
- Extension and multifunctional use of broad dikes;
- Creation of a so-called sand-motor, which provides along the western coast enough sand to strengthen the coastal defence in a natural way;
- Integrated spatial development of the Eemsdelta region, where climate adaptation is combined with redevelopment of urban functions in order to deal with a shrinking population;
- Research on the possibilities to design climate proof at a local level.

The Dutch adaptation strategy and agenda show an approach that deals with the necessity to adapt to climate change in a way, which focuses on initiating developments and is less focussed on conducting research on its own. Cooperation between several partners is an important characteristic of the approach. Instead of a top-down regulative manner the central government tries to make other partners responsible for taking action. This approach implies that the central government only gives directions and stimulates others, other governments, scientists and businesses, to integrate adaptation in their policies and to realise climate proof projects.

1.3 The British Approach

The British approach focuses on a comprehensive program, the UKCIP (United Kingdom Climate Impacts Program). Central in this overall program is the knowledge program BKCC – Building Knowledge for a Changing Climate., which covers research on several aspects.

1.3.1 UK-Climate Scenarios

In the UK high-resolution climate scenarios are developed, which specifically are oriented on weather extremes and the impacts on the urban environment. The scenarios were developed in 2002 and take into account different levels of greenhouse gas emissions. For every climate variable the scenarios are developed for 2020, 2050 and 2080 (Fig. 1.19). UKCIP02 (Hulme et al., 2002) describes the recorded changes like the general warming or the increasing winter precipitation.

Beside historical recordings the scenarios describe future developments as well. UKCIP02 states that the average temperature in 2050 (period 2031–2060) 1–3°C will have risen. It is expected that more dry summers will occur and more wet winters also. UKCIP will present new scenarios by the end of 2008. The first part of the research (recent trends) is been published recently [Jenkins, et al., 2007]. It gives insight in the recent changes for several climate variables (mean temperature, maximum temperature, minimum temperature, days of air frost, precipitation, days of rain, sea level pressure, wind-speed and relative humidity). In general mean temperature has increased (Fig. 1.20), the summers become drier and the winters wetter (Fig. 1.21), while the sea level pressure increases (Fig. 1.22) over the last decennia.

1.3.2 Risk Management

Within the UKCIP program research is carried out on risk management. New methods have been developed to assess the effects and uncertainties of key factors of climate change. Several models were integrated and tested in pilot projects. This resulted in an increased insight in the required decision-making in case of extreme weather events.

For example, the models were used to indicate the production capacity of the hydropower plant of Glendoe. Especially the decreasing availability of snow during this century is an important issue. This causes uncertainty about the delivery of electricity. At the same time the safety of the Glendoe dam is assessed. An overflow should not happen more often than once every 10,000 year.

In a second example, the river-basin of the Thames is assessed with the new models on the availability of drinking water in the future. The results indicate that the river-basin will have to deal with a decrease of water supply.

In the third example the models were used to indicate the reliance of the British rail network in case of changing precipitation amounts and patterns and the effects on the stability of the slopes. The results in this case show that the chance of network failure as result of climate change decreases, but that the western part of

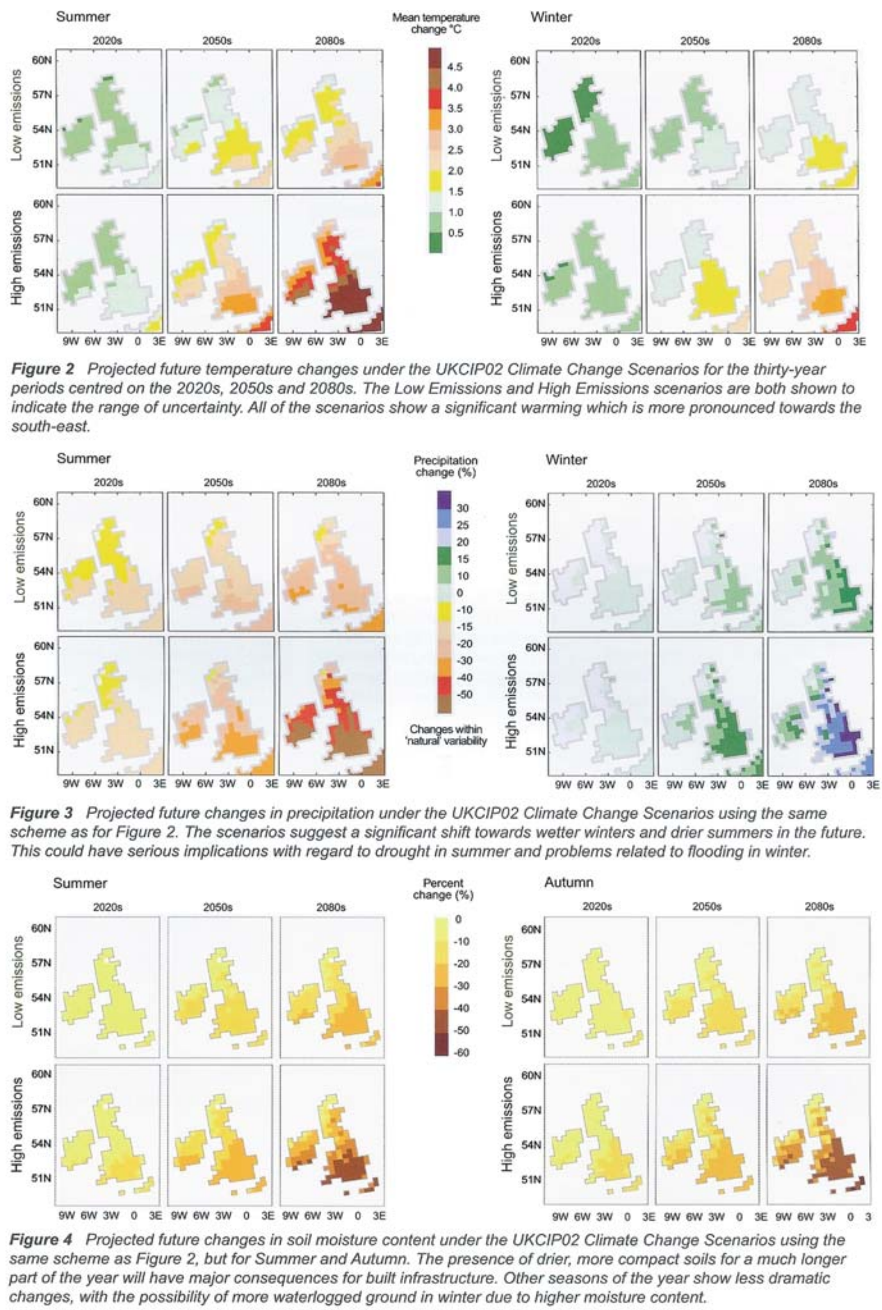


Fig. 1.19 Climate scenarios for precipitation and temperature, United Kingdom (Source: Walsh et al., 2007)

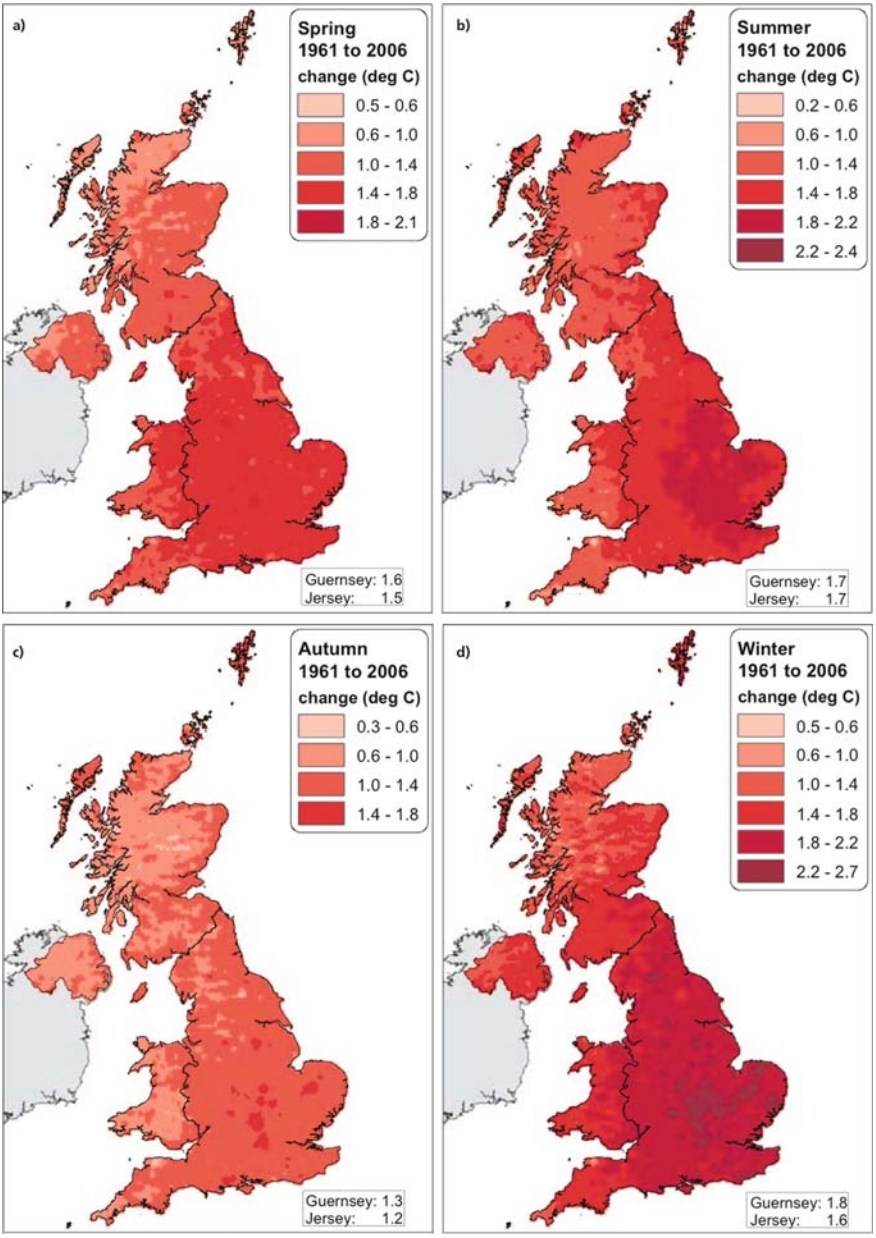


Fig. 1.20 Changes in mean temperature in the UK in four seasons 1961–2006 (Jenkins, et al., 2007)

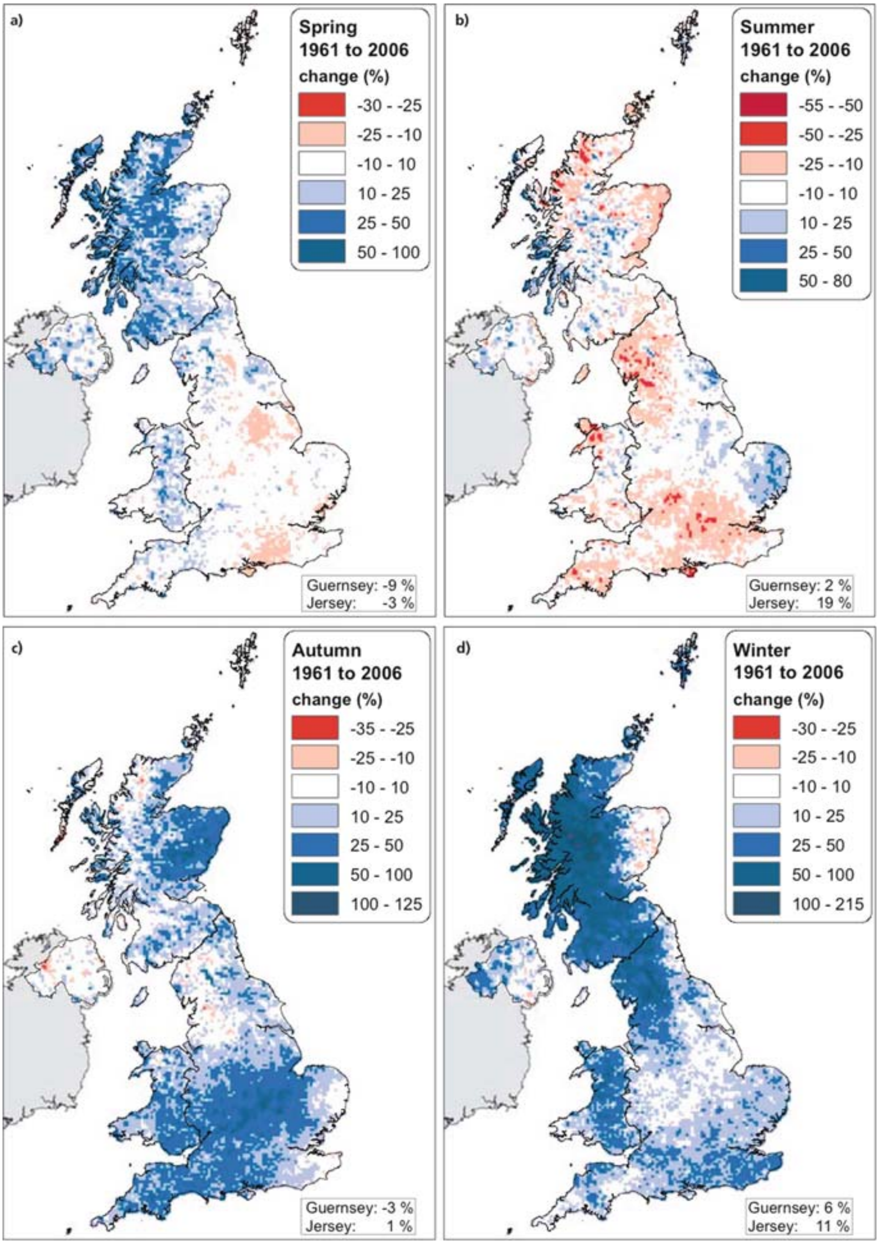


Fig. 1.21 Precipitation changes in the UK 1961–2006 (Jenkins, et al., 2007)

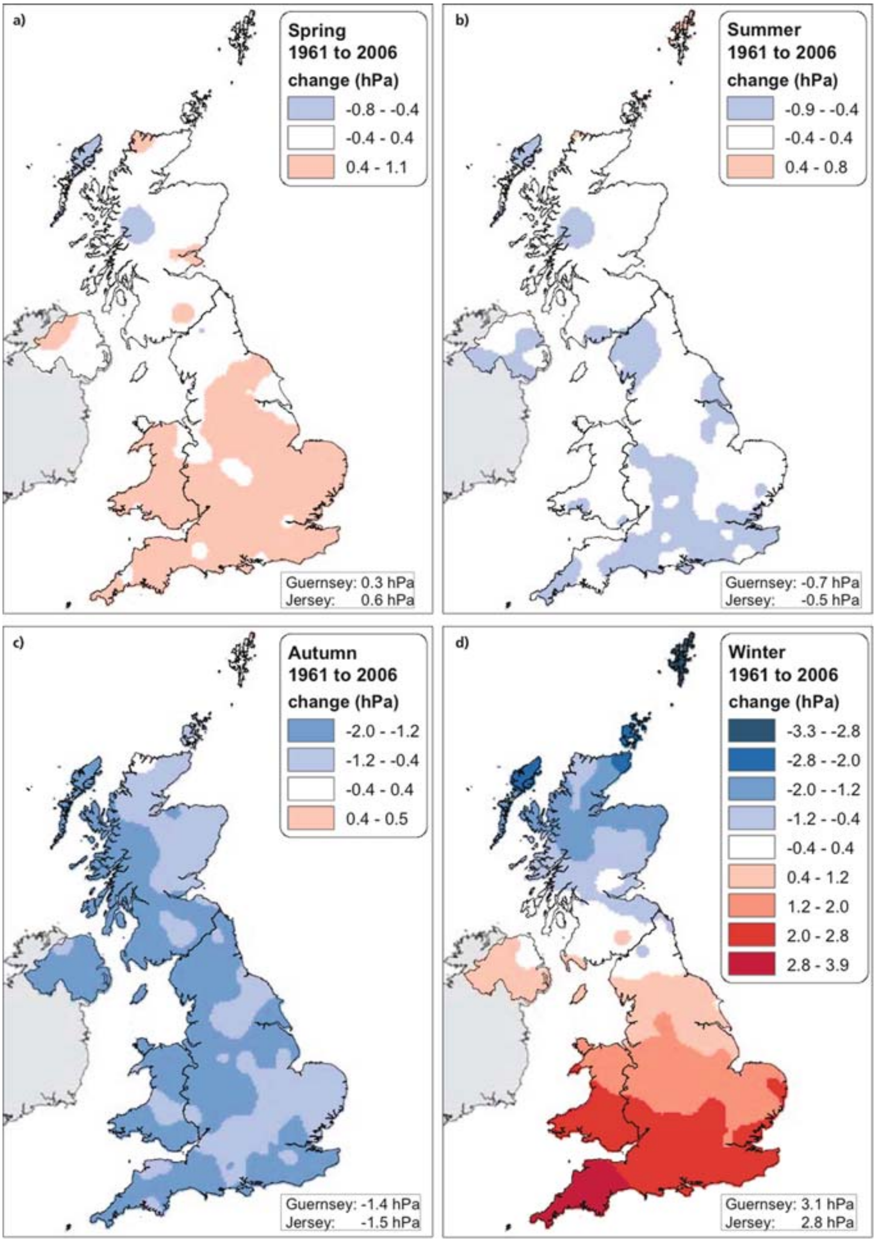


Fig. 1.22 Changes in sea level pressure in the UK 1961–2006 (Jenkins, et al., 2007)

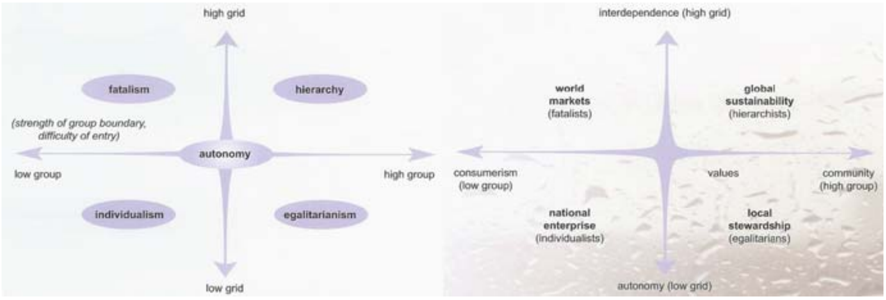


Fig. 1.23 Social-economic and social cultural scenarios (Source: Walsh et al., 2007)

the network has to deal with increased risk, because more slopes are dried out at the end of summer.

1.3.3 Social and Cultural Scenarios

The UKCIP conducts research about future socio-economic developments in the form of scenarios. The objective of this research is to assess the impacts of climate change on the population. The scenarios are indicated by two fundamental principles: governance and values. The combination of dominant social-political values with the interests and constitution of institutions leads to four scenarios (Fig. 1.23): world markets, global sustainability, national enterprises and local stewardship [Newcastle University, 2007].

These scenarios are combined with social-cultural aspects, like the ease to belong to a certain social group (*the adaptive capacity*) and the level of involvement in social life of individuals. The latter is indicated by strong social rules or by strong freedom and individualism (*grid group*). The combination of the social-cultural drivers leads to five cultural types: hierarchical orientated, individualists, equality thinkers, fatalists and autonomors, who are in the middle of the axe.

Furthermore, the combination of the societal and cultural scenarios evolves in four basic scenarios. Each of these scenarios, none of them describe a real future, tell a consistant story about the future.

The differentiation of households and the attitude against climate change changes in every scenario. The scenarios form the edges of a field, which contains most of the expected future trends and developments. They form the societal basis for all other scientific research of the program. They play a contextual role in the background of the debate.

1.3.4 Built Environment

The development of adaptation strategies for the built environment is based on at the one hand side the climate related risks and impediments in urban areas as well

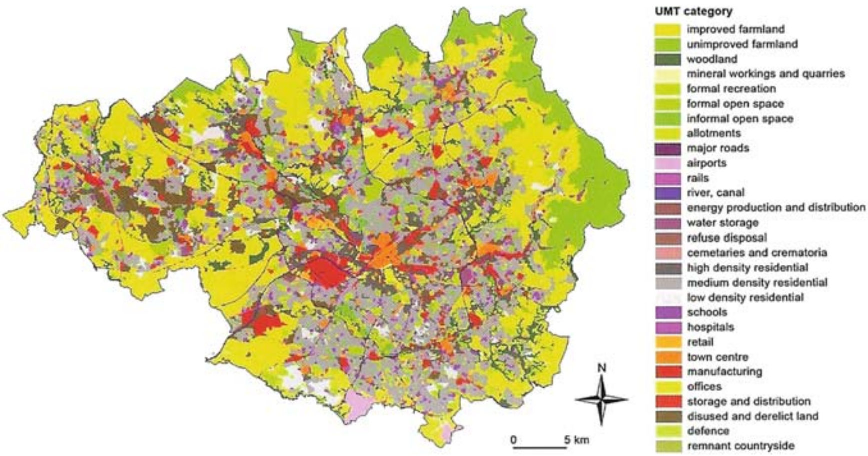


Fig. 1.24 Urban morphology of Greater Manchester (Source: Walsh et al., 2007)

as the effects on the urban environment. Important issues in the urban area are urban green space and comfort, the level of support strategic planning and urban design can offer and the coherence between mitigation and adaptation. In order to assess the effects of climate change and the adaptation possibilities in the city urban types are characterised in thirteen main categories. These categories are placed on maps for Greater Manchester (Fig. 1.24).

These morphological maps offer a solid basis to assess specific risk analyses and modelling the effects of climate change. For every typology the risk and the effects can turn out differently. Based on this urban morphology and the specific risk- and impact analyses, different strategies are developed for every part of the urban area – in comfort, quality of buildings and urban green space (Fig. 1.25).

The consequences of flooding increase if urban intensity rises. The spatial design is capable of attributing to the way risks are treated, for instance by taking adaptation measures at a local and regional level. To what extend buildings are flood proof is the final chapter in the research.

Heat stress is an important factor for human comfort. Therefore, the future changes in heat stress are projected on a map for the city of Manchester. The map with the level of comfort or discomfort illustrates that the inner city of Manchester becomes in August 2080 hardly liveable (Fig. 1.26).

Green urban space offers shadow and the evaporation of these areas lead to a cooling effect. Because of these functions green space is capable of decreasing heat stress. Moreover, these areas are capable of decreasing the rainwater runoff by infiltration and storage of rainwater in these green spaces. Forest areas contain the highest potential to reduce the heat effect. In the Manchester case this may lead to a decrease of the air temperature with 13.8 ºC in 2080. If 10% green space is added in a living area with high density the maximum temperature in 2080 can be moderated to the average level of 1961–1990. The rainwater runoff, which will have increased in Greater Manchester in 2080 with 82%, can be catched by combining

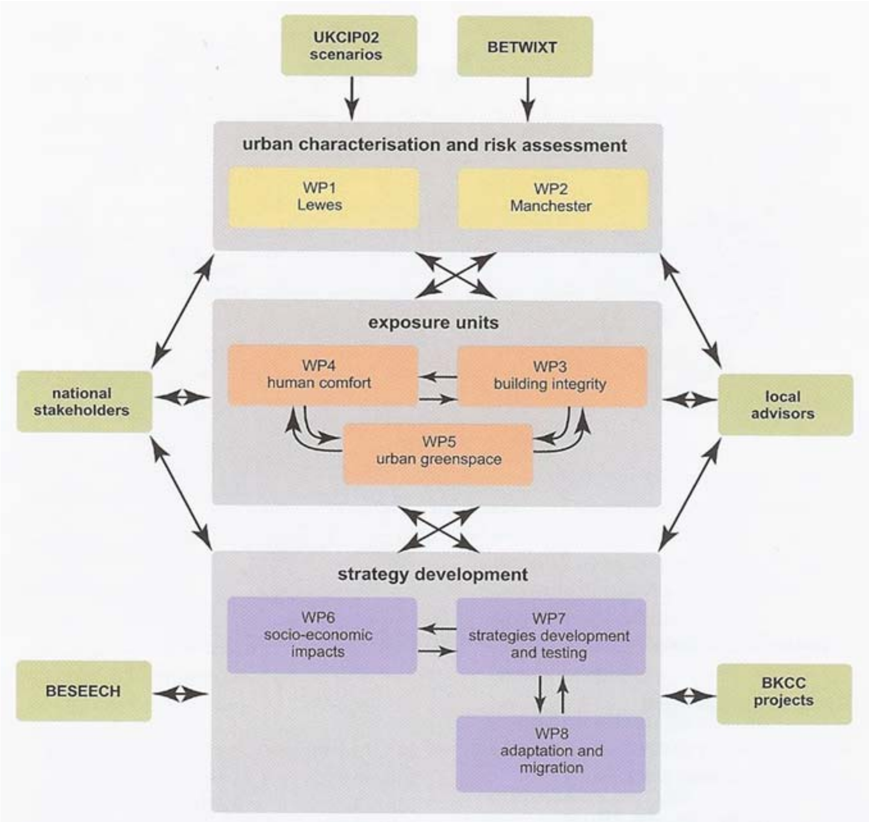


Fig. 1.25 Urban morphology, risk and impact, attention areas and strategies (Source: Walsh et al., 2007)

water storage space with green space. The green space can be seen as a strategic spatial reserve, which can be used in the future to deal with the effects of climate change (Fig. 1.27).

1.3.5 Urban Water Management

To prevent annoyances in the urban area the adaptability of the urban sewage and drainage system is a very important factor in a changing climate. In the UKCIP-program specific research is conducted on the changes in intensities of rainfall and the appearance and uncertainty of heavy showers. The urban water system is the Achilles' heel in case of floods, because the water system does no longer function in a natural way. The intrinsic capacity of storage is no longer available in case of heavy rainfall. Nowadays, the system is fully artificial and lacks the flexibility to store heavy precipitation.

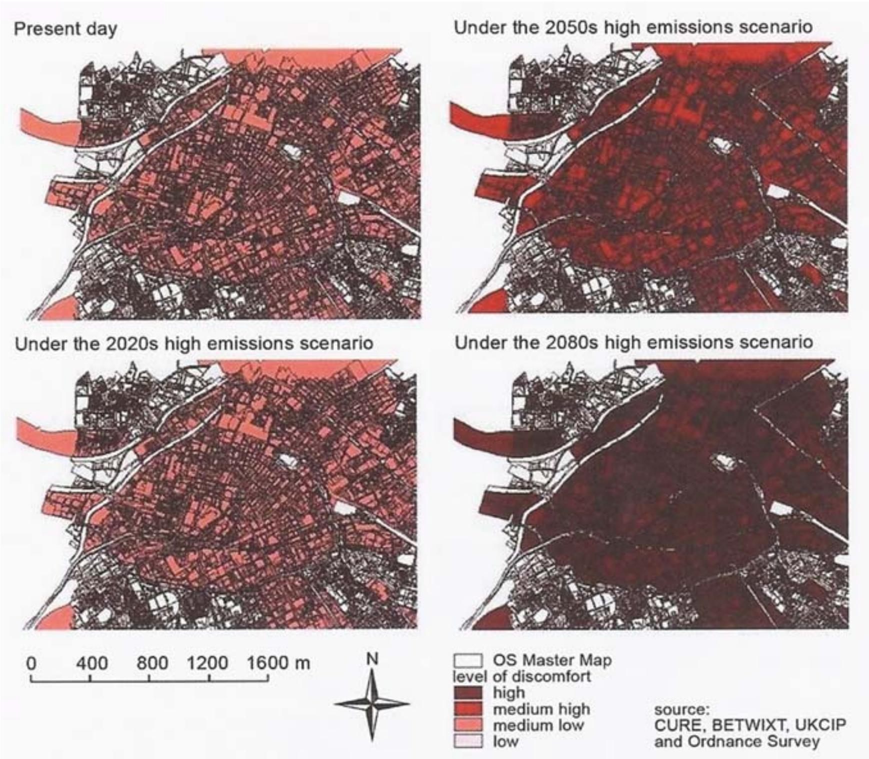


Fig. 1.26 The level of discomfort in the inner city of Manchester – current situation, 2020, 2050 and 2080 (high emission scenario) (Source: Walsh et al., 2007)

Because the water system is outdated in many cities, climate change might have serious consequences. It is very important to develop an urban water system with large margins of 10–40%, because rainfall intensities of the future become increasingly uncertain. Such a flexible system is capable of minimising the effect of flooding and water annoyance in the city. This implies high costs. The necessary adjustments need to be carried out parallel with measures, which needed to be realised anyway because of the outdated system. The measures should be taken in phases and smart and space gaining measures should be found. The system needs to take into account the increase of intense summer showers. Adjustments on buildings and introduction of local drainage may increase the capacity of the entire urban water system.

1.3.6 Energy Supply

The effects of climate change can be a threat for the energy supply. The energy network of supply and demand should be prepared on these changes. In the program research is carried out under which conditions the energy production of the future

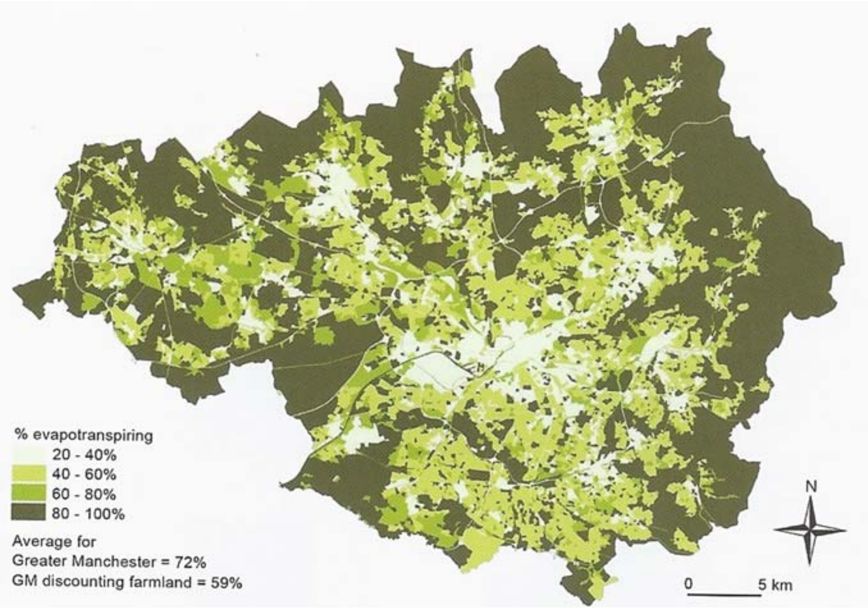


Fig. 1.27 Green space in Greater Manchester (Source: Walsh et al., 2007)

need to function to prevent failure and to match demand and supply. Predictive models are developed, which make it possible to forecast the changes in energy demand in a changing climate. Finally, the network is simulated in order to define the elements of the network, which are overloaded in 2020 and 2080. Especially the eastern parts of the London region will have to face the biggest problems in the network (Fig. 1.28).

1.3.7 Other Research Themes

Beside the mentioned research issues the BKCC-program contains several other research projects. The following research projects are carried out as well: adaptation of slopes, protection of cultural heritage, and the way air traffic should adapt.

The results of the research program are brought together in an integrative framework, which is shared by the stakeholder forum of many involved key players.

1.3.8 Conclusion

The research that is carried out in the UK is comprehensive and broad. Every imaginable issue that is related to the adaptation to climate change is researched thoroughly. The results of all research are consequently shared with involved part-

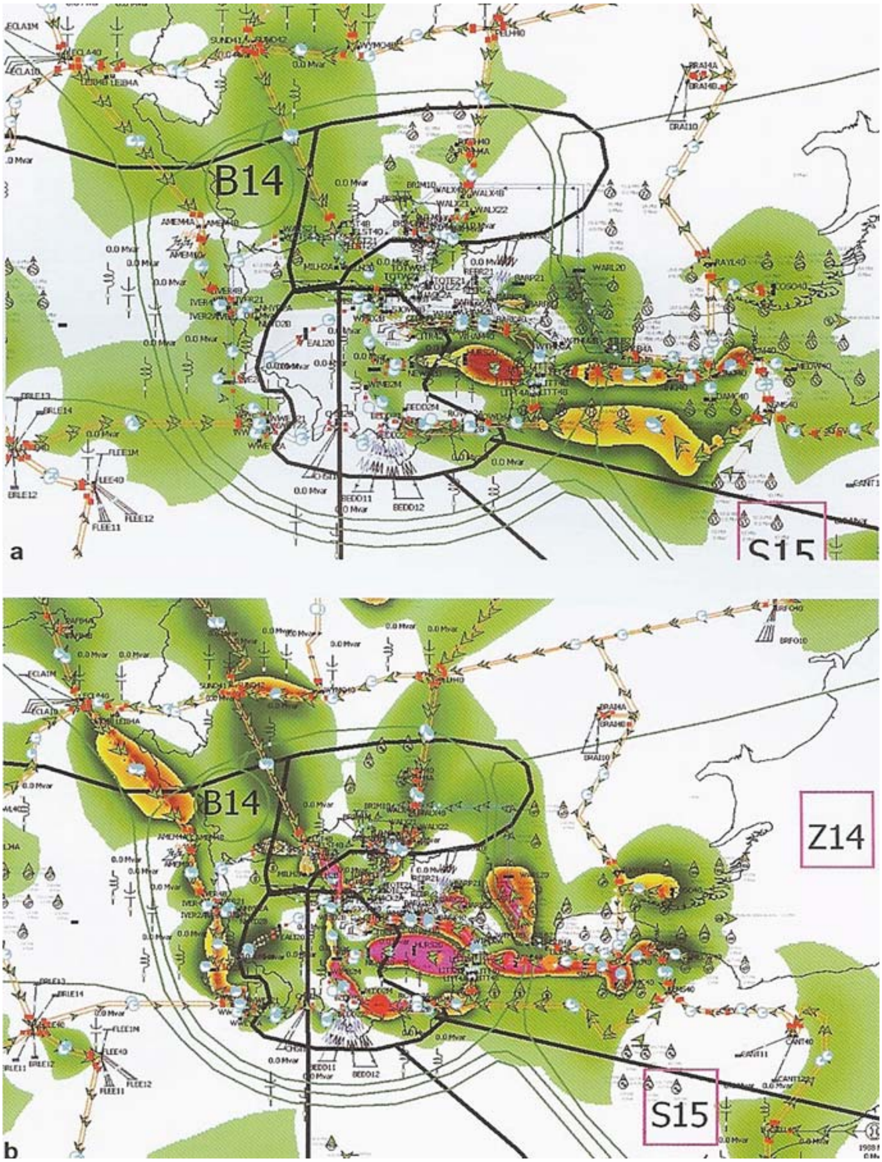


Fig. 1.28 Overload of the energy network in the London region in 2020 and 2080 in a changing climate (Source: Walsh et al., 2007)

ners. It seems that the central steered UKCIP-program settles the issues and the framework of the scientific research.

In the content of the research the focus lies on the minimising risk on problems with networks of energy and water, with a special focus on the urban environment.

1.4 Spanish Approach

The Spanish National Administration launched in 2006 a *National Adaptation Plan to Climate Change* (*PNACC*) (Oficina Española de Cambio Climático, 2006), which represents a general reference framework to target the evaluation of impacts, vulnerability and adaptation to climate change in Spain.

1.4.1 PNACC

The PNACC aims to be useful for all levels of the Administration and to all relevant stakeholders, for their plans and for the implementation of adaptation strategies according to their own competences (Fig. 1.29).

The objectives of the PNACC are (Centro de Publicaciones, 2008):

1. Tailor general climate scenarios for the Spanish geography, according differences in topography, vegetation, coastal zones, etcetera;
2. Evaluate the different impacts, vulnerabilities and adaptation options for socio-economic sectors and ecosystems;
3. Initiate permanent activities on information and communication;

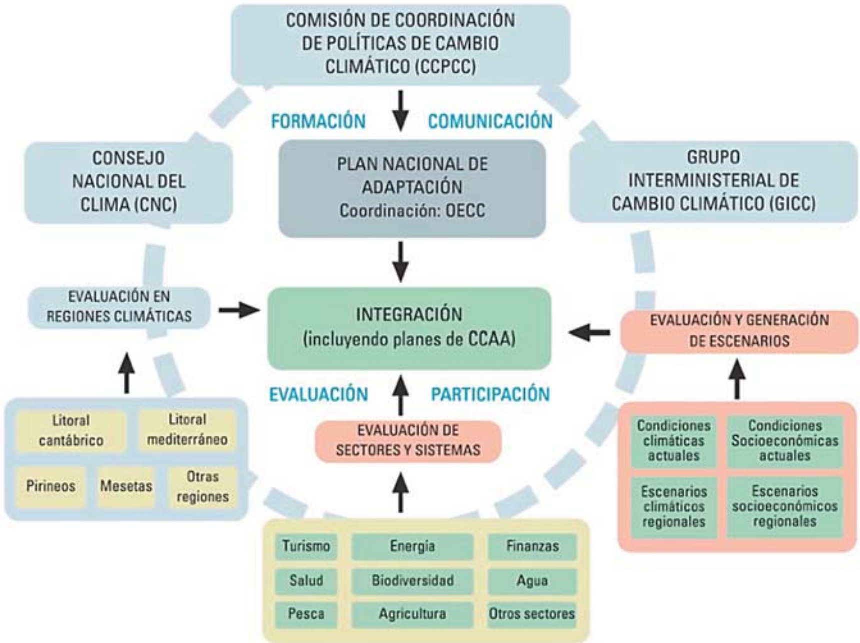


Fig. 1.29 Organisational model of the Spanish adaoptation plan (Source: Oficina Española de Cambio Climático, 2006)

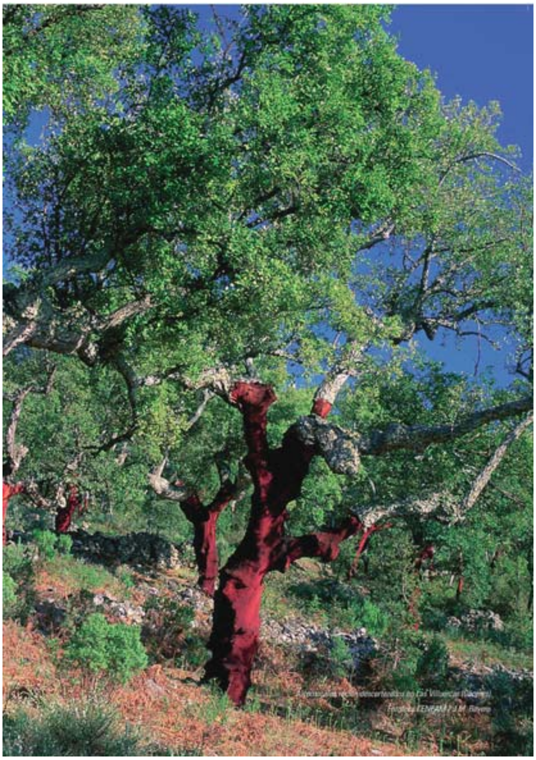


Fig. 1.30 Impact of climate change on forestry (Source: Centro de Publicaciones, 2008)

4. Promote to involve all people in distinct sectors and systems in order to integrate adaptation in sectoral policies;
5. Inform regularly about the results in projects.

The Plan has a sectoral approach and has identified an initial set of 15 relevant working sectors, which are vulnerable for climate change or contain adaptation challenges: Biodiversity, Water resources, Forests (Fig. 1.30), Agriculture, Coastal zones, Inland hunting and fishing, Mountain areas (Fig. 1.31), Soils (Fig. 1.32), Fishing and marine ecosystems, Transport, Human health, Industry and energy, Tourism, Finance/Insurance policies and Urban planning and construction.

For each sector considered, the likely impacts, vulnerabilities and/or needs for adaptation action are dealt with, including those potentially affecting spatial planning.

1.4.2 Implementation Through Work Programmes

The Plan is being implemented through Work Programmes. The 1st Work Programme deals with three key sectors that are expected to have very important

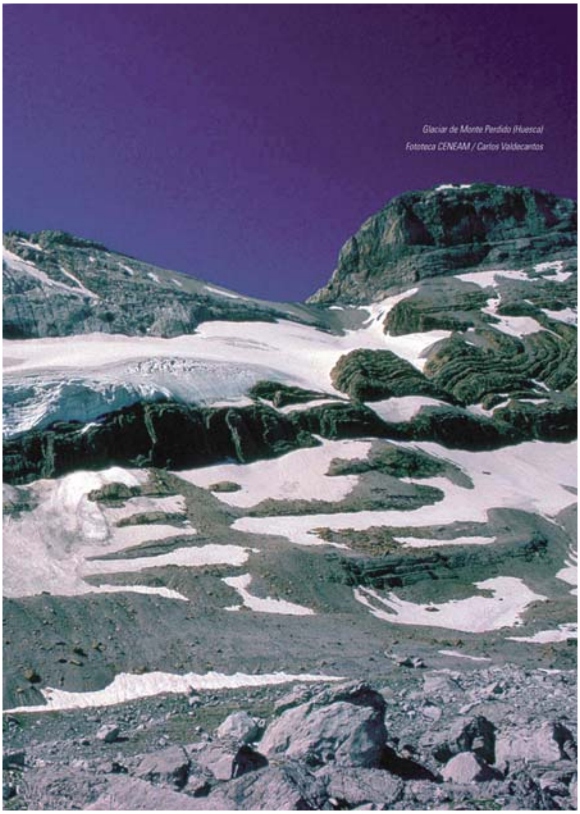


Fig. 1.31 Climate change affecting mountain areas (Source: Centro de Publicaciones, 2008)

outcomes for subsequently feeding spatial plans and the adaptation strategies within sectors.

1.4.2.1 Coastal Areas

The main problem in coastal zones is the changing dynamics near and around the coast, like the rise of the sea level. The major impacts are the decline of deltas and beaches (Fig. 1.33), while rocky coasts are not really at risk. If a rise of sea level is calculated of 50 centimetres most low lying coasts are at risk: the Ebro delta and the Llobregat, Manga del Marmenor, lagoons in the Cabo de Gate and the gulf of Cadiz and Doñana. Another region at risk is Cantábrico oriental, which contains 40% of the beaches has to deal with flood risk.

1.4.2.2 Water Resources

In Spain climate change means the rise of temperatures and a decrease of precipitation. This implies that the availability of water decreases. A temperature rise of 1°C and decrease of 5% precipitation means a decrease between 5 and 14% water

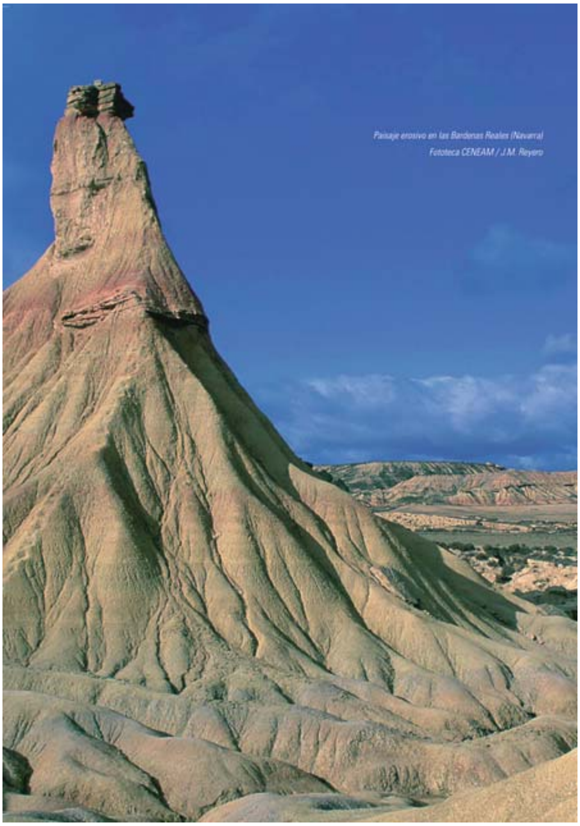


Fig. 1.32 Climate change influencing soil degradation (Source: Centro de Publicaciones, 2008)

availability by 2030. A further decrease of 20–22% by the end of the century is expected. The water availability decreases by almost 50% in arid and semi-arid areas, which contain around 30% of the national territory. The hydrological variability increases in the Atlantic basins, while in the Mediterranean and the interior the water availability is predicted to become very irregular (Fig. 1.34).

1.4.2.3 Biodiversity

The terrestrial water system will be affected by climate change. Permanent water will change into seasonal carrying water bodies and some may even disappear. Lakes, lagoons, rivers and brooks in the mountainous areas will be most threatened as well as coastal waters, which are dependent on supply from underground aquifers or seepage. Biodiversiy of these systems will decrease and their biochemical cycles will change. Ecological reserves, like the swamps of Doñanaor Ebro-delta will undergo changes, lose their characteristics and decrease their ecological richness. The possibilities of these areas to adapt are limited.

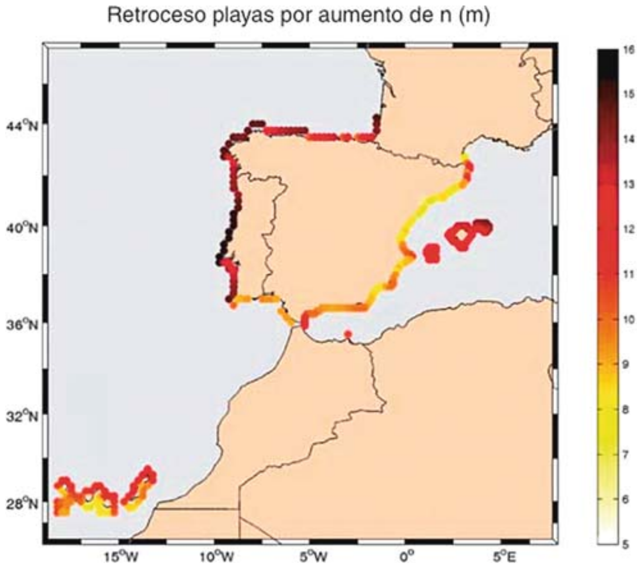


Fig. 1.33 Beaches under threat (Source: Centro de Publicaciones, 2008)

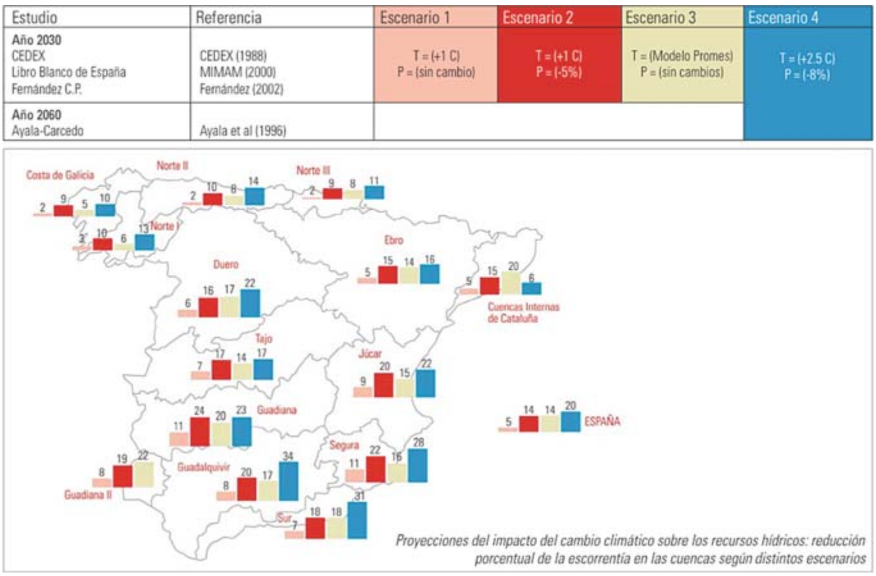


Fig. 1.34 Water availability around the country in different scenarios (Source: Centro de Publicaciones, 2008)

The terrestrial ecosystems differ from their geographical position. The Atlantic terrestrial systems, limited by temperature, might show an increased productivity, while the productivity in the Mediterranean systems, limited by water, decreases. The phenology and interaction between species will undergo changes, from migrations from the highlands to local extensions. Plagues and invasive species will profit from changing circumstances. Those ecosystems that are at the boundary of geographical regions, such as highlands or dry rock formations, suffer the most from climate change.

The biodiversity of vegetations is affected by warming and decrease of availability of water leading to a so-called 'Mediterranesation' of the northern parts of the Iberic mainland as well as drying out and possible desertification of the southern parts. Direct influences are caused by changes in the soil and groundlevel; the regularity of wood-fires and the rise of the sealevel. This causes a loss of biodiversity and local extinctions outnumber recolonisation. The most vulnerable vegetation is located in the highlands, the trees and bushes, which are vulnerable for droughts, forests in the south and southeast and the coastal vegetation.

Finally, the biodiversity of animals is changing. Phenology and populations are under threat and are deregulated. Fractures in ecosystems will increase and interactions, like predator-prey, plagues, competition or impregnation, between species are disrupted. Another effect is the shift between water and land species as well as the intensity of parasites and increase of invasive species. Vulnerability is highest for those species, which are especially under threat, like those living in the highlands.

Spain is an important area for the breeding population of the little bustard. According the simulation (Huntley, et al., 2007) the majority of current breeding places will be disappeared in 2100 (Fig. 1.35).

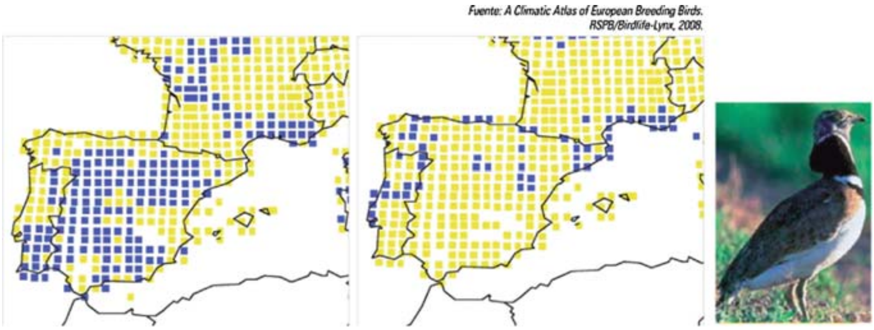


Fig. 1.35 Current and modelled dispersion in 2100 of the Little bustard (tetrax tetrax) (Source: Huntley, et al., (2007))

1.4.3 Spatial Planning and Construction

Strategies of spatial planning and urbanism need to pay attention to the effects of climate change especially in order to make the right decisions on inhabitation and the lay out of functions and activities. The adaptation possibilities and the prevention of the depletion of natural resources – and the negative impact on global climate – need to be a steering mechanism in spatial plans.

Within urban spaces green space (parks and gardens) is the most vulnerable part of the city where adaptation measures are equally important. The effects of climate change will be felt in the comfort of buildings. New climate scenarios need to be used for building directives as well as in realisation of buildings. Negative synergy effects of climate change in relation to the relatively widespread urban patterns in Spain need to be judged. The densities in relation to traffic, the use of energy and water and use of natural resources in general are dependent on the urban patterns designed.

In spatial planning the following actions will be determined:

- Development of good practices on the adaptation of urban designs;
- Support of bio-architecture, especially in public buildings;
- Definition of the most applicable species of plants in gardens and public spaces under new climate scenarios;
- Judgement and evaluation of the impact of low-density urbanism on the use of transport, energy and water.

1.4.4 Accents in the Spanish Adaptation Strategy

The Spanish approach can be characterised as a Step-by-Step one, which starts of with a general strategy on adaptation and an immediate transfer towards work programmes and a choice to focus on a limited number of sectors: water resources, the coastal zone and biodiversity. Adaptation is not seen as a separate field of policy, but is integrated in sectoral policies, making these sectors responsible for carrying out the adaptation strategy. Finally, there is a clear emphasis on the role of spatial planning: in the urban design, in the use of bio-architecture in public buildings, in the choice of species in green spaces and on the relation between urban patterns and the use of resources.

1.5 Climate Adaptation Strategy of Denmark

With the Danish strategy on climate adaptation [Regeringen, 2008] the government emphasises the importance of timely adaptation to meet climate change. The government finds it important that, as far as possible, climate adaptation is continuous (ad hoc), in the sense that the authorities, enterprises and individuals at their own initiative react to the consequences of climate change in good time, within the given legislative, financial and technological framework. To the extent that ad hoc adaptation is not the most optimal approach for society, it may be necessary to launch adaptation measures that have been agreed at political level.

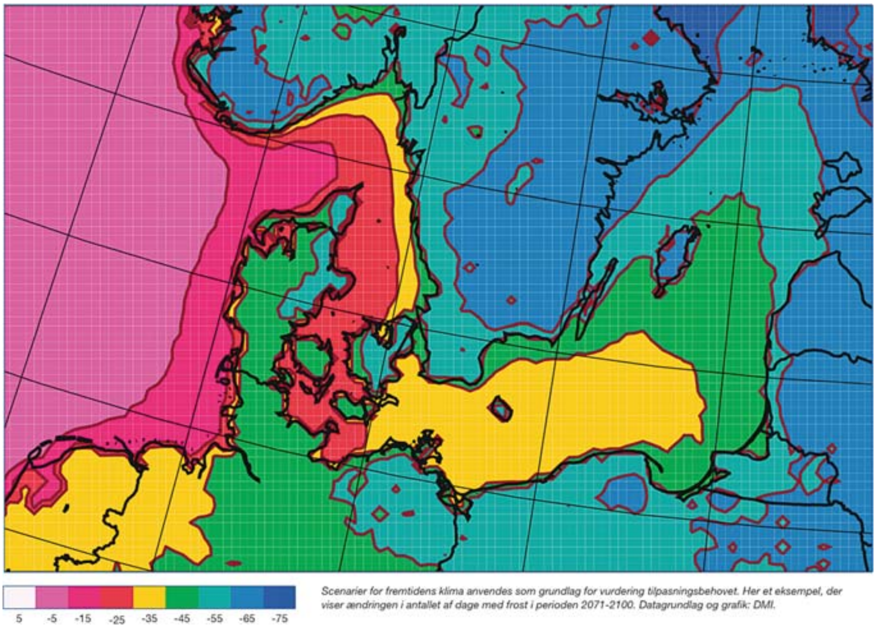


Fig. 1.36 Decrease in frost days between 2071 and 2100 in southern Scandinavia (Source: Regeringen, 2008)

In general, warmer weather, milder (Fig. 1.36) and wetter winters and warmer and drier summers are expected in Denmark. Precipitation over the course of a year increases. However, less precipitation is expected during the summer, a period, which will be characterised by periods of drought and heavy rainfalls. The maximum water level of the waters of both the West Coast and the Danish interior waters is expected to increase, just as the maximum winds and gales are expected to increase. Similarly, there will be a greater risk of extreme weather, with longer heat waves and more violent storms.

1.5.1 Objective of the Adaptation Strategy

The strategy is based on climate adaptation being a long-term process and that there is still some uncertainty concerning the consequences of climate change and the pace of these changes. Therefore, the Danish government will implement information initiatives and start organising the area with a view to ensure that in future climate change is included in all planning and development stages, so that authorities, industry and individuals have the best possible foundation when considering whether or not to incorporate climate change, and if this should be the case when and how to deal with this issue.

This strategy includes the following initiatives:

- A targeted information initiative, including setting up a climate adaptation portal managed by a knowledge centre;
- A research strategy, including setting up a coordination unit with the view to ensuring that Danish climate research is more focused on the issue of adaptation;
- Setting up an organisation, including establishing a cross-ministerial coordination group to ensure that efforts are coordinated between public authorities.

The strategy includes a description of the vulnerability of the sectors where future climate change is expected to have an impact. Emphasis will be on whether initiatives have already been taken for ongoing adaptation, and what can encourage this process.

How a climate adaptation initiative should be dimensioned depends on an assessment of the consequences of climate change, how probable they are, as well as how much it will cost to prevent such climate change. In this connection consideration should be given to the ad hoc manner in which adaptation is being carried out.

1.5.2 Sectors that May be Affected by Climate Change

The strategy should include focus on what can actually be done within each sector in the next 10-year period. This means it must be scientifically, technically and socio-economically relevant to launch a specific initiative within this period.

The following sectors are distinguished:

1. *Coastal management*: It is expected that climate adaptation in connection with the coast and ports will be necessary as a consequence of increasing sea levels and more storms, if the current safety levels and operational conditions are to be upheld. Renewal, dismantlement or renovation of dykes or port installations may be necessary Moreover, ongoing adaptation of disaster and storm flooding contingency plans is needed as well as information on conditions that may affect planning of coastal construction projects in future risk areas;
2. *Construction*: Increased focus on the indoor climate will be necessary, in particular on temperature and humidity conditions. To support adaptation measures to reduce extreme indoor temperatures during heat waves, guidelines for new construction techniques may be needed. Moreover, a compulsory labelling scheme may be introduced for small individual cooling facilities that can be set up at short notice. Drainage systems for roads should be considered in view of the risk of increased precipitation intensity. Increasing temperatures will increase the need for securing the safety installations on railways. As regards increased wind velocity, a risk analysis of possible windfalls onto roads and railways must be performed;

3. *Water supply:* Climate adaptation may entail restructuring water extraction, taking future groundwater resources as well as water flow and the quality of water courses and aquatic areas into consideration. Set targets are needed for a planned restructuring of water extraction so that it is possible to determine:

   - The size of water volumes that will have to be redirected;
   - To which areas it will be possible to redirect these volumes.

4. *Energy supply*: A change in the energy supply is expected including increased production of renewable energy, and changes in consumer patterns including less heating in the winter and more cooling in the summer;
5. *Agriculture and forestry*: A longer growing season will make it possible to introduce new crops and to increase yields. Moreover, changes in precipitation patterns are expected. Increases in the numbers and types of pests are also expected to entail an increase and change in the use of pesticides. At the same time a change in the precipitation pattern will change the need for drainage and irrigation. The present move towards natural forestry in the state forests will be reassessed with a view to either accelerating or adjusting the process*;*
6. *Fisheries*: the industry is expected to develop new tools, fishing methods and vessels. Adaptation and development of new management systems are expected within the existing international cooperation in management of fisheries and marine eco-systems. It is also expected that there will be a need to restructure fish and shellfish breeding in both salt and freshwater;
7. *Nature and nature management*: Several measures are taken to ensure that nature and the environment are healthy and resilient to a changing climate. Amongst the measures are the conversion of selected river valleys into natural wetlands with extensive management cultivation, efforts to curb oxygen depletion in the seas and fragmentation of nature, as well as activities to prevent invasive species;
8. *Planning*: Planning recommendations, identifications or reservations for green corridors or location of buildings and other constructions for instance to create innovative building techniques to deal with flood risk (Fig. 1.37) will be done either in the so-called '*Oversigt over statslige interesser i kommuneplanlægningen*' (Overview of central-government interests in municipal planning) or as a part of the regional development plans. Relevant risk analyses in the form of risk maps will be an important decision-making tool in planning.
9. *Human health:* Adjusting public health emergency, prevention and treatment services, as well as adjusting the monitoring of contagious diseases could be relevant in the face of more frequent heat waves, and other health risks linked to climate change (infection, allergies etc.);
10. *Emergency and rescue services*: Emergency and rescue services have been adapted after the violent storm in 1999 and storm surges and floods of recent years. For the period 2007–2010 the capacity and scope of central-government emergency and rescue services will be examined. An important aspect of this examination will be weather incidents, seen in relation to risks and threats as well as in relation to the capacity of the individual municipal rescue services;

Fig. 1.37 Buildings adjusted to Increased sea level and storm risk on the island of Rømø (Source: Regeringen, 2008)

11. *Insurance-related aspects*: Climate change will prompt insurance companies to adjust premiums upwards and/or make coverage exceptions. Similarly, it may become relevant to develop new financial instruments for risk transferral between non-life insurance companies and the remaining financial sector.

The responsibility for ensuring the necessary sector-specific adaptation to climate change will lie with the relevant ministries. Since adapting to climate change will often be a crosscutting effort like ‘agriculture-the environment-nature’ or ‘health-building and construction-the environment’, there will be a need for coordination between ministries. This will be ensured through the cross-ministerial coordination group and the knowledge centre, which have been proposed for the purpose.

1.5.3 Cross-Cutting Initiatives

1.5.3.1 Targeted Information Efforts

The government will establish an internet-portal for climate adaptation. The portal will allow easy access to the most up-to-date knowledge within the area and it will be developed so that authorities, businesses, specialists and private individuals can use it. The portal will therefore help underpin spontaneous adaptation.

The establishment of an internet-portal on climate adaptation will be the pivot for increased information efforts. In order to provide Danish society with a possibility to adapt to climate change in good time, easy-accessible information concerning the expected change must be available.

This internet-portal will be the point of access to information about trends for a number of climate variables such as temperature, precipitation, wind conditions etc. Similarly, there will be access to a series of oceanographic data such as mean sea levels, storm surge levels, content of oxygen and sea temperatures. A number of decisions dependent on climate development share the same requirement for information, such as information about terrain levels and groundwater conditions, so this information will also be made available on the internet-portal on a regular basis.

By far the majority of this information is related to geographic matters. Therefore, there will be a need to establish a common geographic basis that will ensure efficient comparison and use of data across geographic and administrative borders.

1.5.3.2 Research Strategy

The government will develop model tools for socio-economic assessments of initiatives in the climate adaptation area and establish a coordinating unit for research in climate adaptation.

In recent years there has therefore been increasing focus on the climate question within the Danish research environment, and a number of competent Danish research environments have been established. By far the majority of previous research efforts have been aimed at understanding and describing the changed climate conditions, including possibilities for limiting climate change caused by human activity. Limited research has been carried out on the challenges linked to adaption and preparation Danish society for the climate change of the future.

Therefore, there is a need for climate research to increase its focus on the question of how we adapt. Adapting to climate change must be made an integral part of the remaining research, so that research into climate adaptation contributes significantly to more coherent climate research.

1.5.3.3 Future Organisation

With the strategy for climate adaptation, the government encourages all sectors to unite in the efforts. It is therefore proposed that a cross-ministerial coordination group be established, in addition to the coordination unit for research into climate adaptation mentioned above, with a science centre functioning as secretariat to make sure the initiatives of the coordination group are realised.

Cross-Ministerial Coordination Group for Climate Adaptation

The overall objective of the coordination group is to ensure that the government's climate adaptation strategy is implemented. Additionally, the coordination group is to safeguard a common basis for cooperation and coordination across sectors and authorities. Relevant central-government authorities and a representative from each municipality, region and from the coordination unit will participate in the coordination group.

Knowledge Centre for Climate Adaptation

In order to ensure that the initiatives of the coordination group are realised, it is proposed that a knowledge centre for climate adaptation be established to function as a secretariat for the initiatives. One of the centre's important tasks will be to provide information.

Coordination Unit for Research on Climate Adaptation

The coordination unit is to ensure that the synergy between existing and new projects is exploited, and is to contribute to promoting crosscutting collaboration and knowledge sharing between research environments.

1.5.4 Spatial Planning

When talking about spatial planning the strategy very much is based on an ad hoc attitude leaving a major responsibility to municipalities. This has been criticized from various groupings and also from some municipalities, asking what the responsibility of the Government is exactly. The adaptation strategy does present Governmental actions, but at the same time the National Government reformed Denmark, abolishing the county level, which specifically could have been given the task to make more detailed adaptation action plans. The National Government also transferred – apart from national planning responsibilities – all planning authority to the municipal level. Consequently, the municipalities must face the responsibility for making adaptation plans. Despite the fact that municipalities are ready for this task, an overall framework and guidelines is required and not apparent in the strategy yet. This weakness in the strategy is being notified and it is foreseen that by end of 2008 a completely new digital elevation model (GIS) of Denmark will be developed, which shows purely the topographical surface with a certainty of ten centimetres. This model will be used extensively in order to visualise the spatial impacts of climate change.

1.5.5 Character of the Danish Approach

The Danish strategy can be characterised by a strong focus on regulations and decentralisation towards municipalities. The strategy is formulated in a way that a lot should be done, instead of articulating the measures that will be done. The attention for spatial planning is relatively low. Responsibility for conducting and realisation of adaptation plans is decentralised towards municipalities. The focus on sectors affected by climate change is combined with a crosscutting ministerial strategy, which is supported with a strong emphasis on knowledge development.

1.6 Wise Adaptation to Climate Change, Japan

The Japanese Ministry of the Environment commands a review on the possibilities and necessities for the adaptation to climate change in Japan. This review is called

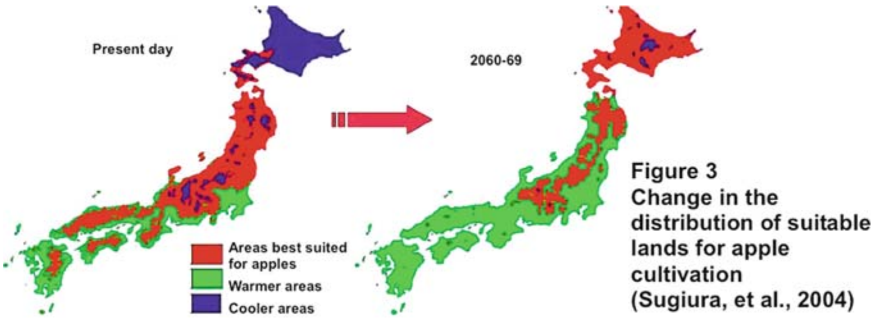


Fig. 1.38 Change in distribution of suitable lands for apple cultivation (Source: Committee on Climate Change Impacts and Adaptation Research, 2008)

'Wise adaptation to climate change' [Committee on Climate Change Impacts and Adaptation Research, 2008]. The main objectives of the review were:

1. Clarification of existing scientific knowledge regarding the impacts of and adaptation to climate change in Japan;
2. Presentation of what wise adaptation (effective and efficient) may imply;
3. Presentation of the challenges and direction of further research

1.6.1 Impacts of Climate Change in Japan

The observed and projected impacts of climate change are described for several sectors: The impacts on *food* (agriculture, livestock and fisheries) contain changes in the rice production, Ukikawa symptoms (detached fruit skin and flesh) in mandarin and grapes due to high temperature and delayed seaweed harvests due to a later cooling down of water temperatures in autumn. It is expected that poor ripening of rice increases, a shift northward will take place for apple cultivation lands (Fig. 1.38), a northward shift of damage and pest, water shortages during rice planting, a decreased habitat for salmon and northward shift for herring, slower growth of the Pacific saury (Fig. 1.39) and a northward shift of suitable aqua-farming of Blowfish (Torafugu).

The impacts on *water environment and resources* are increasing restrictions on water intake and water supply (Fig. 1.40), an abnormal bloom of blue-green algae in lakes and marshes and the increased use of groundwater. It is expected that the risk at drought will increase, the amount of landslide disasters will increase de to a higher frequency of short-term extreme rainfall, the temperatures in rivers, lakes, dam reservoirs and groundwater will be elevate resulting in a higher probability of blue green algae blooms and the groundwater will be salinated due to a rising sea level.

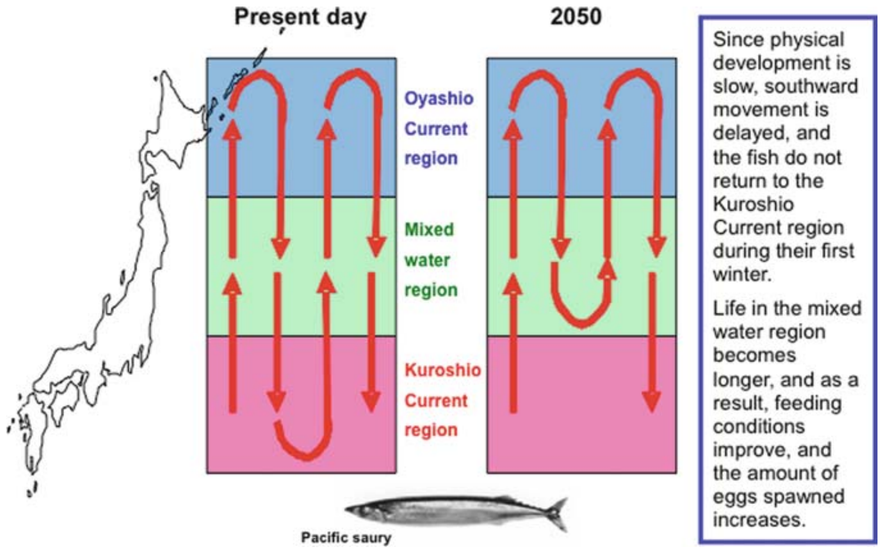


Fig. 1.39 Slower growth of the Pacific saury disables the fish to return to southern waters (Source: Committee on Climate Change Impacts and Adaptation Research, 2008)

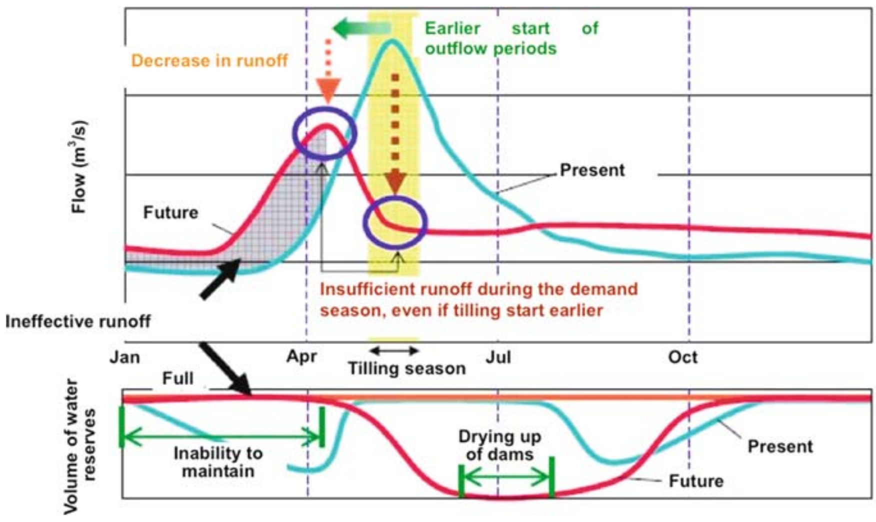


Fig. 1.40 Possible effects of decreased snowfall on water resources (Source: Committee on Climate Change Impacts and Adaptation Research, 2008)

The impacts on *natural ecosystems* vary from a decline of Japanese beech forests and decrease of alpine flora to an aridification of moors and the dispersion of Japanese deer, the stagnation of vertical circulation of lakes and reduction in dissolved oxygen at the bottom, a reduction of distribution areas for cold water fish,

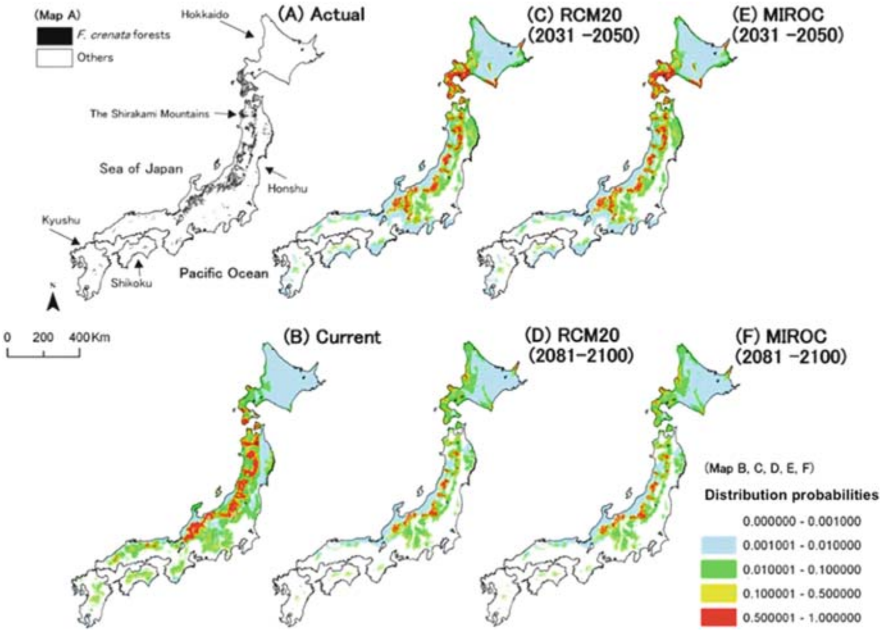


Fig. 1.41 Changes in distribution probabilities of the Japanese beech tree forets in different climate scenarios (Source: Committee on Climate Change Impacts and Adaptation Research, 2008)

an increase of southern species and decrease of northern species along the coast, the bleaching and destruction of coral reefs, an earlier flowering period of Camellia, Japanese *ume*, dandelions and cherry trees, a later stage of leaves colouring and falling of ginkgo and maple trees and the late blooming in Kyushu due to insufficient 'dormancy breaking' caused by low temperatures. It is expected that a decrease of distribution areas suitable for Japanese beech tree forest (Fig. 1.41), sub-alpine belts will take place, a rapid decrease in alpine plant communities, the expansion of bamboo groves in Tohoku region, increased stagnation in lakes and oceans, invasion of alien species in freshwater regions, changes in food chain caused by diminishing sea ice in the Ochotsk Sea and an escalation of the effects on plankton and calcified organisms due to ocean acidification.

The *disaster prevention and large coastal cities* are affected by increased threats of flooding and damage as a result of storm surges and typhoons, leading to inundations and an increased frequency of extreme rainfall (Fig. 1.42) and a decreased amount of water available in the Kiso reservoir.

In the future an increase of the intensity of typhoons is expected, they will probably shift their course leading to other areas at risk and cause increased wind speed and ocean waves. Furthermore, it is expected that wave-overtopping rates due to sea level rise increases, the erosion and loss of sandy beaches will diminish 90% with one meter sea level rise, the flood control safety levels decrease and landslide disasters increase due to snowmelt.

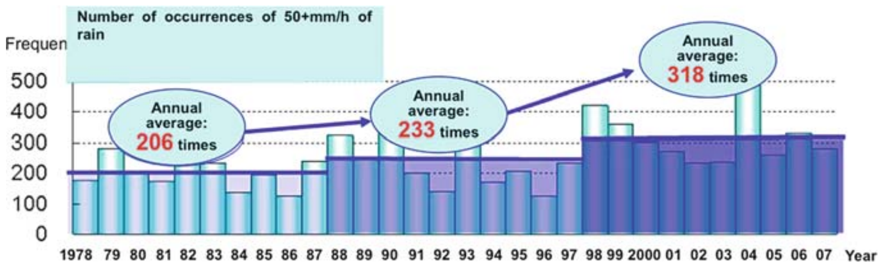


Fig. 1.42 Increase of frequency of heavy rainfall (Source: Committee on Climate Change Impacts and Adaptation Research, 2008)

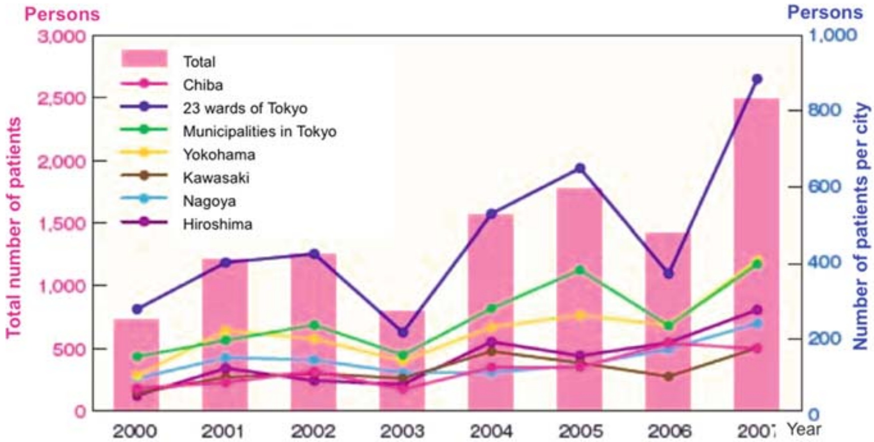


Fig. 1.43 Trends in the number of heat stroke patients per city (Source: Committee on Climate Change Impacts and Adaptation Research, 2008)

The impacts on health show an increase in excess mortality due to heat stress, record high number of heat stroke patients (Fig. 1.43) and the expansion of the distribution area of the Asian tiger mosquito, transferring dengue. It is expected that all of these impacts will increase in the future.

Climate change influences also *citizens and urban life*. The impacts that are defined are the rise of international prices for wheat, corn and Soya-beans, earlier blossoming of Japanese *ume* and cherry trees, tourist and sport climate conditions and an increasing reporting on *akenoumi* (lake fails to freeze) and *No Omiwatari* (no cracks appearing on a frozen Lake Suwa, Fig. 1.44).

Further impacts on citizens and urban life is expected to increase the loss of life and property and an impact on transportation and communication facility due to extreme weather damage like extreme rainfall (Fig. 1.45), an increase of deaths, diseases and heat stroke patients caused by heat waves (Fig. 1.46), burden on household budgets due to higher prices of agricultural products and extended use of air conditioning, the increase of discomfort in daily life due to the increase of extremely hot days and nights, lower possibilities for tourism and recreation, impact on sports

Fig. 1.44 The Omiwatari phenomena at Lake Suwa in 1980 (Source: Committee on Climate Change Impacts and Adaptation Research, 2008, © Suwa Museum)

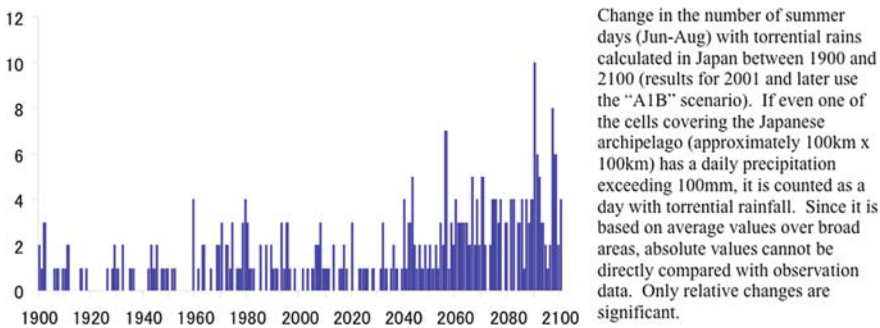


Fig. 1.45 Predicted number of summer days with extreme rainfall in Japan (Source: Committee on Climate Change Impacts and Adaptation Research, 2008)

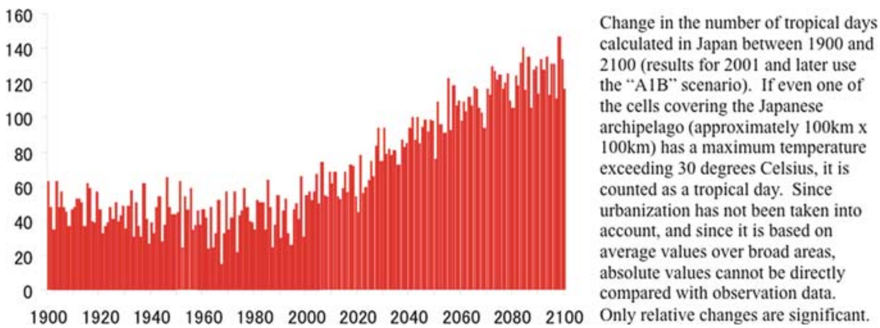


Fig. 1.46 Predicted number of hot days (maximum temperature > 30ºC) (Source: Committee on Climate Change Impacts and Adaptation Research, 2008)

due to less snowfall and the impact on local culture due to a loss of sense of seasons caused by snow season shortages and changes in cherry blossom season.

1.6.2 Wise Adaptation

In order to react on the impacts of climate change, both current and predicted, adaptation measures can be implemented. Several elements are part of a *wise adaptation,* which is effective and efficient, subdivided in technological, policy and socio-economic perspectives.

Elements from a technological perspective:

- Utilisation of a diverse range of options, both in the technical, legal, economic and social fields or focussing on preventive adaptation measures in order to minimise damage and responsive ones that prepare the response after damage. In wise adaptation it is important to combine and utilise adaptation measures according to time, place and opportunity
- Utilisation of observation results. Due to uncertainties in future projections reliance on observed developments is also a valuable base for defining adaptation measures;
- Development of human resources;
- Realisation of low-vulnerability systems with flexible response capacity, which improves the character and mitigates the vulnerability of various systems to the impact of climate change.

Elements from a policy perspective:

- Adoption of early warning systems that utilise monitoring in order to predict extreme events and reduce damage;
- Utilisation of both long-term and short-term perspectives;
- Mainstreaming adaptation by incorporating it in existing policies and plans;
- Cooperation and coalition with other organisations;
- Promotion of co-benefit-type adaptation, which offers the society an extra benefit from the adaptation measure and does not only realise its own adaptation objective.

Elements from a socio-economic perspective:

- Promotion of regional vulnerability assessments in order to successfully implement scientifically rational supplements and reviews of programs;
- Improve adaptive capacity using insurance and other economic systems;
- Promotion of voluntary initiatives.

Possible options for adaptation measures for each sector are defined in Table 1.1.

Table 1.1 Examples of options for adaptation measures

	Technology options		Policy option		Social and economic options	
	Technology	Information and knowledge	Legal systems	Human resources	Social systems	Economic systems
Food	Development and introduction of high temperature tolerant varieties – Shift in cultivation areas – Change in cultivation methods – Controlling feedlot environments – Shift in aquaculture areas and development of aquaculture technologies	Collection and organisation of information from promoters of agricultural improvement	– Development of mechanisms to support and advise on adaptation measures for elderly farmers – Adjustment of fishing seasons to suit fish migration routes and fishing ground formation	– Provision of information and human resources development to promoters of agricultural improvement and farming advisors	Reconsideration of irrigation customs as a result of changes in cropping seasons and delayed drainage seasons	– Utilisation of mutual aid systems (quick provision of damage information and using the information in compensation claims)
Water environment and resources	– Introduction of raw water transmission and discharge control systems as drought measure – Desalination of water – Use of treated sewage water and rainwater – Prevention measures against groundwater salinisation – Eutrophication control measures (blue green algae fences) – Dissimination of water saving devices	– Overall evaluation of the characteristics of sources of drinking water and the selection of suitable water purification processes	– Improvement of water supply – Restriction of deep groundwater pumping to control land subsidence	– Raising of water saving awareness	– Intensification of farmland and reallocation of water rights – Introduction of mechanisms or regional flexible transfer of water during droughts	– Indirect controls using economic instruments such as a levy system in regulations for the use of deep ground water

(Continued)

Table 1.1 (continued)

	Technology options		Policy option		Social and economic options	
	Technology	Information and knowledge	Legal systems	Human resources	Social systems	Economic systems
Natural – ecosystems	– Designation and preservation of refugia – Establishing corridors – Conversion of artificial cedar forest to natural forests – Early detection and prevention of pine wilt – Installation of deer fences in alpine regions – Reduction in nutritive salts and other environmental load substances	–Development of monitoring systems for each ecosystem	–Reconsideration and new designation of nature preserves and national parks – Regulations of artificial transplantation and fish release Restrictions on tourist activities	– Training of volunteers with knowledge and skills who are able to cooperate in monitoring – Awareness raising regarding treading pressure reduction on alpine flora and in wetlands, protection of coral reefs	– Consensus building among relevant entities regarding the identification of and response to climate change impacts	
Disaster prevention and large coastal cities	Alterations in architectural style – Maintenance and improvement of coastal protection facilities – Enhancement of drainage systems – Development super levees with multiple function – Effective utilisation of existing facilities and extension of their lifetime – Comprehensive sediment control in rivers and coast – Reorganisation of dam systems	– Production and distribution of hazard maps – Provision of information (web) – Upgrading monitoring systems (long-term, real-time)	– Changes and regulation of land use based on disaster prevention (relocating of housing, restrictions on constructions in danger zones) Integrated coastal zone management	Implementation of training and education of disaster prevention	– Establishment of voluntary organisations for disaster prevention	– Establishment of a system of inundation insurance for resients – Establishment of funds and subsidies for post disaster restoration

(*Continued*)

Table 1.1 (continued)

	Technology options		Policy option		Social and economic options	
	Technology	Information and knowledge	Legal systems	Human resources	Social systems	Economic systems
Health	– Development of vaccines and new medicines for infectious diseases – of vector mosquitos, larval control – Suspending the emissions of air pollutants	– Production and distribution of health care guide manuals for heat stroke – Thorough surveillance of infectious diseases – Surveys on the incidence and distribution of vectors	– Establishment of institutions and regulations for heat stroke prevention – Care for elderly households	–Capacity development for prevention planning for the control of vector mosquitos – Raising of public awareness on health care	– Support for initiatives at workplaces and schools	
Citizens and urban life	– Strengthening buildings to mitigate damage caused by disasters – Utilisation of heat- blocking and heat-insulating paints and building materials – Removal of suitable condition for emergence of vector mosquitos and harmful insects – Promoting tree planting	– Provision and utilisation of hazard maps – Provision and utilisation of heat stroke alert information	– Heat related countermeasures for the elderly – ‘Cool Biz’ campaigns – Day light saving time	–Implementation of e-training and education of disaster prevention	– Establishment of voluntary organisations for disaster prevention	– Reduction of the extreme weather risk using weather derivates

Source: Committee on Climate Change Impacts and Adaptation Research (2008)

1.6.3 Future Challenges

The review ends with an outline of future challenges. In order to realise wise adaptation it is essential to enhance research and monitoring of climate change impacts and vulnerability in each sector and each region. Highly reliable projections are needed for future temperatures, precipitation amounts, precipitation patterns, snowfalls and extreme events. In addition the adaptation viewpoint needs to be incorporated into various policies, like city planning, urban renewal or redevelopment of obsolete infrastructure. Those adaptation measures, which should be implemented immediately because the impact of climate change has already become obvious to these sectors, need to be selected. An ongoing review structure needs to be introduced, which follows changes and is able to anticipate immediately if necessary. Periodically, information and communication about adaptation to climate change can be derived from these reviews. Further research will still be necessary on the following topics:

- Understanding the climate change impact mechanisms;
- Development of methods to predict climate change impacts, reduction of uncertainties;
- Development is required for vulnerability assessment methodologies and tools;
- Technological research topics include: developing crop varieties that are resistant to high temperatures, appropriately shift cropping seasons and developing aquaculture technology to water temperatures, research on new water supply, developing technologies for converting artificial forests into natural forests and developing vaccines and new remedies for infectious diseases;
- Policy research includes research on legal restrictions at times of drought and the revision of conventional and designated water rights, research on how adaptation should be implemented based on land-use regulations and research of methodologies for the development of volunteers to conduct monitoring;
- Social and economic research topics include research on the social mechanisms to incorporate adaptation measures, the insurance system as mechanism, to diversify and transfer risk and on consensus-building methodologies to promote adaptation measures.

1.6.4 The Japanese Approach

In Japan the strategy is focussed on some important categories, which play a major role in the country. The attention lies on the agricultural aspects due to shifting cultivation zones bound by the sea and to several aspects regarding heat stress, especially in urban environments. Furthermore, the country is affected and under threat of occasionally extreme hazards like earthquakes and typhoons, which apparently become more intense. The attention for regulating and raising awareness in disaster plans is important in the policies. In the review a distinction has been made in measures, which are to be taken from a technological, policy and socio-economic perspective respectively. The advantage is that non-technical measures are not disappeared in the technological storm of ideas and solutions. On the other hand solutions become less integrated and more separated. The Japanese approach shows a large trust in conducting assessments to implement adaptation measures and has a strong belief in monitoring, even to predict changes and weather extremes. Finally, the Japanese include some cultural aspects in their strategy as well. The starting moment of the blossoming season is an important change induced by climate change.

1.7 Finland

The objective of the National Strategy for Adaptation to Climate Change is to strengthen and increase Finland's adaptive capacity (Marttila et al., 2005). This is to be achieved by:

- Describing climate change and its impacts as well as assessing the sensitivity of sectors;
- Assessing current adaptive capacity, vulnerability and opportunities associated with climate change;
- Presenting actions that should be taken immediately and policies for further actions.

1.7.1 The Impact of and Adaptation Measures to Climate Change in Different Sectors

The impacts of climate change are felt in different sectors. In several tables (an example in Table 1.2) is shown which impacts work out positive for the sector and which ones negative and which measures can be taken immediately, on short-term and long-term. Moreover, it is defined which measures should be taken by private partners and for which measures public organisations, divided to the level of government is responsible.

1.7.2 Cross-Sectoral Issues

Besides the focus in the Finnish strategy on a thorough analysis and definition of measures by party and period for each sector, some cross-sectoral issues are designated as well.

1.7.2.1 Development of Administrative Capacities

The capacity within different sectoral administrations needs to be increased in order to integrate the adaptation strategy, both the knowledge about impacts as the definition and realisation of measures, in policies, planning and implementation of each sector.

Table 1.2 Anticipated impacts (top) of and indicative adaptation measures (bottom, *=2005–2010, **=2010–2030 and ***=2030–2080) to climate change on agricultural and food production

Disadvantage	Advantage
– Increased erosion and risk of nutrient leaching – Compaction of clay soil may hamper cultivation if ground frost is reduced – Combined impacts of air pollutants (ozone) and UV radiation on ecosystems will become intensified – Risk of insect damage and plant diseases will increase – Overwintering of plants may become more difficult – Need for irrigation water may increase – impacts of increased extreme events on the quantity and quality of the harvested crop	+ Production potential of plants will increase + Plant cultivation boundaries will move farther nort + Horticultural production will benefit + Outdoor grazing can be increased + Overwintering of perennial plants will probably become easier

		Anticipatory	*Reactive*
Public	Administration and planning	• Attention to production methods adaptable to climate change, production structure and locations in support policy*** • Development of animal disease monitoring systems** • Development of plant disease and pest monitoring systems*	

(*Continued*)

Table 1.2 (continued)

		Anticipatory	Reactive
	Research and information	• Development of new technologies and cultivation methods and providing information on them** • Conceptualisation of climate change and its risks*	
	Economic-technical measures	• Integration of changed climatic conditions and plant protection requirements into plant improvement programmes*	Minimising the disadvantages of the potentially increasing use of pesticides**
	Normative framework	• Assessment of the revisions to water protection guidelines**	
Private		• Introduction of new cultivation methods, cultivated crops and technology**	• Extending the farm animal grazing period*** • Increasing the control of pests and diseases**

Source: Marttila et al., (2005).

1.7.2.2 Observation and Warning Systems

The focus in the Finnish observations lies on the average conditions and less on extreme events. This gap needs to be filled with extra attention in the observation and monitoring systems for the occurrence of different extreme weather events.

1.7.2.3 Research and Development

Information, which supports decision-making can be best produced by integrating information on climate change, its impact and different adaptation measures. Thus, adaptation research always includes both climate research and impact research. The integration of knowledge is the most important research need.

1.7.2.4 Education and Communication

Climate change, the impacts and adaptation need to be integrated into the curricula at all levels of education. The education must be oriented in a way that in the future there will be experts in climate change issues in Finland.

The communication of the Adaptation strategy will be done through the general communication on climate change as well as by communications within the different sectors.

1.7.3 The Finnish Strategy

The character of the Finnish adaptation strategy is thorough and sectoral. For each sector the impacts and measures are defined into great detail. Every sector now knows what must be done at which pace and who is responsible for this. Hopefully tall sectors re very enthusiastic and start implementing the adaptation measures immediately. But it may be a bit less optimistic in practice. What if budgets are limited and the day-to-day decision-making takes over? After the attention on the necessity to adapt during extreme weather events, the daily routine will withstand the implementation of all defined measures.

1.8 Comparison of Strategies

Comparison of the different national strategies (Table 1.3) learns that every country puts its own accents in the strategy, depending the specific regional changes, the geography of the country, the existing functions and the cultural dimensions. The Netherlands takes a participative multi-partner approach, both within the governmental arena as in conjunction with market or societal partners. The geography leads to a strong focus on the coast, rivers, water management and the countryside. The Netherlands show a strong emphasis on the way adaptation plays a role and becomes a part of spatial planning (processes). The UK organises the issue a bit

Table. 1.3 Comparison of the adaptation strategies on key issues

	NL	UK	ES	DK	JAP	SF
Year of publication	2007	2002	2006	2008	2008	2005
Government/partnership	G+P	G	G	G	G	G+P
Cross ministerial	Yes		Yes	Yes		Yes
Regulations and rules				X	X	
Sectoral/integral	I	I	S	S	S	S
Thematic focus						
Coast	X		X			
Rivers	X					
Agriculture					X	
Forestry					X	X
Energy						X
Ecology/biodiversity			X			X
Water	X	X	X			
Urban environment		X			X	
Health			X	X	X	
Evacuation				X		
Disaster planning					X	
Experts/science	X	X		X		
Spatial planning	Yes		Yes			
Communication/PR				X		

more hierarchal, initiated from a separate group of researchers. The stakeholders are involved later in the process. In the UK the urban environment is a major issue, both from a water management point of view as well as from the heat island effect issue. In Spain the adaptation strategy is to be implemented through the different sectors. The government has a strong role in the process and clear accents are on spatial planning. The main themes in Spain are water, ecology and the coast. The Danish strategy contains both sectoral as well as cross-cutting policies. The translation into spatial planning is weak and the most important role for the implementation of adaptation policies and measures is delegated to the municipality level. In Japan the most important issue are clearly country-coloured: a strong emphasis on the urban environment/heat stress, disaster planning and cultural factors. There is not much focus on spatial planning. Instead, there seems to be a strong belief in the power of assessments. The Finnish strategy is very detailed and thoroughly executed. Adaptation is seen mainly per sector and the responsibility for implementation of measures is laid down by many parties both governmental as non-governmental. Less attention lies on spatial planning or a more integrated project-wise approach. Strong focus on Finland specific themes, like forestry and ecology.

1.9 Conclusions

Many countries are or have been formulating their adaptation strategies. And every country puts its own accents. Most of the countries re-create regional climate models, derived from the IPCC-scenarios. In the strategies the same issues are raised:

shifting nature through higher temperatures, the need for alternative crops in agriculture, the attention for surpluses of water or droughts and risk management. The differences between strategies are on the specific geographical situation and the involvement and cooperation between government, science and stakeholders. In some cases the government is the central steering unit and produces its own documents, while in other countries a strong cooperative process is chosen with a strong position of scientific research and stakeholder involvement. It seems that a cooperative approach in combination with a small and selective central steering committee of scientists and policymakers could be the best way to success. Most strategies are not putting a lot of effort in communication. It seems that first of all the content is to be researched extensively, before communication can start. No strategy starts with a chapter on how to get the message across.

Finally, the spatial challenge remains. In almost no strategy the field of spatial planning is a central mean to realise the adaptation strategy. This is a bit strange, because most of the thematic issues and sectors described in the strategies are spatially or do have spatial impact. The other way around, the spatial conditions can be created in order to facilitate or realise the adaptation measures.

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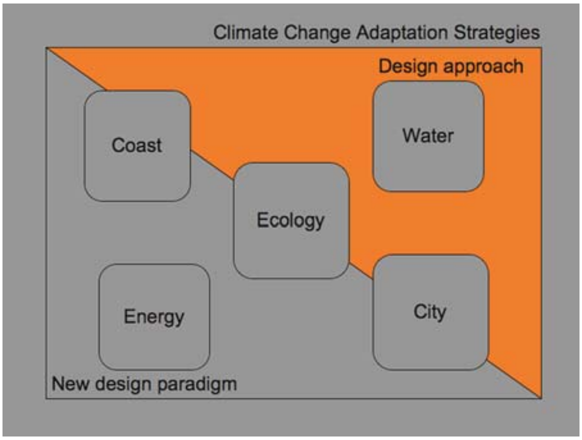
Chapter 2
Design Adaptation to Climate Change



Abstract The adaptation to climate change is well represented in strategies, policies and the media. It can even be found in sectoral measures, but integrated designs for adapted spatial plans are hardly available. This is curious, because adaptation to climate change needs to be implemented and realised mainly through spatial patterns and lay out. Several reasons may cause this. It may be plausible that the subject is just recently put on the political agenda, which makes it just a matter of time before spatial adaptation plans will be designed. Another reason may be that people, experts and politicians, think that adaptation measures are expensive and difficult to implement. The power to change the course of existing policies is not strong enough yet. But if it can be made clear that adaptation planning requires only slight adjustments to the existing planning practice and budgets, adaptation designs will be carried out. The involved planners have difficulties to transfer incomplete knowledge or uncertainty about climate change to politicians and planners simply do not

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have sufficient time/capacity to take care of the new challenge of climate change. The last reason for the absence of adaptive plans may be a shortage in knowledge. It may well be that many initiatives for adaptive planning are taken, but that it is just not known what the best adaptation strategies include. The development of climate atlases for certain areas may help to fill up this gap in knowledge. Based on the information in the atlases spatial strategies for regions may be designed.

Beside the knowledge gap there is a cultural phenomenon, which stimulates not to include innovations in existing practices (Ponting, 1992). Act the way was it was usual in existing practices is far easier than try to change the paradigm and implement innovative strategies. Design plays a central role in shifting the minds. The design makes visible what a future world may look like and how society will function under new conditions. The designs show the chances and challenges, coming along with climate change. And if the natural system of altitudes, water and ecology is understood the designs give shape to and offer answers for the question how can be dealt with unpredictable futures and climate change. The Chinese examples in this chapter illustrate that the spatial developments within large urban plans can improve resiliency if the natural system is taken as the base for the designs.

The design approach in the Groningen case proves that integration of adaptation in spatial planning is possible, easy and offers new ideas and combinations of functions.

The design is often an underestimated tool to give form spatially to a changing climate. The design is capable to make abstract numbers and unimaginable sentences visible in what climate change implies for inhabitants and visitors. Beside this function designs are also capable of formulating innovative answers to complex problems, which are regularly answered in a sector oriented way. Thus, they are the messengers as well as the inventors of an integral climate proof future. There is only one, very important, limitation and that is the difficulty to change existing land uses in regions.

2.1 Design of a Climate Proof Netherlands

Climate changes and the consequences become more and more apparent (see also Chapter 1). Examples of these visible changes are changing in precipitation patterns, leading to water annoyance or droughts, and the changes in temperature, which affects the living conditions of heat-loving species positively. Once the future changes in climate are, within certain margins, known, this knowledge needs to be included in policies and in designs. The Dutch Adaptation Strategy and Agenda (Chapter 1) focuses on both policy and design. Spatial measures can be developed, which offer design oriented solutions, if anticipated on upcoming changes. In the Dutch House of Lords a motion was accepted, which asks attention for long-term planning in national policies (Eerste Kamer, 2005). The national policies in the Netherlands can be characterised as plans with a short time-horizon, in which climate change plays a minor role.

According the national policies, the majority of investments will be done in Randstad Holland. This area is for its largest part below sea level and therefore vulnerable for floods. A design approach would offer chances at solutions for the defined questions. If a design point of view is chosen, this implies look at the problems with a broad view, in which integrated and robust solutions can be found. This approach differs from the political and societal discourse: here the facts and the search for the 'truth' dominates. Dealing with uncertainties and surprises is not yet included in the discourse. Thus, politicians and scientists stick to climate scenarios of 2006 (KNMI, 2006). And the greater part of the research on climate change and spatial impacts is still directed by the urge to reduce greenhouse gas emissions and not on possible creative and inspirational spatial solutions to deal with climate change. As a matter of fact this is a strange situation, because further research on facts and figures are in a way inflexible, while future uncertainties ask for flexibility, creativity and robustness of solutions. Research and development of good practices, which focus on the spatial implementation of changes caused by climate change, should become more dominant. This research needs to focus on three issues: the transformation of climate knowledge to spatial means i.e. maps or atlases, the development of design principles and the appliance of the principles in spatial planning and design. But first of all, an innovative and creative attitude needs to be developed.

2.2 The Role of Spatial Planning

Spatial planning can be a very powerful tool to spatially shape climate proof regions. In the formal regional planning, with a time horizon of ten years is not the most suitable tool to realise this. On the one hand side the reason for this is that climate change is a problem, which develops over decennia or a century and for these kind of planning periods there are no formal instruments. The other aspect is that formal regional planning only influences new developments and is capable of changing functions in only these areas. The rest of the landscape and built up areas are not easy to change and the same function will stay there unless new developments are introduced. Instead, long term planning needs to be developed, in which the rough contours for the developments in a certain region are given. The document and maps that are drawn in this planning tool need to be sticky: they are very communicative and if an image is seen once it sticks in your mind forever.

In the process of adaptation to climate change the role of regional spatial planning is important but limited. It gives directions for the future on a number of themes that are relevant at a regional scale. Adaptation in health, functional shifts in crops, adaptation in buildings to name e few are not regulated within the scope of regional spatial planning. The streamlining of adaptation and regional spatial planning is a matter of selection and a full integration. Those themes and aspects of adaptation (probably water, ecology, agriculture, urban settlements), which are relevant on a regional scale, need to be selected and fully integrated in the regular planning processes. Besides this, it is advisable to develop a planning tool, which aims at the longer term of 50–100 years. This tool should contain its own characteristics of communication and regulation.

2.3 An Innovative Approach

No matter if changes are proven yet, a spatial design approach should anticipate on them. This implies a focus on the possibilities to use the changes for a positive development instead of preserving, protecting or control developments. This attitude requires genes of our ancestors: pro-active and forward-looking, qualities that were richly available until the 1970s. Without competences like visionary engineering and the expertise of designers, it is hardly possible to solve today the long-term spatial issues. Since 1970 the managers, procedure-guys and jurists took over power in the building practice in the Netherlands, urges for a figurative dike breakthrough (Roggema, 2005). When the national history and knowledge is given enough room again, it could be possible to make a national climate proof design, which can be compared with the Zuiderzee-works of eng. Lely and the plan for the Deltaworks. These designs were excellent in progressiveness, highly valuable in engineering and wise in simplicity. Our ancestors should be smart as the Greenlanders: They wouldn't live where the chances on floods were highest. In order to be prepared on an uncertain future, it is necessary to develop an unorthodox perspective. This kind of future vision needs to make use of old-fashioned smartness and traditional expertise of engineers. The Netherlands traditionally needs to be protected against the sea. In the winter-period storms will increase in intensity. The historic response to this would be to heighten the dikes, but doing so, the vulnerability of the country increases as well. A small breakthrough might have dramatic consequences. The question is if the Netherlands are at risk as much as New Orleans was in 2005. The answer is possibly no, but in any case it proves anticipative thinking if the country would introduce a coastal defence which is more flexible and resilient. Such a coastal defence might consist of new islands in front of the Dutch and Flemish coast (Fig. 2.1), which might temper the heaviest waves of the storm. These islands – or comparable new Wadden islands – create a lagoon full of nature. New nature emerges not only in the lagoon itself, but also in the deeper parts of the North Sea, where the sand for the islands is gained. The islands are suitable for recreation and new living areas and this makes it possible to finance the construction (Boskalis, 2008; Roggema et al., 2006).

Inland the sea will intrude the country more due to sea level rise. Therefore it is required that more space is created for the big rivers. More water needs to be discharged through Rhine, IJssel and Waal towards the sea, but the influence of seawater requires more room also.

2.4 Climate Atlases

In the Netherlands nearly every province uses a climate atlas to base its spatial policy on. The knowledge about what the effects of climate change are and where

Fig. 2.1 The plan to develop new islands in front of the Dutch and Flemish coast (Source: Boskalis, 2008)

the effects take place is essential in taking adaptation measures. The climate atlases provide the regional governments with this essential information.

The changes in climate imply changes in the physical environment. These indirect effects, like drying out, wetting, flood risks or salination, are seen as secondary effects in the atlases. The secondary effects are dependant on the physical-geographical characteristics of an area, like relief, soil, river- and brook-system and the way an area is laid out with water discharge systems, dikes, pavements and overgrowth. For example, the sea level rise increases the chance of flooding is in the lower lying delta area of the Netherlands more than in the coastal zone near Dover. And the effects of longer periods of drought have lesser impacts in an area, which is capable of keeping water for a longer period in the area, like clay soils can, than areas that are not capable of doing so, like sandy soils. Clay soils are better capable of keeping water in the soil and do have more reserves to provide plants longer with enough water. Because of that the plants are able to survive longer in dry periods (Table 2.1).

Table 2.1 Examples of primary and secondary effects of climate change

Effects of climate change	
Primary effects	Secondary effects
Sea level rise Temperature Precipitation Wind	Water surplus (wetting and annoyance) Water shortage (drying out and salination) River discharge

The threats and challenges of the secondary affects depend largely of the projected function. For example, the effects of water shortages differ tremendously between an urban area or an agricultural area or nature reserve.

The issues on a regional level require a detailed insight in climate change at that level. Therefore, it is important that the primary and secondary are put on maps to show the consequences for different functions and what possible and desired adjustments need to be for new and existing functions.

The following issues are important:

- Are agricultural functions, nature, the water system and urban developments positioned at the most optimal places?
- Is the typology within these functions the right one on changing circumstances?
- Are the nature and water system robust enough to survive changing circumstances? Is the storage capacity of water areas flexible enough and is space enough available? Is enough room enough to provide large ecological connections and habitats, which offer new species survival opportunities?
- What are the required functional adjustments (extensions, connections, shifts) in order to keep the functions functioning?

- What are the physical and supportive structures and systems (dike systems, infrastructure) that are necessary to keep the functions function?

For each function the following questions can be formulated:

- Is the Ecological Main Structure robust enough and positioned at the right location?
- What are the best locations to develop new urban functions?
- Is the urban water system robust and flexible enough to keep on functioning in extreme weather events?
- Is the existing urban system flexible enough to adjust itself to an increase of hot days? Is it, if necessary, possible to add – temporarily – green and water in an existing urban area? And is space available in the city to position building blocks in a way that they stimulate ventilation during hot days, while protecting the public space against cold during cooler days?

The relation between primary and secondary effects of climate change is essential in understanding the required spatial measures, which affect the different spatial functions. For the province of Groningen the different effects of climate change are, in a sketch-like manner put on maps (Roggema, 2007a; DHV, 2007). This analysis aims to visualise which requirements climate change implies for the spatial development of the region. The insights are used to design the new regional plan for the province of Groningen. The maps were sketched, based on general research on the effects of climate change and the consequences in combination with expert judgements on the Groningen context. However regional climate models – based on the KNMI06 scenarios were not yet available, valuable climate proof policy options could be recommended. Figure 2.2 shows an example of such a sketch with the possible consequences of climate change for the water supply and annoyance in Groningen according the W+ scenario (KNMI, 2006).

The sketch-maps deliver insights in the consequences of climate change on different functions. This visual information, put together in an atlas, fits smoothly in planning and design processes at a regional level. The content of the climate atlases consists of maps with the primary climate effects for the year 2050, originated by the KNMI and the secondary effects. What are the changes in different climate variables (temperature, precipitation, sea level rise) and what are the effects on water surplus and –shortage and changes river discharge on different functions. The consequences of these effects for several areas typologies and spatial functions are described in the atlases (Fig. 2.3).

On top of the consequences of climate change on spatial functions the socio-economic changes of the future are combined in an integrated spatial climate atlas

[1]The key in Fig. 2.2 states “Climate change according KNMI”. This is not fully correct. The climate change on which this map is based shows most similarities with the W+ scenario of the KNMI06 scenarios. However, the regional climate models were not available when this map was produced.

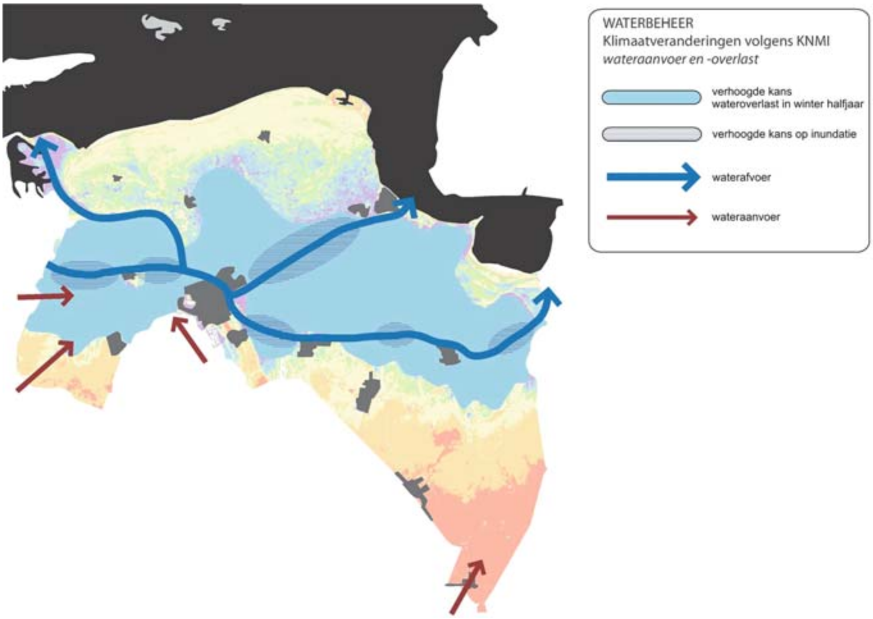
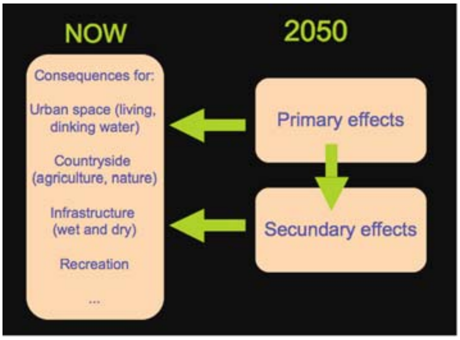


Fig. 2.2 Sketch of the effects of climate change for water management in Groningen[1] (Source: DHV, 2007)

Fig. 2.3 Climate effect atlases (Source: Alterra et al. 2007)



(Fig. 2.4). For the Dutch situation the so-called WLO-scenarios (CPB, MNP, RPB, 2006) are used to give an estimate on the socio-economic spatial claims for 2050. The combination of spatial information offers a spatial image of the adaptation task for a certain province in 2050.

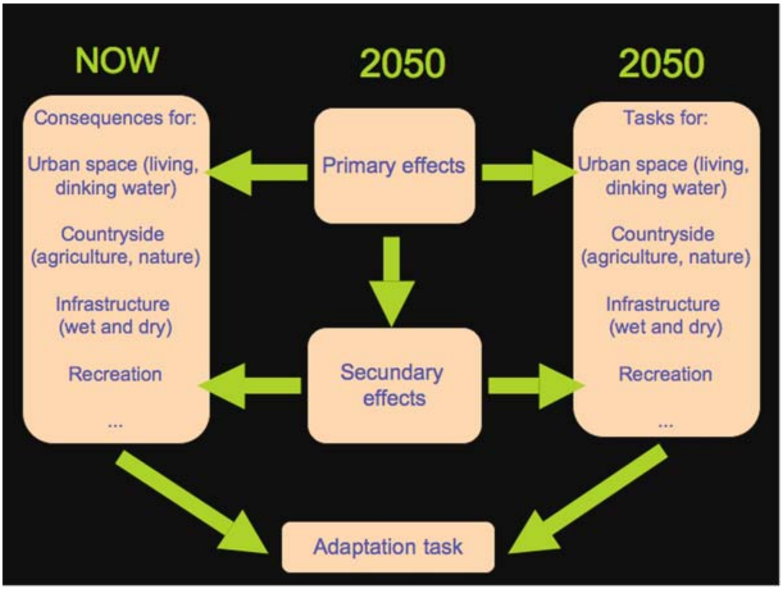


Fig. 2.4 Spatial climate atlas (Source: Alterra et al. 2007)

2.4.1 First Results

The climate atlas of the province of South Holland includes maps on which the climate variables are visualised. The maps with climate change data show an indicative image of climate change. The fluid lines on the maps need to be seen as rough contours, without information about regional differences. The climate scenarios of the KNMI do not include differences between regions, but the changes are assumed to be the same in the entire country. Thus, the patterns of the existing and future climate are identically.

The maps are made for current climate data and those of 2050. The W and W+ scenarios (KNMI, 2006) are used, because they represent the highest expectations of the KNMI scenarios. Apart from that, they indicate the fastest pace of changes. Thus, if climate changes less fast there is more time to implement the adaptation measures. However, the necessity to take measures stays important anyway.

Furthermore, the maps do not indicate a one to one relation between changes in primary effects and the secondary consequences. For example, it is possible that a small increase in precipitation leads to big problems, like floods, while larger increase at another location does not lead to any problem.

2.4.1.1 Temperature

The four KNMI scenarios show a rise in temperature in 2050. The winter (December–February) temperature rise varies from 0.9 to 2.3ºC and the

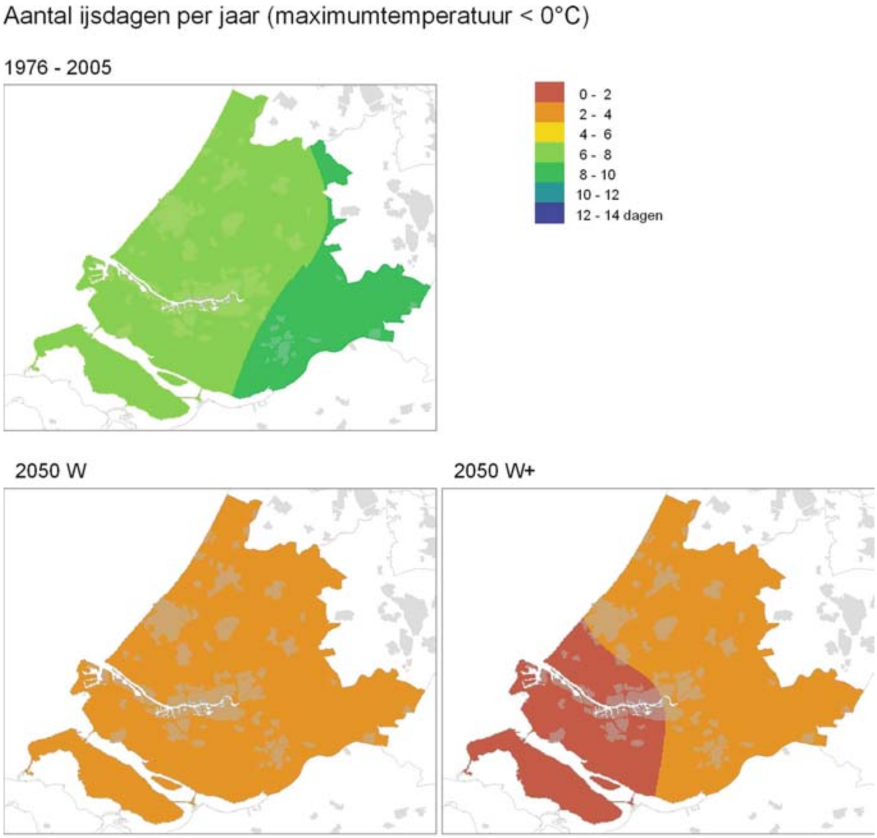


Fig. 2.5 Decrease in number of ice days (Source: Alterra et al., 2007)

temperature rise in summer (June–August) summer varies from 0.9 to 2.8ºC (KNMI, 2006). Figure 2.5 shows the consequences in number of ice-days (freezing all day long) in South Holland. The chance that speedskaters still can skate in the 2050 winter has decreased.

The summers in South Holland will become warmer as well. The 2003-summer was warm and dry. In Rotterdam, the average temperature in that summer was 18.6°C, almost 2ºC warmer than normal (in the period 1971–2000). In Europe a lot of deaths were counted as a result of heat stress in the same summer. On the other side a lot of people enjoyed the perfect beach weather of that time. This summer was extraordinary in the current climate, but according to the W and W+ scenarios this summer would be an average one in 2050. Figures 2.6 and 2.7 show the number of summer days (maximum temperature ≥ 25ºC) and the number of tropical days (maximum temperature ≥ 30ºC).

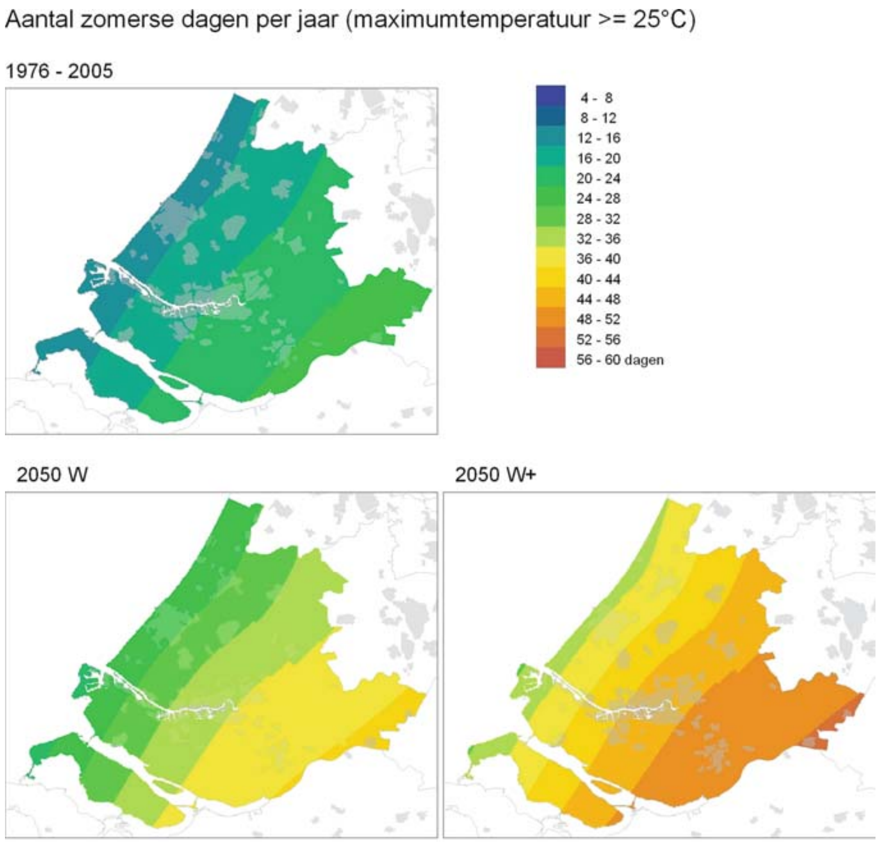


Fig. 2.6 Increase of the number of summer days (Source: Alterra et al., 2007)

Precipitation

According the IPCC (2007) expects a rise in average precipitation in Northern Europe and a decrease in Southern Europe. The Netherlands will have to deal with a slight average decrease of precipitation in summer and a substantial increase in winter. In the summer there is a sharp contrast between the Northern and Southern part of the country. Will the precipitation increase in the Northern part of the Netherlands, the Southern part has to face a serious decrease of precipitation. This makes the developments in summer precipitation relatively uncertain. The South Holland maps show this with a big difference between the W and W+ maps. In Fig. 2.8 the average winter precipitation increases in both scenarios while in Fig. 2.9 the W map shows an increase in summer precipitation and the W+ map shows a strong decrease. However, in both scenarios the number of intense showers increases (Fig. 2.10). For the province of South Holland this means an increasing chance at water annoyance in both the countryside as cities. The dry summers may lead in the W+ scenario to water shortages and groundwater level. If water shortages occur the drinking water

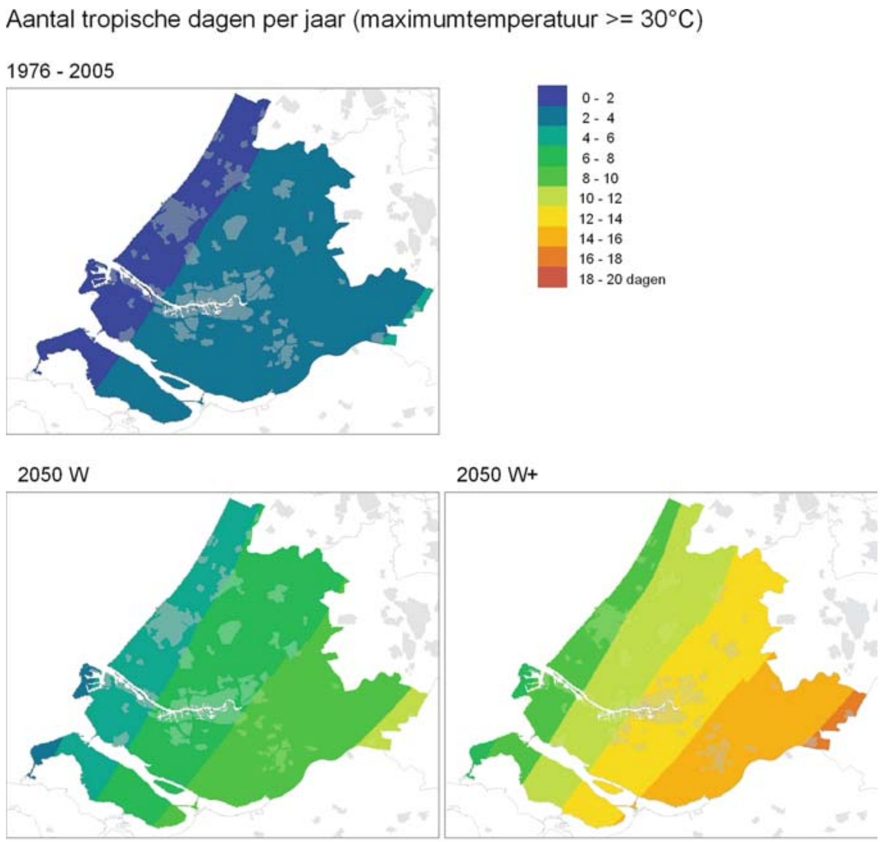


Fig. 2.7 Increase of the number of tropical days (Source: Alterra et al., 2007)

facilities are under pressure, especially when the supply from rivers decreases in dry summers. Due to low groundwater levels it becomes difficult to keep the water levels at minimal required levels necessary for minimising the effects on rottening foundation piles in the clay soils of South Holland.

2.5 Development of Design Principles

If the most important climate variables and the expected changes are known, design principles can be developed. These principles are dependent on the specific context of the region and can be applied on national, regional or local levels. The following design principles can be developed for the Netherlands:

- Build mainly at higher altitudes in the landscape, use waterproof and innovative solutions in lower areas;

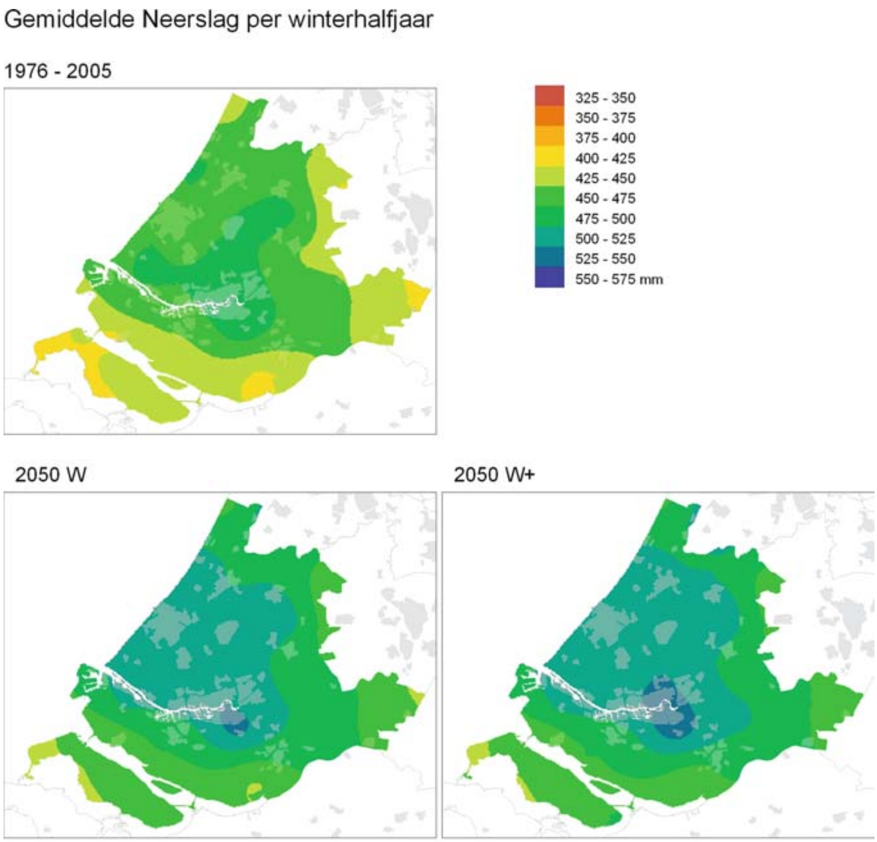


Fig. 2.8 Average winter precipitation (Source: Alterra et al., 2007)

- Create a new coastal defence in front of the existing one;
- Create a robust ecological structure in the lower areas of the Netherlands, which stay wet during dry periods;
- Inundate periodically in lower areas if necessary;
- Protect the valuable economic and cultural-historical places, also in the lowest parts of the country;
- Create water buffers in order to keep fresh and clean water available in dry periods for drinking water and agricultural purposes;
- Use water as a steering principle in spatial planning.

In Fig. 2.11 these principles are used to design an image of a future climate adaptive Netherlands [Roggema, 2007a].

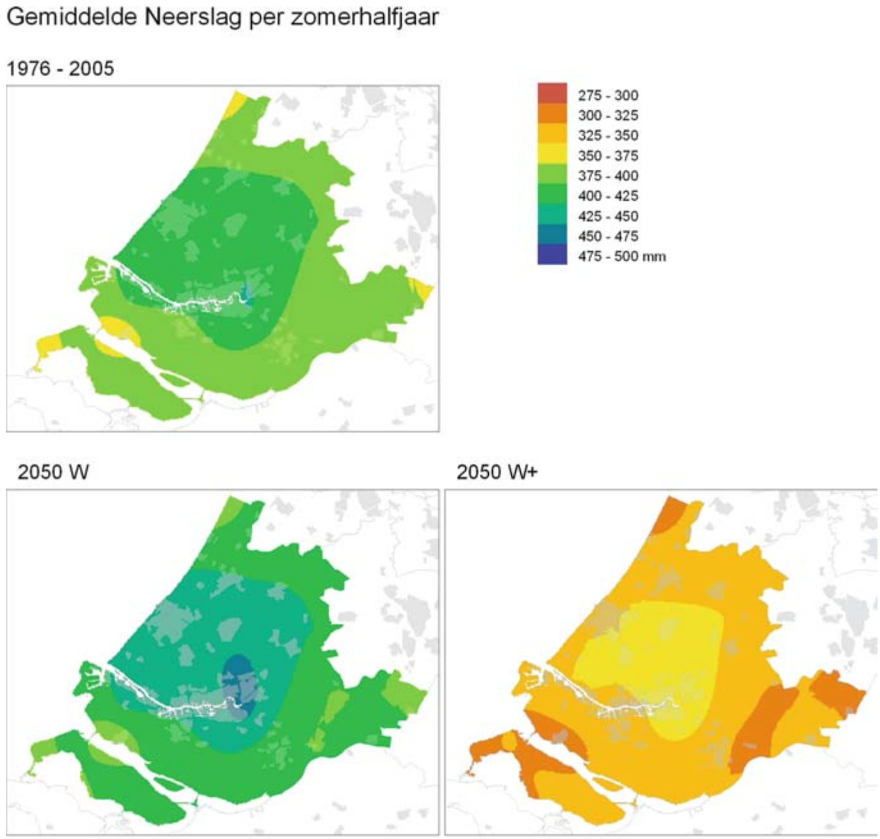


Fig. 2.9 Average summer precipitation (Source: Alterra et al., 2007)

2.5.1 Meaning for Nature and Agriculture

The nature and agriculture will face changing growing circumstances (see also Chapter 5). The summers will be warmer, last longer and contain more heavy showers, while in the winter period precipitation increases. This means that in the summer less water is available and that too much water causes problems in winter. The average temperature will increase with at least two grades Celsius until 2100 and this leads to chances at the development of new crop-species and new nature.

Depending on the soil type, the 'humidity calendar', temperature and duration of growing season these new crops and nature will gain importance. The may lead to shifts in the spatial patterns of the ecological main structure and the agricultural main structure as well.

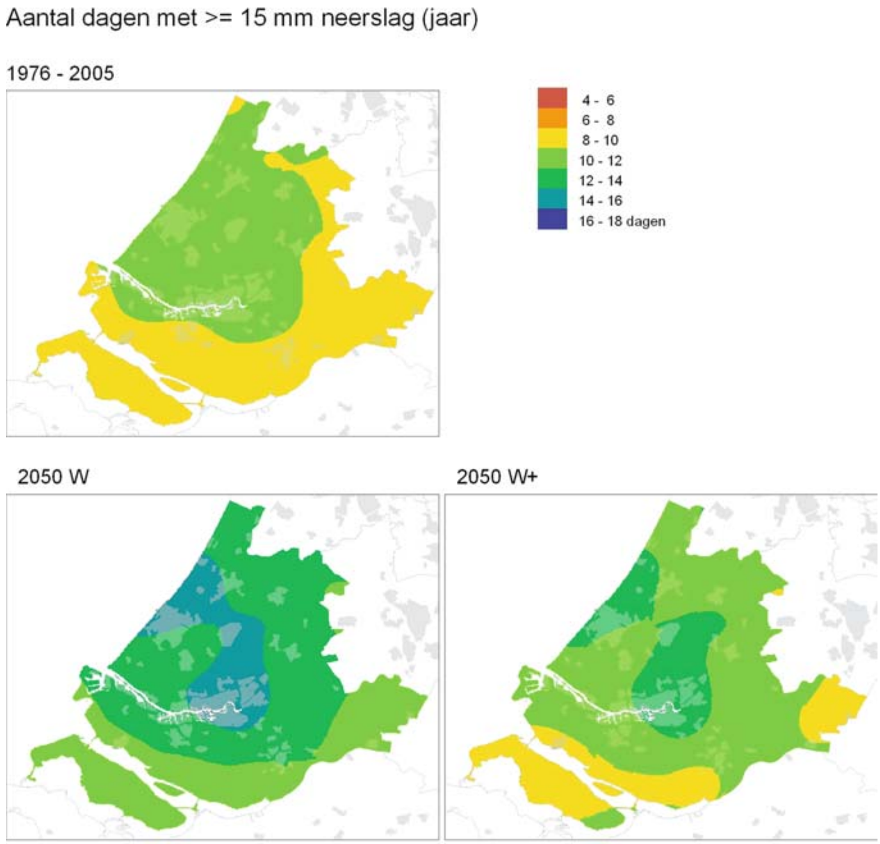


Fig. 2.10 Number of days with intense showers (Source: Alterra et al., 2007)

2.5.2 Meaning for Spatial Patterns

The spatial lay out of the Netherlands needs to adjust itself to a changing climate. The biggest part of urban areas should preferable no longer be positioned in areas, which are under threat of flooding, i.e. the lowest parts of the country. This is not only a matter of safety, but also economically driven. The increased concentration of economical functions in the Randstad Holland leads to increasing costs to safeguard these values. The fact that the Netherlands keeps on investing in the Randstad can be better explained from a historic point of view, the fact that most decision makers live in this area and the fact that changes of functions are not arranged by drawing up a regional plan than that climatic reasons underpin these choices. It illustrates once more that people continue to think about the short-term future. The incentive to move complete settlements would be only acceptable for landowners, politicians and the public if recently a large-scale disaster has happened.

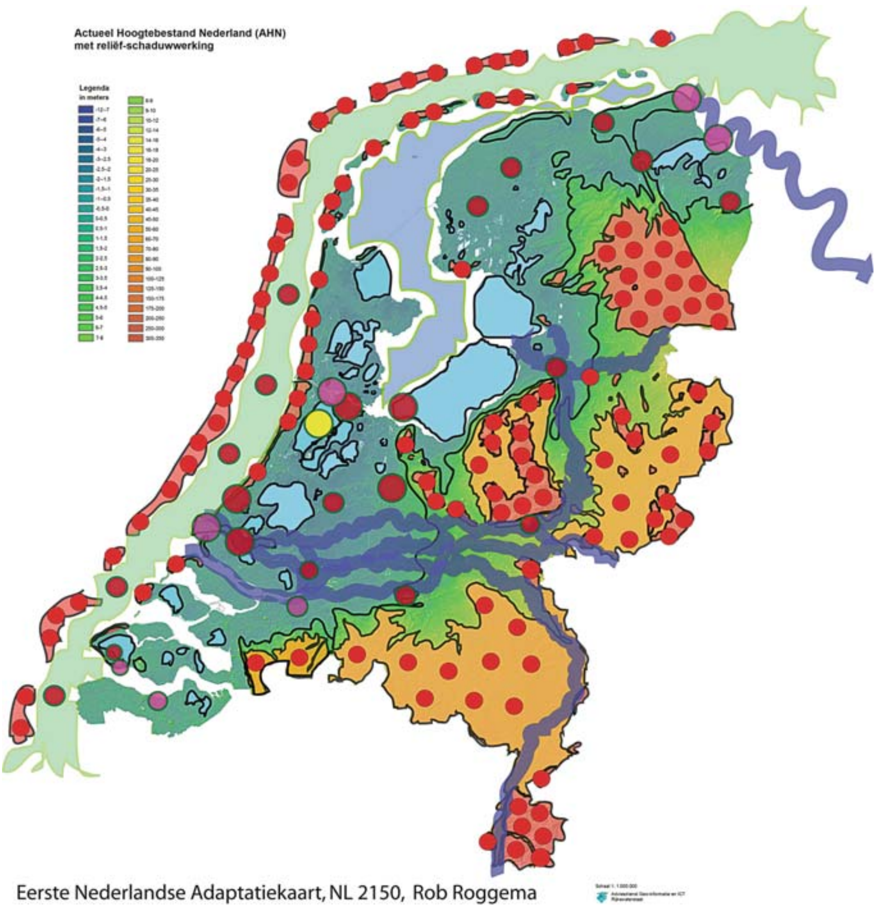


Fig. 2.11 Map of a climate adaptive Netherlands (Source: Roggema, 2007a)

Wouldn't it be more logic – if the long-term is taken into account – to invest in economical development, spatial structures and infrastructure in areas, which are due to their natural characteristics resilient against climate change (Fig. 2.12)? The economical, spatial and infrastructural investments would have been done in areas of higher altitudes, while the lower and more risky areas would have been used for climate buffers (Bureau Stroming, 2006), which are capable of temporarily storage of water and where new nature can be developed (see also Chapter 5).

2.5.3 Time

Climate change is not happening today or tomorrow. As a matter of fact climate change is already happening and will continue for at least the upcoming century.

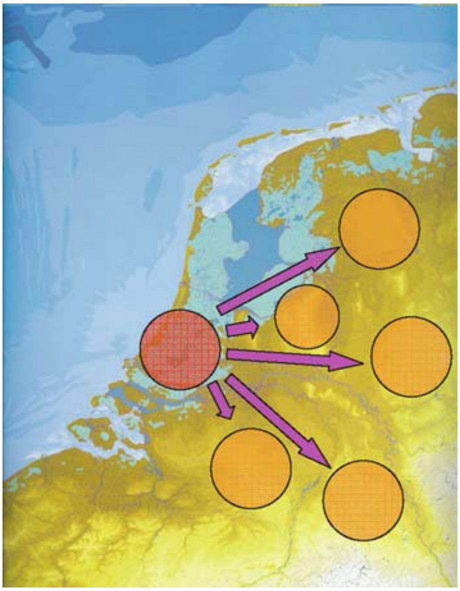


Fig. 2.12 Shifting spatial investments (Source: Roggema, 2007a, Basic map: MUST)

So far, large climate change impact, different than in other parts of the world, have not yet struck Europe. However, the fact that the changes take place over a longer period does not mean that adaptation measures can be postponed until 2100. The timeframe and the bandwidth of change are known already. This makes it possible to anticipate. The time to do so is (still) there.

The opposite is true also. Waiting to take adaptation measures until climate impacts have happened at a large-scale means an arrearage. Then, it is too late to invest in measures, which might support society to move with the changes. Then, it is too late to anticipate.

2.6 The Groningen Case

The province of Groningen has used this anticipative approach, while it designs its new regional plan. Beside the – more regular – themes of economy and demography, climate change is the third meaningful pillar in the planning process. The regional plan is carried out in three phases: analysis, interaction and reflection. In each of these phases climate change is connected to the steps in the planning process (Fig. 2.13).

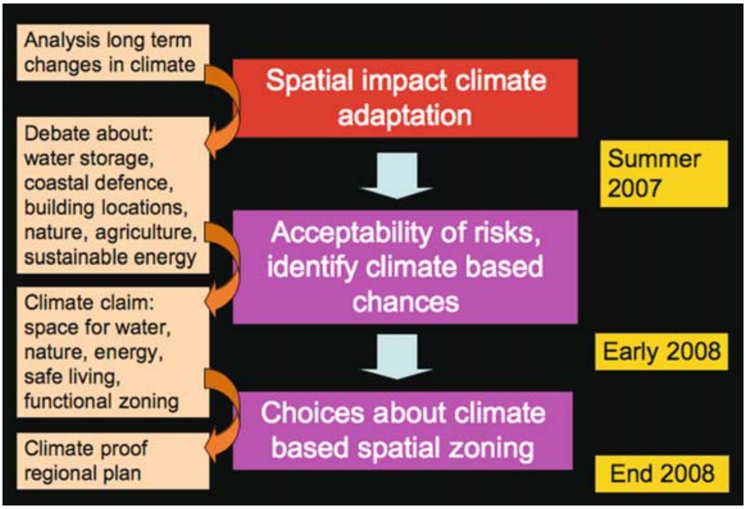


Fig. 2.13 Anchoring of adaptation to climate change in the planning process (Source: Roggema, 2007b)

2.6.1 Starting Point Groningen: Two Scenarios

The Intergovernmental Panel on Climate Change (IPCC) brings together the latest scientific knowledge. In 2007 the fourth assessment was published (IPCC, 2007). In the assessment the climate is not predicted, but the best possible projections and scenarios are developed. Ideally these scenarios contain the largest part of the uncertainties of the future. In the IPCC, the KNMI and the National Environmental Agency (MNP) represent the Netherlands. The knowledge that is available and is brought together in the IPCC is made available for the Dutch situation in 2006. The KNMI developed four Dutch climate scenarios (KNMI, 2006), which describe the bandwidth for future climate change and offers the basis for policy decisions. For the Groningen situation the most extreme elements out of the KNMI scenarios were used to build one new scenario (DHV, 2007). Scientifically and methodologically not the most pure form, but the use of one scenario makes it possible to understand the complexity of the scenarios better. Beside this combined scenario, an extreme scenario is developed, which uses the starting point of an accelerated melt of the ice-caps of Greenland and western Antarctica. This scenario is seen as less probable, but arctic researchers expect that extreme developments on the poles might be realistic and that the KNMI scenarios are too moderate (Carlson, 2006; Haquebord, 2007). In this scenario the sea level rise is predicted to rise ten times faster than the last 10–15 years has happened. This seems very unlikely. However, by developing two scenarios, a moderate and an extreme one, the debate on possible measures took

Table 2.2 The Groningen scenarios for 2050

	Elements from the KNMI scenarios	Extreme accelerated melting of land-ice
Precipitation spring and autumn	+ 20 %	+ 30%
Precipitation summer	– 20%	– 40%
Precipitation winter	+ 15%	+ 30%
Temperature	+ 1.5	+ 3.0
Sea level rise	+ 35 cm	+ 150 cm

Source: Roggema, 2007a.

place in full bandwidth. The starting point of the two scenarios are summarised in Table 2.2.

2.6.2 Knowledge of Climate

Information on climate change is available on a national scale so far. The knowledge will be available on a regional scale in the form of climate atlases. Groningen runs ahead of this by visualising three important factors for spatial functions: temperature, precipitation and sea level rise (Roggema, 2007a, DHV, 2007). Precipitation and sea level rise are discussed here.

2.6.2.1 Precipitation

The possible changes in future precipitation amounts and patterns are shown in Fig. 2.14. The maps show the possible changes for Groningen and Drenthe provinces (Alterra et al. 2008) in 2050 in two KNMI '06 scenarios (KNMI, 2006) for the winter and summer period.

The main conclusions of the precipitation-analysis are:

1. In the summer period drought will most likely increase. In the 'dry' scenario of the KNMI (W+) in the eastern part of the provinces (the Peat Colonies) drought becomes a serious problem. Nowadays, water shortage in this area is already a problem. Currently, the inlet of water from the IJssel Lake solves this problem. The question for the future will be if this water is still available and if the quality of the water is good enough. The problem of water shortage and uncertainty of supply will increase in the future, due to longer dry periods in summer, which are caused by climate change. Another change in precipitation is the increased intensity of severe rain showers. This happens mostly in the summer period.

[2]The development of scenarios was done based on the KNMI06 scenarios. The most extreme element were taken from the different scenarios and were combined in one set of data, which is methodologically not correct.

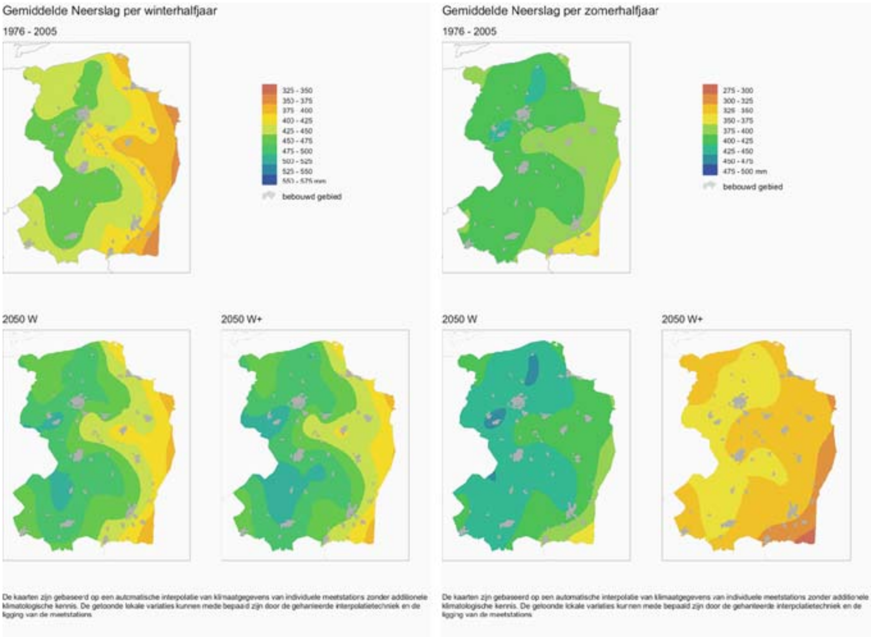


Fig. 2.14 Precipitation in the winter and summer 6-month period (1976–2005, W- and W+-scenario) (Alterra et al. 2008)

When it rains in summer it pours. This effect is not visible in the maps, but it has a huge impact on water management and implies an increased risk of floods in urban areas;

2. According to the KNMI ’06 scenarios (KNMI, 2006), autumn, winter and spring become (much) wetter. Although a dry summer will have its ‘drying’ effects in autumn, which leads to average dryer autumns, the total amount of precipitation in the winter period increases. This raises questions as to how the water management must be arranged. Is an increased discharge towards the sea (with accompanying increase of pump capacity) the best solution or is an increased amount of water storage preferred? Beside the primary effects of changes in precipitation, there are also secondary effects, which are driven by these changes in precipitation.
3. There is an increasing necessity to store the extra water in wet periods or pump it into the sea with heavier pumping engines;
4. In dryer periods an increasing demand for water, especially in dry areas, asks for extra supply;
5. The question may be raised if agriculture and nature are capable of withstanding and surviving the longer lasting dry periods;
6. Urban areas increasingly have to cope with the impossibility to discharge the extra water, falling in the form of severe showers in the summer period, leading to periodical floods.

2.6.2.2 Sea Level Rise

The sea level will continue to rise for the next decades and most probably for the next centuries. The speed and degree of sea level rise is dependent on the pace of melting processes of land ice on Greenland and Western Antarctica. Even if the emissions of CO_2 could be frozen at today's emissions level, the melting process would continue for the next decades. Therefore, adaptation to the rise of the sea level is inevitable. The maps (Fig. 2.15) show the possible impact of the rise of the sea level for Groningen, compared with current altitudes, in two scenarios (+50 and +150 cm). The maps show the maximum impact, because they were modelled with an undisturbed flooding by the sea after a dike breach. In reality several obstacles (roads, little dikes) in the landscape prevent the sea from entering the land without barriers.

The maps show an indication of what might happen in the two sea level scenarios. The images are based on altitude lines and do not take into account the real circumstances in which a breakthrough takes place, namely when the sea level is much higher than normal (spring tide) and heavy rain and wind are present. Also, the map does not show the positive effect of good maintenance of dikes in order to keep them strong, which makes a breakthrough less likely to happen. On the other hand, the impact of a much faster melting land ice, leading to possible sea level rises of 3 m (Gore, 2006) or up to 10 m (Carlson, 2006) above the current level, is not visualised in the maps either.

Based on these maps a couple of conclusions can be drawn:

1. The southern parts of the province (Peat Colonies, Westerwolde, Southern Western-quarter) and the city of Groningen are the highest parts of the province. In these areas flood risk is low. Naturally, a sea level rise of 3 m or more would place these areas at risk as well;
2. The industrial areas of Eems-harbour and Delfzijl are located at artificially constructed higher levels. These areas are relatively safe, even in a more extreme sea level rise scenario;
3. Though not visible in the maps, the salinity of agricultural land along the coast increases, due to the sea level rise, which results in increased seepage;
4. The lower and wetter parts of the province show a spatial connection between Lauwers Lake and Dollard. This connection, together with the brook system in Drenthe is potentially the most important wet ecological structure for the future. Here, nature is able to survive the longer periods of drought.

Another effect of sea level rise is the possible disappearance of parts of sandbanks in the Wadden Sea. Stive (De Boo, 2005) expects that a fast sea level rise, up to 60 cm in this century, will lead to an inability of the sedimentation process to supply the sandbanks with enough sand, which results in the drowning of the sandbanks. It is estimated that in this case 50% of the sandbanks will have disappeared within 40 years from now.

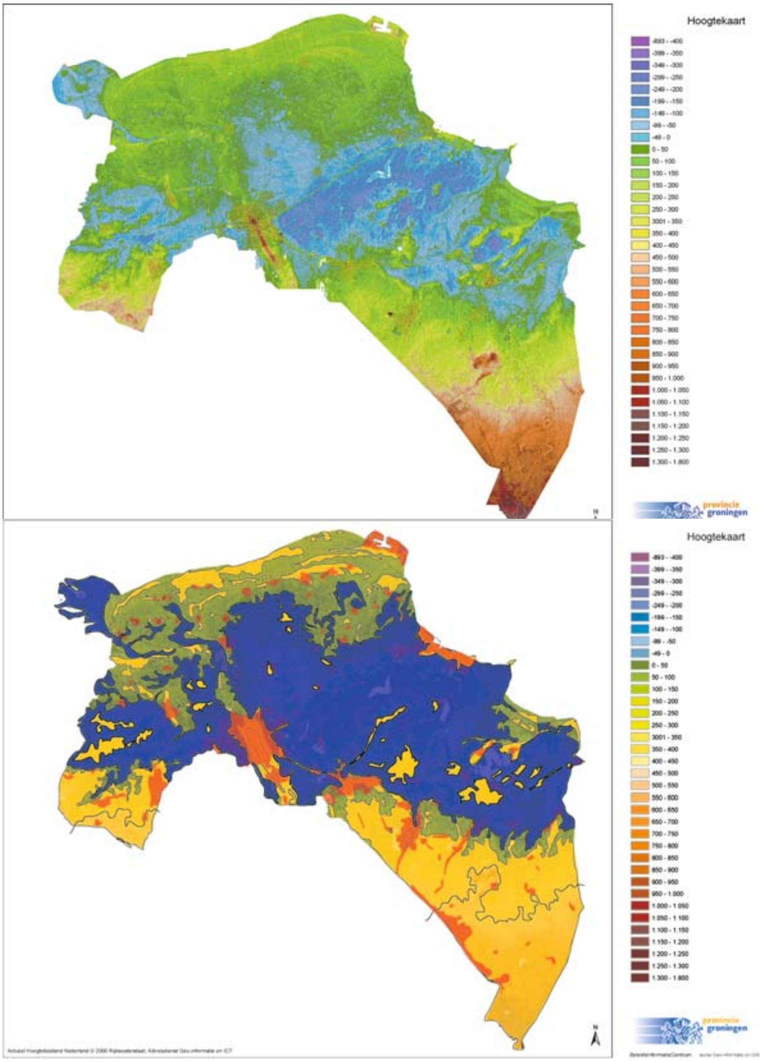


Fig. 2.15 Flooding according to altitude lines (current situation (*left*), 50 cm sea level rise (*centre*) and 150 cm (*right*), (Roggema, 2007a)

2.7 Consequences for Different Functions

2.7.1 Nature and Agriculture

Nature and agriculture is dependent on the soil type. This means for the Groningen situation that the peat colonies, with a sandy dry soil, have a different starting point for development than the Groningen Highland, with its clay soil, or the area around the city of Groningen.

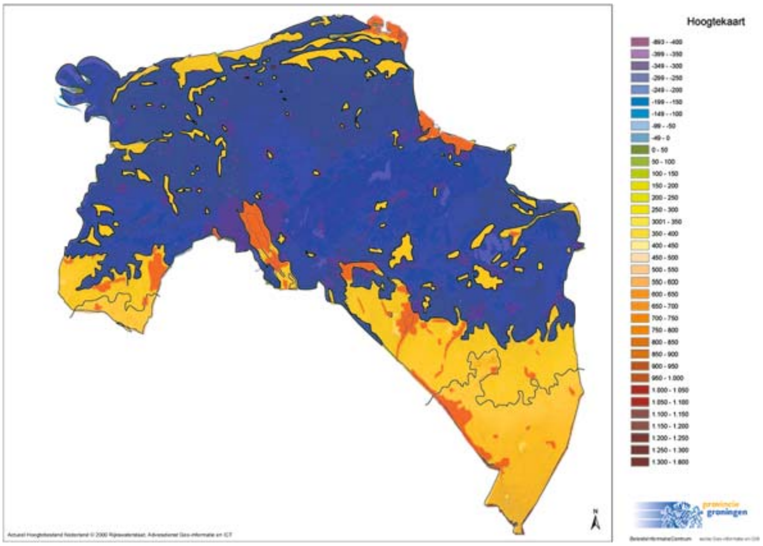


Fig. 2.15 (Continued)

The question in the peat colonies is whether water can be stored in the increasing wet wintertime in order to use it in the dry summers with water scarcity. The realisation of water storage areas is expensive, but will be necessary in the future because the availability and quality of IJssel lake water, which provides the peat colonies with water today, is uncertain.

In the clay areas of the Groningen Highlands wheat production has an advantage because the availability of water in dry summers in this area is better, because clay is better capable of keeping water in the soil. There is a disadvantage as well. The wetter spring causes difficulties in cultivating the land. A good drainage is essential. Irrigation from storage basins, where surpluses of water is collected (Meerstad, Blauwe Stad and agricultural saving basins) is in the Highlands only necessary in extreme dry summers, but it might be the solution to provide the sandy areas of the pet colonies with water during the entire summer. The effectiveness of such basins needs to be judged, because of the evaporation and possible negative consequences of fluctuations in watermark.

In the area southern of the city of Groningen, the Hondsrug, extension of existing forests of sandy soils (oak and beech), can be applied to prevent the area from drying out.

If seawater inundates at several places along the coast, salt water will flow over the fields in the winter period. These saline fields are suitable for saline crops, which can grow in early spring. Nowadays the market chances of these saline products are not yet very large and will probably stay a niche market in the future. But the future is unpredictable. Who would have thought in the 1980s that this strange green cauliflower-like vegetable was brought to his student-home by a Wageningen

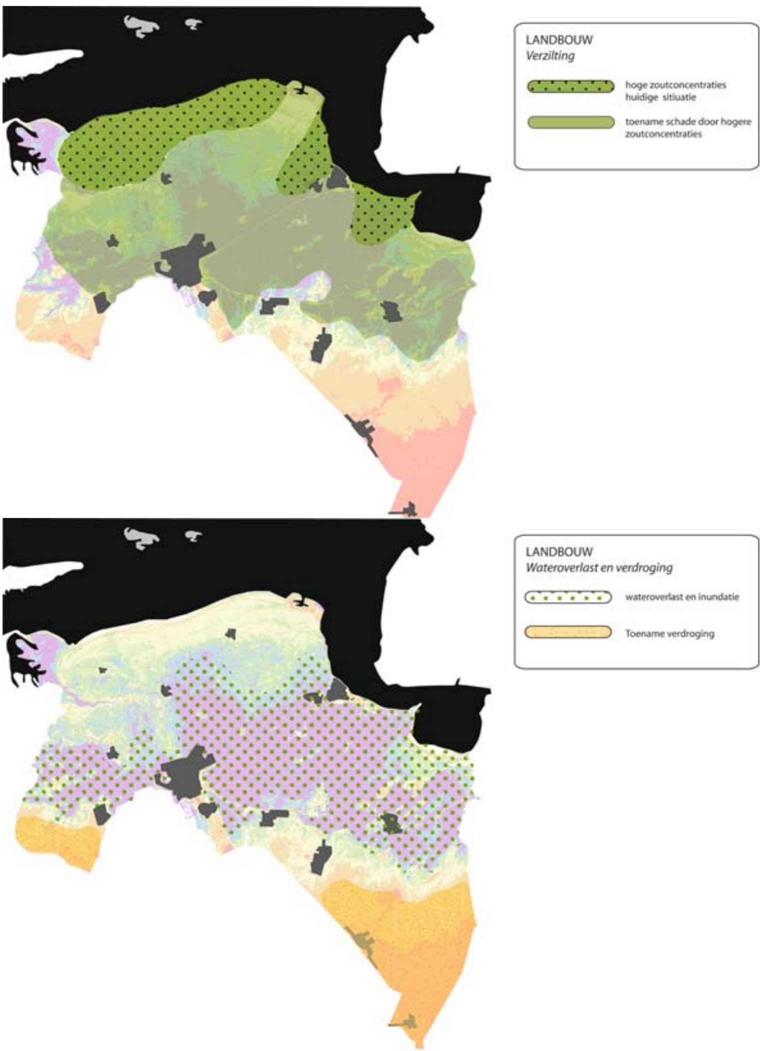


Fig. 2.16 Consequences for agriculture in Groningen (Source: DHV[3] , 2007)

plant-breeder, today is at least once a week on every Dutch dinner table: the broccoli (Figs. 2.16 and 2.17).

Dry nature will have to face difficulties to survive, due to the drying out. The Wadden Sea is in danger as a result of a rising sea level. A possible solution might be an offensive coastal defence, for instance in the form of a new protective line

[3]In the key of these maps the term 'climate change according KNMI' is used. This has to be 'a compilation of elements from different KNMI'06 scenarios'.

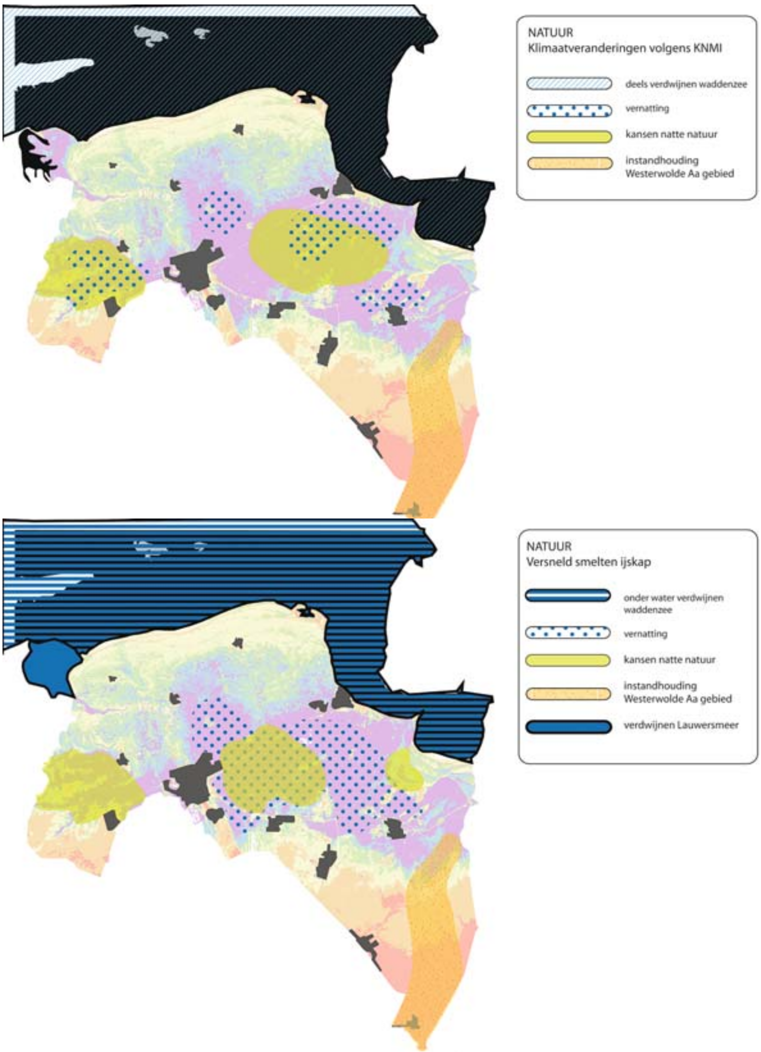


Fig. 2.17 Consequences for nature in Groningen (Source: DHV, 2007)

of new islands or an artificial reef. These interventions are meant to create a quiet lagoon, where more sand is able to sedimentate and more sandbanks will fall dry during ebb-tides. The effect of this intervention should keep the ecosystem of the Wadden Sea intact. The creation of such large scale and robust natural reserves is needed to give nature better chances to survive.

Ecological structures in the province of Groningen need ideally be connected to the lowest and wettest parts of the province. These areas contain enough water in the dry summer periods to allow the ecosystems to survive. The east-west connection between Dollard and Lauwers Lake is very suitable for this. The edges of the brooks are in these long dry summer periods most vulnerable. It can be questioned if these gradients will survive these changing circumstances.

2.7.2 An Offensive Coastal Defence

In order to protect the Netherlands against a rising sea level and heavier storms there are two options. On the one hand side the dikes can be heightened and strengthened. This is a well-known technique, which is tested and measured in a lot of studies. On the other hand natural processes of wind, water and sea can be used to create an offensive coastal protection.

The latter option is able to improve the flexibility and the resilience ability of the coastal zone. Such a flexible defence can be realised for example in the form of a new row of Wadden islands in front of the existing ones (Alders, 2006; Roggema et al., 2006). These new islands are capable of minimising the heaviest waves in case of a North Western storm. If these islands are realised with a strong protection against the sea they may function as a safe and luxury living and recreation area. Moreover, they create a quiet lagoon, where the circumstances are excellent for developing high ecological values of typical Wadden Sea wetlands. Behind the new islands the existing ones form natural quiet zones amidst an enlarged Wadden Sea. These are the new ecological key areas, where birds and sea animals find protection during storms and where enough food can be found. The third protection layer is the existing sea dikes, which need to be maintained well in order to protect the province of Groningen. These dikes do not or only minimal have to be heightened. Finally, the original brooks of Lauwers, Reitdiep and Damsterdiep can be regenerated and recover their original flexibility and dynamic if the risen sea is allowed to enter these brooks again. Valuable new brackish nature reserves will emerge here (See also Chapter 5, Climate buffers).

The introduction of a new row Wadden island in front of the Northern Netherlands coast has several advantages (Roggema et al., 2006). Sedimentation of sand is stimulated if a quiet lagoon is created. The result of this is that the growth of mud rises equally fast as the rise of the sea level. The sandbanks will stay as high as necessary to fall dry during ebbtide and the existing ecosystem can be kept intact. Moreover, the result of the creation of new islands extends the area of valuable wetlands. The islands protect the land against storms by breaking the waves in an early stage and the islands can be utilised as living area and recreational facility (Fig. 2.18).

Another design for the islands may include the combination of different functions (Fig. 2.19). These islands consist of a basin, which is empty in regular circumstances but may be flooded in case of a storm. These fall-lake functions as a energy producer, using the hydropower when water enters the island and uses wind-energy to pump the water out again. Use of the extra storage during stormy weather may support the protective power of islands. Beside this function these kinds of islands give room to intensive harbour connected industries, which are difficult to implement on land.

Fig. 2.18 An offensive coastal defence for Northern Netherlands (Source: Roggema et al., 2006)

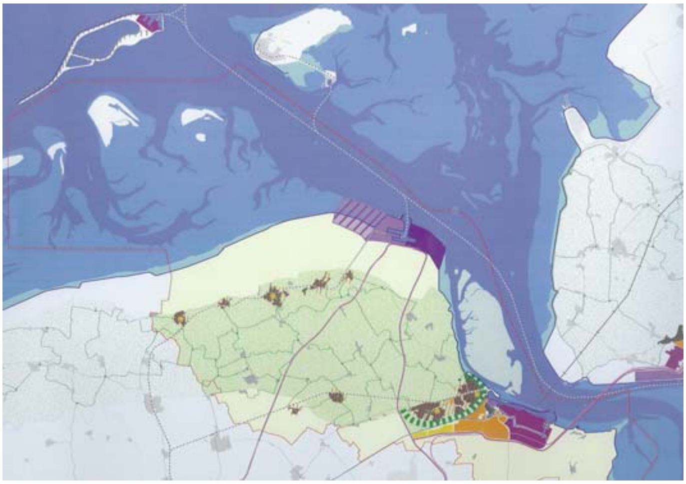


Fig. 2.19 Harbour island in front of the Northern Groningen coast (Source: MUST, 2007)

An island like this may be positioned in the Eemsdelta area up north in front of the Groningen coast (MUST, 2007). This leads to a harbour typology in the northeastern part of the Netherlands: Eemsharbour with green energy and Delfzijl with its green chemicals.

2.7.3 Urban Developments

The urban functions in the province of Groningen are under threat of floods. Therefore, economic values need to be protected. Existing artificial hills – the so-called wierden – have historically a higher altitude, which makes them easy to protect against water. Eventual new living areas in the Groningen Highland, but also around the city of Groningen should be build on a new variant of the old wierden of other innovative water proof techniques must be used. The safest way to house the people in the province is to choose locations for concentrated living areas at higher altitudes in the landscape. Existing lower areas with a high historic value, like the old villages of Appingedam, Oudeschans or Bourtange. These villages may be transferred into new islands in the landscape, which will be surrounded by water from time to time. A firm bastion needs to protect these valuable villages. Another development in the province of Groningen is that several municipalities shrink in population. If the developments of flood risk and shrinking population are combined, the idea may be raised to concentrate the shrinkage in those villages, which are most under threat of floods. If this strategy is accepted, there is half a century time for people to move to new houses at higher locations in the landscape: on new wierden, in the higher altitudes of the peat colonies, in Westerwolde and on the Drenthe plateau. The highest part of the province, the uttermost piece of the Hondsrug in the middle of the city of Groningen densities may be risen tremendously. A new high-rise zone can be developed here, where a new typology of dwellings can be developed, which are suitable not only for living but where working, recreation and shopping can be integrated in the buildings also. The people, who do not want to live in high-rise buildings, the opportunity needs to be created to live – may be more expensive – in low densities spread out over the peat colonies. If the spatial lay out in the province is made like this a natural order is created, fully based on the natural characteristics of the landscape, which allows people to live and work at the – from a risk point of view – safest locations. Added advantages are that the infrastructure in such a lay out can be kept minimal: only short distances need to be bridged and the basis for public transport is increasing. In the lower lying outskirts of Groningen the population will decrease. And if the sea level rises accelerated, is a depopulation program desirable in order to remove people from the most risky places? If people want to live in dangerous areas, they should do so on artificial hills or with innovative building techniques and if people want to live spread out in low densities in scarce safe areas, the price will be higher (Fig. 2.20).

A new Groningen emerges, where nature, landscape and recreation is dominant in the outskirts and on the islands and where the space for working and living

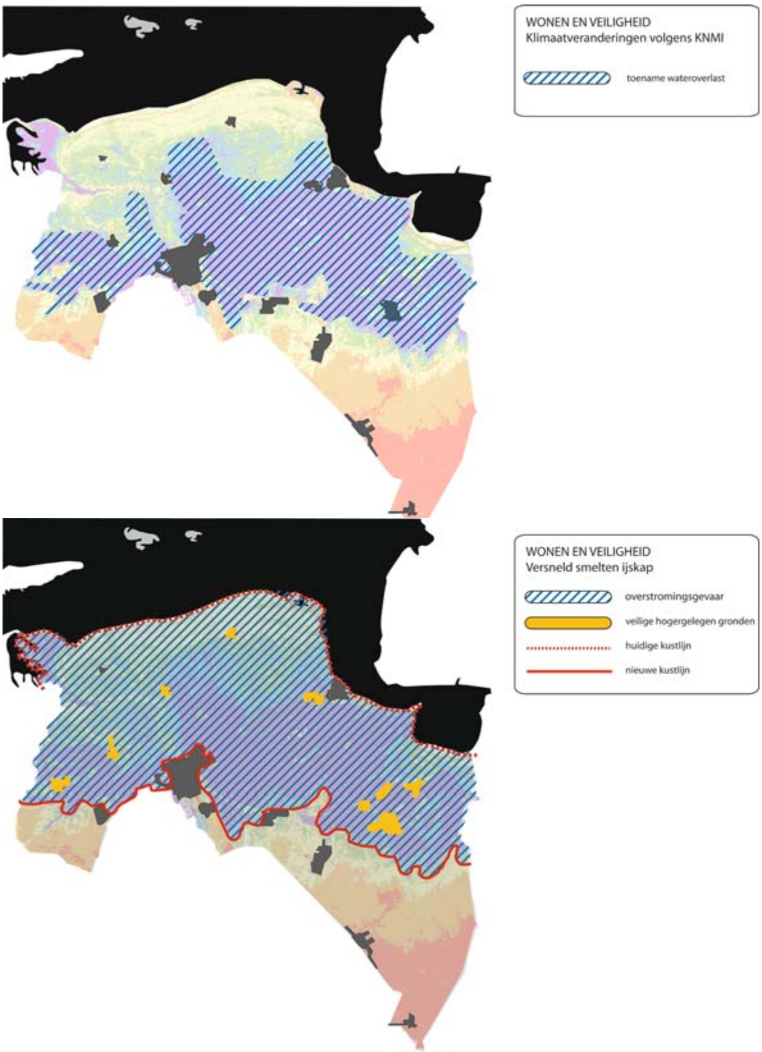


Fig. 2.20 Consequences for urban developments (Source: DHV, 2007)

efficient, multifunctional and in high densities takes place at higher altitudes. This new Groningen is capable of moving along with climate change. Not tomorrow, but ocver a period of decennia, step by step.

2.8 Idea-Map Climate Adapted Groningen

Climate analyses (KNMI, 2006; Alterra et al. 2008; Roggema, 2007a) and the effects on existing functions (MNP, 2005) are integrated in an Idea-map for an

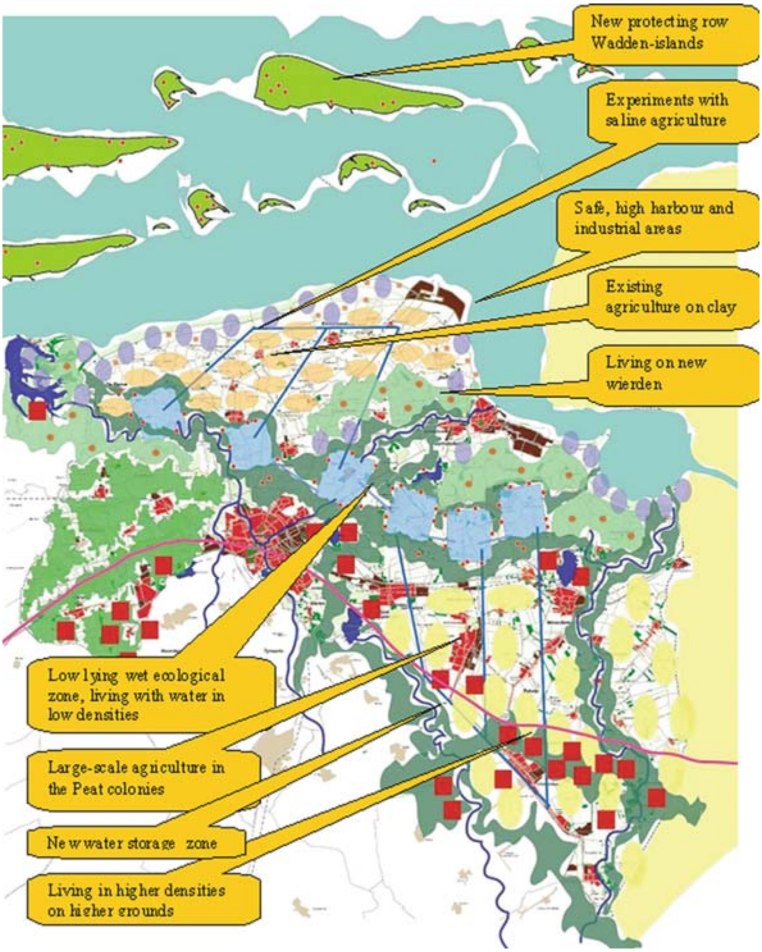


Fig. 2.21 Idea-map climate adapted Groningen (Source: Roggema, 2007a)

adaptive Groningen (Fig. 2.21) (Roggema, 2007a). This map represents a future vision on a climate proof Groningen with spatial measures. The map was developed by the spatial adaptation design team within the province of Groningen and was used in discussions about the new regional plan for Groningen.

The following principles are part of the Idea-map:

1. In the lowest parts of the province, water is stored. Even in dryer periods, water is kept in this lowest area and creates wet circumstances in a natural way. This enables nature to develop a robust ecological connection between the Dollard and Lauwers Lake. Existing brooks discharge their water from the higher grounds on the Drenthe plateau. In the ecological zone existing as well as colonising species are able to find suitable habitats;

2. The water storage areas also function as the water resource to provide agriculture with enough water of good quality. This is especially relevant in the Peat Colonies, where drought has the largest impact. The water can be transported towards the agricultural ground by making use of the existing canal system in the Colonies. The availability of water is essential for the potato starch production in the area. The supply with clean water is necessary from a quantitative point of view, but is also needed for a qualitative reason. In the 'dry' KNMI-scenarios, the groundwater level will drop and might even become saline. Addition of sweet water prevents the available water for agricultural use from becoming useless; (Haren et al., 2007)
3. The salinity along the northern coastal zone increases, due to the sea level rise and the increased salty seepage. This makes this area suitable for saline agriculture and aquacultures;
4. Near Lauwers Lake, Dollard and around Delfzijl space is created to inundate water from the sea into 'climate buffers' (Bureau Stroming, 2006). A brackish environment emerges. The combination of salt and sweet water makes it possible to generate energy in an osmosis plant;
5. In front of the Northern Coast new Wadden Islands are created to protect the province, to develop nature and to provide development locations for living and recreation.
6. The safest parts in the province to create living areas are found in higher elevated areas: Around Leek and the city of Groningen and in the southern part of the Peat Colonies and Westerwolde.

2.9 Chinese Demonstration Projects

The Chinese Ministry of Construction and the Dutch Ministry of Housing agreed on the cooperation on sustainable building in China. The cooperation consists of de definition of several demonstration projects in different areas of China (Fig. 2.22). Within these projects, mostly large developments, knowledge about the integration of measures, which increase the preparedness of the area for changes in climate, is exchanged and implemented in the plans. The aim is to improve the quality of integrated and adaptive spatial plans.

The Chinese context differs from the Western one.

The *pace* of developments is fundamentally different. The full continue workforce in the building sector leads to the draft of plans and designs almost during the ongoing building process. This offers chances, but contains some difficulties too. The chances can be found in the fact that a design is never final until it is built. This means that until the very last phase of planning and design the integration of climate adaptive measures can be realised. The other side of it is that planning processes are running so fast it is hardly possible to propose adjustments because actuality shifts from one day to the next. If adaptation measures are implemented in the planning process they will be realised immediate.

Fig. 2.22 Three demonstration projects in China: Guiyang, Chongqing and Shenzhen (Source: Map courtesy of Johomaps.com, www.JoHoMaps.com)

The second aspect of the Chinese context is the strong *hierarchy*. Central regulations will be carried out throughout the country and will be executed immediately. Until a certain measure is declared form Beijing no one would think about these measures, but the moment a declaration from Beijing is known everyone implements it. This results in a very effective implementation of measures if the congress agrees on them. For example: since the congress decides on energy saving measures energy-saving lamps can be found around the country.

Another characteristic is the *attitude* of the Chinese. They are very curious about new developments and technologies. Different from the Western style, which sticks in planning processes often in proven techniques and old traditions, the Chinese are open to new findings and ideas. This leap frogging of simply skipping the phase of sector based planning makes it easier to implement climate adaptation measures.

The last relevant contextual element is the *competitiveness* between Chinese project developers. These parties are conscious of the fact that they can profit from rapid developments, but in order to continue their building pace and selling schemes, they need to distinguish themselves from the others. This makes green building and the implementation of adaptation measures popular and the developers have a srrong emphasis on becoming a demonstration project. This competing and scoring in trying to be the best developer leads also to immediate implementation of adaptation measures in the projects.

2.9.1 The Longhu Project, Chongqing

The Longhu project is located just outside the built up area of Chongqing, China. It is part of a widespread development zone, where living areas are combined with amenities, infrastructure and recreation (Bing et al., 2006).

2.9.1.1 Climate Change Effects

Chongqing is located in the transition area between the Qinghai-Tibet Plateau and the Middle-lower Yangtze Plain. It is part of the humid sub-tropical monsoon climate belt. The annual average temperature is 18–20°C with a low temperature of 4°C in winter and a high temperature of 40°C in summer. Chongqing is also a fog city that has about 100 foggy days a year usually in spring and summer. Chongqing receives abundant rainfall, averaging about 1000–1400 mm annually. It has plenty of evening rain all year round, but most of it falls in summer.

The effects of climate change in the region are expected to show an increase in number of hot days in summer. This will eventually lead to higher impact of heat island effects in urban areas. In the summer period the rainfall is predicted to decrease, which will, in combination with lesser snowfall in the Tibetan mountains, leading to lower water levels and droughts in summer. More farmland becomes too dry to cultivate and the aces to drinking water becomes for more people a problem. Due to droughts ecology will meet difficulties in surviving these hot and dry summers and biodiversity decreases.

2.9.1.2 Analysis of the Site

The landscape pattern is very rich: A diffuse network of hills, slopes, flat areas and curving routes can be distinguished in the site. There is a large difference in altitude between the northern and southern part of the site. The steepness of the slopes varies largely. A highly differentiated and fine mazed water system exists in the area. The water is slowed down in many steps. By putting open or close down little dikes or stones the water is kept or transported to the next field. Finally, the water is used over and over again for many different purposes, production of crops, washing clothes, etc.

2.9.1.3 Aim

In order to meet the difficulties caused by climate change a combination of measures are integrated in the plan. The increasing droughts and the heat island effect in summer as well as the decrease of biodiversity are seen as combined problems, which are solved by using the natural circumstances optimally: the existing water-bodies in the area are used to keep rain water as long as possible in the project area and have a cooling effect on the urban spaces, the hills and plains are used to create natural ventilation in order to minimise temperature rises and the different expositions of slopes are the base for an enriched ecology, which has a cooling effect on the city also.

2.9.1.4 Water-Bodies

The large amount of existing water-bodies in the project area cause a very flexible system. If much water is available it can be directed to many different places and kept in the area. If the landscape is transformed to an urban area, the water-bodies can be adjusted, but not minimised or removed. If they stay in the area the resilience can be kept at a high level. The water-bodies function as a system that is able to incorporate large amounts of water and the water can be kept for a long time in the project area, thus being available in dry summers. The water-bodies are also capable of mitigating the urban heat island effect, which is due to increase if the area is urbanised and the number of hot days is increasing

2.9.1.5 Natural Ventilation

During summer the site can get warm and sticky and the number of hot days is increasing in the future. The urban heat island effect will increase if the site is urbanised. The most natural way of cooling and ventilation is to create winds and ventilation in the area. This can be done by the positioning of buildings (in between he building stronger winds occur there occur, which create ventilation) or by implementing green walls.

The most common wind direction is from the Northwest. Positioning of high-rise buildings (Fig. 2.23) at this side of the area will lead to stronger ventilation in the northern part. Positioning of buildings at the edge of the site (located just at the top edges of the steepest slope) results in the same effect for the lower parts of the area. If a green belt is positioned at the edge (Fig. 2.23), the same effect is reached and it also adds more humidity to the air. If high-rise buildings are added at the bottom plateaus a cool breeze will occur in the stickiest parts of the site. Introduction of this natural ventilation does not increase energy use and mitigates the urban heat island effect.

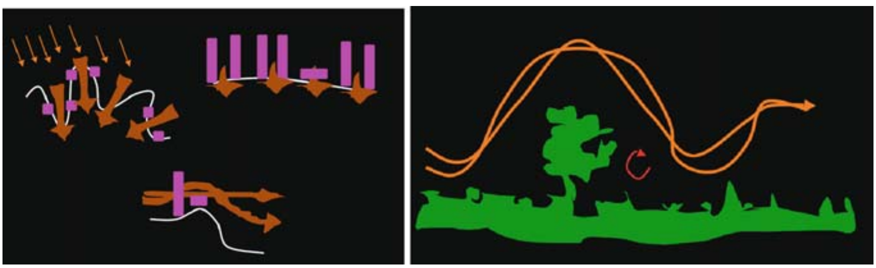


Fig. 2.23 Increasing natural ventilation by positioning of buildings (*left*) and by introduction of a green belt (*right*) (Source: Bing, et al. 2006)

Positioning of buildings to improve the natural ventilation increases the readability of the landscape also. As a result of this the highest buildings are located at the highest altitudes, and lower buildings at the lowest places of the site. Different living environments emerge: On and In the Water-living, At and On the Slope-living, Water-garden-living and Living with a view (Fig. 2.24).

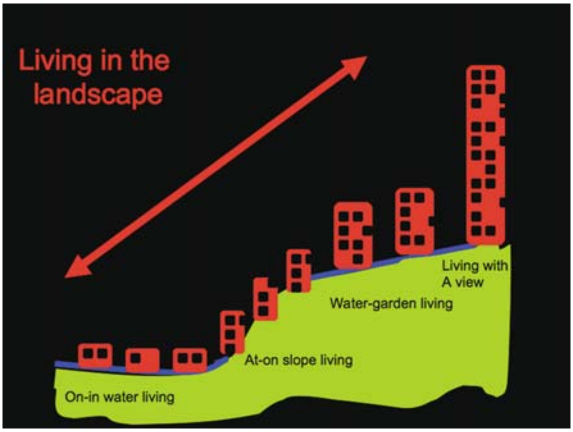
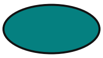
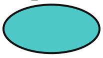


Fig. 2.24 Several living typologies in the landscape (Source: Bing et al., 2006)

2.9.1.6 Biodiversity

In order to withstand a decrease in biodiversity the main element is to deal with droughts. Therefore, the ecological qualities and the water elements show a strong connection. If there is not enough water the ecological qualities will be different. Based on the existing landscape four different qualities are defined (Fig. 2.25):

Fig. 2.25 Ecological differences (Source: Bing et al., 2006)

1.  A balanced eco-aquatic ecosystem. Clean water provides fish and water-plants with enough air and water at flat plains. Water is kept here as much as possible to provide wet circumstances in dry periods;
2.  The ecology of slopes: these gradients are positioned in the middle of residential areas and buildings. Park-like gardens with water-basins form an ecology, which can be used by inhabitants;
3.  Steep-slope ecology: at the steep slopes the water is running down quickly in the form of waterfalls. Grasses and mosses fill the slopes with vegetation. Humid and fresh circumstances attract specific birds, reptiles and insects;
4. Façades-ecology: green building walls provide subtropical birds and insects with appropriate habitats.

2.9.1.7 The Elements: How and Where Positioned

The water bodies, ecological elements and green belts and building blocks are positioned in relation with each other and are based on the differences the existing landscape has to offer. The gradients and slopes direct the possibilities for the creation of water, natural ventilation or biodiversity. The intensity of altitude lines gives an estimate on the steepness of the slopes in four categories (flat, slow, steep and very steep) and the slopes direct the water system (Fig. 2.26). Is it possible to store the water at a certain place or is it running down. Stagnant water is apparent in the flat areas. Only when enough water is available or dikes are opened the water is transported to the neighbouring area. Slope categories two and three contains running

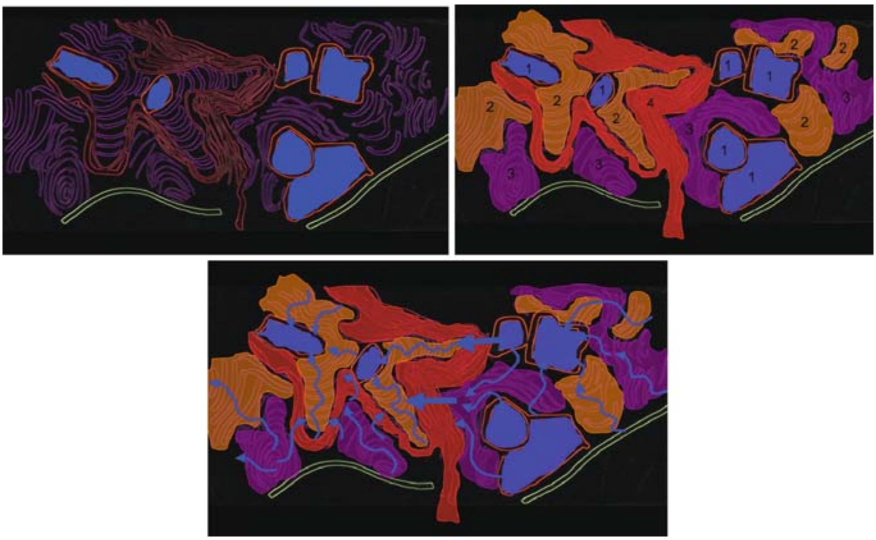


Fig. 2.26 Intensity of altitude lines, slope types and the water system (Source: Bing et al., 2006)

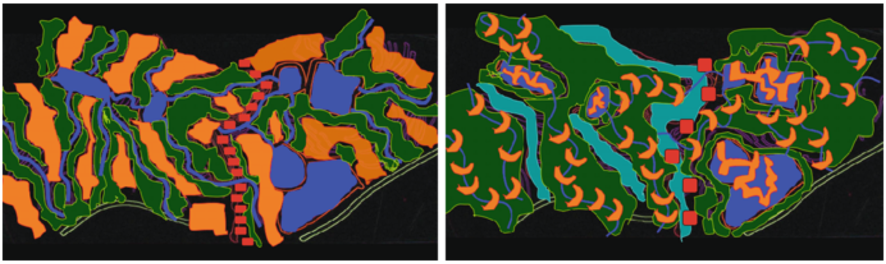


Fig. 2.27 Two climate adaptive models (Source: Bing et al., 2006)

water, but at a slow pace. The water at the steepest slopes is running down like waterfalls. Thus, every slope-type is connected with a specific water type.

2.9.1.8 Models

Based on the landscape and water system different models can be developed (Fig. 2.27). The first model reserves building sites next to the brooks and water-bodies. The buildings are surrounded by green, which is planned at the edges of the water. The second model combines building zones with the water system. Building structures are positioned on and across the water system. Both models are able to react and anticipate on future changes in precipitation, natural conditions and rises in temperature.

2.9.1.9 Integrated Water System

Based on the natural water system the scheme for the different water-flows can be derived (Fig. 2.28). In this scheme the water, which is discharged from the roads (purple) is cleaned with a different technique than water from the baths and showers (orange) or from ponds (green).

2.9.1.10 An Integral Model: Rough Zoning Plan

The models and ideas are integrated in one integrated vision on the site (Fig. 2.29). The building zones are projected between the natural water-structures. The residential areas are located at the slopes and the high-rise buildings are projected at the flat plains. Two car traffic routes connect the different building areas: one through the higher northern part and one cul-de-sac in the lower southern area. In the centre of the area the major amenities are placed and are combined with a green belt that provides the lower parts with natural ventilation. The site is able to store as much water as possible in the fine mazed water system and the differences in slopes are used to create different ecological typologies. Both natural ventilation, the ecological spaces as well as the water-bodies provide the area with a cooling effect. Thus, the expected droughts and increase of the number of hot days are dealt with in an integrated manner.

Fig. 2.28 The bath-rain-surface system (Source: Bing et al., 2006)

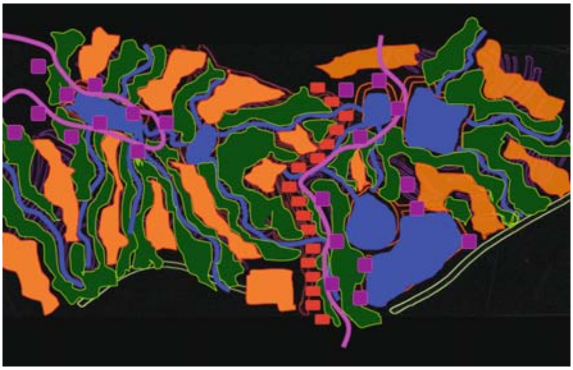


Fig. 2.29 Integrated model (Source: Bing et al., 2006)

2.9.2 Yu'an and Anjing in Yunyan District, Guiyang

The Yu'an and Anjing district, in the centre of Guiyang City, is sparsely inhabited. The people living in the area – mostly farmers - are poor and live in bad conditions: hardly any sanitation, some chemical factories and a polluted river nearby. Although the density of houses is relatively low, every part of the area is in use for agriculture or living. It is almost impossible to find a place where the natural undisturbed landscape can be experienced. The natural landscape can be characterised as a hilly area with sometimes very steep slopes, cut through by a scenic, but polluted river: Nan-ming river. The visual qualities can be defined by the constantly changing views on the river with some times high value historic elements and the different mountains. This scene after scene sequence offers potentially a very beautiful landscape. Because of all the differences in slopes, hilltops and relatively flat areas the biodiversity of the area is potentially high, though in practice very low. This is caused by a wide spread pattern of all kind of buildings, small factories and small-scale agriculture (Atkins, 2007). The intensive use of the landscape not only causes a low biodiversity, it also decreases the visual quality of the landscape (Bing et al. 2008a).

2.9.2.1 Climate Change Effects

Guiyang falls within the monsoon climate in subtropical zone that is temperate and humid without severe winters or hot summers, characterized by abundant rainfall and longer frost-free period, with the annual average temperature 15.3. The hottest days in July are only 24°C on average and the coldest days in January 4.6°C. The rainfall is 1197 mm of which around 75% falls between June and October. The relative humidity is 76.9% and the frost-free period lasts about 270 days. The hottest day occurs in late July, and the coldest in early January. But drought or waterlogging often occurs because of the rainfall unbalance among the seasons. It is expected that precipitation in summer periods will decrease and that floods increase due to more intense showers. The effect of intense showers in combination with the intensively used landscape is that large parts of the hills will be ecological worthless.

2.9.2.2 Aim

The aim for the project site is to increase the biodiversity in the hill area and to provide year round enough water available both for drinking water as well as for the landscape. The approach chosen therefore is to minimise the impact on the landscape and realise the building program at the same time.

2.9.2.3 Analysis

If the area is analysed on density options several scenarios can be developed (Fig. 2.30).

In case the buildings are not spread over the entire area, but are concentrated along one major road (1140 m alt. and 80 m. wide) the total program can be realised, keeping the rest of the area free from buildings. This contains several advantages. If the mountaintops are kept free from building activities, these areas offer space for water retention and the biodiversity can be increased. Also, the visual quality is improved, because the mountains stay visible as distinctive landscape elements in the area. This concept can be called: ‘living on top of the world’ (Fig. 2.31)

2.9.2.4 Rainwater Approach

The increase of biodiversity can be reached if the rainwater is stored as long as possible on the hills and the hillsides. Every level of the hill contributes to the cleaning and storage of rainwater (Fig. 2.32).

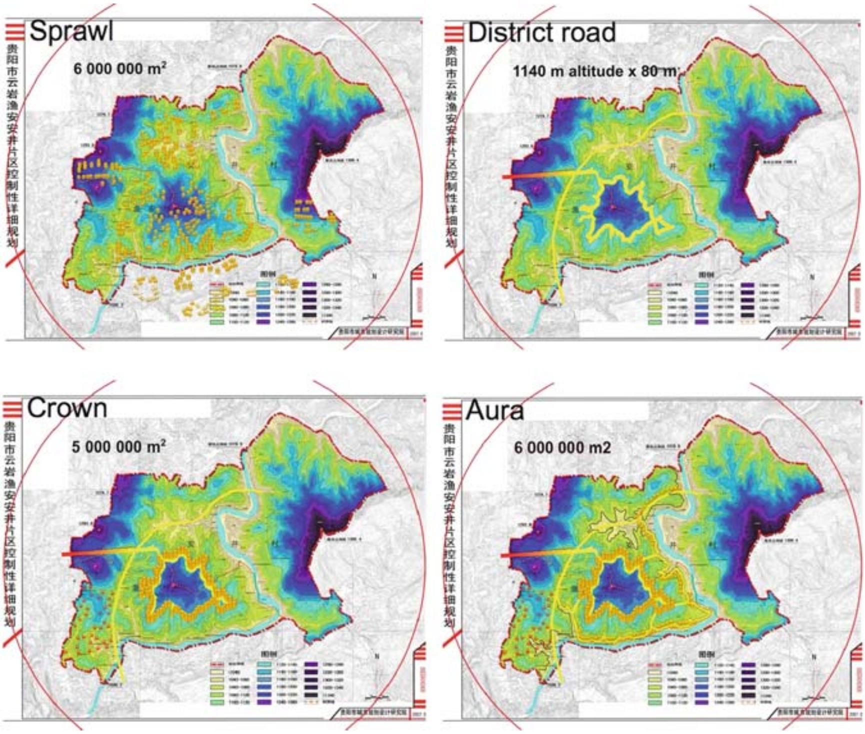


Fig. 2.30 Conceptual analysis of building capacity and the sensitive landscape by Prof. Dr. Teake de Jong (Source: Bing et al. 2008a)

Fig. 2.31 Living on top of the world: the concept of increased building densities and 'naturalising' the landscape (Source: Bing et al. 2008a)

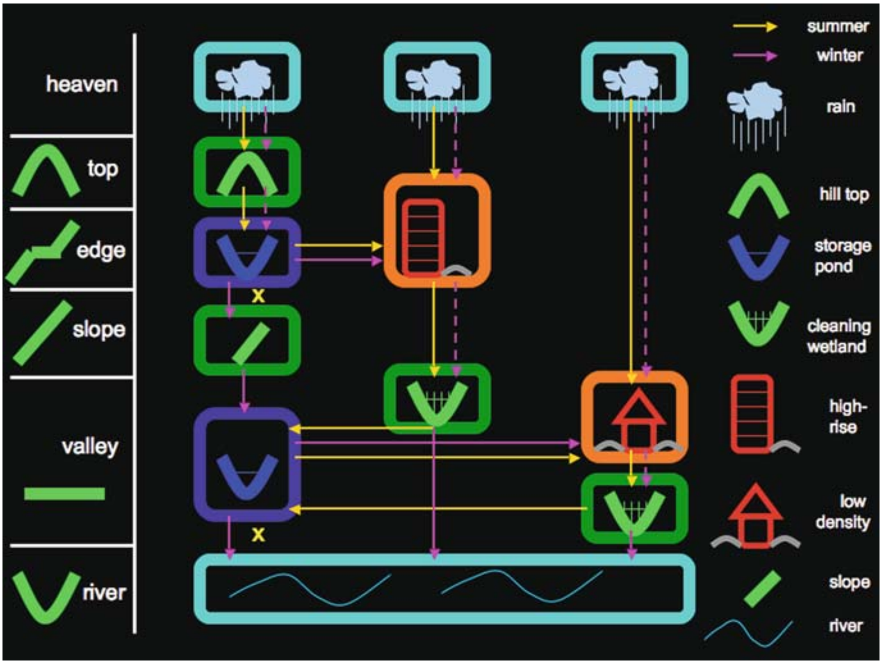


Fig. 2.32 Landscape typologies and appropriate rainwater measures (Source: Bing et al. 2008a)

1. *TopMountain*. Mountains summits are kept free of any building. These places are reserved to retain water as much as possible and to improve the natural quality and biodiversity. The rainwater is kept at the mountaintops to improve biodiversity.
2. *Edge1140*. At 1140 m altitude an edge is created, where a central road is suggested. At this edge the high-rise buildings are concentrated in order to maximise the use of the road and to shorten the length of roads, cables and pipelines. In this zone rainwater is collected and stored. In the summertime the water is stored in basins and it can also be used as grey water in the high-rise buildings. In the wintertime rainwater is used in the high-rise or flows downhill. At high-rise buildings, green roofs are proposed to keep the water high on the hills.
3. *Slope*. The slopes, especially steep ones are not used for any building. They are kept green in order to improve the natural quality and biodiversity. Green slopes are also able to clean rainwater from roofs and roads in ‘vertical wetlands’. At the bottom of the slopes this cleaned water is collected.
4. *Valley1060*. The edge of the valley can be used to store cleaned water from the slopes and collect rainwater, falling in this zone. In the summer rainwater is retained and used as grey water in low-density buildings, which are concentrated at the edge of *Valley1060*. Water from roofs and roads needs to be cleaned in wetlands. The cleaned water is stored in basins in summer, and is put through directly to the river in the winter. To keep the rainwater as long as possible in

the area green roofs is used, the rainwater is infiltrated in the soil or the water is filtrated in sand-beds.

5. *River*. The edges of the river are the last possibility to clean rainwater from roads and roofs. If wetlands are projected here the water can be cleaned before entering the river. In the winter clean water is added to the river

2.9.2.5 Fit in the Site

If these principles are fit in the site (Fig. 2.33) the high-rise buildings are concentrated and positioned at *Edge1140* and low-density buildings gathered at the edge of the valley. By doing so, larger areas stay free from building activities and the biodiversity and the quality of green space is improved. Moreover, it increases the possible use of space for water retention. Last but not least it creates a free ecological zone alongside the river, very important as a base for ecological development.

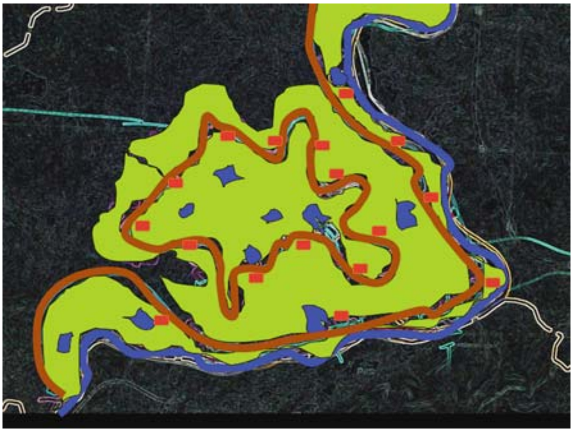


Fig. 2.33 Principles fit in the site (Source: Bing et al., 2008a)

In more detail, the concept is designed for a distinct water-catchment area (Fig. 2.34). The hilltop is reserved to grow a forest. Water is kept here to supply the trees. At *Edge1140* the high-rise is concentrated around the horizontal road and surrounded by ponds (to collect and store rainwater) and reed beds (to clean roof and road water). The steepest slopes are planted with native plants and prevent the slopes from erosion. In *Valley1060* the low-density buildings are gathered and are accompanied by wetlands (to clean roof and road water) and ponds (to retain rainwater before it enters the river). The river valley is mostly kept free of buildings – it only contains the Shui Dong Road and the business units for headquarters – in order to give room to ecological processes alongside and inside the river. The ecological banks are functioning as a green zone, where native wildlife has the chance to develop. There is some co-use possible in this area. For instance, extensive recreation, traffic on bikes or by foot and hot springs may be introduced in this zone.

Fig. 2.34 Detail of the concept for one water catchment area (Source: Bing et al., 2008a)

2.9.2.6 The 'Cake': Concentrating Building Densities

The result of implementing the concentrated building concept is that the landscape regenerates its original quality and beauty. Distinct building zones are mixed with specific green areas. The mountain is as a cake (Fig. 2.35), has a crown around the top and a collar at the bottom.

2.9.3 Vanke's Stream Valley, Shenzhen

The Stream Valley project is located in the surroundings of Shenzhen in the Southern part of China. The area is of high value. The ecological values in the area must be maintained or the existing qualities must be improved if urban developments are undertaken. The effluent of water leaving the area must meet high quality levels. The quantity of water leaving the area must be kept at the same amount. Building

Fig. 2.35 The cake with a crown and a collar (Source: Bing et al., 2008a)

activities should minimise their impact, both during the building period as afterwards and if road are build eco-crossings must be provided to ensure the richness of biodiversity (Bing et al., 2008b).

2.9.3.1 Climate Change Effects

Shaped by the subtropical marine climate, Shenzhen has a mild climate as well as plentiful sunshine and rainfall all year round. The measured temperature is 22.4°C on average. However it should perhaps be noted that Shenzhen is located at the estuary of the Pearl River and is therefore an area, which is often influenced by typhoons. Generally the most significant typhoons occur from May to December and especially from July to September. The annual rainfall is 1900 mm, of which 75% is falling between May an September. The differences between the seasons indicate extraordinary circumstances in the project area of Stream Valley. Abundant growing circumstances, combined with a high runoff of rainwater and steamy air are present in summer, while a shortage of water and less abundant circumstances characterise the winter period. These basis climatic differences lead to extremely high ecological qualities.

Based on the meteorological data during 1953–2004, the characteristics of climate change in Shenzhen in the recent 50 years are studied. The temperature is increased. The warming rate is larger in summer and autumn. The increase in temperature at night is larger, which means that the daily temperature ranges become smaller, particularly in autumn and winter. The lowest temperature increases as do hot days. Precipitation days, sunshine times and relative humidity are decreasing. The main concern in this area is that the differences between summer and winter increase. Differences in temperature and precipitation increase. For the project area this means that the hot summers become warmer and the runoff water leaves the area at a rapid pace. The winters are dry and there is almost and lesser water available. These circumstances lead also to a decreasing biodiversity. Especially the steep slopes in the area are under pressure due to heavy showers in summer or the absence of water in winter.

2.9.3.2 Aims

The expected changes in climate are incorporated in the design for the project area. Measures are taken to slow down runoff water in summer. This is meant to store more water in the project area than currently in order to have water available in the dry winter period. Water in the public space has also a cooling effect in the urban environment, which is desirable if temperatures are rising in the future. The vulnerable ecology in the area profits also from apparent water, both in summer as winter. The land degradation of the hillsides needs to be stopped by planting and water deliverance, but also by taking care of valuable ecology during the building activities.

2.9.3.3 A Short History of Stream Valley

Before 1998 the area was occupied with low-scale agricultural activities. In 1998 the farmers, who owned the area were removed. Between 1998 and 2004 the ecological quality improved a lot, because of the absence of human activities. In 2004 Vanke got the right to build sparsely (120 houses) in the area. But in 2005 national regulations prohibit building developments in ecological valuable areas like Stream Valley. This dilemma of the right to build and at the same time the impossibility to build the area is only to solve if the building activities prove to be able to improve the ecological and water system qualities.

2.9.3.4 Ecology

The ecological system shows a clear distinction between the southern, uphill areas and the northern, downhill area. The ecological qualities are strongly linked to the water system and the year-round availability of streaming water. The ecological developments differ between the northern and southern slopes. The northern slope has a relatively low quality and is degraded. Grassy plants overgrow the northern slope bit by bit and lead to a decreasing quality. This natural process is difficult to stop and turn into an ecological emergent system. Removal of the grassy plants might not be a good idea because removal will lead to slide of the uphill plants, leading to erasure of all ecological qualities. The creation of wet and stable habitats uphill might be a better solution. These ‘hotspots’ are able to function as centres of dispersion and feed the other areas on the hill. The southern slope is ecologically much richer and more in balance. Even here, the creation of these hotspots may support the ecological system.

2.9.3.5 Water System

The natural qualities in the project area are dependent on the availability of water. The water in the area has also a regional function. After leaving the project area it feeds the drinking water reservoir (Fig. 2.36). The drinking water reservoir depends on the Stream Valley water. Therefore it is important that the amount of water from Stream Valley stays at least the same as now.

The water-function at the project level is based on the existing altitudes and slopes. The water storage and retention is best done at the lower and flat areas. Runoff water, feeding the streams, is located uphill. This typology of natural functions may be used to increase the future sustainability within the project-area.

There is a big difference between the summer and winter period (Fig. 2.37). The summer period is wet and humid. Almost all rain falls in this period. The winter period is less warm and dry. Precipitation in this period is low or absent. This has consequences for the project area. In summer there is more water available in the project area. Currently this water is transported rapidly from the area towards the drinking water reservoir or further away. To prevent the streams from flooding the water is discharged as quickly as possible. In winter period the water level drops and

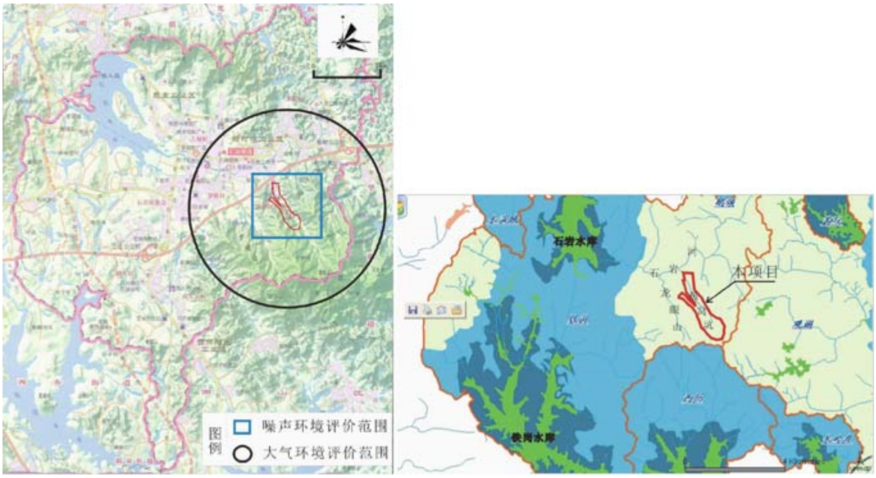


Fig. 2.36 Stream Valley as drinking water resource (Source: Bing et al., 2008b)

almost no water is discharged anymore. By the end of the winter period (in May) the water level is lowest and the area no longer functions as a resource for the drinking water reservoir. The shortage at the end of winter leads to a decreased water quality. The shortage of water in winter is flushed away during summer. It is proposed to store more water in summer in order to keep enough water in the system for the winter.

Fig. 2.37 Amount of water in summer (*left*) and winter (*right*) (Source: Bing et al., 2008b)

2.9.3.6 Conceptual Suggestions

If the central objectives of storing more water in summer and increase the overall biodiversity are met, the area is prepared for future climate change and an interesting area with high qualities can be realised. Because the area is very vulnerable a strategic approach is chosen. In this approach the measures, which restore the natural qualities of the water and ecological system are realised before any building activities take place. Even if buildings are realised, they should be kept foot-loose from the underlying natural system of water, soil and ecology. In Fig. 2.38 this strategy is visualised.

The central stream is the main structure in the valley. In order to increase the storage capacity at several places ponds and lakes may be created, which slow down the discharge speed in summer and preserve water for the drier winter period. The water flows from the hillsides towards the central stream. In order to keep these side streams intact there should be created enough space to let these streams function undisturbed. There should be as much as possible side streams and every building activity should respect the required space. The side streams also store and slow

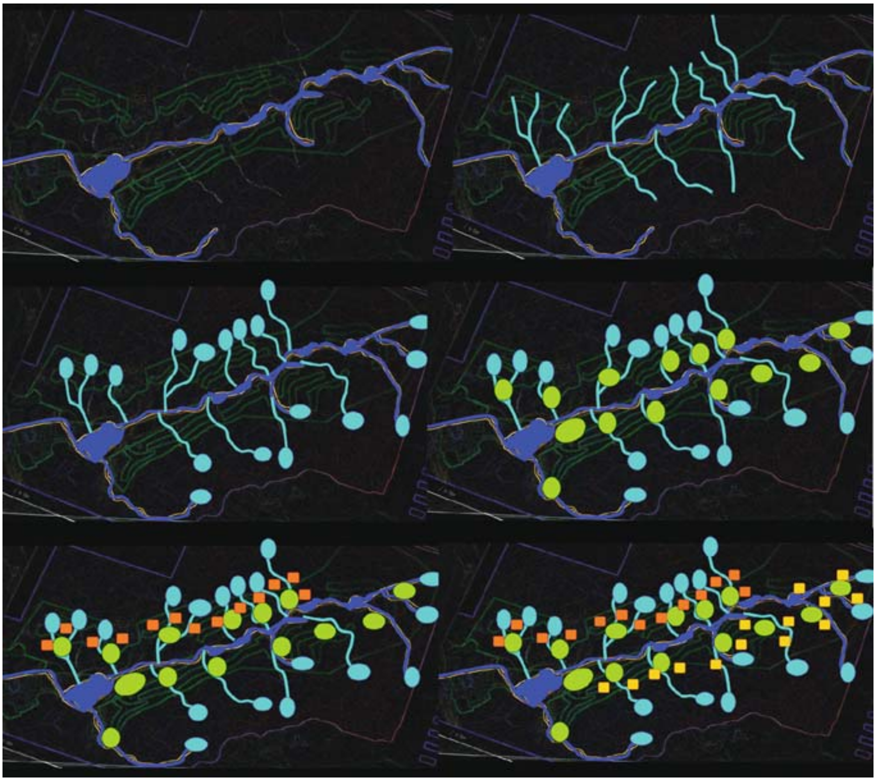


Fig. 2.38 Step-by-step development of Stream Valley (Source: Bing et al. 2008b)

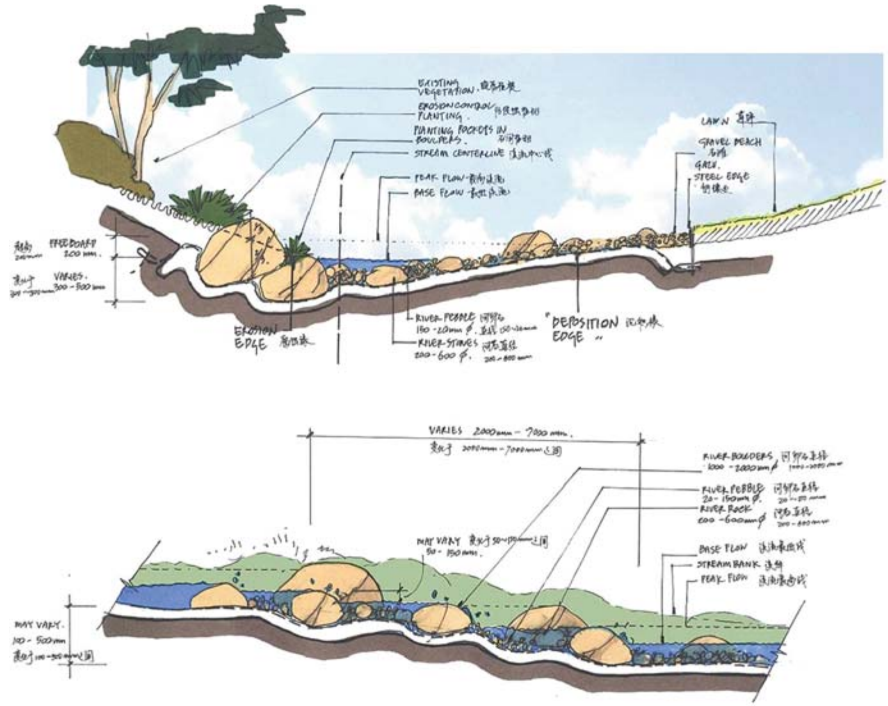


Fig. 2.39 Cross-sections of possible measures to slow down runoff water (Source: Bing et al., 2008b)

down runoff water. In order to slow down the runoff rocks might be positioned in both central and side streams (Fig. 2.39). Where ever small flat spaces can be found half way uphill storage ponds can be realised. These ponds not only store water, but function also as ecological hotspots. Water is essential to increase biodiversity and especially in dry winter periods these ponds function as ecological centres. These ponds can be realised by positioning groups of rocks in the side streams. Water, which runs off the hill, can be cleaned extra in a natural way. Even if the water that runs off the hill is very clean already, the introduction of natural wetlands before water from side streams enters the central stream may be encouraged. This way the quality may increase even more, anticipating on potential developments later on, which may decrease the quality of runoff water. If wetlands are created before any building activities take place, the area anticipates on future developments. Later on, water from roads can be cleaned in these, already functioning, wetlands. This improved water and ecological system shall be realised before any building activity takes place in the area. After realisation of this ecological improved situation a minimal impact road may be constructed and the first houses can be built. The houses should be build in a way that they minimise their impact, during building and afterwards, on their environment. This can be realised by lifting the houses above the landscape and construct them on one pole/column (Fig. 2.40). It is suggested to

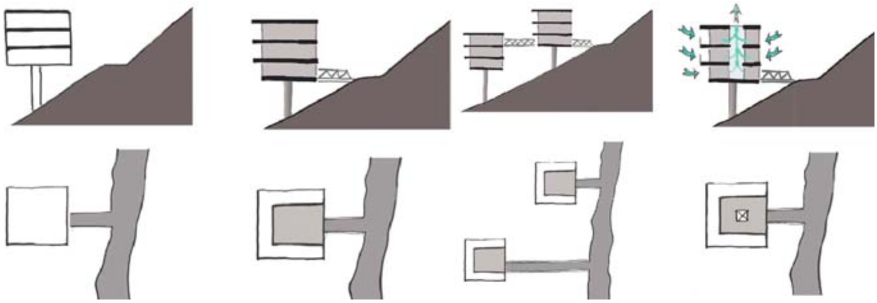


Fig. 2.40 The house like a tree in the landscape, connected by a bridge and the chimney effect (Source: Bing et al., 2008b)

start the phasing at the northern slopes, because the ecological value at that hillside is relatively low. By doing so, the building process can be stopped any time. The most valuable parts of Stream Valley are occupied latest.

The construction of the houses with minimal impact on the landscape and ecology and improving sustainability in comfort and energy use at the same time can be visualised in several steps. The house is built on one pole like a tree and connected with the road, above the houses, with a bridge. The house provides shade beneath it on the hillside. Within the houses natural ventilation through the so-called chimney effect is reached.

Water and electricity is provided from the road and the sewage system is organised through the pole. The required amount of external electricity is minimised by the provision of PV-panels on the roofs (Figs. 2.41 and 2.42).

2.9.4 Chinese Experience

Looking at the three Chinese projects the first element to be mentioned is hat these three projects are sustainable building demonstration projects. This simple fact makes it logical that in the plans a relatively big attention is for the adaptation to the effects of climate change. However, the majority of the developments probably show a lack of attention to this subject.

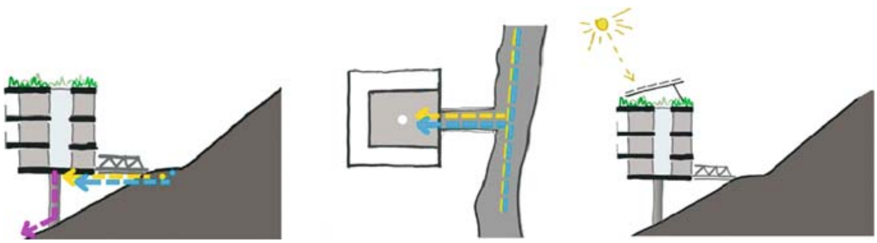


Fig. 2.41 The water, electricity and sewage solutions (Source: Bing et al., 2008b)

Fig. 2.42 Visualisations of the design for Stream Valley (Source: Bing et al., 2008b; artist impressions: RAU & Partners Architektenburo BV)

Generally, adaptation to climate change is in China not a big issue yet. The main efforts go, as in many other countries, towards minimising climate change by energy saving or usage of sustainable energy.

However, the three projects illustrate that incorporation of measures anticipating on expected changes in climate is easily done. The measures direct the character and layout of the design and contribute to the resiliency of the entire area.

The main issues in the Chinese examples are the unbalance in water availability between summer and winter, leading to floods or droughts and the decrease of biodiversity, due to various reasons.

The integration of climate proof measures in large-scale Chinese urban development projects is easy to do. The Chinese projects show that if the natural circumstances, like altitudes, slopes, water and ecology are taken as central steering elements in the design the resilience and anticipative capacity of the project area can be improved. The internal capacity to store water and increase biodiversity reduces the vulnerability of the site for unexpected events like heavy rain or droughts. The designs for the various areas are integrated designs and the climate measures are a regular part of it. It seems that in the Chinese context climate adaptation measures are not seen as new ingredient, which have difficulties to be fitted in an old fashioned tradition of planning. Besides this, in China a jump forward takes place on issues like energy use and climate adaptation. Policy makers, designers and project developers are open to incorporate these issues in the designs.

Compared to the Dutch examples and situation, the Chinese attitude towards these issues seems more susceptible. Integration of climate change is just a regular issue, which, if explained by external experts, is easily integrated and realised. The Western and Dutch planning practice can learn from this in the sense that new knowledge can be adapted much more quickly in the planning processes with less reservedness. In the Chinese examples the project developer works together with the central government and scientific experts in a design project. This work process is not regular practice in the Netherlands.

Finally, the Dutch planning practice can learn from the Chinese examples in a way that the impacts of climate change are integrated and designed in the plan. The effects of climate change, whether it is biodiversity, the absence of water or heat islands effects became steering in the lay out of the projects. The different sectors are contributing to the central direction of the design and one sector is not trying to become more important than another one. In the Netherlands the structure of spatial planning is based on the aims and policies of added sectors. Instead of aiming the same integrated objective (be prepared for the effects of climate change) and designing the planning process around it, the sectoral influences find themselves still too important to leave their interests behind and cooperate to reach a common goal. Caused by this focus on the individual sectors, the adaptation of spatial structures is made more difficult than necessary and it is difficult to reach the best results. The planning system could be adjusted a bit around common goal definition. Besides this, a stronger involvement in the planning process for developers and scientific experts could be arranged

2.10 Chances of a Design Approach

In the debate on how to adapt regions best to the effects of climate change the role of design is underestimated. The belief is that if objectives regarding climate change are formulated in policy documents, these objectives will be reached. But setting the rules is not enough. Adaptation to climate change is such an issue. It is, for example in the Netherlands a big issue in policy, but if realised plans are taken into account not much adaptation measures are realised yet. Firstly, this is caused by the fact that adaptation to climate change is a relative new subject in planning. Secondly, the subject of adaptation is a complex and long-term one, for which simple and one-dimensional solutions are not effective or available. A simple sentence in a policy document or a sectoral solution does not meet the requirements and characteristics of the adaptation to climate change, which requires a more integrative approach.

Design offers the changes that are not available sector oriented planning or policy-making. Integrated thinking and visualisation are very useful in making complex and long-term issues clear and at the same time give concrete and spatial solutions for these issues. The creativity and challenging *being* of design processes are capable of shaping a new image for the future world in a certain region. The regional spatial level is very well suited to give shape to developments on the longer term. In order to understand the possibilities of the regional spatial system to deal with climate change, knowledge on the regional natural system is essential. Once this system is understood the design process is capable of shaping a future image. A rough estimate on the future changes in climate is enough information to do so. A thoroughly and scientific sound research, giving exact figures, is not necessary.

2.10.1 Implementation

Trust that *design processes* are the mean that will include climate adaptation and will solve all problems of implementation is not advisable. More is required to implement, anticipate and realise adaptation measures. A nice drawing of a climate proof region only does not take care of that.

- Firstly, policy makers should be made aware of the importance of climate change and the unavoidability of adaptation. Knowledge has to be made available to reach the policy makers.
- Secondly, politicians should be supported that in their choices to prioritise issues not only short-term elections are important, but the long-term safety of the population might be more important. For politicians it is very difficult to take action if their knowledge base is not sufficient. Thus there is a need for a politically harmonised and approved state of the art on climate changes to be expected.
- Thirdly, planning processes need to be adjusted in a way that the planning and design processes are less sectoral oriented and linear. The process needs to create space for non-linear issues such as climate change, which is complex and oriented on the longer term. Besides the adjustments of the planning process it is also necessary to add climate proof requirements in regulations in order to safeguard climate proof developments.
- Fourthly, the financial consequences of adaptation to climate change need to be placed in a long-term perspective.
- Finally, the designers need to use their capacity to integrate several problem fields in a design and use their creativity to keep the future developments in mind instead of day-to-day demands.

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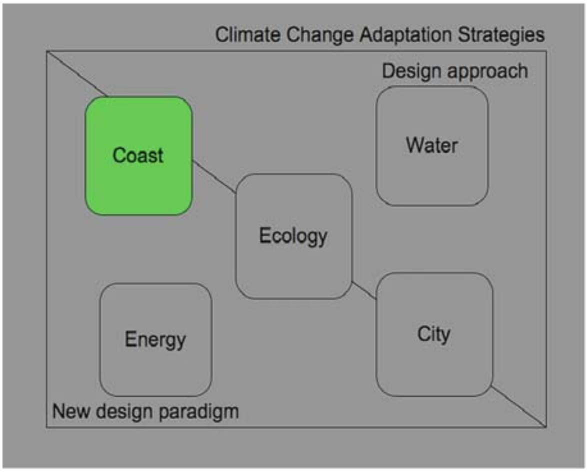
Chapter 3
The Coast



Abstract Due to global warming the sea level is rising. The IPCC predictions vary from 35 to 85 cm at the end of the century. However, around the globe there are big differences in expected future sea levels. For small islands in the Pacific a small elevation means the difference between exist or not exist. In a European context the rise of sea level will be counted in decimetres, but a strong acceleration of land ice melting might increase this expected number. In many other regions risk is a combination of a rising sea level with more intense weather events, such as hurricanes or typhoons. The question how to deal with the risks involved can be answered in different ways. Try to create a technical protection, which offers a minimum level of safety or create a robust zone with much higher safety levels. Trust on a belief in technique and engineers or, on top of that, turn the risk into a challenge and become innovative. The amount of solutions is large and they vary from a simple seawall

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to entire new naturally build coastal zones. The examples from the Netherlands, Hamburg, New Orleans and London illustrate that there is not one best solution to deal with coastal defence, but that different approaches can be useful. In general, the combination of a strong defensive wall with the development of new spatial functions in the coastal zone seems to be provoking the imagination most, but when it comes to realisation these concepts rarely score best. If the sea level rise accelerates a shift in thinking may be required, because an ongoing heightening of dikes increases the risk factor also. A seemingly strong dike causes a lot of damage when it breaks and the higher the dike the more unexpected the breech will be. The vulnerability behind the dike is high and resilience low. Therefore, an anticipative approach, which is preparing people for surprises and accepting future higher sea levels in today's environment, may well be the future. Vulnerability will be lowered if integrated and multifunctional solutions are built with natural processes instead of against it. In order to find new solutions, the development of extraordinary projects, like the Pink Project in New Orleans or the Arkway project in the Thames Gateway, need to be encouraged.

3.1 Introduction

In this chapter four areas, which are considered to be vulnerable to global climate change and sea level rise, are presented. As a country lying for a large part below sealevel, the Netherlands has to decide on future strategic decisions regarding flooding protection and reducing risks for the population and investments in the areas below sea level. Hamburg is a specific example of a major city, which tries to combine harbour activities and living in an area increasingly prone to flooding due to deepening the Elbe-river, which causes increased tidal amplitudes. Similar problems occur in the greater London area where different options have been suggested. The final example considers the situation around New Orleans, which was hit by a tropical cyclone that caused major flooding of the city. In all four regions numerous suggestions have been made both for short-term measures as well as for long-term strategies to reduce risks and cope with future sea level rise.

3.2 Dutch Coastal Defence

3.2.1 A forever Changing Coastline

The coast of the Netherlands has always been subject to natural changes. In history, the coastline has changed, due to these changes, a lot (Fig. 3.1).The actual coastline is protected by human influence through dikes and sand suppletions.

In order to monitor the safety of the coast, the Dutch government defined after the 1953-flood the so-called Delta-standard (Rijkswaterstaat, DWW, 2003). This

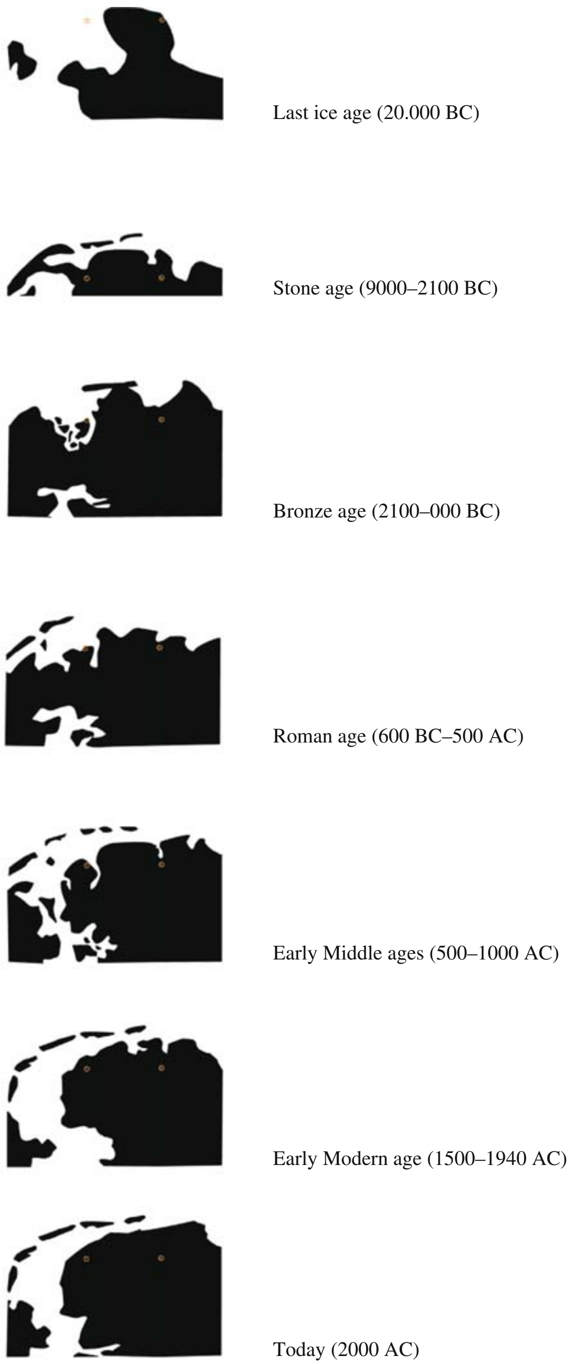


Fig. 3.1 The coastline of the northern Netherlands though times (Source: Vries et al., 2006)

standard examplifies the safety of the coastal defence in a way that the defence only once in a certain number of years under severe threat collapses. In the river zone the dikes need to withstand a high water level, which occurs every 1250 years. Along the western coast this standard is put on once every 10,000 years. The detailed standard is dependant on the economic value and the density of population in a certain area. The Delta-standard is set more than 50 years ago. Since then, the value behind the dikes has increased tremendously. Thus, the question is if the right standard is still actual for the different areas. If the values increase the standard has to do so as well. Another question is if the protection level according the standards is realised in a time that has to expect a higher sea level and increased river discharges due to climate change. This is the reason that in the Netherlands the project 'Safety in the Netherlands on the Map' (VNK) is conducted, with new methods to calculate the real risk better. The first results show that the Randstad Holland is not as good protected as expected (Rijkswaterstaat, DWW, 2003).

The coastal defence is under pressure of a rising sea level and the expected increase of heavier storms. Different views on the best way to protect the country are explored. This discussion is recently put back on the political agenda, because climate change requires long-term thinking. A good example of this renewed attention is the installation of the Deltacommission, which has the assignment to look at the far future and advise on the long-term layout of the country, bearing climate change in mind. This chapter gives an overview over the different old and new plans, concepts and ideas for a safe coastal defence.

3.2.2 Dutch Weak Links

The Dutch coast has to deal with an increasing sea level rise. Beside this, the effect of wave-attacks on the coast increases as a result of wave amplitudes and wave periods. This requires extra robustness of the coastal defence. Along the Zealand and North and South Holland coast several places need to be strengthened in the coming 50 years. This is necessary in order to obey the safety requirements (Ministere van Verkeer en Waterstaat, 2003). These places are the so-called 'weak links' in the Dutch coastal defence. The approach to work on these weak links aims to guarantee the safety of the hinterland. This is why spatial reservations are made, which are capable of withstanding a sea level rise of 200 years. The spatial reservation can be realised at the land as well as the seaside of the coastal defence. Beside the safety several other objectives play a role. For example, the sand balance should be kept stable, the ecological quality must be improved, the economic continuity must be guaranteed and the spatial use must be optimised – like vital coastal cities and nature reserves. Along the Dutch coast ten weak links are defined (Fig. 3.2) of which eight have priority. A part of the coast gains priority if it does not meet the safety standards between now and 20 years.

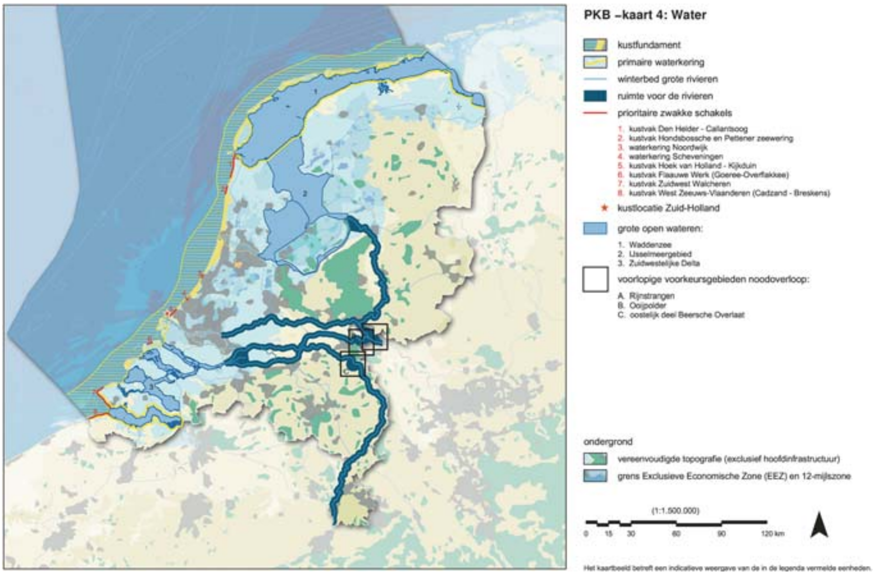


Fig. 3.2 The weak links in the Dutch coast PKB-map in the National Spatial Plan (Source: Ministeries van VROM, LNV, VenW en EZ, 2004)

3.2.3 Integrated Development Perspective for the South Holland Coast

For the South Holland coast an integrated perspective is developed (Bureau Nieuwe Gracht, 2005), in which the weak links play an important role. In the perspective is reasoned from different points of view: the typology of coastal landscape, the relation between urban developments and the sea and the typology of seaside resorts (Fig. 3.3). This framework map offers the context of the South Holland weak links. Within the context the lay out of the area is designed. It makes a big difference if a weak link is combined with a natural reserve or with a seaside resort. Every weak link contains its own specific spatial solutions. The framework map shows the position of different elements alongside the South Holland coast.

After the design of the framework map ideas are developed for the weak links how the coastal defence relates to urban developments. The basis for the Delflandse coast (Fig. 3.4) is a seaward extension in the form of a green fundament, which ensures the safety. In the different scenarios this green fundament is combined intensively or extensively with urban functions. This varies from a moderate scenario (a green living area behind the dunes), a little more challenging scenario (design of urban strips in a seaward direction) to an extreme scenario (by gaining land on which the city and nature can be developed).

Most of the weak links along the Dutch coast are treated like an urgent necessity: the coastline needs to be strengthened and it has to be done quickly. They are supplied with sand or the dike is made stronger and safety is the only issue during the

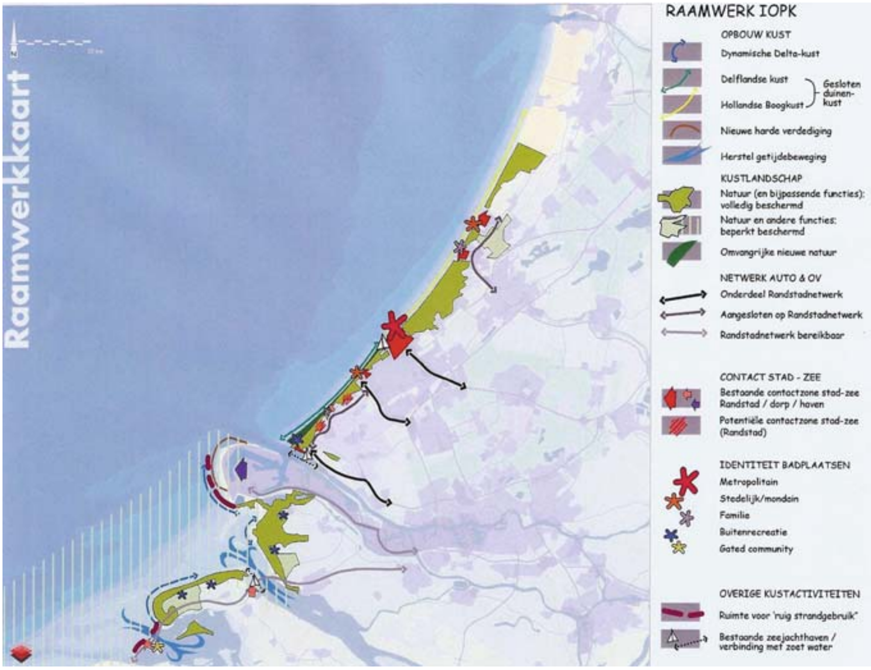


Fig. 3.3 Framework map of the integrated development perspective South Holland coast (Source: Bureau Nieuwe Gracht, 2005)

planning process. It is a sectoral and simple, though sometimes costly, approach. The exception is the weak links, which are integrated in the development of the South-Holland coast. Here, an integrated development is proposed, in which the weak links are incorporated. This results in an embedded configuration: the weak links are irremovable from the spatial plan. This makes it cheaper, but the realisation is also dependent on the pace of the planning. If the planning process delays, the weak links do so as well.

3.2.4 ComCoast

The ComCoast project (www.comcoast.org) aims at changing the existing dikes into a multifunctional coastal defence (Fig. 3.5). This is necessary because of climate change, sea level rise, increased wave activity and level of tides, increased pressure on the coast by human activity and coastal erosion. A multifunctional coast is more resilient for these changes and is capable of incorporating more functions. Within the Interreg-project is cooperated in eleven locations along the coasts of South East England, Belgium, the Netherlands, Germany and Denmark. In the project, managed by Rijkswaterstaat, is cooperated between the province of Zealand and Groningen, the University of Oldenburg, the Environmental Agency (UK), the Min-

Fig. 3.4 Four scenarios for the Delfland coast (Source: Bureau Nieuwe Gracht, 2005)

istry of the Flemish community (B), the Danish Coastal Authority (DK), the municipality of Hulst and the water boards Zealand islands and Zealand Flanders.

The possibilities to develop a multifunctional coastal zone can be found at land as well as seaward (Fig. 3.6).

Within the ComCoast project five different concepts are developed (Oedekerk, 2006).

The front shore defence (Fig. 3.7) consists of a construction in front of the coastline, which improves the defensive qualities of the primary defence, the dike, by decreasing the wave-activity. The area between the dike and front shore defence develops as a brackish zone with a decreased wave-action and is suitable for the development of nature, recreation and saline agriculture.

Over time this front shore defence might be developed into a permanent defence (Fig. 3.8).

Suppletion (Fig. 3.9) with sand, mud, shingle or gravel in front of the coast strengthens the natural defence and offers a valuable habitat for several species. This sedimentation zone offers chances for nature, recreation and saline agriculture. On the other hand, if a lot of sand is required to protect the coast – and due to a quick rising of the sea level this is expected –, the living ecosystem of the beach

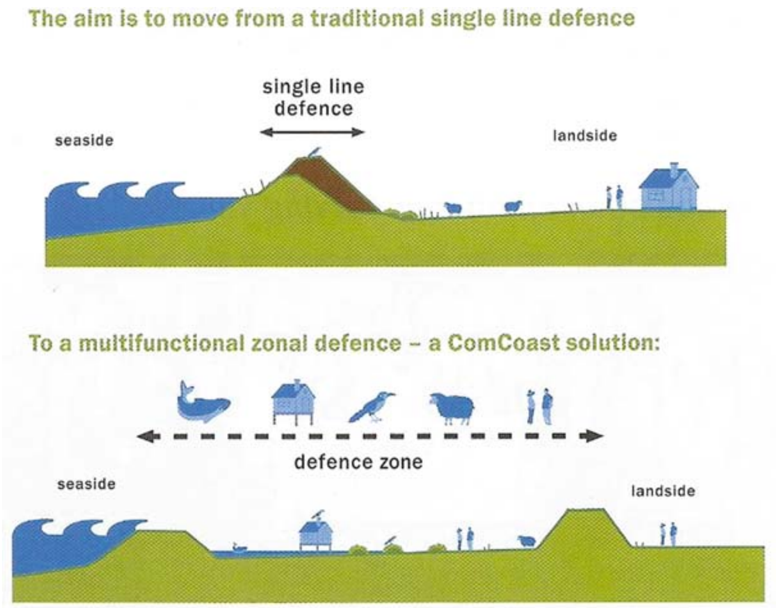


Fig. 3.5 Change from a single dike towards a multifunctional coastal defence (Source: Comcoast, 2007b)

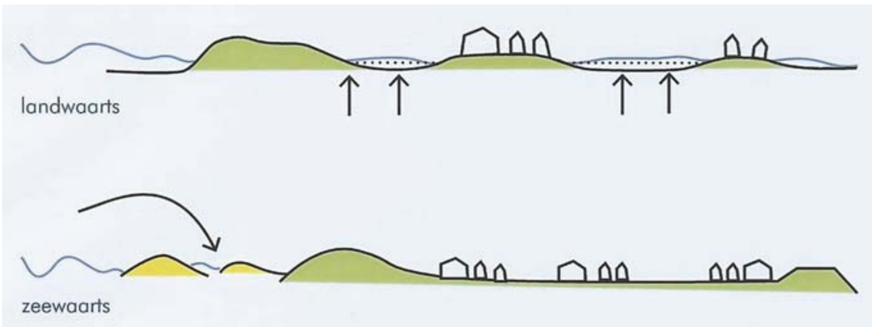


Fig. 3.6 A land and seaward multifunctional zone (Source: DHV, 2006)

Fig. 3.7 Front shore defence (Source: Oedekerk, 2006)

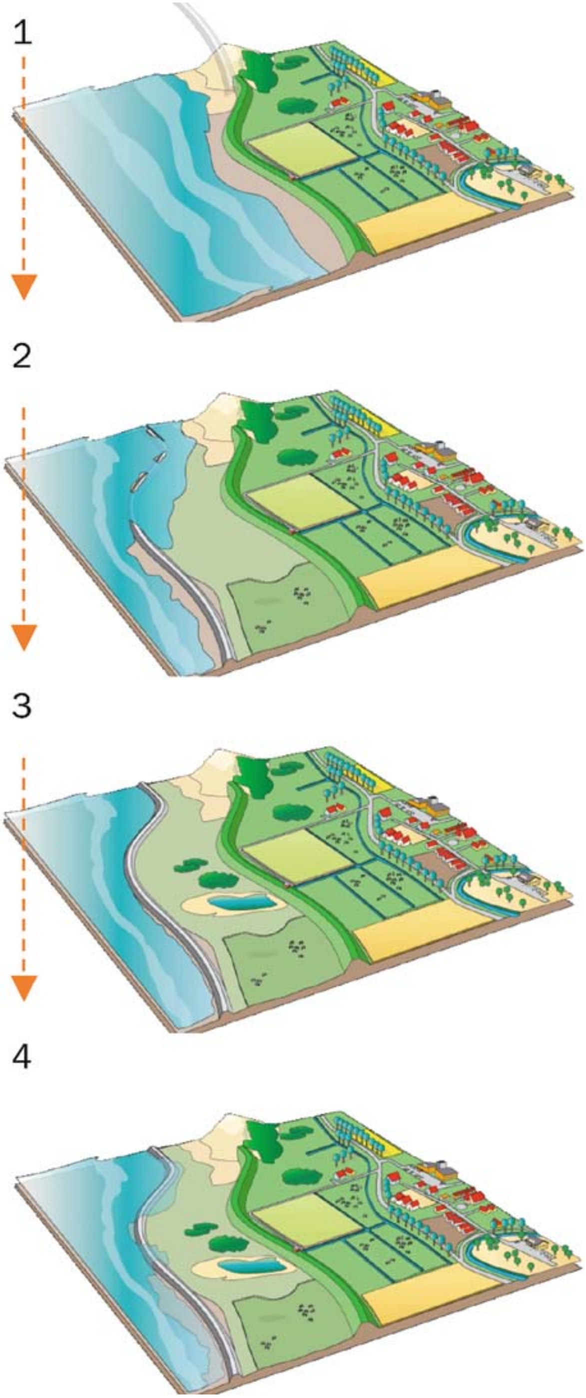


Fig. 3.8 In four steps towards a new closed defence (Source: ComCoast, 2007a)

Fig. 3.9 Suppletion (Source: Oedekerk, 2006)

Fig. 3.10 An overflowing dike (Source: Oedekerk, 2006)

zone is under threat by suppletion. If enough space is created for natural processes and beach reserves are created, this negative effect of too much sand on the sandy coast that kills all life underneath, can be averted (Janssen, 2008).

Instead of heightening the dike, it is possible also to allow seawater to flow over de dike. This requires a strengthening of the inside slope with durable material (Fig. 3.10), which prevents the dike from being damaged. The overflowing water needs to be stored behind the dike or needs to be discharged. If the water is stored a second dike is required and in the area between the two dikes a wet zone, which is suitable for salt and brackish nature, recreation, saline agriculture and housing.

If an existing dike is opened and seawater is able to reach the hinterland, a new primary coastal defence will be necessary (Fig. 3.11). Between this new dike and the old one a dynamic area emerges, which floods regularly. This results in decreased wave pressure on the new dike. The area in between is rising because mud and sand sedimentates here. By enhancing these natural processes it is possible to keep up with the sea level rise. These higher altitudes in the landscape do have a positive effect on softening the waves and it increases the safety.

If seawater is allowed to enter the hinterland a regulated tidal inlet arises (Fig. 3.12). A transition area emerges where sea influence is apparent. This area is filled up with mud and sand at a place which meets the tempo of the sea level rise. Nature can be developed and this area is suitable for recreation a saline agriculture.

Fig. 3.11 Back draw of the dike (Source: Oedekerk, 2006)

Fig. 3.12 Regulated tidal inlet (Source: Oedekerk, 2006)

Land or seaward developments do have different consequences, especially on the long term. For the province of Zealand is researched for both directions how the province might be developed on the long term (Fig. 3.13). For both options a sound safety level is required. However, the option differ in the necessary space and the chances it offers for new functions.

If the defence is developed on land, especially in the agriculture the changes are felt, but it offers chances for nature development and temporary living areas (DHV, 2006). Seaward development offers chances for recreation, nature and energy. It leads to different images (Figs. 3.14 and 3.15).

Many of the solutions developed in the ComCoast project are adjusting the direct dike zone. Most of the solutions aim to create a multifunctional zone. The most limited solution seems the most realistic. Let the dike overtop with sea water, create an extra strong structure at the foot of the dike and let Many of the solutions developed in the ComCoast project are adjusting the direct dike zone. Most of the solutions aim to create a multifunctional zone. The most limited solution seems the most realistic. Let the dike overtop with seawater, create an extra strong structure at the foot of the dike and concentrate the seawater in a small zone behind the dike. Other solutions are creating broader zones with many functions towards the sea or inland, they are more expensive and require more space.

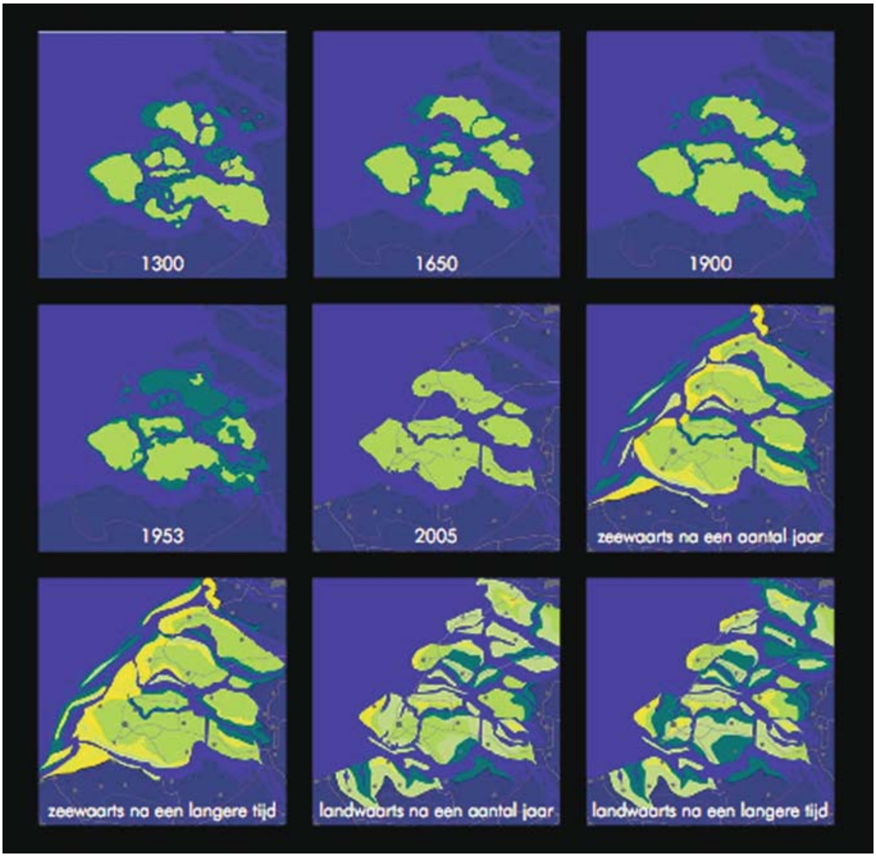


Fig. 3.13 Long-term changes in Zealand in both land and seaward direction (Source: DHV, 2006)

Fig. 3.14 Seaward development offers chances for energy production and leisure (Source: DHV, 2006)

Fig. 3.15 Landward development offers chances for nature and temporary living (Source: DHV, 2006)

Fig. 3.16 An extensive dike

3.2.5 Land in Sea!

The coastal defence can be limited to modifying the dike or the zone around the dike, but more far-reaching alternatives may be explored as well. The creation of new land in front of the coast is such a far-reaching idea, which is a very popular issue in the Netherlands. In the past and recent history many different ideas are explored. The background idea of all these ideas is that the realisation of a row of new islands is minimising the wave power, which minimises the chance at a dike breech. The easiest way to do so is the creation of a reef or long dike in the sea (Fig. 3.16), but it may be more inspirational if beside the defence also space is created for new functions.

Mother of all these visions is without doubt the Waterman plan (Fig. 3.17), in which a long island, suitable for urban functions, nature and recreation, in front of the South Holland coast is projected (Bos, 2001). The Bhalotra plan (Fig. 3.18) for

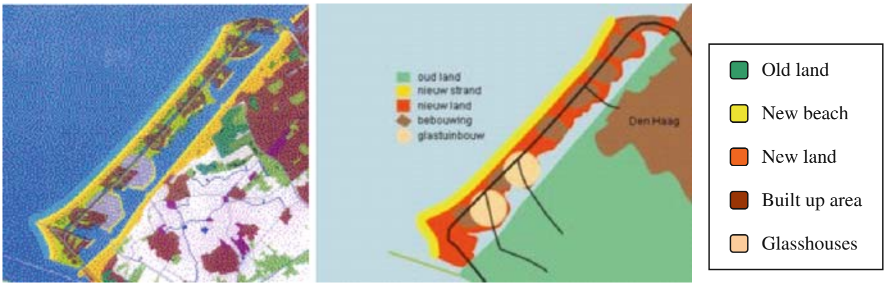


Fig. 3.17 The Waterman plan (Source: Bos, 2001)

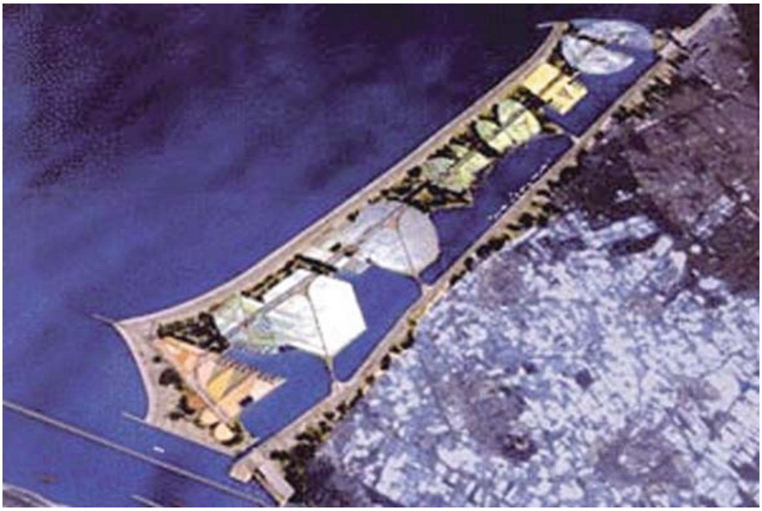


Fig. 3.18 The Bhalotra plan (Source: Bos, 2001)

the same location is based on the same principles: at 500 m out of the coast in front of Hoek van Holland a long urban island should be realised.

Willem Bos developed plans and visions for the Western Dutch coast as well. He based his ideas on existing folds near the Maasvklakte and IJmuiden and created a hollow coastal curve (Fig. 3.19), where space is available for brackish wet nature in a strong and extended dune landscape, for bays with extensive beaches and for the existing harbours in between (Bos, 2001).

In the design that is developed by Adriaan Geuze for Boskalis a series of islands is created in front of the Dutch coast (Fig. 3.20). The islands function as protection for the coast, but create new valuable fishing zones in the North Sea also, because deep fishing spots are created by sand depletion at the right places. More new fishing area is developed than old ones are destroyed. Still, one can argue about the rationale behind this. Moreover, the islands enhance the development of new nature in the lagoon behind the islands and they support the sand transportation towards the Northern Netherlands.

A variant on the ideas of Geuze is the plan of the innovation platform (www.minez.nl). This plan proposes the development of a polder in the North Sea shaped in the form of a tulip (Fig. 3.21). The motion of member of Parliament Atsma, aiming to start a feasibility study on the realisation of such a polder was accepted by the House of the Commons by the end of 2007 (Atsma, 2007). The reasons to realise such a polder are not only the protection potential, but could also solve the spatial scarcity of the Randstad Holland, which can be solved in many other ways as well (other land reclamation area, intensive building options, shift to peripheral regions in the country). The shape of a tulip must be read as a symbol and not as a serious proposed form of an island.

A comparable way of thinking is followed in the research to realise a new airport in the North Sea (Flyland, 2003). The available space in the Haarlemmermeer polder

Fig. 3.19 Willem Bos' plan for an extensive hollow coastal bow (Source: Bos, 2001)

Fig. 3.20 Row of islands in front of the Western Netherlands coast (Source: Boskalis, 2008)

and around Amsterdam, without the hinder of noise contours, could be used for urban developments. This is only possible if Schiphol airport is moved towards sea.

The province of North Holland proposed a complete different island: an island for one season (Provincie Noord-Holland, 2007). This island should be realised without any coastal defence at 100 m out of the coast (Fig. 3.22). After a certain time this island will be erased and disappears in the sea, but during its existence it has a defensive as well as an ecological and recreational function. This solution seems to be very ineffective: relatively expensive and very temporal ecological function, if any.

Fig. 3.21 North Sea polder in tulip shape (Source: www.rtl.nl)

Fig. 3.22 Proposal for an island for one season (Source: province of Noord-Holland, 2007)

Within the Grounds for Change project an island archipelago (Fig. 3.23) in front of the Northern Netherlands coast is designed (Roggema et al. 2006). These islands have several functions.

Fig. 3.23 A second row Wadden Islands (Source: Roggema et al, 2006)

In the first place they contribute to the safety of the country by softening the waves during heavy storms and spring tide.

Beside this, the islands create a lagoon with quiet water, where sand sedimentates more easily. The increased sedimentation compensates the erosion because of an accelerated sea level rise. The increased amount of sand enforces the sandbanks to grow along with the level of the sea and doing so, the sandbanks keep falling dry during ebb tide. If the sedimentation is not increased it is expected that in 2040 about 40% of the sandbanks in the Wadden Sea might disappear (De Boo, 2005).

Thirdly, the islands offer the room for new functions, like housing, nature and recreation. Moreover, the islands offer the space for functions that, due to climate change, need to be removed from the mainland, like nature, which finds its northern boundary in the northern part of the Netherlands.

Part of the development vision for the Eemsdelta is the realisation of a new island North from Schiermonnikoog (MUST, 2007). This island (Fig. 3.24) hosts mainly economical functions, like a harbour where ships are able to enter with dirty cargo or ships that are too large to enter the Eems harbour or the Ems-river. Moreover, the island functions as an energy producer, using hydropower and windmills. In case of a storm, the basin gets filled up with seawater and the island softens the wave power on the coast.

In history and today many ideas for new (is)land in front of the Dutch coast have been proposed. Most ideas are developed for the Western coastline, because the weakest defence may be found here and behind the coastal defence the most valuable area is apparent. So far all ideas have not been realised. This is caused by the strange mechanism that the plans are judged in a technocratic way while the plans are visionary. Ideas to create a new world with many different functions,

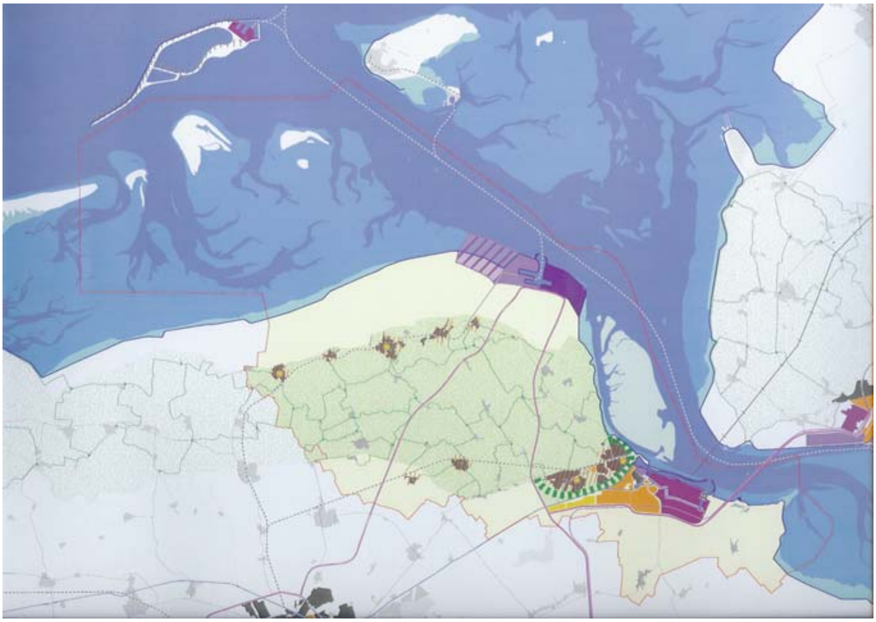


Fig. 3.24 Economical energy-island in the Eemsdelta (Source: MUST, 2007)

where people live and nature is developing were judged in a way that the costs of the investment are compared with the costs of a safe defence only. A multi-functional development is seen as non-functional. The Netherlands is famous because of its engineers-solutions for defending against water, reclaiming land from the sea and control over the water management of canals, lakes and rivers. In such a country only the minimalistic and functional reasoning gives room for new solutions. There is no broader perspective available and there is no grand view or a senseless reason to create something rich. Because of its sobriety and thriftiness the Dutch never found the reason to create a broad and generous solution to defend the coast and realise an entire new landscape at the same time. With a rising sea level at stake, the ideas are presented again, but even in these circumstances the Dutch say: if the sand-grain can do the work, why should we build islands to defend ourselves. A new world of opportunities is out of sight, again.

3.2.6 Groningen Combinatory of Coastal Defences

A regular solution to protect the country from flooding is the heightening of the dike. This approach may solve problems if circumstances are not too extreme. However, if sea level rises more than a meter per century and storms become more intense, the dike needs to be supersized. This makes the system vulnerable. Even a strong dike can break and if a very high dike does, the damage is very large. Therefore, the vulnerability behind the dike is high and the resilience low as the people seemed and believed they are safe. If circumstances become extreme, and they will within the 21st century, another approach will be necessary. This alternative approach consists of the best combination of coastal defence measures. By implementing several measures at the same time, the vulnerability of the system decreases and resilience can be improved. For every specific area the most optimal mix of measures can be chosen.

The province of Groningen explored this multilayered way of thinking (Provincie Groningen and Climate Changes Spatial Planning, 2008). Several new coastal defence measures were judged and if proven useful they were mapped. If a certain measure could be used the locations will be shown on the map (Fig. 3.25). The different solutions are described here shortly. For a more extensive description: www.klimaatbestendiggroningen.nl: De kust van Groningen (Provincie Groningen and Climate Changes Spatial Planning, 2008).

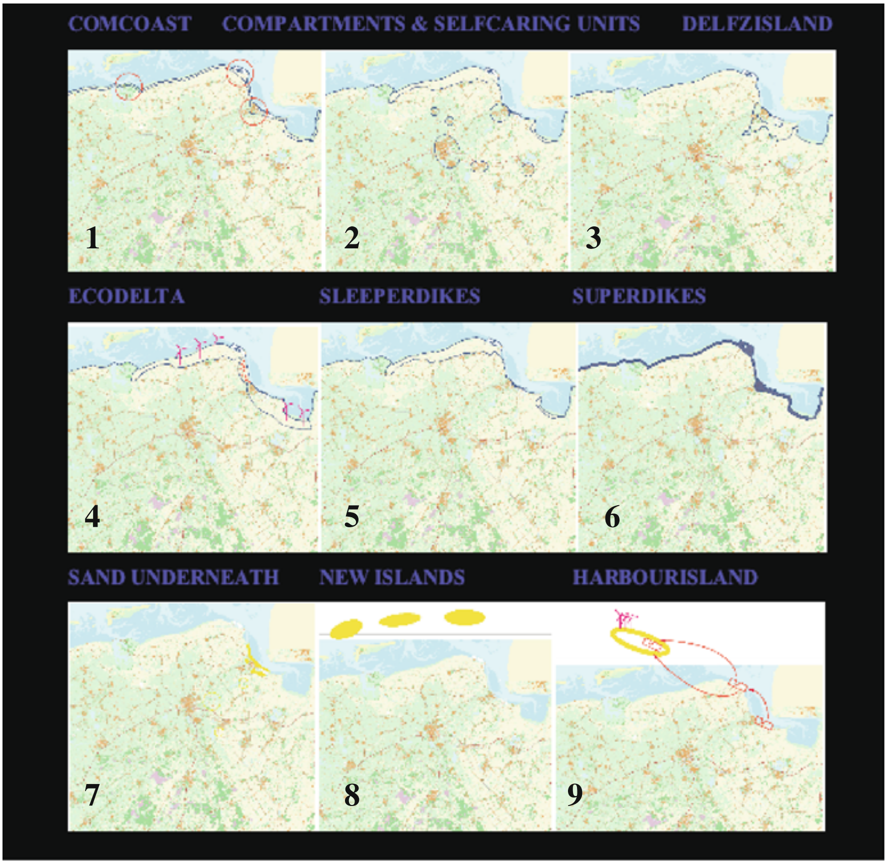


Fig. 3.25 Nine new solutions for the Groningen coastal defence (Source: Province of Groningen & Climate Changes Spatial Planning,2008)

The nine different solutions for Groningen include the following:

1. *Comcoast* (see also Section 3.2.4) aims to create a coastal zone, where a multifunctional layout increases the possibilities to deal with high sea levels and storms. For example, one of the ideas is to let sea water flow over the dike.
2. *Compartments* and self-providing cells aim to create smaller compartments in order to minimise the effect of a flood to a small area. If, beside the compartments, self-providing cells are created, where people gather in case of a flood, the damage can be kept to a minimum.
3. *Delfzisland* (see also Section 7.3) creates a floodable zone around urban concentrations. Seawater as well as a surplus of rainwater can be stored in this area temporary.
4. *Ecodelta* creates a broad coastal zone, where ecological development is combined with an attractive new living environment.
5. *Sleeper dikes* are old sea dikes, which ran out of function when new land was reclaimed and a new sea dike was build. If the old dikes are restored and maintained they may very well function as a secondary defence. If the first dike breaks, the sleeper dikes prevent the water from flooding the entire hinterland.
6. *Super dikes* are extra broad dikes. If dikes are broadened it is hardly possible to break them. It may be possible that water flows on or over the dike, but a breakthrough is hardly possible.
7. *Sand Underneath* proposes the extra heightening of urban concentrations with sand up to a level that will not be reached by a rising sea level. This way the urban areas can be kept safe.
8. *New Islands* are protecting the coast because they break the heavy waves in case of high tide and a storm situation. If the islands are positioned right they are not only minimising wave power, but are capable of creating a quiet lagoon-like wetland behind them.
9. *Harbour-island* also aims to protect the coast by breaking waves, but combines a function as harbour with the production of energy. Windmills and a fall-lake in combination with tidal, wave or osmosis plants are giving the island an energy image.

If all measures are combined on a coastal mixture map (Fig. 3.26) it becomes clear which measures are best to combine in specific areas. This combination of coastal defence measures optimises the protection at every location along the coast, but it enhances a multifunctional development as well. Finally, the combination of measures offers higher resilience, which makes the society less vulnerable for floods.

The approach to combine several good solutions at suitable places along the coast is attractive, because it offers extra safety (if one defence option malfunctions, the next one still does), it is possible to create at every small place a solution which is made to measure, it offers the chance to combine new functions and it offers the change to experiment with innovative solutions, which would never have been used if they were the one and only defence mean at a certain spot.

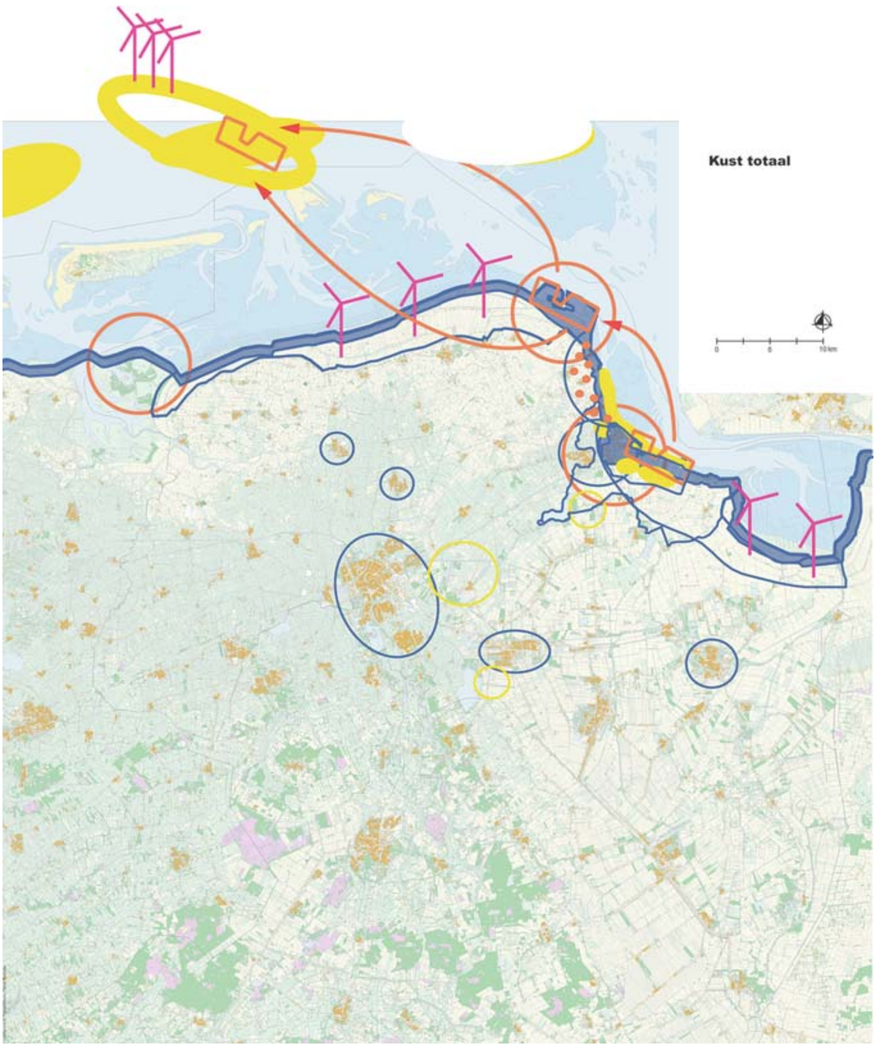


Fig. 3.26 Combinatory of Groningen coastal solutions (Source: Province of Groningen & Climate changes spatial planning, 2008)

3.2.7 Attention for Safety

The AVV-project (Attention for Safety) aims to develop a Decision Support System, which is able to analyse the durability of the safety policy for the coming 15–20 years, bearing in mind the changes that take place on the long term (50–100 years). In the project new safety strategies are developed, which are able to deal with long-term in climate, soil dropping, land use and governance. The project not only looks at the coast but at the water systems on land as well. However, the biggest flood rik

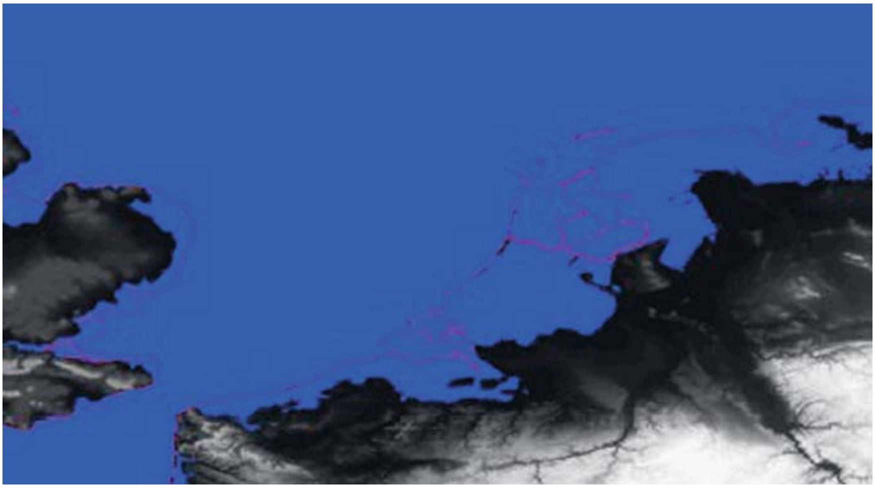


Fig. 3.27 The Netherlands if the sealevel rise is 6 m (Source: ATLANTIS, www.ivm.falw.vu.nl)

is expected to happen from sea. The project looks at extreme sea level rises of +5 m (Fig. 3.27). This approach leads to unorthodox perspectives on the future.

Three questions are crucial in the research of the future safety of the Netherlands: What are the expected long-term developments, which governmental, societal and economical boundaries are relevant in case of flooding and water annoyance and what are the safety perspectives that are capable of dealing with the long-term.

Three rough perspectives for 2100 were developed during several workshops with experts (Aerts, 2007).

The first perspective is called *Business as Usual,* in which current techniques and practice is the standard. The dikes will be heightened, space is created for rivers and coastal suppletions are done on a regular basis, even if the rising of the sea level reaches five metres.

In the second perspective – *Raising Holland* – parts of the Netherlands are heightened if the sea level rise further (Kerkhof et al., 2007). All new building activities are realised at minimal 5 m above current sea level, on mega-*wierden* (artificial hills). Sand from the North Sea is used to do so. After this first phase of heightening the higher areas are connected with each other by long super dikes, which protect existing cities against floods. Randstad Holland can be protected with one long inhabited dike, by combining the new super dikes smartly with existing dikes (Fig. 3.28).

In the third perspective – *Widening Holland* – the Dutch coast is extended. The new coast is realised at higher altitudes in order to be able to live there, even if the sea level rise is five metres. Behind the broad coast the lower parts of the country still can be inhabited, while the bigger part of the population lives in the higher parts of the country (Fig. 3.29).

The perspectives are developed to include the full bandwidth of possible futures and find solutions for the entire scope of possibilities. Some solutions seem extreme,

Fig. 3.28 Scenario 2100 Raising Holland (Source: Aandacht voor Veiligheid, www.adaptation.nl)

but they are necessary to test the Decision Support System for less predictable variants. By doing so it can be guaranteed that the System functions in all situations of water annoyance or floods and can produce information on costs and spatial claims. The next step is to test the Support System in some pilot cases, in which the solutions will vary again from probable and logical to exceptional and away-from the average.

3.2.8 The Dutch 'Delta Commission'

In September 2007 the Delta commission is inaugurated. The first Delta commission was active after the Flood of 1953. The Minister of Traffic and Public Works has the

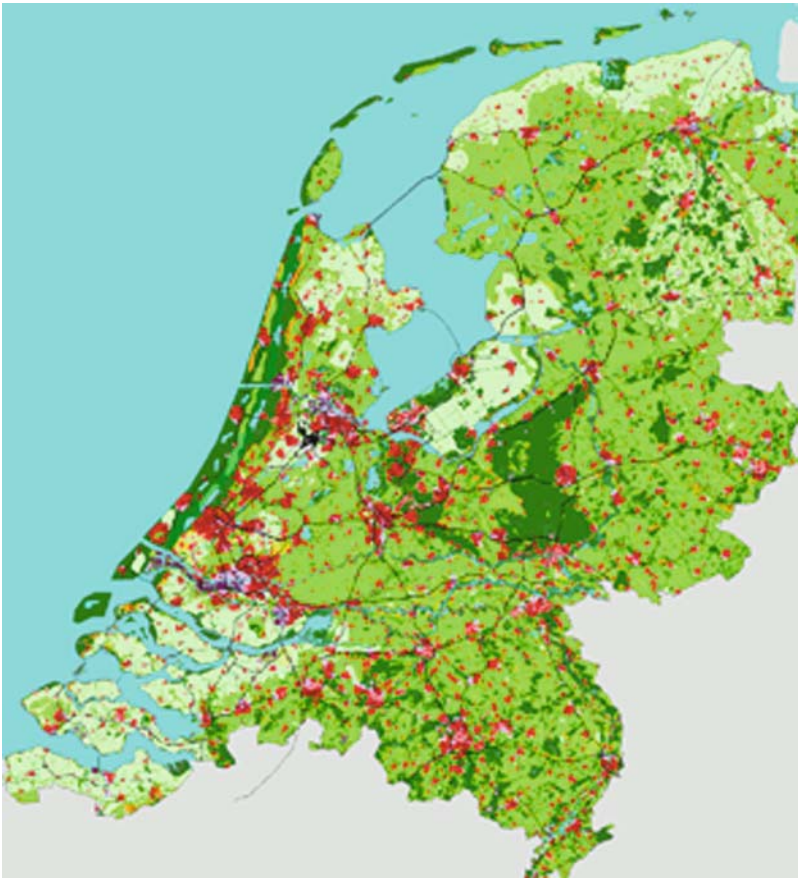


Fig. 3.29 Widening Holland (Source: Aandacht voor Veiligheid, www.adaptation.nl)

opinion that it is currently, with sea level rise and climate change, essential to look at the protection of the Dutch coast and the hinterland. The assignment for the second Delta commission, chaired by former minister Veerman, is to raise insight on the expected sea level rise and other climatic developments, which will have impact on the Dutch coast. Beside this, the commission advises on a comprehensive policy for a sustainable development of the Dutch coastal zone (Ministerie van Verkeer en Waterstaat, 2007).

The commission answers in its report (Deltacommissie, 2008) the question how the Netherlands can be protected against climate change and how the Netherlands may look like if on the very long term the country is laid out in a climate proof way. In its analysis the commission takes broad scoop. Beside protection against flooding and safeguarding the fresh water reserves, integration is sought with many different functions (working, living, recreation, nature, landscape, agriculture infrastructure

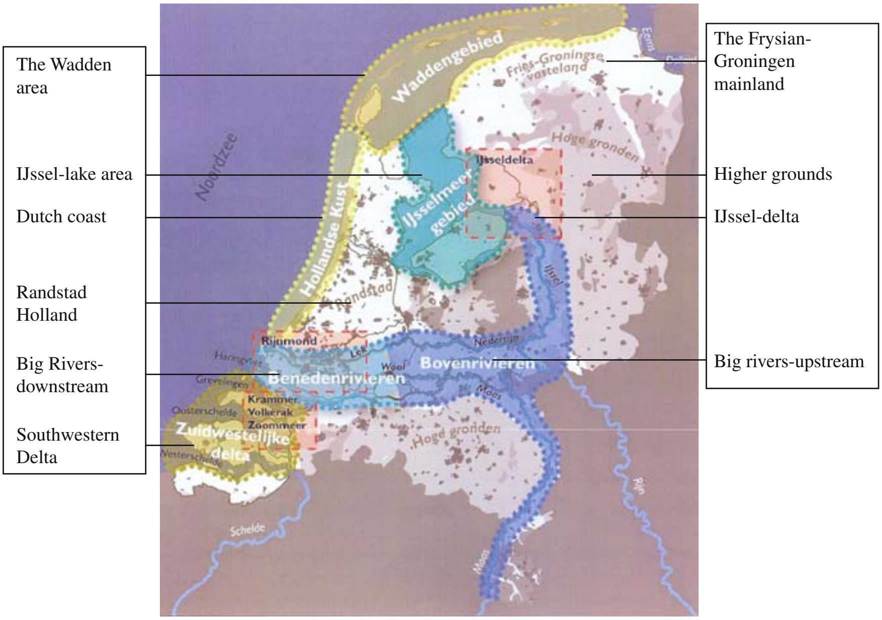


Fig. 3.30 Different subregions in the Dutch water system (Source: Deltacommissie, 2008)

and energy). Therefore, the coast as well as the river system is subject of the report. The commission advises not only on how to deal with the effects of climate change, but aims at creating new changes and challenges also. The Deltacommission states that solutions may differ for each region and these regions are defined based on the national water system (Fig. 3.30).

3.2.8.1 Urgency

The urgency to act now, while the problems become manifest on the longer term is found in several reasons (Deltacommissie, 2008):

1. Many locations along the Dutch coast do not satisfy the set standards. The standards themselves are outdated;
2. The changes in climate are developing in a rapid pace and seem to accelerate;
3. The sea level rises faster than assumed up to now. It is estimated that the sea level rise in 2100 will be 65–130 cm and in 2200 between 2 and 4 m;
4. There is an increasing change in extreme variables in river discharges. The summer discharge will be much lower as the winter extremes become much higher. In 2100 the Maas capacity needs to be maximal 4600 m3/s and this standard for the Rhine is 18,000 m3/s, much more than estimated so far.

3.2.8.2 Emerging Problems

The following problems emerge over the next century (Deltacommissie, 2008). The solving of most of these problems needs to be started in the next years.

1. Up to 2050 the sandbanks in the Wadden Sea are capable of growing with the rising sea level. If the sea level rises as predicted somewhere between 2050 and 2100 they are no longer capable to do so;
2. Up to 2050 it is possible to sluice water from the IJssel Lake into the Wadden Sea freely. Between 2050 and 2100 this is no longer possible;
3. The fresh water reserve in the IJssel Lake becomes too small to provide different parts of the country with fresh water all year by 2050 and this is becoming worse in 2100;
4. The influence of seawater in the river system increases by 2050 and is moving further upstream in 2100;
5. Flooding chances in the Maas increase by 2050 and for all rivers by 2100;
6. Pay attention to the strength and height of dikes and dunes;
7. The Delta works in South Holland and Zealand need to close more often in 2050, but are malfunctioning in 2100;
8. The inlet of freshwater in the Randstad is increasingly disrupted;
9. Increased amount of saline seepage in lower parts of the country;
10. Retention area for river water discharge is required (Fig. 3.31)

3.2.8.3 Future Vision

The Deltacommission developed a future vision for the Netherlands. How need the Netherlands be adjusted if is focussed on possible developments in the far future. The Netherlands stays the safest delta in the world. The country stays attractive to live work, invest and recreate in. This is safeguarded by investments in two pillars: safety and sustainability. The living conditions of today are kept and improved.

In order to make this ambition come true several objectives are formulated (Deltacommissie, 2008):

1. Efficient use of water, energy and other raw materials. The cycles of water, energy, sediment and other raw materials must be closed;
2. The layout of the country needs to be based on natural processes on location. Space is needed for the dynamic of sea and rivers and new biodiversity and landscapes are to be created, leading to adjusted living environments;
3. Energy can be produced at or near the coast in the form of wind parks, osmosis and tidal plants;
4. The Randstad Holland stays the heart of the country. The lowest parts of the Netherlands play the major role in the national income, culture and history and food production;

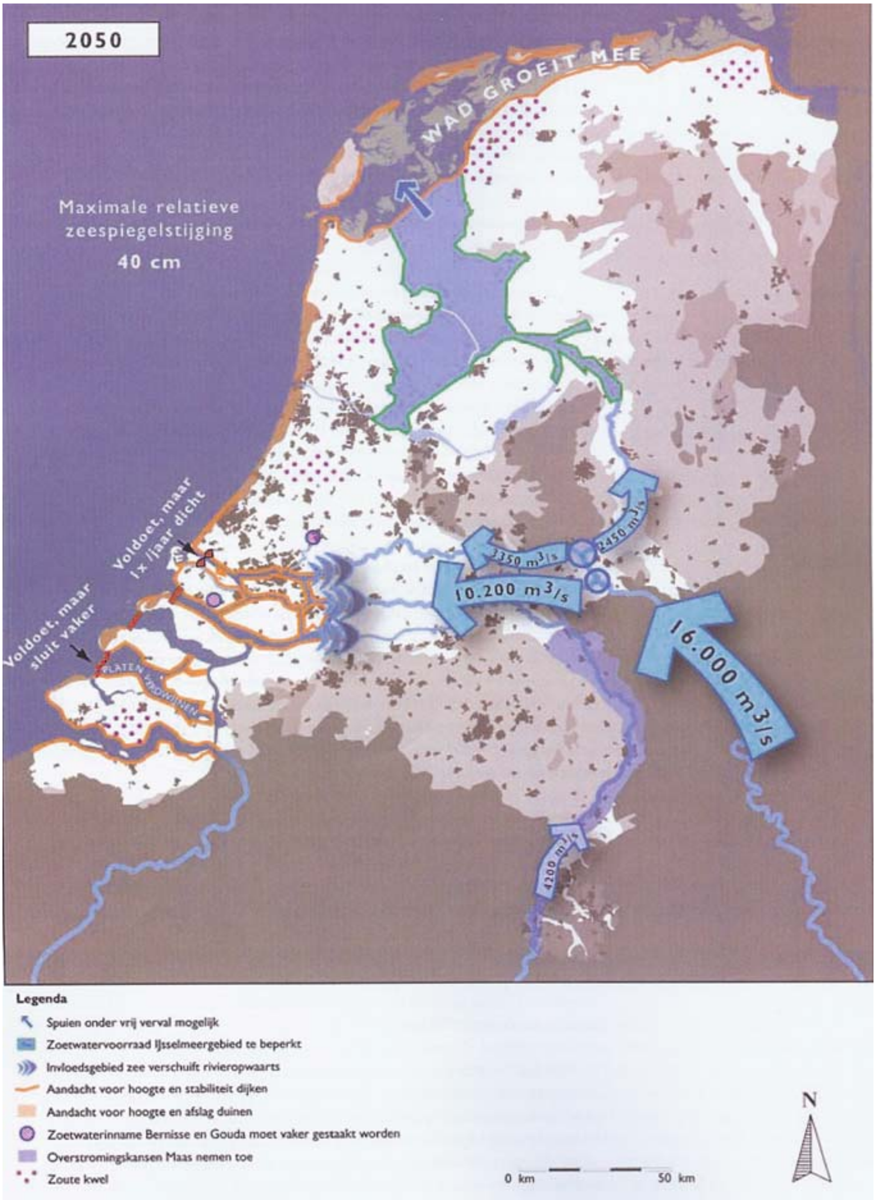


Fig. 3.31 Developing problems in 2050 and 2100 onwards (Source: Deltacommissie, 2008)

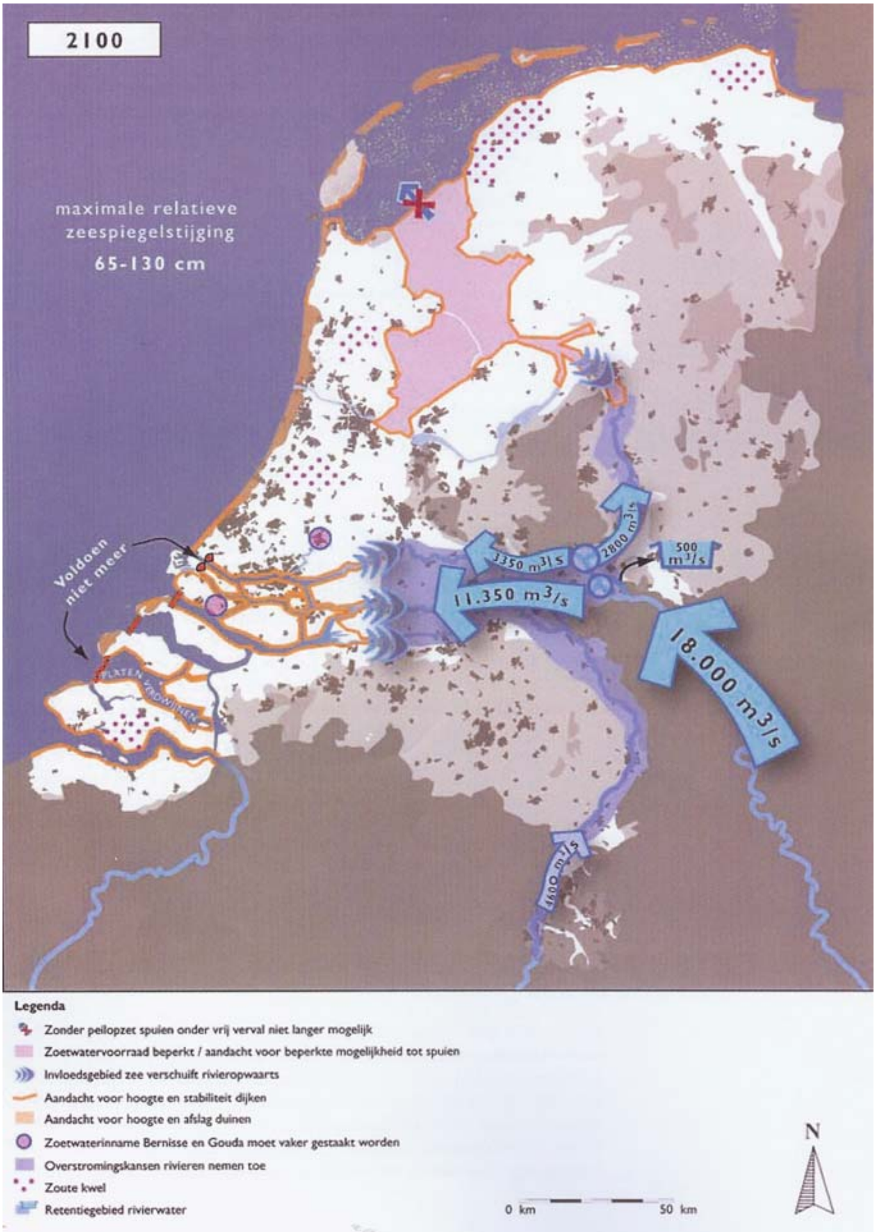


Fig. 3.31 (continued)

5. Enough fresh water must be available;
6. Develop the country with the changes in climate and not against it. Move with natural processes gives people and nature the chance to adapt to the changes easily.

3.2.8.4 Short and Mid-Term Measures

Based on the future vision the Deltacommission defined 12 measures (Fig. 3.32), which should be implemented for the short (2050) and mid-term (2100):

1. The safety level of each dike ring in the Netherlands should be improved by a factor 10. If there are any urgent locations the concept of the Deltadike (high or broad) should be sustained. A careful look at local situations is required and solutions should be made to measure;
2. If new building activities are planned at physical un-logical places, the extra costs should be carried by the beneficiaries;
3. If the discharge capacity of the rivers can be secured, building in outer-dike areas is sustained. The owners are responsible for measures which reduce the effects of floodings;
4. In front of the North Sea coast sand needs to be supplied in order to enhance the transportation and dune forming of the sand up to the Wadden Sea. This 'sandmotor' provides the coast with enough material to extend its size;
5. Supply the Wadden Sea with material helps the wetland to grow with the sea level. After 2050 this process can no longer be guaranteed and the Wadden Sea as we know it might disappear. The kwelders of the North Netherlands coast and island polders need to be protected against sea level rise;
6. In the Southwestern Delta the Oosterschelde has a lack of tidal processes and intertidal areas are absent. On the long term both tidal processes and the forming of intertidal areas should be resolved by reintroducing tidal dynamic;
7. The Westerschelde must be kept open and function as natural as possible as an estuary. Dikes along the shore need to be strengthened;
8. In the Krammer-Volkerak-Zoommeer temporary water need to be stored. An interesting sweet-salt gradient can be developed here. If this is realised an alternative fresh water reservoir needs to made;
9. In the River area the measures in Room for the River need to be implemented quickly and by means of buying land, there need to be anticipated on the required capacity of 4600 and 18,000 m3/s;
10. In Rijnmond the 'Closable Open' principle needs to be implemented. The main discharge of river water needs to be done through the South-Western Delta and sweet water needs to be imported from the IJssel Lake. Local storage of surplus of water in deep polders;
11. The water level in the IJssel Lake (except the Marker Lake) is brought up by maximal 1.5 m in order to make free sluicing of water towards the Wadden Sea still possible. The Lake functions as the strategic fresh water reserve for Northern Netherlands, North Holland and Western Netherlands;

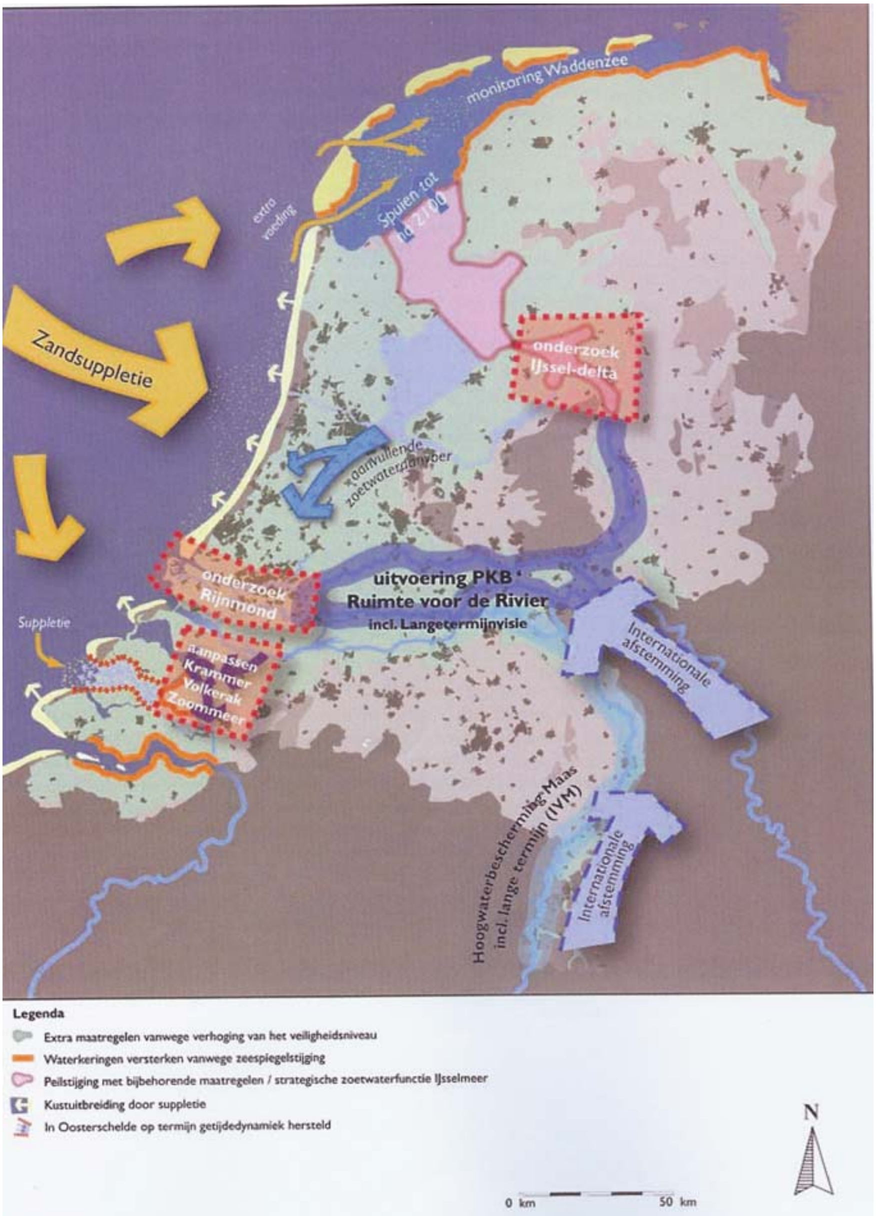


Fig. 3.32 Overview of measures in the Delta-program (Source: Deltacommissie, 2008)

12. The governmental organisation needs to consist of a steering committee at the national level chaired by the Prime Minister and a delegated responsibility to the regional authorities, a National Delta foundation and a new Delta law.

3.2.8.5 Broad Dikes

The Delta commission has chosen to defend the country against high tides, from sea and rivers, for an open defensive system, because this offers a higher environmental and ecological quality and on the long term, with further rising sea levels and higher river discharges, more flexibility and perspective. Among the different solutions of large or small dike rings, heightening partially the country and broad dikes, the commission favours the introduction of so-called broad dikes at weak places in the coastal defence in the Netherlands. This solution contains several advantages (Vellinga, 2008): It decreases the number of casualties and damage, realisation is technically relatively simple, it offers more safety and it offers new planning opportunities. Main disadvantage is that this solution requires political courage. Current dikes breech if high tide reaches a level of 5 m above average. A broad dike never breaks, it just overtops with a little water annoyance as result. A broad dike can be laid out as a coastal zone, which varies from a broadened dike at current altitudes or it may be realised as a multifunctional zone, with ecological values, attractive living environments and chances for new functions (Fig. 3.33 and 3.34). In many cases it is possible to realise a wet zone behind the dike, where seawater can be let it and provides the area with unique qualities

The Deltacommission is ambitious. Fundamental changes in the National water system are proposed. The heightening of the IJssel Lake water level, the transformation of discharge routes of the big rivers and the introduction of the large increase of suppletion of sand in front of the Western coastline are major interventions, which will give the Netherlands definitely another structure. On the other hand, the commission stays with the well-known techniques from the past, like a strong belief in the technical possibilities of dikes. Higher and higher dikes need to provide a safe situation behind the dike. This is the priority and second and third strategies are literally second best options. This is, at least, the suggestion resembling from the report. Two conclusions can be drawn from this. In the first place, the structural National measures need to be transformed to local and regional planning levels. If the suggestion from the national is that the strengthening of dikes is the first priority no local authority or regional will eventually ‘invent’ unorthodox alternatives. Derived from this, the second conclusion might be that the advise does not really encourage people to become creative and find new solutions aiming to look at the coastal defence as a multifunctional assignment, which needs to be designed integrally. The combinations of functions such as nature, water management and living near or on top of the dike zone will be developed rarely. With a rapid and uncertain future regarding climate change, flexible and resilient solutions are required. These solutions need to be capable of functioning as coastal protection under unexpected and unpredicted conditions.

Fig. 3.33 Masterplan and impression for design contest Almere coastal zone, West 8 urban design and landscape architecture (Source: www.west8.nl)

3.2.9 Synthesis

The synthesis of all the Dutch plans shows that a large number of suggestions have been made to combat risks of flooding on the mid- and the long-term. The estimates of the Delta-Commission shows that several strategic decisions can be made to substantially decrease the risks of flooding for larger or smaller parts of the country. Especially promising seem the suggestions to create broad dikes, create a sandmotor to supply the coastal zone with sediment and create efficient zone for overtopping seawater. These suggestions will provide safety for a long period and for the majority of circumstances. In case climate change worsens in the next decennia there is time enough to explore more unorthodox solutions to defend the country from flooding. Meanwhile it is important that in thinking about the coastal zone the ecological qualities are not underestimated. In supplementing the coast and minimising the efforts to keep the country safe, the ecological qualities can be developed at the same time. This is not only a matter of safety, but is also required to create an adaptive system of nature reserves and connections (see also Chapter 5). Grand views and innovative proposals need to be stimulated at the same time in order to be ready of circumstances change unexpected. A strategy in which both the short-term measures as well as the innovative chances are stimulated, the Groningen approach, is especially worth to explore, because it safeguards existing safety policies and explores new ways at the same time.

Fig. 3.34 Example of a broad dike near Perkpolder: climate buffer and fishery plant (Source: Vellinga, 2008)

3.3 Hamburg – Hafencity

3.3.1 Masterplan

Hamburg is located in the northern part of Germany. The distance from the North Sea is about 100 km. Still, the city is under influence of tidal changes and vulnerable for storm surges and high tides. The way the city tries to deal with the coastal defence is integrated in the urban context. The approach contains two basic insights: heighten parts of vulnerable areas and realise a waterproof lay out and buildings in areas that are not heightened. In the Hafencity project these principles are used.

Next to the city centre of Hamburg an old harbour area exists. The restructuring of this area – Hafencity – makes it possible to extend the city centre towards the river Elbe. In the area historical buildings are placed in a Dockland-like environment. The area lies outside the main protective flood defence, which makes the area vulnerable for floods. Especially during high tide the narrow river causes uprising of water levels and large parts of the area are flooded every year.

The main objective of the redevelopment is to create a mixed-use area, where functions, like culture, tourism, working and living are combined [Hafencity Hamburg GmbH, 2000]. A metropolitan character arises with a maritime atmosphere, where ships and quays are visible and contact with water is secured. The

Fig. 3.35 Urban design for Hafencity (Source: GHS, 2002)

total size of the site is 100 ha and eventually 1.5 billion m^2 will be realised in 5500 dwellings and 20,000 jobs, mainly in services and shopping.

As starting point for the urban planning concept (Fig. 3.35) several design principles are defined:

1. Enhance the resemblance of the history at the site;
2. Create a multifunctional and mixed-use space;
3. Create splendid water related spaces: waterfront promenades, squares and boulevards;
4. Design a hierarchical structure, where main and less important places are combined. In the urban design spaces are mixed: spectacular and non-spectacular, broad and narrow, closed and open;
5. Aim for an ecological, economical and social sustainable urban planning. A planning, which includes minimal use of energy and materials, uses renewable resources and designs long lasting urban structures;
6. Identification of the area should not only be based on rational criteria, but also on the emotional side, including art and cultural dimensions as well as spatial quality in architecture and public spaces;
7. The Hafencity needs to be connected strongly with the city centre and neighbouring city parts.

3.3.2 Dealing with Potential Flooding

The entire Hafencity area is located outside the flood protection structures (Fig. 3.36).

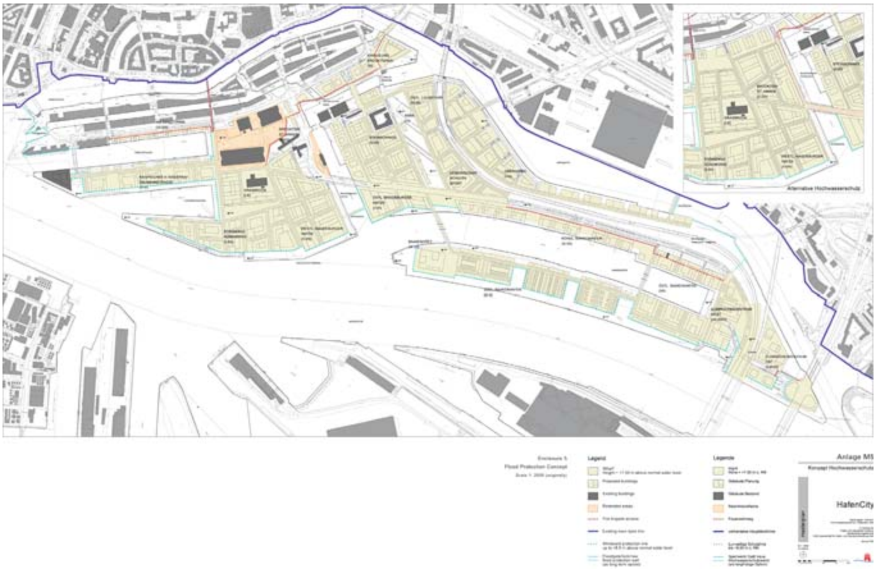


Fig. 3.36 Flood protection plan (Source: GHS, 2002)

This means that two options for protection are available: close the area with a dike or adjust the urban design to flooding and high tides. Because a dike would have disconnected the site from the river physically and visually, the choice was made to find solutions in the urban design. This resulted in a two-level city. A part of the site is heightened in order to stay dry during high tides and the rest of the area, the lower levels, is prepared for wet circumstances. The elevated parts are realised at least at 7.5 above normal level. Footbridges and bicycle-paths at these levels can be used for emergency transportation and evacuation in periods of flooding (Fig. 3.37).

The heightened parts are located in the central areas of the piers and are at least 20 m away from the quay. This results in lively interaction between public space, which occasionally is flooded, and the water of the river. The ground level of the buildings is positioned at least 20 m away from the quay, but it is aloud to build

Fig. 3.37 A footbridge becomes an emergency and evacuation route (Source: GHS, 2002)

Fig. 3.37 (continued)

second floors over the public space and the water. This results in the design of unique buildings (Fig. 3.38), which are overlooking the water-edge, but are also including public spaces and routes. The base of the buildings is treated in order to withstand flooding by the use of extra thick glass for the windows on the ground floor and by using wooden protection against large floating material.

Because the entire area contains these unique 'balcony-buildings' it seems that this part of the city centre is uplifted and becomes more or less footloose, even if there is no flood (Fig. 3.39). The Hafencity area is lived at three levels: the water level, ground level and balcony level.

The Hafencity project illustrates that high tides and floods can be inspirational and lead to architectonical and urban diversity. The threat is not opposed by a pure technical and single-minded solution, but forms a challenge for the urban design.

Fig. 3.38 Examples of buildings above exceptional flood levels (Source: GHS, 2002)

Fig. 3.38 (continued)

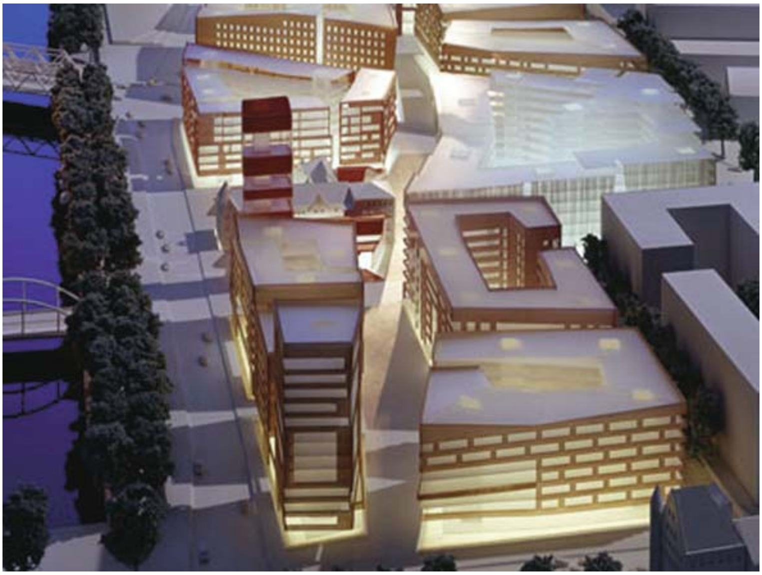


Fig. 3.39 Elevated buildings above a flood level proof public space (Source: GHS, 2002)

This approach combines the safety of the inhabitants of the area with spatial qualities. The area contains different habitats during times the environment is changing. It is positioned in, on and along the river Elbe.

3.4 Thames Gateway – London

3.4.1 Thames Estuary 2100

The estuary of the Thames is in direct connection with the North Sea, which indicates that tidal influences will be felt in the Thames. As sea level rises and amount and strength of storms increases the chances at flooding are increasing as well. In order to prepare the estuary for these future changes the so-called Thames Estuary 2100 project is conducted.

In general, the UK Environment Agency defines four major focal points in adapting the country to climate change (Environment Agency, 2007a). The first point is to increase the investments in flood defences. Secondly, a more strategic approach to manage the coastline is required. Organisations that are involved along the coast need to work together to take sensible, long-term decisions about the way the coasts are used. The protection of the coast from future flooding and the risk of storm surge, as well as realignment, and possibly relocating people and homes or abandoning agricultural land needs to be reconsidered. The third objective is to use water more efficiently, because due to climate change it is expected that the amount of available water will decrease. Finally, conservations and habitats need to be protected. Existing nature conservations are to be made resilient to climate change and the movement of species needs to be encouraged by managing habitats at a landscape scale.

The effects of climate change, such as sea level rise, increased rainfall and storm frequency mean that London and the Thames Estuary will be at greater risk of flooding in future years. Furthermore, many flood risk areas are undergoing development and regeneration, meaning that more people, buildings and infrastructure are likely to be exposed to the risk of flooding in the future.

Although London′s existing tidal defences offer a high level of protection from today′s flood risks, they were only designed to provide protection up until 2030. While slight modifications to these defences could extend their useful life by a few more years, the need for a long-term, strategic look at London′s flood defences is becoming increasingly apparent.

Thames Estuary 2100 is an Environment Agency project (Source: www.environment-agency.gov.uk/te2100) to develop a tidal flood risk management plan for the Thames estuary through to the end of the century. The final plan will recommend what flood risk management measures will be required in the estuary, where they will be needed, and when over the coming century, based upon the climate changes and sea level rises we face.

The plan will take into account the increasing flood risk due to:

- Climate change;
- Rising sea levels;
- Natural ageing of flood defence infrastructure;
- Changes in land levels;
- New developments in the tidal flood plain.

Thames Estuary 2100 is the first step of the process and will help shape the way in which future flood defence schemes are designed and managed. Taking action now will allow time for research, design and the physical construction of the defences.

Thames Estuary 2100 aims to:

- Look at tidal defences in the context of the wider Thames Estuary setting;
- Assess the useful life of the existing defences and gain an understanding of the ′drivers′ (i.e. climate change, urban development, social pressures and the environment);
- Inform and gain support of political and funding partners and stakeholders; and
- Prepare and manage a programme of studies (linked with consultation) that will eventually lead to a strategy for flood risk management in the Thames Estuary for the next 100 years.

3.4.2 Delivery Plan for the Gateway

As a part of the Estuary, the Thames Gateway is a large area, which extends from the eastern part of the London City (Fig. 3.40) towards the North Sea coast. The area suffered from bad economic times and this is why it is one of the areas, which is supported by the so-called Objective 2 development programme. Beside the required economic regeneration, the area is located around the Thames estuary. The changes in climate, together with the firm tidal differences in the Thames, force the area to adapt to the circumstances. The regeneration is used to create jobs and houses, but also to prepare the area for a safe future. For the area a Delivery Plan has been developed (Department for communities and local government, 2007). This plan was put together in a cross-government way, making sure that the plan has focus and has commitment from across government. The plan is structured around three driving forces: enforcing a strong economy, creating a high quality of life for local communities and development of the area as an eco-region.

The objective to tackle climate change is a central issue in the development of the region as an eco-region. This objective is translated into the following concrete measures:

1. Preserve green spaces by locating new developments mainly on brown-fields;
2. Provide public transport in order to minimise the emissions from traffic;

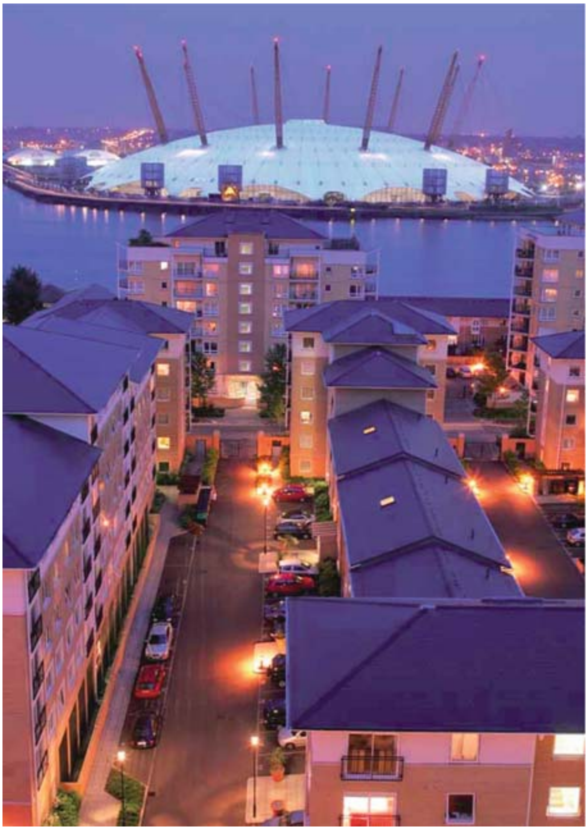


Fig. 3.40 Eastern City of London (Source: Department for communities and local government, 2007)

3. Encourage the development of an eco-quarter, which is separately build and meets the highest sustainability standards;
4. Stimulate environmental infrastructure to ensure the use of renewable energy, community heating and cooling and large scale mixed-use developments;
5. Improve the (energy and water) efficiency in existing buildings;
6. Support the development of environmental technologies, services and jobs;
7. Develop the Gateway as a Zero Construction Waste Zone;
8. Make the Thames Gateway water-neutral.

Finally, the flood risk management of the Thames Gateway is mainly organised by the existing system of barriers, like the Thames Barrier. However, these physical defences cannot be extended continuously. Therefore, measures need to be taken in spatial planning. Every development needs to make sure that it is designed and laid out in a way that the consequences of river and surface water flooding are reduced. Therefore, river, sea and drainage water is integrated in all stages of the planning process, developments in high risk areas are to be avoided, developments are only

Fig. 3.41 Thames Barrier (Source: Environment Agency, 2007b)

allowed with a suitable protection and the re-creation or safeguarding of flood plains and wash-lands is undertaken to reduce risk for existing communities. The aims and standards are to be implemented in all spatial developments. They function as inspiration for the design and aim to improve the level of safety as well as spatial quality.

3.4.3 Element in the Gateway: Thames Barrier

One of the most strategic physical defences and the largest one in the Thames Estuary is the Thames Barrier (Fig. 3.41).

Up to the 1970s it was common to built higher and stronger river walls and embankments. After a serious flood in 1953 and the awareness that this flood could have caused enormous damage if it had reached the central parts of London, the opinion on the way flood defences are build changed radically. The defence no longer consists of higher and higher dikes, which block the Thames from view, but the design of the flood defence included rising gates. The advantages of this solution were a high level of protection, easily building and minor interference with river traffic. The rising gates provide the defence with the possibility to close in case of high tides in combination with a heavy storm. Together with several other physical barriers (Fig. 3.42), upstream and downstream, the flood protection is arranged and guaranteed up to 2030.

As weather becomes stormier, the South East of the UK tilts downward, the sea level rises and London is settling into its clay bed, the tides in the Thames Estuary rise with 60 cm per century. A storm surge happens if specific weather conditions (low pressure at the Atlantic) cause a hump of water in the relatively shallow

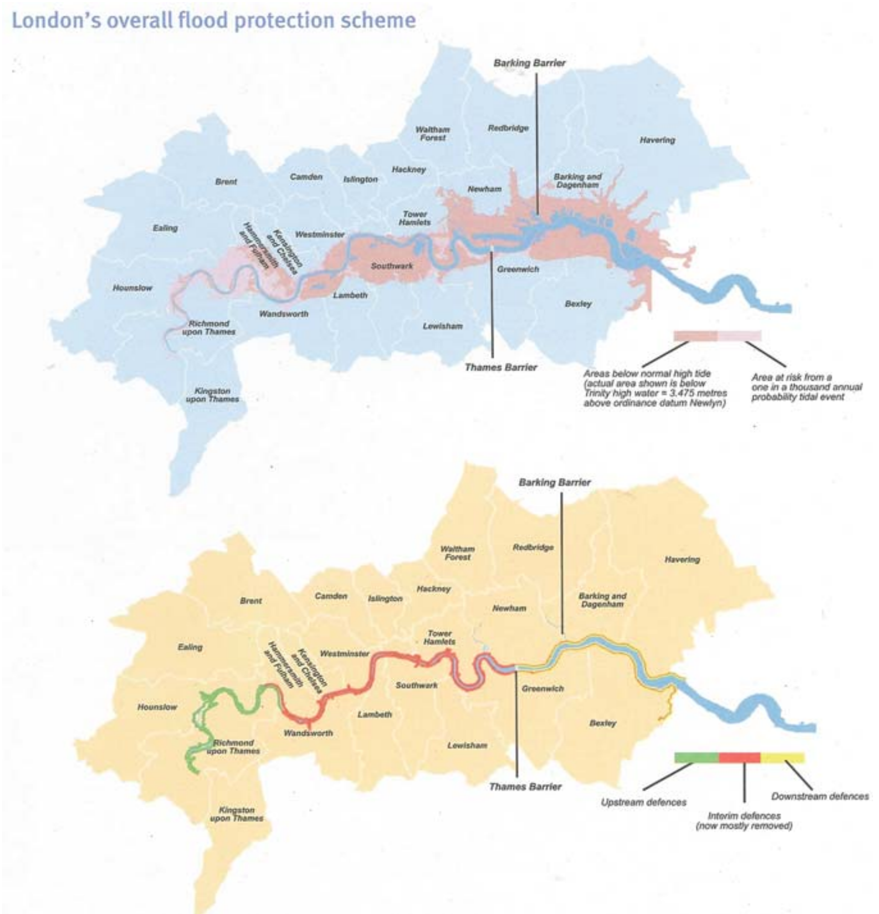


Fig. 3.42 London flood protection scheme (Source: Environment Agency, 2007b)

Southern North Sea. If this happens in combination with spring tide a real chance at floods in the Thames Estuary occurs. In this situation the Thames Barrier needs to close. During the last decades a slow rise in the amount of closures of the barrier can be noted (Fig. 3.43).

The closure of the barrier seals off the upper part of the Thames. If a high tidal surge is expected the rising gates are moved up into a 90° position in order to close the river (Fig. 3.44). Under normal conditions the gates rest out of sight in recessed concrete cills in the riverbed. Ships may pass the barrier easily.

For the future an increase of the overall risk is predicted due to a faster rising sea level, more rain and flow of rainwater through the Thames in winter and stormier weather. Currently is research being conducted within the Thames Estuary 2100 project on how and where the flood defence requires any adjustments. It seems evident that raising physical defences only will not be sufficient to meet the changes.

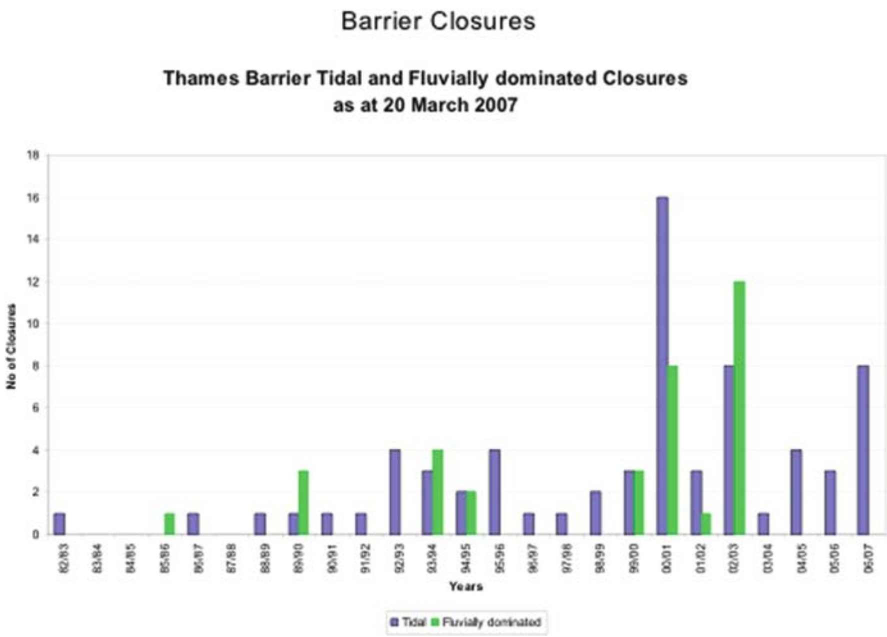


Fig. 3.43 Increasing closures of the Thames Barrier (Source: Environment Agency, 2007c)

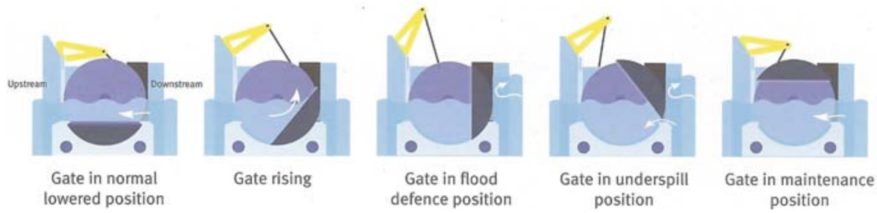


Fig. 3.44 The barrier in action (Source: Environment Agency, 2007b)

Changes in the way urban developments are planned are necessary also. New developments are to be realised in lower risk areas, are more resilient to floods and have appropriate emergency planning.

3.4.4 A Floating City

Circumstances in the Thames Estuary will change rapidly in the coming century and this urges for innovative concepts. After 2030 an entirely physical flood defence is no longer sufficient and new ways need to be found in the planning of urban developments. On the one hand side these developments should not be located in higher risk areas, but if a development is positioned in a risk area the resilience of this development needs to be extremely high. Many new developments and plans

Fig. 3.45 London and the Thames Gateway (Source: www.jafud.com)

are being produced (see also Chapter 7, Isle of Dogs and East Tilbury). The most extreme variant of building with natural processes is a floating city – Arkway (www.jafud.com/aka_welcome.html) –, an idea that is proposed for the Thames Gateway.

The Arkway project proposes to create a floating city. It is inspired by the local circumstances, where land, water and sky meet and are accomplished by the constant movement of the natural forces over time. The constant change in the world is taken as major driving force and used to connect flows and fixing points. The flows are industrial processes of reusing floating structures, are social and economic connections and are flows of natural forces. The fixing points are piers that connect existing settlements with the water-city in the Thames. These long armatures, which are formed out of assembled segments of ships, host, like ocean-liners, different usages and provide the infrastructure and shelter for smaller structures, ranging from fixed business rigs to free floating single homes. The structure as a whole adapts to all kind of changes within the city, from a yearly event to the daily tides. Making use of the water in the Thames Gateway it offers London more space eastward along the river (Fig. 3.45).

Because flooding is expected to become one of the biggest problems of the Gateways future (Fig. 3.46 shows the maximum flooded area of the Thames without protection), the floating city offers an answer by using the changing conditions and the, from time to time, available water. It builds on the edge of land and water, moving in a flexible way along with tidal changes. Thus, it meets the needs of contemporary people to stay flexible and mobile in their life-plans.

In the Thames estuary the circumstances change constantly. The edge zone of land and water creates different conditions simultaneously and natural forces manifest themselves strongly. The settlement tries to make use of the natural forces, like tidal cycles or the transition zone between land and water. These processes of building up and breaking down structures enforces constant change and create new

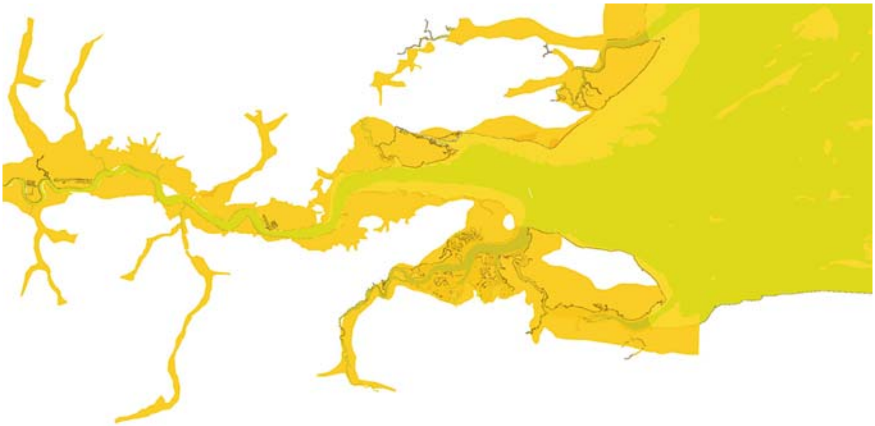


Fig. 3.46 A flooded Thames Gateway (Source: www.jafud.com)

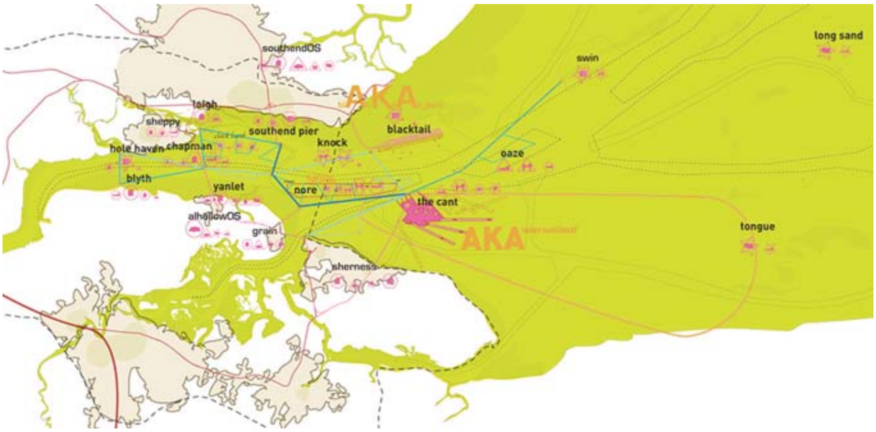


Fig. 3.47 Arkway in between existing settlements (Source: www.jafud.com)

or lost connections. The Arkway is one a core structure in between other existing settlements in the Thames Mouth (Fig. 3.47). Water based transport connects the settlement within and to the surrounding.

While the settlement is floating it has the flexibility to reconfigure and adapt to changing conditions. The structure is in a constant process of organising, according to natural forces and inhabitant's desires. Figure 3.48 shows a still from a movie that illustrates the constant moving and reconfiguring of the floating city.

Because the structures are constructed from recycled floating structures like oil-rigs and ships the settlement introduces a new REUSE-industry to the area. A special feature is the so-called Clockbank restaurant (Fig. 3.49), which is only accessible during low tide. The special adventure is that a visit might take a little longer than expected.

Fig. 3.48 Still of the constant process of organising according to natural forces and desires (Source: www.jafud.com)

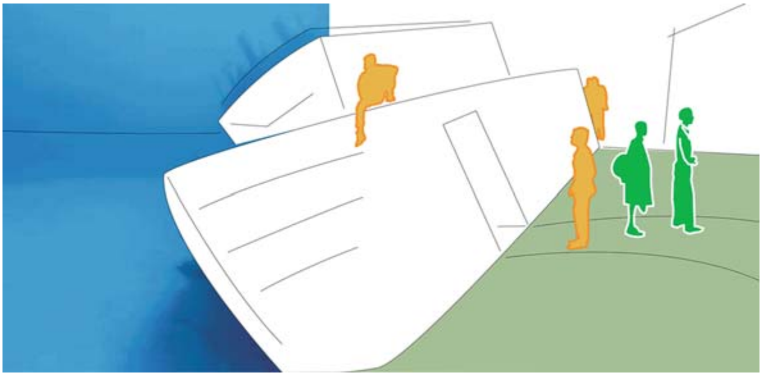


Fig. 3.49 The Clockbank-restaurant, accessible during low tide (Source: www.jafud.com)

The settlement is built up on the principle that every unit provides connection to the next one (Fig. 3.50) just like in Dutch canals and harbours it is normal to connect to the ship that is connected to the shore. Every next ship is connecting to its neighbour and the rule amongst the shipmen is that you are aloud to trespass the other ships in order to reach the shore. This network is used for the flow of people, goods and information. The exposed to strong forces can be answered by larger structures providing shelter for smaller ones.

In the so-called MID area industrial flows pass through. Inside the structure the connection between units provide access to the entire area. Large units form a shelter for inner basins (Fig. 3.51).

The use of space needs to be carefully designed, not wasting any valuable and scarce space. Some spaces may be used during the week for different purposes. A dry-dock can be used for a match of soccer when vacant (Fig. 3.52).

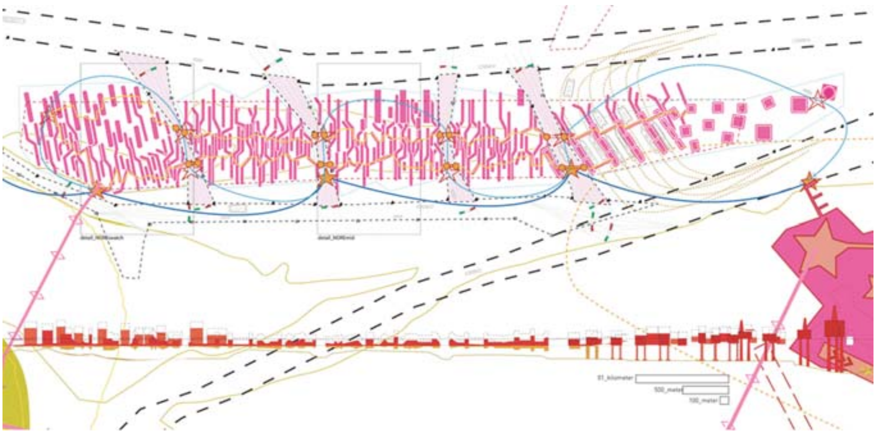


Fig. 3.50 The structure of connected units (Source: www.jafud.com)

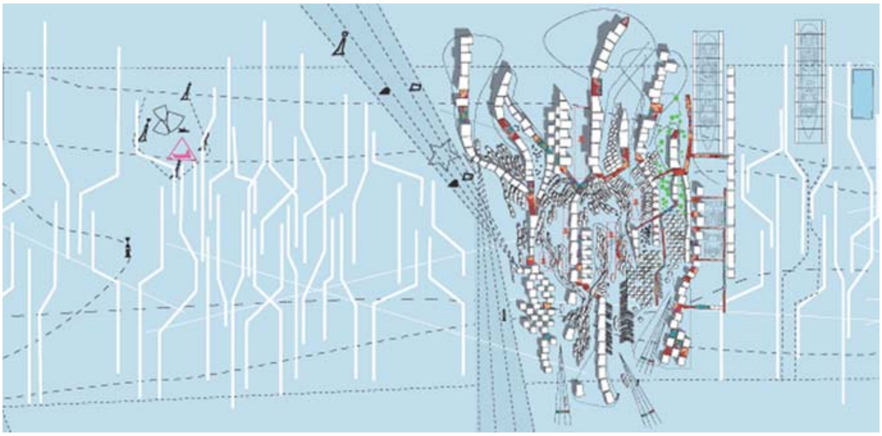


Fig. 3.51 The MID-area (Source: www.jafud.com)

The constant changing environment configures the floating city differently. Different settlements are connected to certain locations (Fig. 3.53), but may change the way they are organised from day to day.

3.4.5 Three of a Kind

The example of the Thames Gateway shows a range of solutions that are possible in a tidal landscape that has to deal with an increasing rise of the sea level. Three ways of adapting to the changes are presented here and they differ a lot.

The Thames Barrier is a technical solution to withstand storm surges and to protect the city of London.

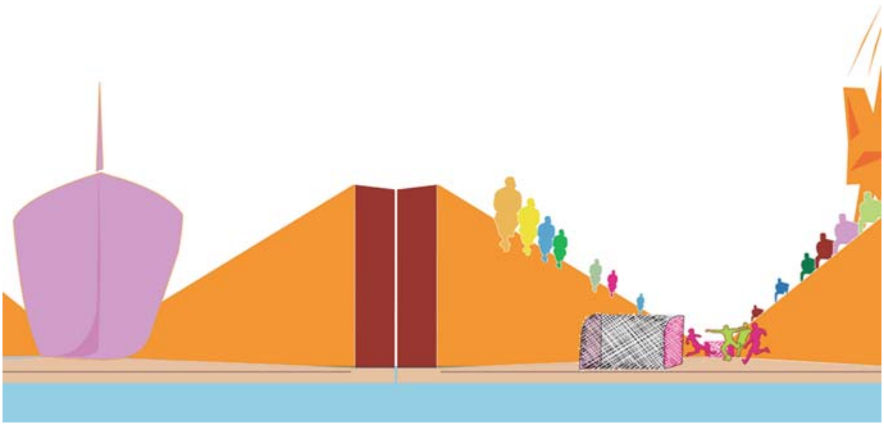


Fig. 3.52 Soccer match in a dry-dock (Source: www.jafud.com)

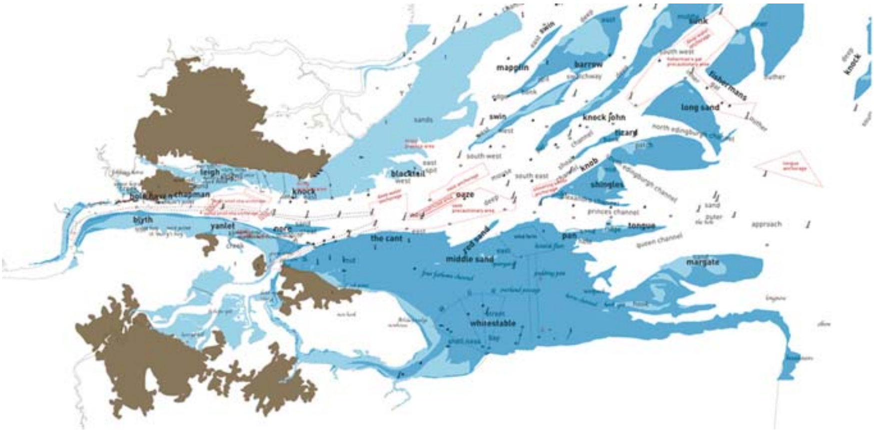


Fig. 3.53 Assemblage of different floating settlements in the Thames Mouth (Source: www.jafud.com)

The delivery plan for the Thames Gateway illustrates that a subtle integration of tidal influences with urban developments may lead to inspiration for the spatial quality of the urban environment. In this respect it can be compared with the Hafencity development in Hamburg.

The Arkway plan needs to be seen as an experimental design, which turns around existing views of protection and dealing with water. The example shows an alternative view, because it uses the dynamics of the tidal system and bases the urban developments upon it. The flows and tidal differences create the patterns in the urban structures and like connected ships the city is moving along with the changes in tides and seasons.

Not one approach tackles flood problems completely. It would be appropriate if a region combines the three approaches. Developing high technological standards in case heavy protection is required, at the same time integrating water in the daily life of the urban population and transform water from a threat into a quality and find space for experiments in which a sub-cultural lifestyle can be explored and maybe delivers solutions for problems that are not known yet.

3.5 New Orleans

In August 2005 hurricane Katrina (Fig. 3.54) hit Louisiana. 80% of New Orleans was flooded and many homes were destroyed. This event marked a fundamental change in thinking about coastal protection.

Fig. 3.54 Hurricane Katrina from the air (Source: LACPR, 2007)

3.5.1 Coast 2050

Long before Katrina, people in Louisiana were aware of the environmental problems of the Louisiana coast (Fig. 3.55). In 1992, Andrew led to a lot of damage as well. The problems and strategic solutions were recognised and a vision was developed on a sustainable future for the Louisiana Coast: Coast 2050 (Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority, 1998).

The main problems are caused by hydrological changes and, contradictory, levees. Levees protect homes, businesses and farms from flooding, but they prevent sediments, that nourish the valuable marshlands, from reaching them. And

Fig. 3.55 Aerial view of the Mississippi delta (Source: Dijkman, 2007)

Fig. 3.56 Louisiana's coastal land loss between 1956 and 1990 (*in red*) (Source: Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority, 1998)

without these sediments, together with water and nutrients subsidence overtakes marsh growth: a net land loss (Fig. 3.56).

The hydrological changes add up to these problems. The North-South oriented canals cause an increase of saltier water and stronger tides in the marshlands. The East-West canals hold excess water on marshes and swamps. These conditions kill wetland vegetation and during hurricanes water rips up the marshland and erodes islands and shores. It is expected that 1000 mile^2 of marsh and swamp will be lost in 2050 and changed into open water. And this threats the existing pipelines, wells, ports and roads, necessary for oil and gas extractions, if they are exposed to open water conditions. And this will be a costly threat.

The objectives to manage these problems are described in the Coast 2050 vision as follows:

1. Sustain a coastal ecosystem with the essential functions and values of the natural ecosystem;
2. Restore the ecosystem to the highest practicable acreage of productive and diverse wetlands;
3. Accomplish this restoration through an integrated program that has multiple use benefits; benefits not only for wetlands, but for all communities and resources of the coast.

The strategic solutions were made visible on a map (Fig. 3.57). The solutions manage and use the available natural forces, like the river, the climate and the rise and fall of the Gulf of Mexico. Solutions need to contribute to the creation of a sustainable marshland and a variety of habitats. The accumulation of sediments, the varying of salinities, the protection of key landforms and the exchange of energy and organisms contribute to these solutions. In the first place watershed management is proposed. River diversions, in order to restore a more natural hydrology, and improved drainage are the main measures. Secondly, watershed repair needs to be undertaken. The most important measures here are the restoration of barrier

Fig. 3.57 The Coast 2050 strategic solution for a sustainable ecosystem (Source: Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority, 1998)

islands, the closure of the Mississippi River Gulf Outlet navigation channel (as soon as possible), the building of two new Deltas by realisation of a 60 mile conveyance channel and the introduction of seasonal locks at the mouth of navigation channels in order to help marsh to recover from salinity stress.

All these measures cost a lot of money, but not implementing them costs even more on the long run.

The Coast 2050 report focuses mainly on restoration of the natural ecosystem of coastal Louisiana. It is expected that a natural functioning coastal system is better equipped to minimise the effects of storms, hurricanes and floods and improves the ecological and landscape quality in the area. The report does not focus extensively on flood protection and safety as such. Once a disaster happens, as it did with Katrina, all subtle and valuable objectives become out of sight, because all attention is going to immediate rescue and in a later stage to protection and safety. New plans are developed to meet these changed desires.

3.5.2 US Army Corps of Engineers (USACE)

The US Army Corps of Engineers is responsible for the coastal protection. The Corps is preparing an evaluation of the performance of the hurricane protection system (IPET, 2008) of the coastal zone of Louisiana, analysing the functioning of the system during Katrina. The main conclusions of the evaluation are:

- In the US there is no coherent and comprehensive water resources strategy. The level of protection is marginal and the investments focus on local situations, the short-term, are cost-benefit based and aim to tame natural processes instead of move along with natural processes (build with nature). A new national emphasis on holistic water policy, with public safety as a mandatory component, is strongly required;
- The hurricane protection system was overwhelmed by a rare and major event, but it was also below current standards in performance. The system before Katrina operated based on decision making driven by competing priorities, incremental decision making and funding inadequate consideration of change and de facto far too low standards;
- A national cultural malady exist, in which no clear standard for planning, design and development of public infrastructure for water resources is apparent and where new knowledge is incorporated too slow and solutions are optimised based on short-term gains instead of long-term requirements. Life cycle solutions are important to the future and the 100-year standard (once in 100 year a heavy storm may break a dike through) is far too risky for a continued vitality of the economy;
- Man made measures alone cannot sufficiently reduce risk for vulnerable areas. Natural processes, like marshes, mangroves or barrier islands, need to be integral to a systems strategy for risk reduction;
- A lack of resilience of the protection system caused major losses and ultimate flooding;

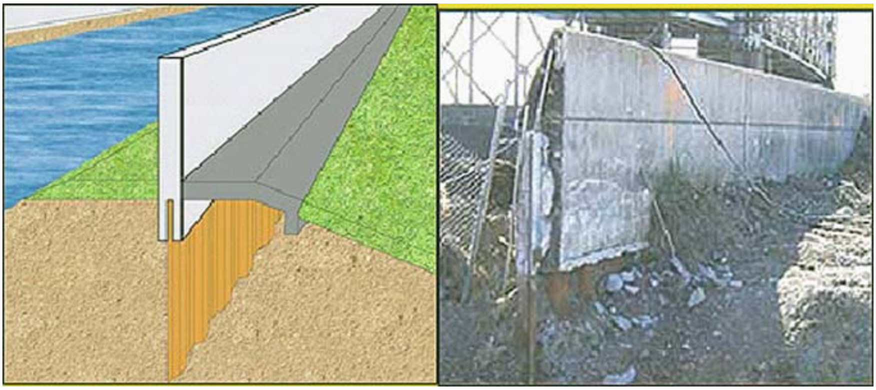


Fig. 3.58 Pre-Katrina floodwalls (Source: Russo et al. 2008)

- As the risks increase along the coastline, both due to the increase of severe hazards as due to an increasing number of people and property being allowed to reside at risky places, the changing hazard cannot be treated, but reduce the exposure of people and property to the hazard lies within reach. The dichotomy between land use authorities and the dependence on continuous development prevents the right actions taken;
- Further research is necessary to understand the way to work with nature rather than control it. The art of building and sustaining natural environment is especially important;
- Current policy and practice does not deal with change. A more anticipatory and adaptive approach is desirable.

These conclusions exceed current practice. The task of USACE to maintain and realise a coastal protection includes a standard of 1:100. This standard, in the evaluation described as far too low, can be partly explained by more intense natural forces, but does not meet the standards in, for instance, the Netherlands (1:10,000) (Trouw, 2008). And despite the fact that most of the 560 km are meeting these standards again, an integrated approach as proposed by the evaluation is yet far way. Current practice is to protect people and property by floodwalls, simple concrete walls, and not with broad green dikes, which deliver more protection. The main causes of breakthroughs during Katrina were caused by malfunctioning floodwalls (Fig. 3.58). After Katrina they were strengthened (Fig. 3.59)

Another measure is used to safeguard railroad underpasses. A U-levee is realised, which is capable of preventing water flooding from one side or the other (Fig. 3.60).

Immediately after Katrina these measures were implemented at a city level (Fig. 3.61) and in neighbourhoods (Fig. 3.62)

These measures reinforce the pre Katrina standards, but the USACE is aware of the fact that these measures alone does not reduce the risk for the people if another

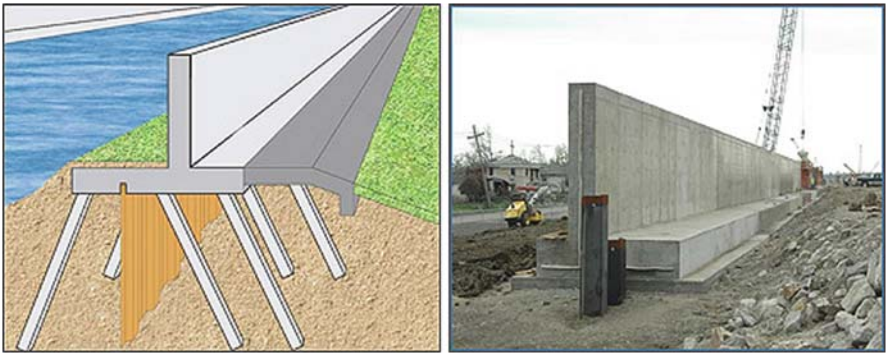


Fig. 3.59 Post-Katrina floodwalls (Source: Russo et al., 2008)

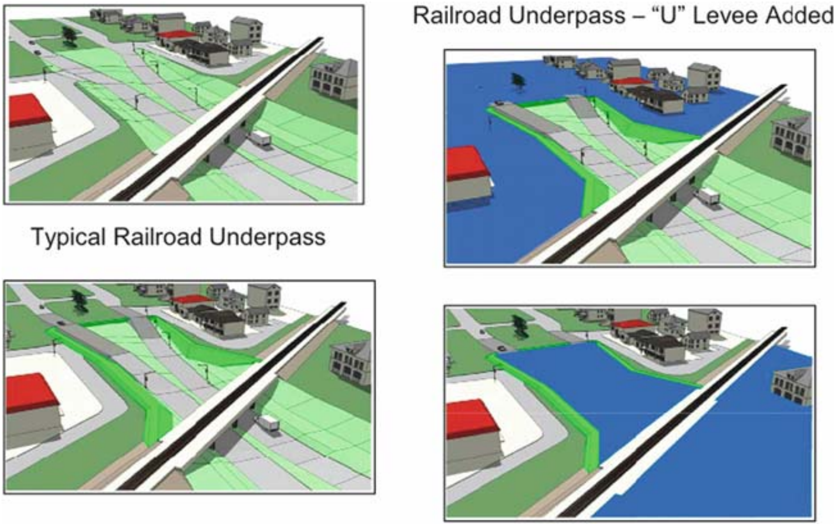


Fig. 3.60 U-levee, implemented under a railroad underpass (Source: LACPR, 2007)

Katrina happens today. Therefore the water management needs to be viewed at a higher level of scale. The so-called hurricane highway, which allows water from the Gulf of Mexico to strengthen and flood into the city of New Orleans, asks for a fundamental solution. A Dutch partnership advises USACE which combination of measures can be taken to increase the level of protection, both for the Louisiana coast as for New Orleans (Dircke, 2008). The first measure to be taken is to strengthen and heighten the dikes. The second type of measures is more fundamental. For two important navigation channels storm surge closures are proposed: the Inner Harbour Navigation Channel and the Gulf Intra-coastal Water Way (Fig. 3.63). Several closure types are compared on protection level, size of protected area, costs, effects on the environment and desired type of navigation.

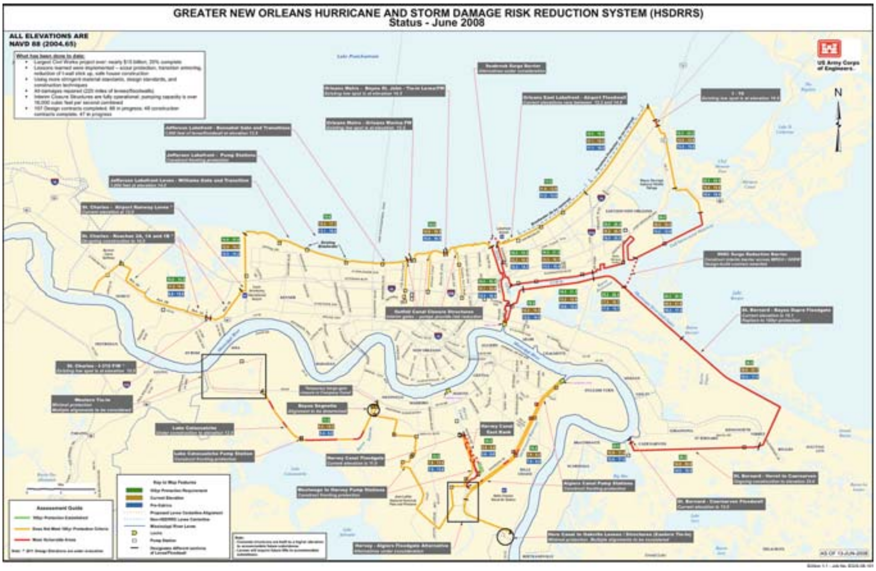


Fig. 3.61 New Orleans hurricane risk reduction system (Source: LACPR, 2007)

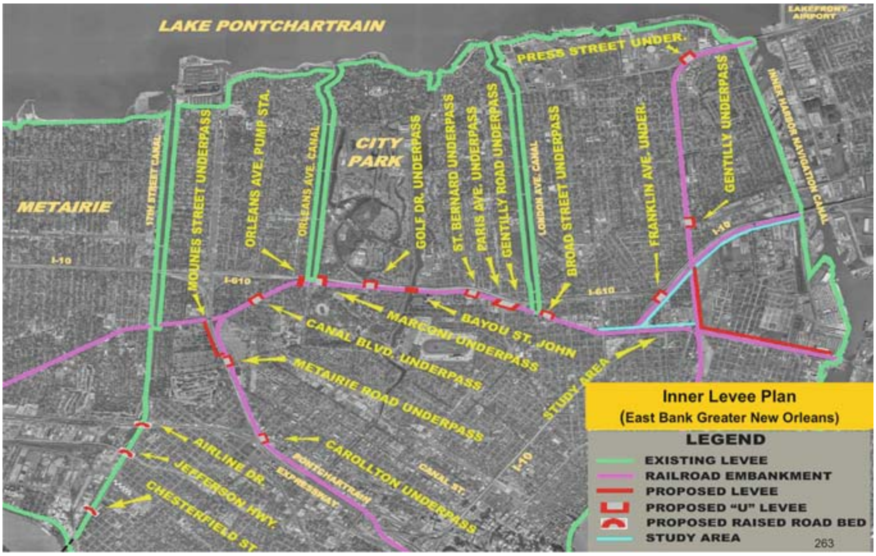


Fig. 3.62 Inner levee plan for New Orleans (Source LACPR, 2007)

The types of proposed solutions not only stabilise the delta and the coastal zone, they protect the city of New Orleans as well (Dijkman, 2007). The preferred strategy (Fig. 3.64) to protect the area consists of the following measures:

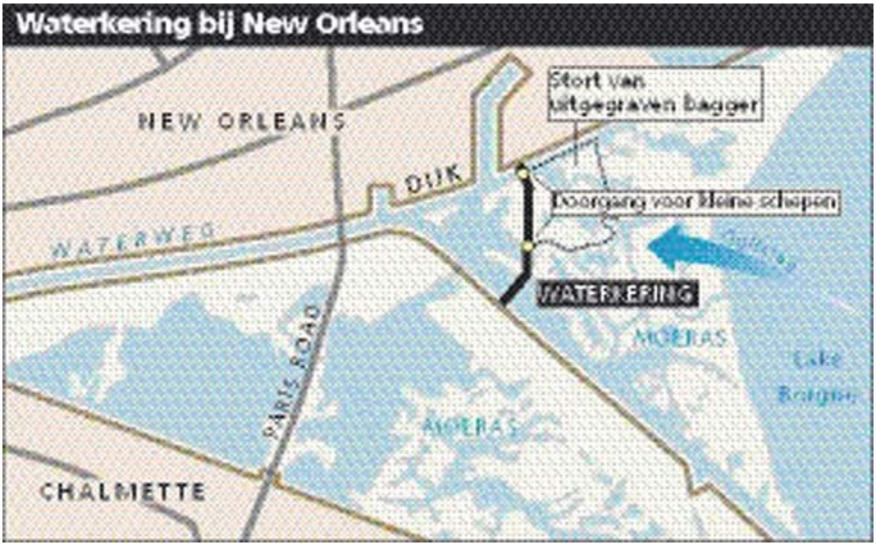


Fig. 3.63 Storm Surge Closure in the Gulf Intracoastal Water Way (Source: Trouw, 2008)

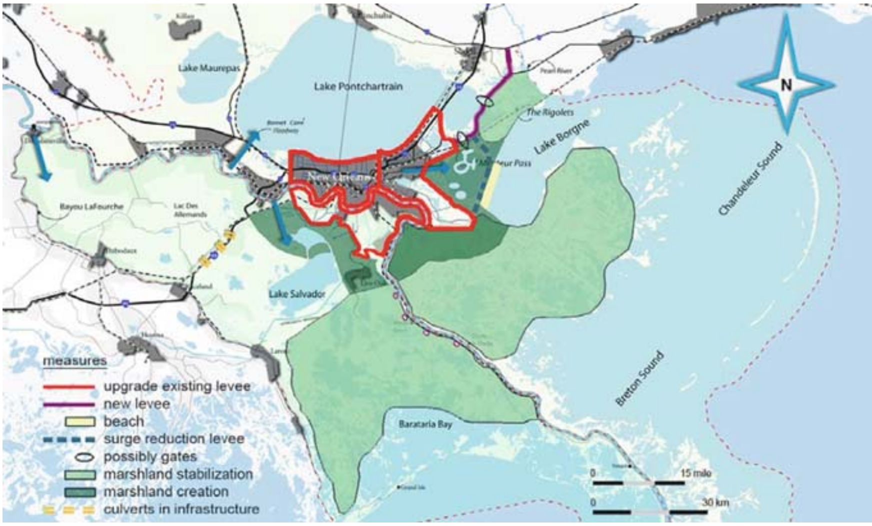


Fig. 3.64 Preferred strategy (Source: Dijkman, 2007)

1. Improve the organisation of flood risk management;
2. Upgrade the levee system in New Orleans to a 1:1000 level and enclosing it with a belt of fresh water cypress tree swamps;
3. Create in the Pontchartrain Basin a semi-open system, with a levee and several gates or keep it open and heighten the levees along the Lake Pontchartrain.

Stabilise the existing wetlands and create new wetlands to reduce surges and waves and to close the belt of fresh water swamps
4. Create an open system in the Barataria basin with wetland stabilisation measures.

Due to the combination of civil engineered waterworks and ecomorphological measures natural processes are given the change to contribute to the resilience of the area and the safety level is improved.

3.5.3 State of Louisiana Master Plan

The State of Louisiana carried out a Master Plan (CPRA, 2008) for the entire coast of Louisiana (Fig. 3.65).

In order to find the most severe weaknesses an analysis was conducted on the hurricane surge elevations in the area (Fig. 3.66).

In the Master Plan this information was used to raise awareness that protection levels should be heightened and a protection strategy was needed.

The following the main objectives were defined:

1. A conceptual vision of a sustainable coast needs to be created;
2. Long-term and comprehensive coastal protection and restoration must be achieved;
3. Discrete areas of action need to be integrated: flood protection and wetland restoration

Fig. 3.65 Project area (Source: CPRA, 2008)

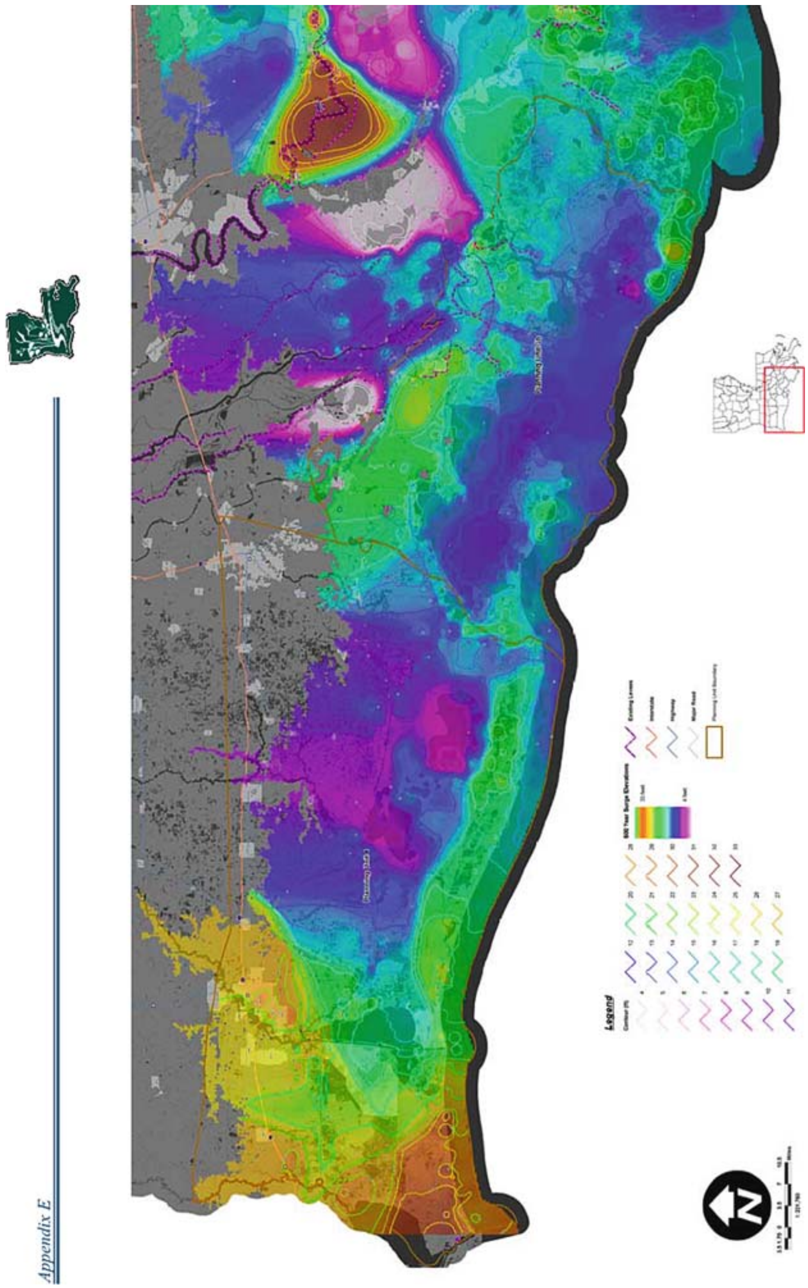


Fig. 3.66 Maximum hurricane surge elevations for 0.2% probability hurricane (Source: CPRA, 2008)

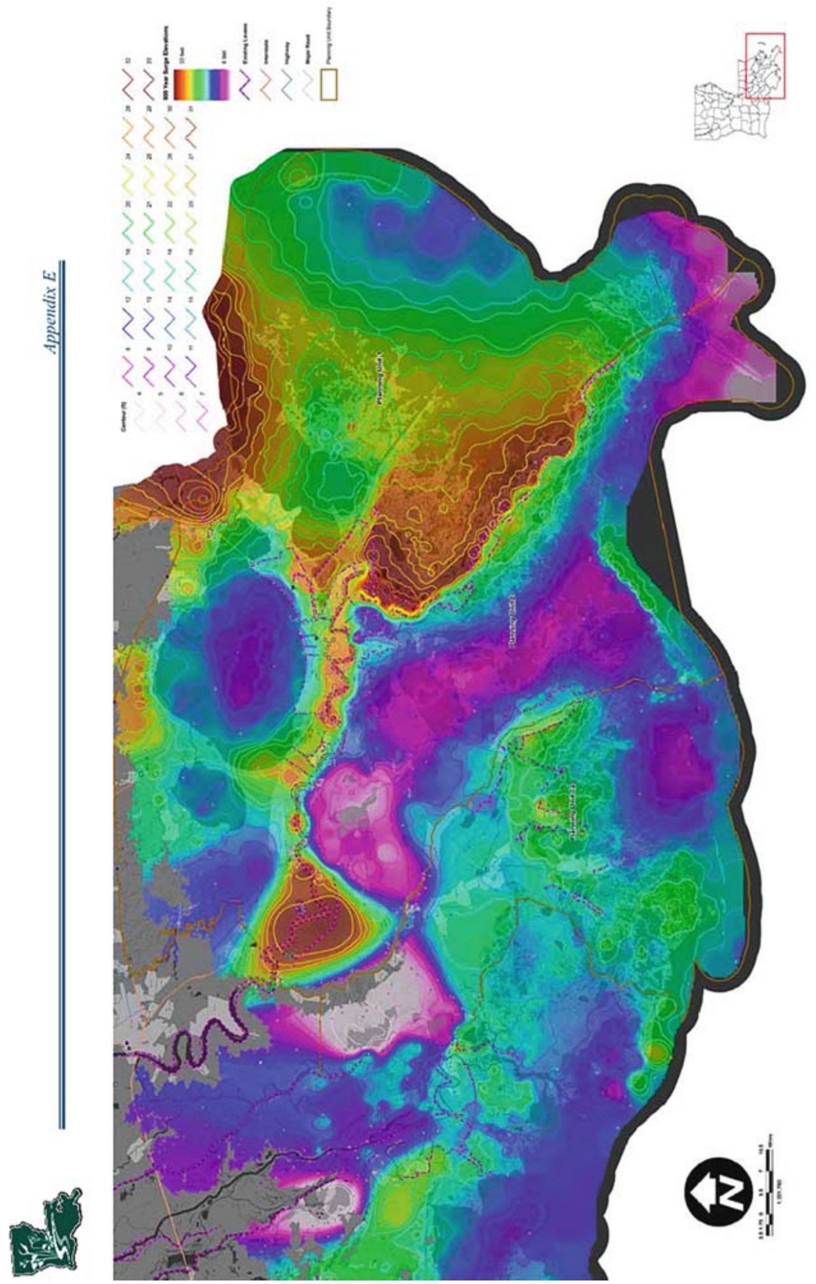


Fig. 3.66 (continued)

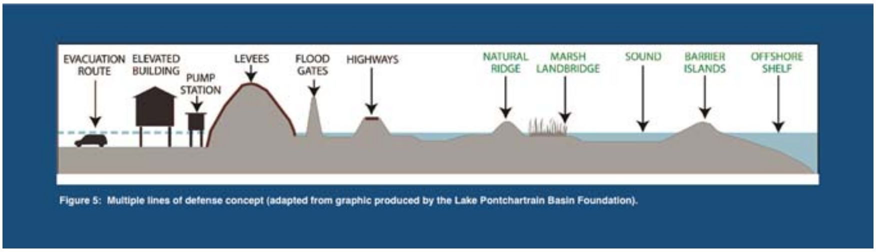


Fig. 3.67 Multiple lines of defence (Source: CPRA, 2008)

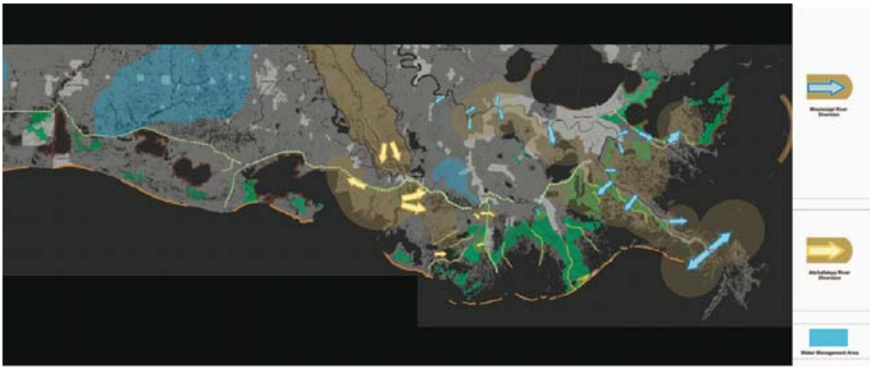


Fig. 3.68 Restoring and maintaining critical landscape features (Source: CPRA, 2008)

The Master Plan consists of maps and explanations as well as a management strategy for implementation.

The need for realising the Master Plan is acute. Every year the coast of Louisiana is losing land and this causes a risk for pipelines, navigation channels, fisheries, century old settlements and priceless ecosystems. These problems are strongly intensified by hurricanes Katrina and Rita.

The Mater Plan is a living document, which can be adjusted if circumstances change. It lays emphasis on three elements:

1. A sustainable landscape is a prerequisitive for both storm protection and ecological restoration;
2. Change is inevitable;
3. Hurricane protection relies on a strategic planning concept: a contains multiple lines of defence (Fig. 3.67)

The integral Masterplan thus aims to reduce risk to economic assets, to restore sustainability to the coastal ecosystem, to maintain a diverse array of habitats for fish and wildlife and to sustain the unique heritage and culture of the region.

The measures in the Masterplan belong to three categories: Mississippi Delta, Atchafalaya Delta and Chenier Plain and Hurricane protection.

The restoration of sustainability to the Mississippi River Delta aims to reconnect the Mississippi River to the wetlands through controlled diversions in order to restore flows of water through the wetlands so that the ecosystem can retain sediment and nutrients. This can be done through the following measures (Fig. 3.68):

- Land building restorations will create new delta lobes and nourish existing wetlands;
- Land sustaining diversions reduce losses and restores the sustainability of existing wetlands;
- Marsh restoration with dredged material;
- Use existing navigation channels, which can distribute channel water to remote areas of the coast;
- Barrier shoreline restoration to serve as a first line of defence and form the habitat for endangered animal species and birds;
- Ridge habitat restoration are deflecting storm surge and support woody vegetation and provide habitat for a variety of wildlife species;
- Shoreline stabilisation to preserve the boundaries of water-bodies and protect the hinterland;
- Closure of the Mississippi River Gulf outlet to deep draft navigation and for the construction of a closure dam. It will restore the integrity of the Bayou LaLoutre ridge and use the remainder of the channel to convey fresh water.

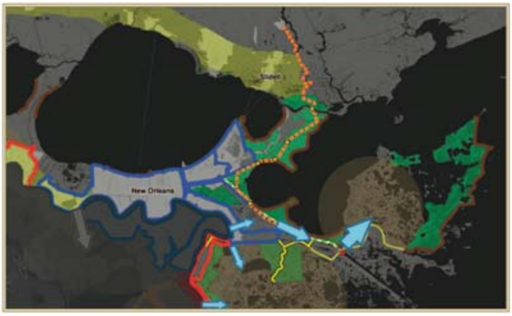
The Restoring of sustainability of the Atchafalaya river delta and Chenier plain aims to enhance the land building capacity of the Atchafalaya River Delta and prevent saltwater to penetrate inland in the Chanier Plain by taking the following measures:

- Managing water and sediment to reduce the impact of saltwater intrusion;
- Marsh restoration using dredged material in order to create new land;
- Barrier shoreline restoration to maintain the integrity of the shoreline and protect interior marshes, while allowing tidal exchange;
- Lake shoreline stabilisation to prevent catastrophic effects after breeching and prevent wave induced erosion of marsh, cheniers and coastal prairie.

Hurricane protection needs to protect people and property proportional to the apparent assets.

- The entire system must be considered to deliver water, sediments and nutrients to wetlands, improvement of the hydrology, to reduce flooding in low lying communities and prevent flood water from being trapped in the system;
- Non structural measures like keeping wet areas wet, evacuation plans and maintenance of evacuation routes as well as adjustments of buildings must be carried out;

- Focused structural solutions must be implemented by building hurricane protection systems in Lake Pontchartrain (Fig. 3.69), Barataria Basin (Fig. 3.70), Plaquemines Parish (Fig. 3.71), Terrebonne Parish, LA Highway Corridor, Acadiana and Chenier Plain.



Alignments #1 and #2 are fairly similar, although #1 would not enclose the Golden Triangle and would thus have the least direct ecosystem impact. However, without proper design Alignment #1 could change water flow and restrict animal and boat access through major channels. Of the three conceptual alignments, this one does the least to address the existing funnel effect and provides no water storage landward of the levee.

Figure 13. Lake Pontchartrain Barrier Alignment: #1-Interior at Golden Triangle.

Unlike Alignment #1, this alignment would enclose the Golden Triangle, and would thus have a greater ecosystem impact. In addition, without proper design, Alignment #2 could change water flow and restrict animal and boat access through major channels. Impacts to the habitat of the Gulf Sturgeon, a threatened species, would also need to be addressed. Alignment #2 would reduce the funnel effect; further modeling will reveal the extent of this reduction.

Figure 14. Lake Pontchartrain Barrier Alignment: #2-Rim of Lake Borgne.

This alignment may provide the most reliable protection against storm surge because it eliminates the funnel effect and provides water storage to accommodate overtopping. However, it could be the most challenging of the three alignments to build because it would be situated in the open water of Lake Borgne. This alignment would also pose the greatest challenges for maintaining ecosystem function, including maintaining adequate water exchange and animal movement. Issues related to the Gulf Sturgeon, a threatened species, would also need to be addressed. Innovative storm barrier concepts, such as pile-supported concrete structures, could be used to increase the feasibility of this alignment.

Figure 15. Lake Pontchartrain Barrier Alignment: #3-Lake Borgne.

Fig. 3.69 Hurricane protection: Lake Pontchartrain Barrier Allignment options: Interior at Golden Triangle, Rim of Lake Borgne, Lake Borgne (Source: CPRA, 2008)

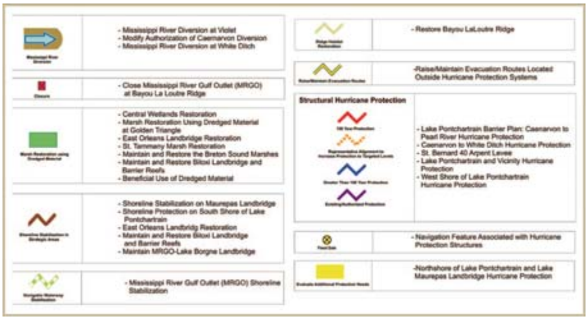


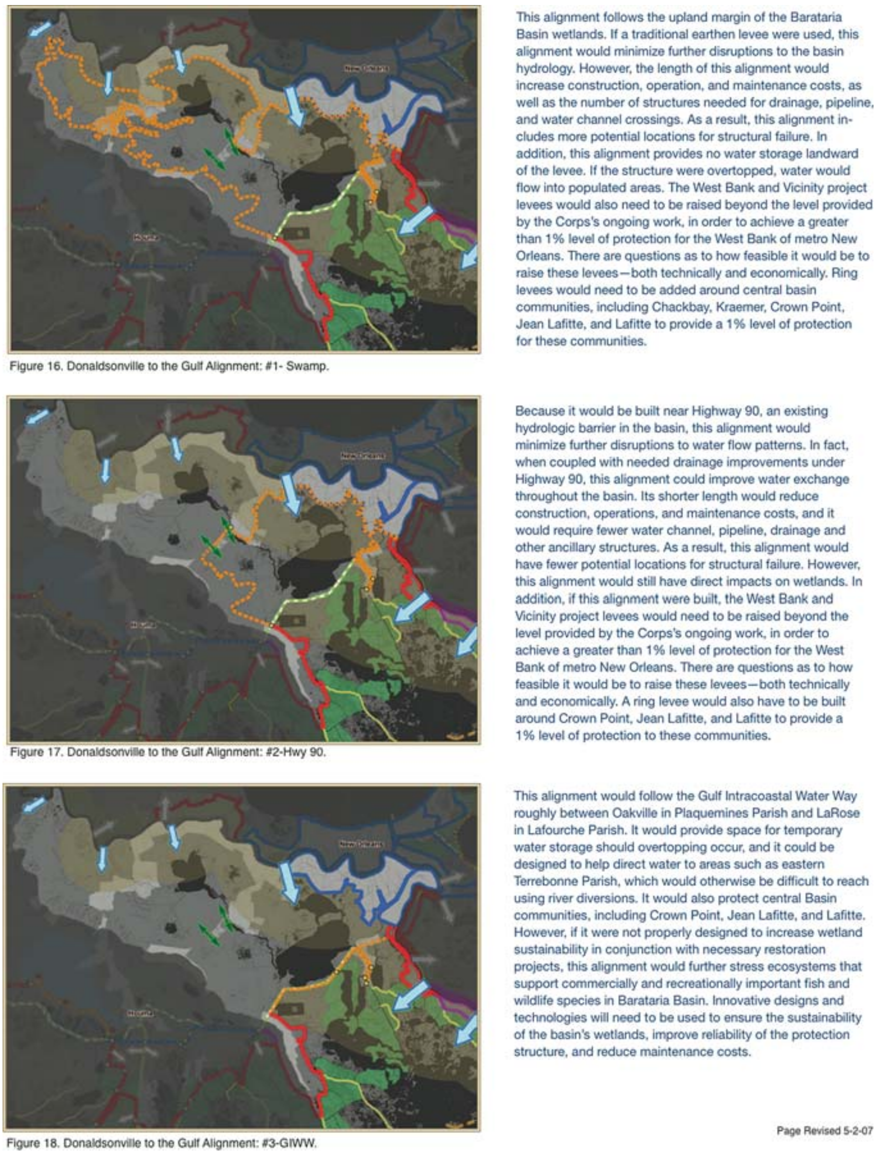
Fig. 3.69 (continued)

3.5.4 The MIR Project

While federal and state governments work on policy plans and implementations concrete action after Katrina was undertaken also. Brad Pitt initiated the MIR-project (Make it Right-project, www.makeitrightnola.com) as a reaction to the slow action taken by the American government and the initial emergency. Pitt helped residents of the Lowr 9th Ward to rebuild. He started an architecture competition to gain ideas how to rebuild the area sustainably. Make it Right aims to be a catalyst for redevelopment of the Lower 9th Ward by building a neighbourhood comprised of safe and healthy homes that are inspired by Cradle to Cradle thinking, with an emphasis on quality of design, while preserving the spirit of the communities culture. The goal is to accomplish this quickly on order to give residents the chance to return to their homes as soon as possible. Immediate action was taken by set up temporary buildings in sharp pink colours to attract global attention and to make clear that the residents are not forgotten (Fig. 3.72).

Pitt asked four local, four American and five international architects with a reputation in sustainable building to design affordable, sustainable and reproducable houses for Lower 9th Ward, which need to be resistant to new dike breeches. All architects designed houses that are in one way or another lifted from ground level (Figs. 3.73 and 3.74).

The initiative of Brad Pitt illustrates that high quality designs of the homes are raising attention for the situation and increase public awareness. Concrete and visible support to problems of individuals is able to create the start of redevelopment. Meanwhile, state and federal authorities find themselves back in time-consuming processes of defining regulations and policies on the most appropriate approach to deal with coastal protection and restoration. Extensive analyses of the lack in current protection systems and talks on responsibilities are in the way of taking appropriate actions. And despite the fact that an integrated approach is proposed by both the State of Louisiana and USACE it seems that political decision-making systems and procedures are in the way of change. At the same time Ike and Gustav gain strength and attack the southern coast of Louisiana. Hopefully, next hurricane season can



This alignment follows the upland margin of the Barataria Basin wetlands. If a traditional earthen levee were used, this alignment would minimize further disruptions to the basin hydrology. However, the length of this alignment would increase construction, operation, and maintenance costs, as well as the number of structures needed for drainage, pipeline, and water channel crossings. As a result, this alignment includes more potential locations for structural failure. In addition, this alignment provides no water storage landward of the levee. If the structure were overtopped, water would flow into populated areas. The West Bank and Vicinity project levees would also need to be raised beyond the level provided by the Corps's ongoing work, in order to achieve a greater than 1% level of protection for the West Bank of metro New Orleans. There are questions as to how feasible it would be to raise these levees—both technically and economically. Ring levees would need to be added around central basin communities, including Chackbay, Kraemer, Crown Point, Jean Lafitte, and Lafitte to provide a 1% level of protection for these communities.

Figure 16. Donaldsonville to the Gulf Alignment: #1- Swamp.

Because it would be built near Highway 90, an existing hydrologic barrier in the basin, this alignment would minimize further disruptions to water flow patterns. In fact, when coupled with needed drainage improvements under Highway 90, this alignment could improve water exchange throughout the basin. Its shorter length would reduce construction, operations, and maintenance costs, and it would require fewer water channel, pipeline, drainage and other ancillary structures. As a result, this alignment would have fewer potential locations for structural failure. However, this alignment would still have direct impacts on wetlands. In addition, if this alignment were built, the West Bank and Vicinity project levees would need to be raised beyond the level provided by the Corps's ongoing work, in order to achieve a greater than 1% level of protection for the West Bank of metro New Orleans. There are questions as to how feasible it would be to raise these levees—both technically and economically. A ring levee would also have to be built around Crown Point, Jean Lafitte, and Lafitte to provide a 1% level of protection to these communities.

Figure 17. Donaldsonville to the Gulf Alignment: #2-Hwy 90.

This alignment would follow the Gulf Intracoastal Water Way roughly between Oakville in Plaquemines Parish and LaRose in Lafourche Parish. It would provide space for temporary water storage should overtopping occur, and it could be designed to help direct water to areas such as eastern Terrebonne Parish, which would otherwise be difficult to reach using river diversions. It would also protect central Basin communities, including Crown Point, Jean Lafitte, and Lafitte. However, if it were not properly designed to increase wetland sustainability in conjunction with necessary restoration projects, this alignment would further stress ecosystems that support commercially and recreationally important fish and wildlife species in Barataria Basin. Innovative designs and technologies will need to be used to ensure the sustainability of the basin's wetlands, improve reliability of the protection structure, and reduce maintenance costs.

Figure 18. Donaldsonville to the Gulf Alignment: #3-GIWW.

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Fig. 3.70 Hurricane protection: Donaldsonville to the Gulf Alignment options: Swamp, HWY90, GIWW (Source: CPRA, 2008)

be approached with more realised coastal protection measures at a higher safety level. The only thing necessary is just to start realising the proposed measures in the Master Plans on the Coast.

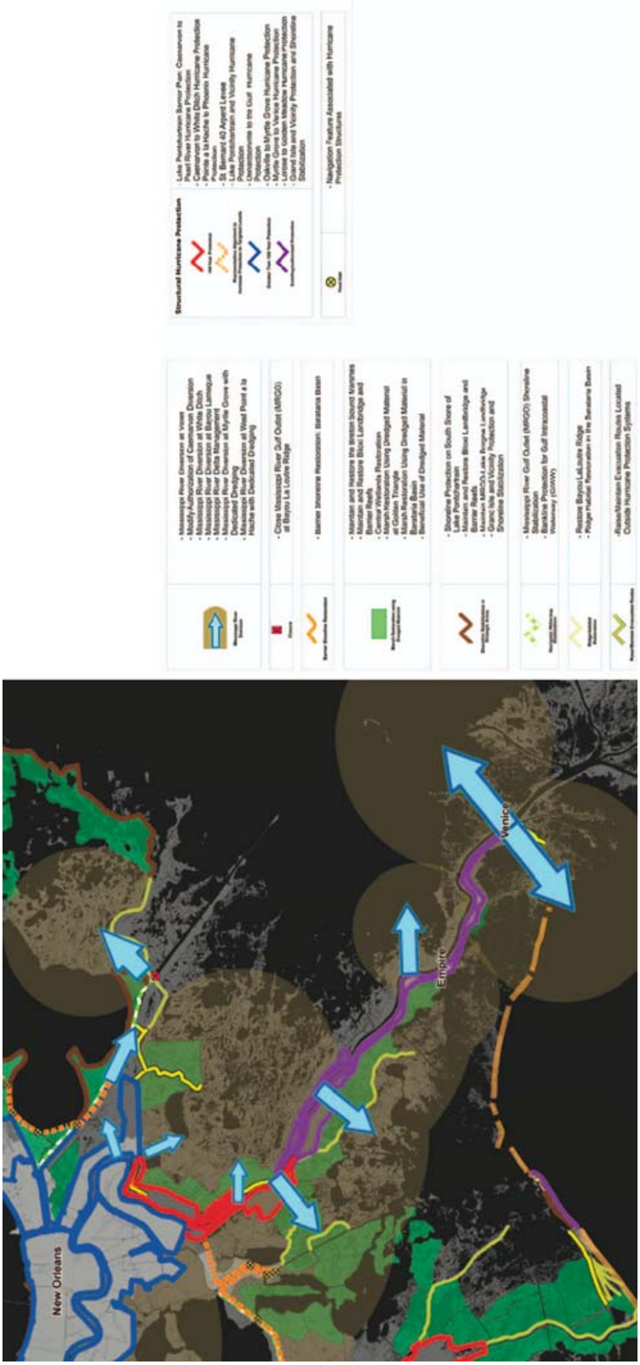

Fig. 3.71 Hurricane protection in Plaquemines Parish (Source: CPRA, 2008)

Fig. 3.72 The Pink project at night (Source: www.makeitrightnola.com, photos courtesy of Mavis Yorks)

Fig. 3.73 Design by MVRDV (Source: www.makeitrightnola.com)

3.6 Conclusion

The coast is a vulnerable part of land in times of rapid climate change and rapid sea level rise. It not only is under threat of serious attacks from hurricanes, storms and high tides and may well lose parts of its size, a more serious threat must be considered, namely the increasing possibility of a breakthrough. This places many people and property at risk. The way to deal with these increasing problems can be approached in different ways. The rise of sea level can be accepted and be integrated in the urban design. The Hamburg example illustrates that it even becomes possible to live outside the primary dike-protection. Another option is to combine different risk levels in the same area. In the Thames Gateway strong dikes and barriers are built, but at the same time flood risk is integrated in urban designs along the Thames. And the third level is the most innovative one: let the city float and make use of different tides in the lay out of the (flexible) city. The example of New Orleans shows

Fig. 3.74 Design by Trahan (Source: www.makeitrightnola.com)

that political-cultural habitat (responsibility thinking and historic existing low safety levels) and the size of the disaster almost paralyses realisation of plans. Innovative and immediate ideas, like the Make it Right movement is able and needs to solve a part of the problem. It seems that not necessarily more money is needed to provide quick solutions, but a breakthrough in the procedural dikes of existing decision making may make a difference. Finally, the innovations in the Netherlands invented at the national level could enhance natural processes to strengthen the coastal defence. A sand motor, which provides the coast, dunes and wetlands with enough sediment to grow along with the sea level or the introduction of broad integrated and multi-functional dikes are such innovations.

What becomes clear after all: if the sea level rises rapidly (up to 1 m at the end of the century) the regular technologies become more and more inadequate and innovative and integrative solutions, which make use of the power of natural processes need to be proposed.

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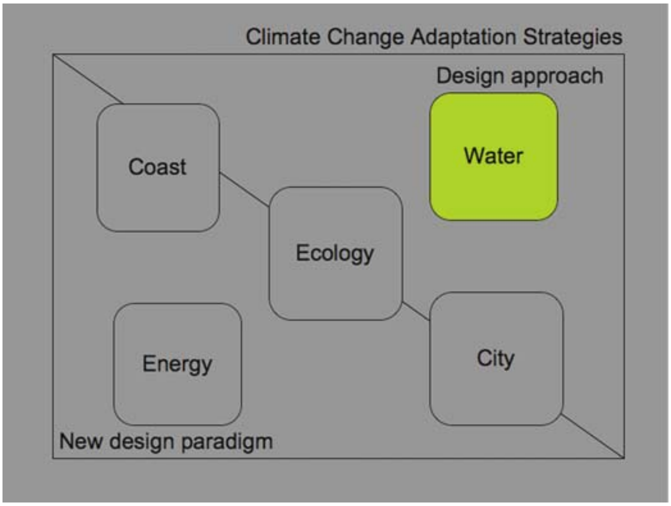
Chapter 4
Water Management



Abstract River discharges will perform increasingly variable in the future. The question in the summer will be if there is enough water in the river to stay suitable for passing ships while in the winter period the question is if the riverbed is broad enough to discharge all the water without flooding neighbouring areas. Especially the discharge in wintertime causes major problems and floods. The way this problem is tackled ca be divided in two approaches: there are ways to prevent floods and there are ways to deal with the effects of a flood.

Beside the protection by making regulations on what is aloud and what is not aloud in or near the riverbed, another way to prevent the river from flooding is to create stronger defences, like dikes. The other approach is to move with the dynamic of the river. The river dynamics are offered more space in order to mitigate the most extreme dynamic. Around the river basins and ecological zones can be created to prevent large amounts of rainwater to enter the river immediately. Finally all kinds

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of adjustments can be made at buildings. The houses can be closed in times of flooding or floating houses can be developed. The needed adjustments are different depending on the location of the house: standing in a deep polder close to the river is more dangerous and requires heavier measures than a location in shallow places further from the river.

The risk at a flood can be determined from the chance point of view or from a possible damage point of view. Both ways can be used to decrease the risk. Protection is as important as the mitigation of the effects of a flood.

If the flexibility in and around rivers is increased there is a better chance that floods can be prevented and the impacts of huge river discharges can be minimised. If the river is tamed with strong and fierce structures eventually an unexpected or uncalculated rise in water levels leads to a surprising flood.

4.1 Water Policies in The Netherlands

4.1.1 Risk

The Netherlands lives at the edge of land and water. This means that certain risks at floods and annoyance is always apparent in the country. Due to climate change this risk is increased, for instance by a rising sea level or by an increasing amount and intensity of precipitation. The risk increases also if the value of an area under threat is higher, for instance if more people inhabit the area or the potential economical damage is high. In general the formula risk = chance × effect indicates the level of risk for an area. The risk for a certain area equals the chance at a flood (protection level) times the effect of the flood (damage and casualties). This is the reason why dike-rings in the Netherlands have different protection levels (Fig. 4.1). If a flood has lower effect, the protection level can be lower as well, while the risk level stays at the same level, compared with an area where the effect is higher but the protection level also. By the way, the counted value within a dike-ring is not always in harmony with the real level (as compared in Figs. 4.1 and 4.2). The comparison shows that the Northern part of the Netherlands a relatively high economical value, while the protection level is beneath the level of the Randstad Holland. It seems that the protection level of the North is underestimated or the level in the Randstad overvalued. The question is to what extend the risk spiral upwards can be followed. A heightened safety feeling leads to the increase of investments, which require higher dikes, which increase the feeling of safety, which leads to more investments and so on [Rijcken, 2007]. While at the same time, a dike breech of heightened dikes lead to big disaster. This would pledge for a spread out defence against floods with once in a while a controlled flood that lead to minimal and predictable damage. In this way of thinking, the adjustment of the spatial lay out to the effects of flooding gains importance. Both approaches – heightening the dikes to minimise flood risks and dealing with the consequences of controlled flooding – are necessary.

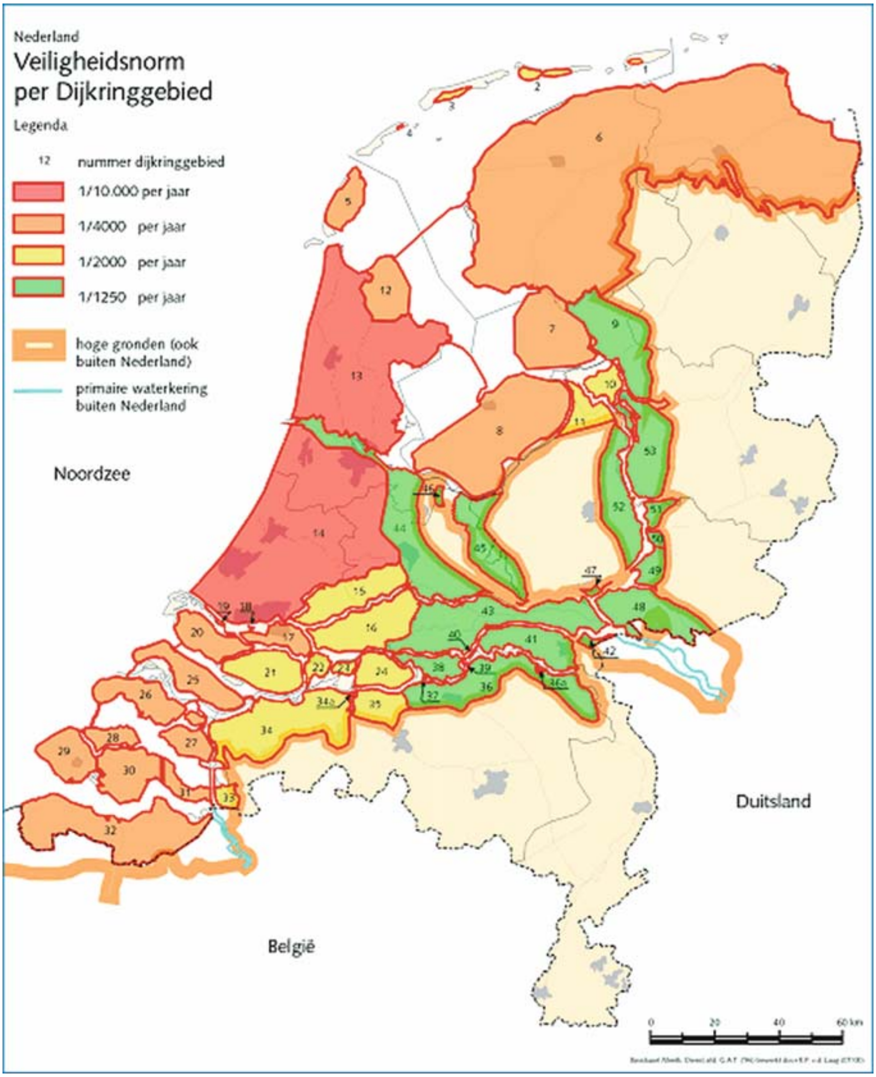


Fig. 4.1 Safety level by dikering (Source: Ministerie van V&W)

4.1.2 Water Policy in the 21st Century

The problems in water systems are caused by the technical way the water was treated [Commissie Waterbeheer 21ste eeuw, 2000]. The natural resilience of the water system has decreased because floods needed to be prevented, navigation needed to be provided with enough depth in waterways, the agriculture needs to be provided with enough fresh water, the energy plants with enough cool water, marshy polders

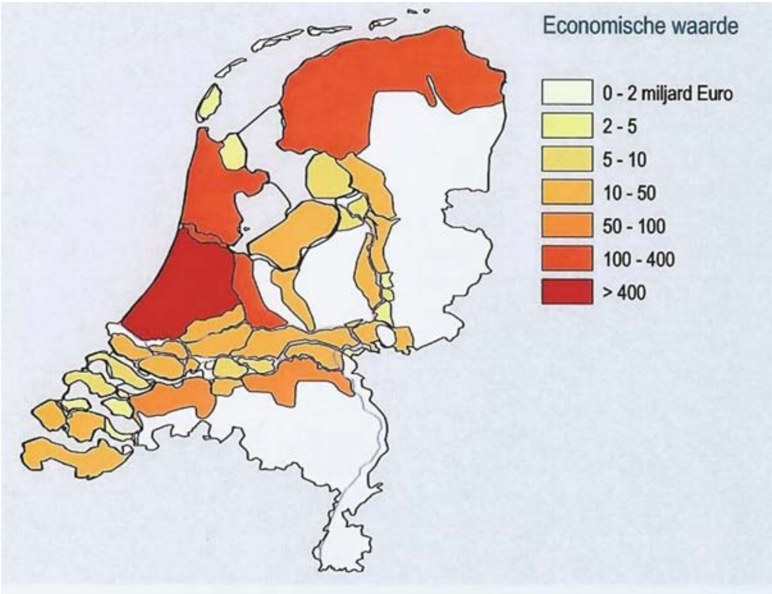


Fig. 4.2 Economical value by dikering (Source: Watervisie, Ministerie V&W, 2007/MNP)

needed to be reclaimed in order to make it suitable for housing and as much land as possible was reclaimed, because water was worthless (Ministerie van Verkeer en Waterstaat, 2007). Due to climate change the pressure on the water system increases. Larger amounts of precipitation need to be discharged in shorter periods, while sea level rise makes it increasingly difficult to discharge the water in a natural way. Therefore, it is necessary to increase the resilience of the water system again. Natural processes need to be recovered and the water system needs to get the space to function. The advice of the commission water management in the 21st century several proposals were done already. The problems of climate change and sea level rise were taken seriously and the conclusion was that the current water system was not very good prepared on the future. A three-steps-strategy was suggested: Start with retaining as much water as possible, secondly store water and finally – if no other option is left – discharge it. The objective of this strategy was to prevent the roll off of problems towards other areas or people. The water system needed to be adjusted to reach this goal. Extra room for rivers was required, areas needed to be realised as storage basins, a higher and broader coastal defence needed to be realised and the water policies needed to be detailed at a regional level. If these measures were taken, water was able to play a steering role in spatial planning by creating more space for water or to realise multifunctional land use (Commissie Waterbeheer 21ste eeuw, 2000).

4.1.3 Dutch National Water Vision

The adjustment of the water system is undertaken even more thoroughly in the national water vision. The aim is to have a national water plan ready by the year 2009, in which a sustainable and integrated climate proof water management for the entire country is laid out. The national water plan contains a target image for the long-term is connected with a spatial structure vision for the Netherlands, in which the spatial consequences are laid down as well as a working program for the first six years is formulated (Ministerie van Verkeer en Waterstaat, 2007). In the water vision five steering points are defined:

The first one is a climate proof Netherlands. The adaptation of the water system to climate change in the lower parts of the Netherlands needs to be realised in a way that all build up capital behind the dikes is not given away to the sea. Beside the adjustments of the coastal defence (see Chapter 3), adjustments in the spatial lay out and the way buildings are build will be necessary. Space is required to store water or to make storage in the future not impossible. Moreover, natural processes of the future need to play a steering role today in the development of spatial lay out of urban development, industry, nature, landscape and recreation. Furthermore, the vulnerability of the Netherlands can be minimised if investments are done in a climate proof way. The starting points for a climate proof lay out and a decision-making framework for the choice of locations, lay out of areas and the design of infrastructure and buildings will be put together (see also Adaptation agenda, Chapter 1).

4.1.4 Water Safety

Water safety aims to minimise the chances at a flood, but also to minimise the effects in case a flood happens, for instance by the creation of compartments within dike-rings, by building water proof or by keeping vital infrastructure usable during a flood.

The rivers in the Netherlands will have to deal in the future with an increasing amount of water that needs to be discharged. The discharge capacity of the big rivers in the Netherlands needs to be increased. The program Room for the River aims to realise this increase (Fig. 4.3). The rivers are given more room, for example by realisation of new high-tide channels. Other measures include the removal of obstacles, lowering the outer marches, lowering river jetties, reposition dikes, depolder, deepening the summer-bed or strengthening the dikes. If new high tide channels or changing the riverbeds offer chances at the realisation of attractive living environments (Fig. 4.4) and offers the river more space at the same time. Moreover, extra nature and recreation can be realised.

Fig. 4.3 Overview over the Room for the River measures (Source: Ministerie van V&W, 2006a)

Fig. 4.4 Building water proof in the riverbed (Source, Ministerie van V&W, 2006b)

4.2 SAFER and ELLA Projects

In a European context and funded by the EU, several initiatives are explored regarding flood risk management and prevention in relation with spatial planning. SAFER and ELLA both are dealing with these issues.

4.2.1 ELLA

In recent years, the Elbe river basin was confronted with great flooding events, such as the most extreme one in 2002 (Fig. 4.5).

Within the ELLA-project the following countries cooperate: Germany, Chech Republic, Austria, Poland and Hungary (Freistaat Sachsen, 2006). The Ella

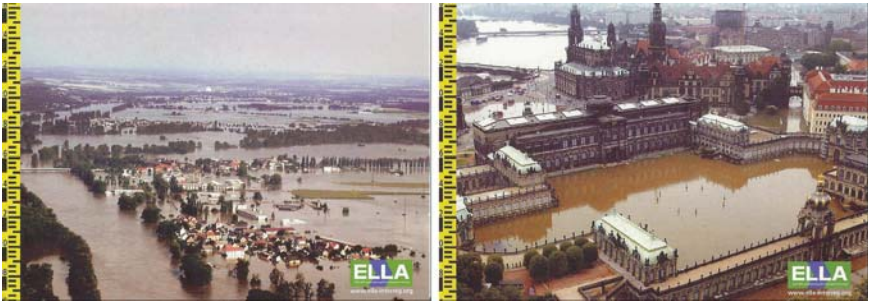


Fig. 4.5 *Images of Elbe flooding*

partnership takes the trans-national requirements as starting point, because land use in the upper reaches of the river affect the water level in lower reaches. Measure taken in lower reaches can only be effective if they are matched by water and land use management upstream. Preventive flood protection is not a simple water management task, but requires a comprehensive, interdisciplinary and trans-national examination of the flood risks and possible preventive measures. Spatial planning measures and instruments can contribute to prevent flood damage.

The spatial measures are divided in five categories (Fig. 4.6).

Fig. 4.6 Five fields of activity in the Elbe river catchment area (Source: Freistaat Sachsen, 2006)

1. *Protection of existing retention areas.* The flood plains and zoning of flood areas need to be defined in spatial plans. Flood plains need to be represented in land use plans or building development plans. Undeveloped flood plains need to be protected outside settlements and construction needs to be prohibited. Conflicts regarding land use in or around retention areas need to be solved;
2. *Redevelopment of former retention areas and polders.* Potential retention areas and polders need to be protected in spatial and land use plans. Potential retention areas need to be protected against inappropriate use. Conflicts regarding land use in and around potential retention areas and polders must be solved. Spatial planning procedures need to be completed in order to protect the sites;
3. *Retention of rainfall in the catchment area.* Flood originating areas, like precipitation or discharge, need to be integrated in spatial plans. Land use guidelines need to be developed to reduce the discharge in the main flood originating areas. Cooperation programmes with land users and water management authorities must be initiated. Retention and water use concepts need to be integrated in planning and re-planning of settlements;
4. *Reduction of damage potential.* Drawing up and provision of risk maps, which are to be integrated in regional plans, building development plans and flood management systems. New buildings in risk zones need to be prevented or precautionary measures to reduce damage must be taken;
5. *Technical flood protection measures* like dikes, dams or retention basins, which are mainly part of regular water management with little spatial impacts or spatial contributions.

4.2.2 SAFER

In the SAFER project five organisations (Regierungspräsidium Stuttgart-Germany, Dublin City Council-Ireland, Forestry Commission Scotland, Federal Office for Water and Geology Biel-Switserland and Ecole Polytechnique Fédérale de Lausanne-Switserland) cooperate. Their objective is to develop innovative strategies and develop and mitigate fluvial and coastal flood damage (SAFER, 2008).

The first element in the project is to develop flood hazard maps, which show the extent of different flood events as well as the depth of water. Based on the maps precautionary measures and flood management can be developed. The example of the Neckar catchment area (Zeisler, 2005) shows two maps for the expected depth and the spatial impacts of a flood (Fig. 4.7) and the influence on different functions along the river in cross section (Fig. 4.8).

The second focus in the SAFER project lies on the creation of partnerships. It aims to create a direct link between the flood protection measures and the people who might be affected by flooding. The partnerships function as a platform to discuss flood protection, raise awareness and exchange of knowledge.

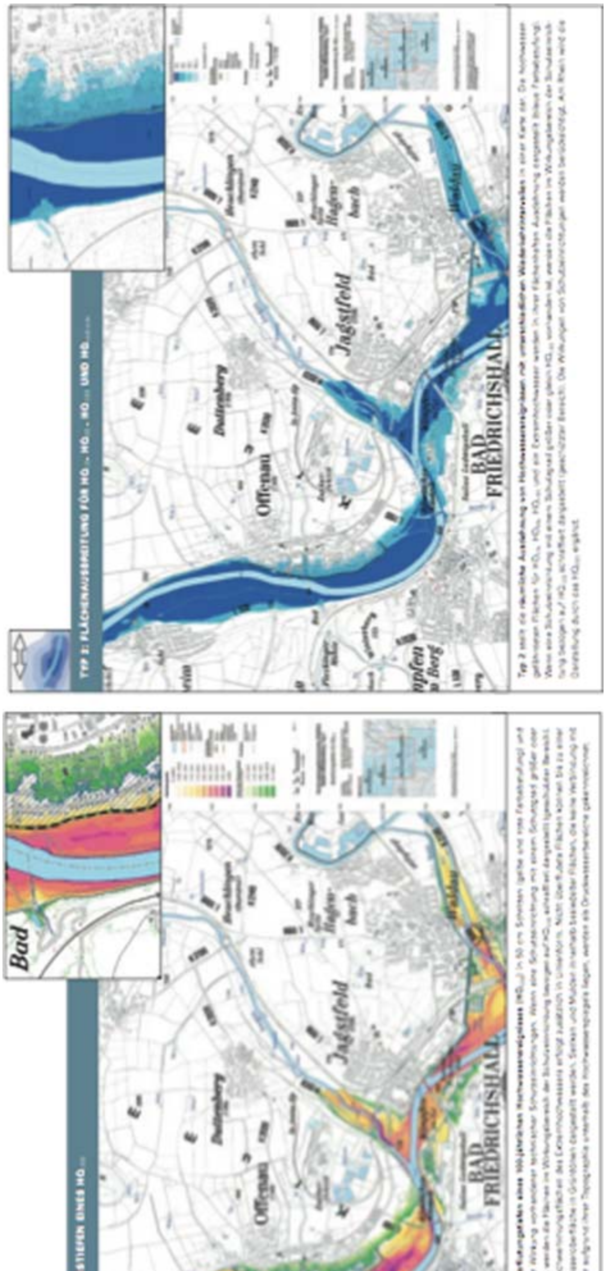


Fig. 4.7 Depth of a once in 100 year flooding (*left*) and the spatial impact of different strengths of floods (*right*) in the Neckar catchment area (Source: Zeisler, 2005)

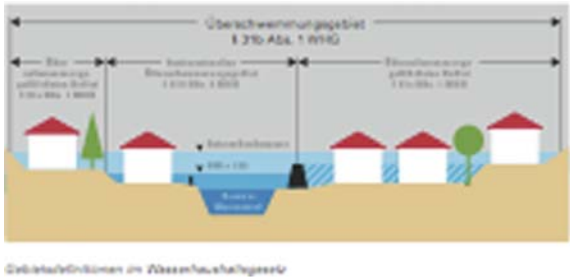


Fig. 4.8 Cross-section of the spatial impact of different flood extremes (Source: Zeisler, 2005)

The third component in the project is the development of flood emergency management systems. The enhancement of the internet-based flood information and decision support system includes an early warning system, support emergency services, the alarm system and community action plans. The warnings are divided in three categories: long-term, astronomical spring tides (a year in advance), medium-term, sea surges (10 days in advance) and short-term, any tide (24/36 h in advance).

4.3 Flood Risk

The chance at a flood times the effect of the flood determines the risk. In the Netherlands, the protection against water from outside has been in order for centuries and therefore many people think they are living at a safe place. This is why continuously new investments are done in the area behind the dike. Because of that, the potential effect of a flood increases. If the risk needs to be decreased solutions at both ends of the risk formula can be found. In the first place, flood risk can be decreased if the dikes are strengthened. But the safety cannot be guaranteed for the full 100%. And this becomes even more difficult if the pressure on the dikes increases due to sea level rise and the peak discharge in rivers increases as well. This is why measures to minimise the effects of floods need to be taken as well and become increasingly important. Spatial adjustments are necessary to minimise the effects. By decreasing the chance at a flood and minimise the potential damage at the same time, the safety can be made maximal (RPB, 2007). The supposition that every acre behind the dike is equally safe is not correct. The depth of the ground level, related to the sea level indicates the safety of an area, while the distance from the dike and the appearance of obstacles are able to break the flood and are important for the safety as well. Safe and less safe parts emerge within one dike-ring. Not so deep areas, which are far from the dike with a lot of obstacles in between, are safer than deep areas close to the dike (Fig. 4.9).

If the risk zoning in a certain dike-ring is mapped, the next step is to define the mix of spatial (and governance) measures. The RPB (Dutch National Spatial Research Centre) developed a typology of possible measurements and for which

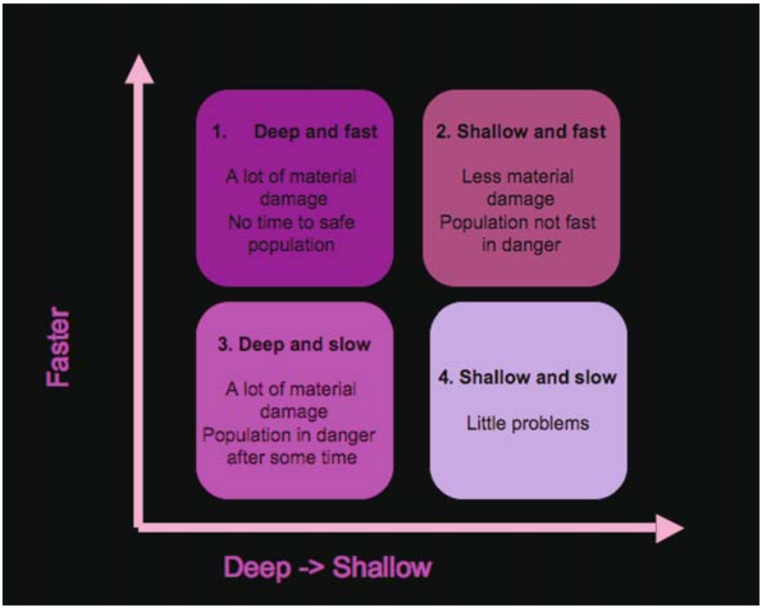


Fig. 4.9 Risk approach for floods inside a dikering (Source: RPB, 2007)

situations the measures are suitable. Depending the situation, a combination of suitable measures can be taken to optimise safety in a certain dike-ring (Fig. 4.10).

4.4 Building a House

Building a house in wet circumstances or in an area vulnerable for floods, several possibilities are available. It is very important to match the kind of house with the type of water-problem. The *'Directive to build in wet areas'* is developed to deal with this (www.waterbestendigbouwen.nl). These wet areas are areas are traditionally difficult to build in. Building in these areas will increase in the future, because:

1. Climate change leads to permanent attention for waterproof building;
2. The availability of suitable building area decreases, leading to the increased use of alternative – with water-rich circumstances – locations;
3. Development of multifunctional location gains importance and leads to an increased attractivity;
4. Increased popularity housing on or next to the water.

Building the type of house should be matched with the type of water.

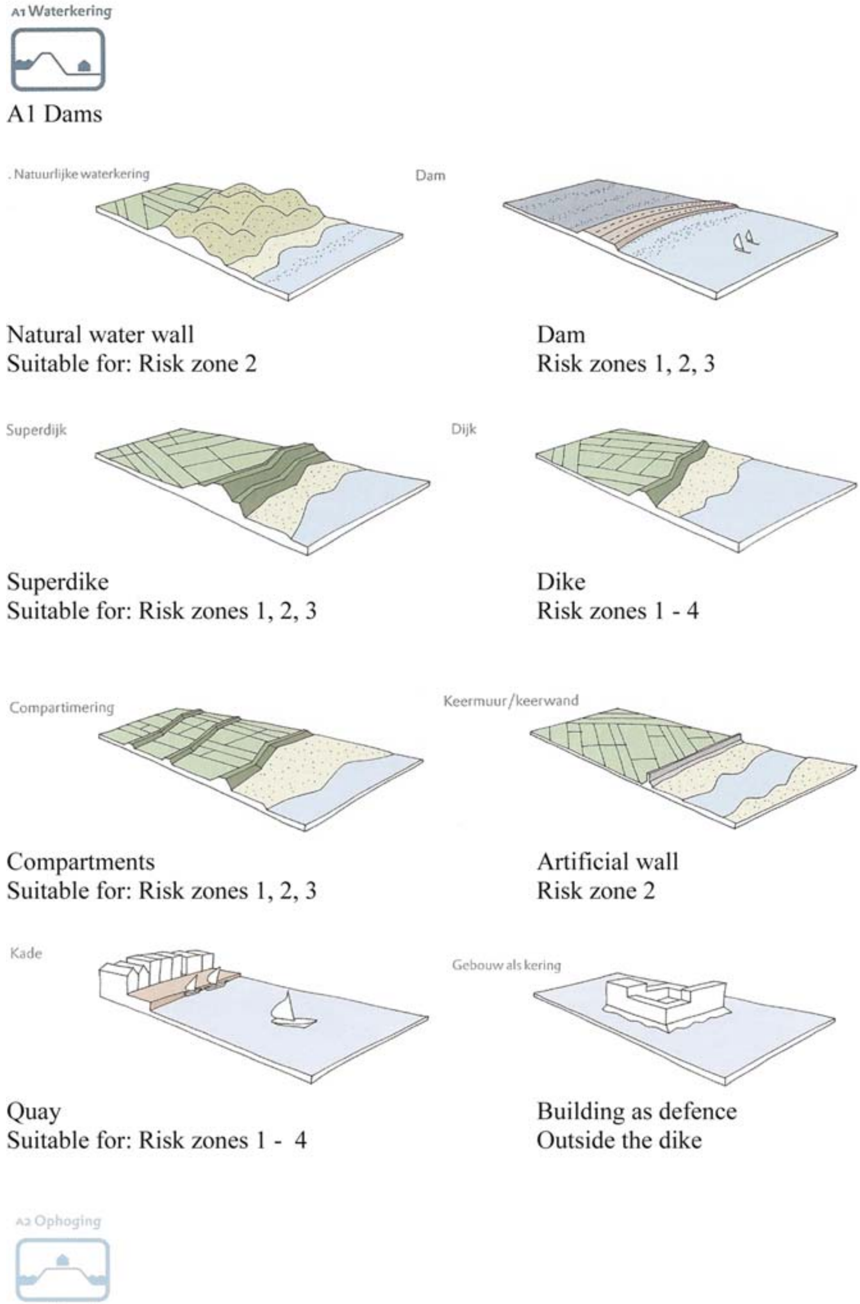
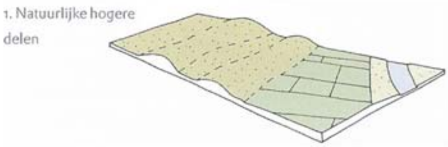
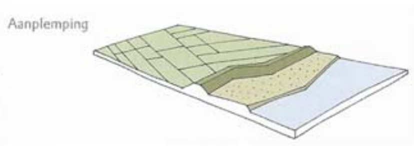


Fig. 4.10 Typology of measures to minimise risk (Source: RPB, 2007)

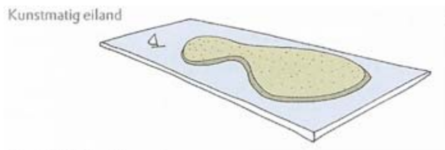
A2 Heightening



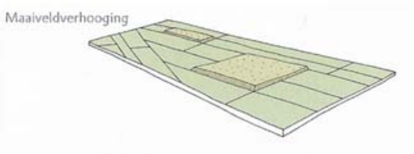
Natural higher parts
Suitable for: Risk zones 1 - 4



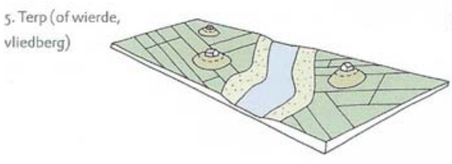
Fill up
Outside the dikes



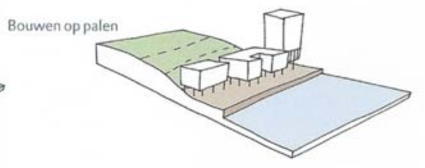
Artificial island
Suitable for: Risk zone 2



Heightening ground level
Risk zones 1 - 4

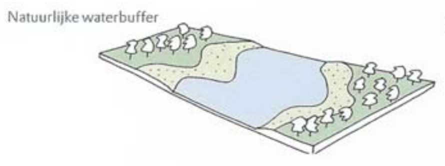


Artificial hill (wierde)
Suitable for: Outside the dikes

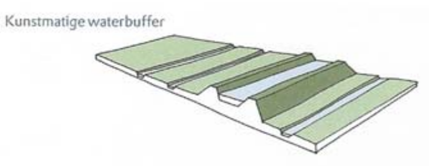


Building on poles
Risk zones 2, 4

A3 Storage



Natural basin
Suitable for: Risk zones 1 - 4



Artificial basin
Risk zones 1 - 4

Fig. 4.10 (continued)

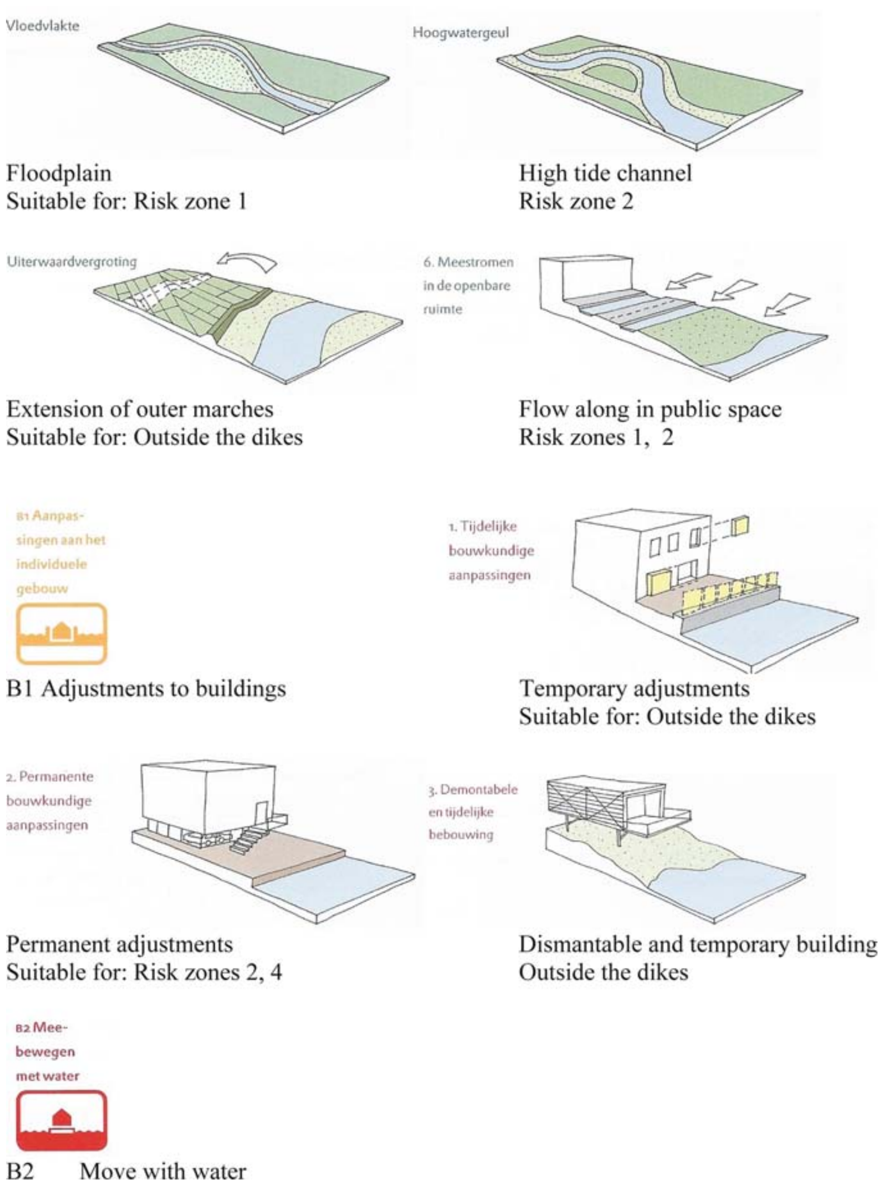
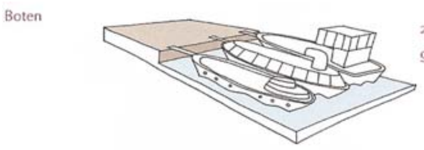
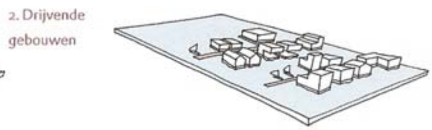


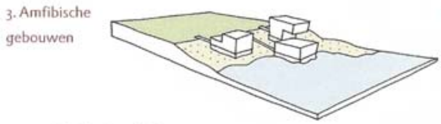
Fig. 4.10 (continued)



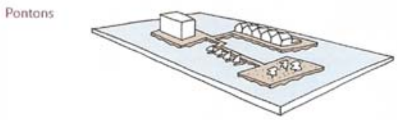
Boats
Suitable for: Outside the dikes



Floating buildings
Outside the dikes



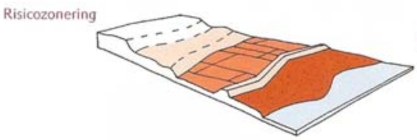
Amphibic buildings
Suitable for: Outside the dikes



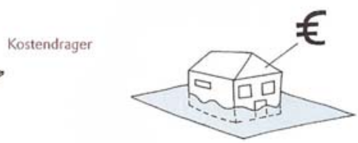
Pontons
Outside the dikes

B3 Regulations

Rules
Suitable for: Risk zones 2, 3

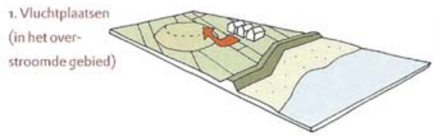


Risk zoning

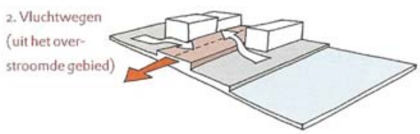


Financial carrier
Suitable for: Outside the dikes

B4 Evacuation



Escape places
Suitable for: Risk zones 1, 2, 3



Evacuation routes
Risk zones 1, 2, 3

Fig. 4.10 (continued)

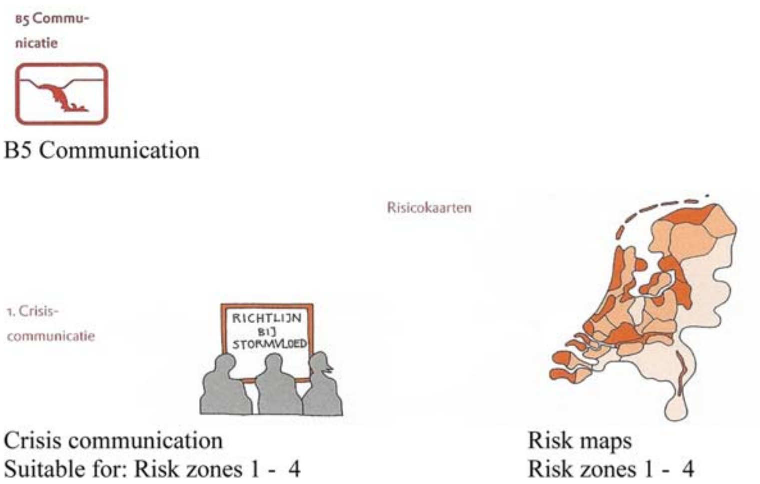


Fig. 4.10 (continued)

4.4.1 Type of Water

Five water types are distinguished, each of them with its own characteristics.

4.4.1.1 Peak Storage

A peak storage stores temporarily superfluous water, resulting of extreme precipitation. The storage prevents other areas from water annoyance. The water system does not have the capacity to discharge all the precipitation and the peak storage stores temporarily the surplus. The storage functions year round (Fig. 4.11).

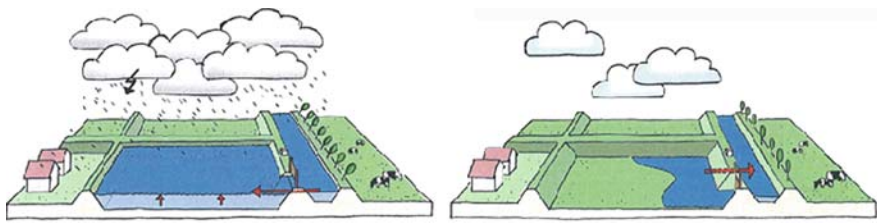


Fig. 4.11 Peak storage (Source: Hoogheemraadschap Rijnland, 2003)

4.4.1.2 Seasonal Storage

The seasonal storage stores water in wet periods. In dry periods the storage functions as a buffer. The buffer prevents water system from the need to let water in from another area, which water is most of the time of less quality (Fig. 4.12).

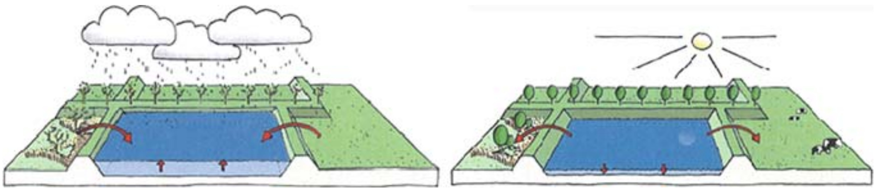


Fig. 4.12 Seasonal storage (Source: Hoogheemraadschap Rijnland, 2003)

4.4.1.3 Calamity Storage

Storage in times of calamity takes place in urgency flood plains. These areas are pointed out beforehand and are ready to receive the water if necessary. The storage of water in the calamity basins prevents breakthroughs of dikes elsewhere (Fig. 4.13).

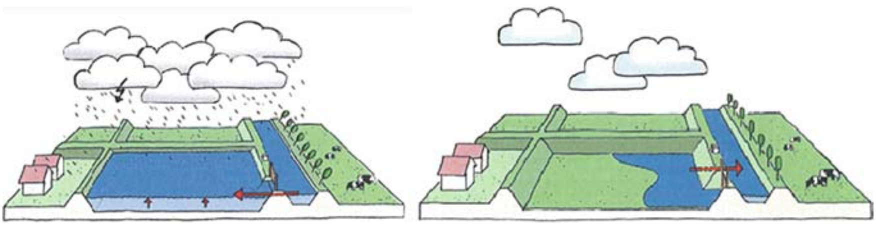
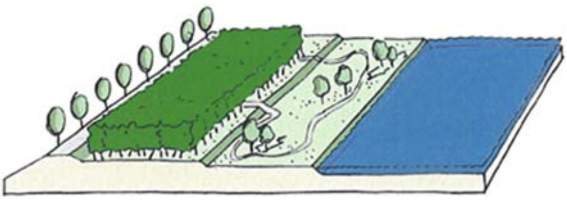


Fig. 4.13 Calamity storage (Source: Hoogheemraadschap Rijnland, 2003)

4.4.1.4 High Tides

Storage of river water in the outer marches prevents the breech of dikes along the river. The water is so high that it flows over the summer dike. The water levels are the result from melting water or precipitation (Fig. 4.14).

Fig. 4.14 High tides (Source: Hoogheemraadschap Rijnland, 2003)



4.4.1.5 Groundwater Annoyance

If there is a surplus of groundwater there is no surface water that needs to be stored. The soil needs to store the water. Due to this storage the distance between groundwater level and ground level becomes less. The slight drainage causes annoyance (Fig. 4.15).

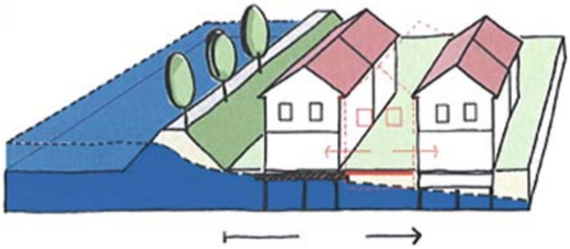


Fig. 4.15 Groundwater annoyance (Source: Hoogheemraadschap Rijnland, 2003)

4.4.2 A Japanese Experience

Within the Tokyo metropolitan area urbanisation increased rapidly. At the same time rainwater runoff, due to heavy rainfall, increased as well. The basin of the Motoara-river suffered large damages caused by floods. Within Koshigaya Lake Town (Fig. 4.16), a new development, a regulation pond was implemented in order to reduce flood damages (Koshigaya Land Development Office, 2005). The purpose is to create an environment, which is safe for the residents and comfortable (Fig. 4.17).

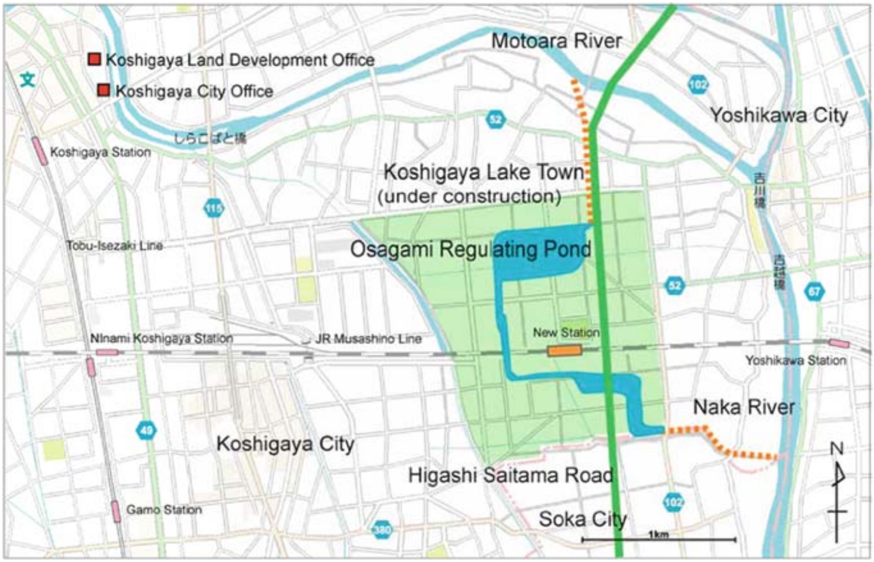


Fig. 4.16 Location of the regulation pond (Source: Koshigaya Land Development Office, 2005)

Fig. 4.17 A safe and comfortable environment (Source: Koshigaya Land Development Office, 2005)

The regulating pond is developed as an integrated part of the urban development of Koshigaya Lake Town. The regulating pond captures part of the excessive water during heavy rain from the Motoara-river preventing the river from flooding. In order to function well the development contains a flood control function, which includes an overflow-type of dike, a control gate, a diversion channel a drainage channel and a drainage gate (Fig. 4.18). Furthermore, the water quality and water level is controlled by a sluiceway for purification the channels and gates and a drainage pump station.

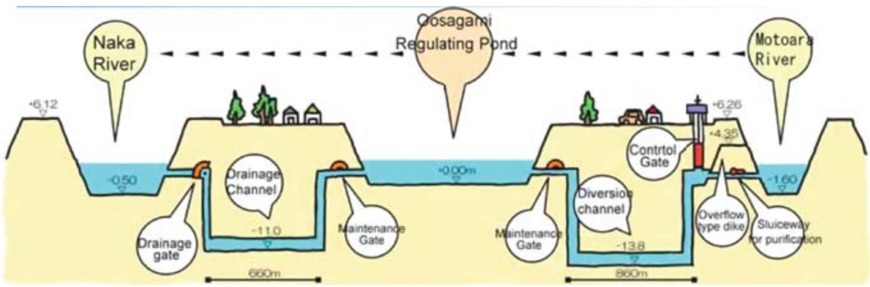


Fig. 4.18 The overflow dike, control gate, diversion and drainage channels and drainage gate (Source: Koshigaya Land Development Office, 2005)

The different elements of the system are visualised in Fig. 4.19. The regulation pond stores temporally water, which flows in the river at times of heavy rain. The drainage pump station pumps water from the regulation pond into the Naka-river. The diversion and drainage channels are connecting the pond both with the Motoara and Naka-river. The overflow-type of dike, which is realised lower than the neighbouring dikes, allows water to flow over the dike into the regulation pond in times of floods. The sluiceway for purification regulates the amount of water that runs in the regulation pond from the Motoara-river and cleans it at the same time.

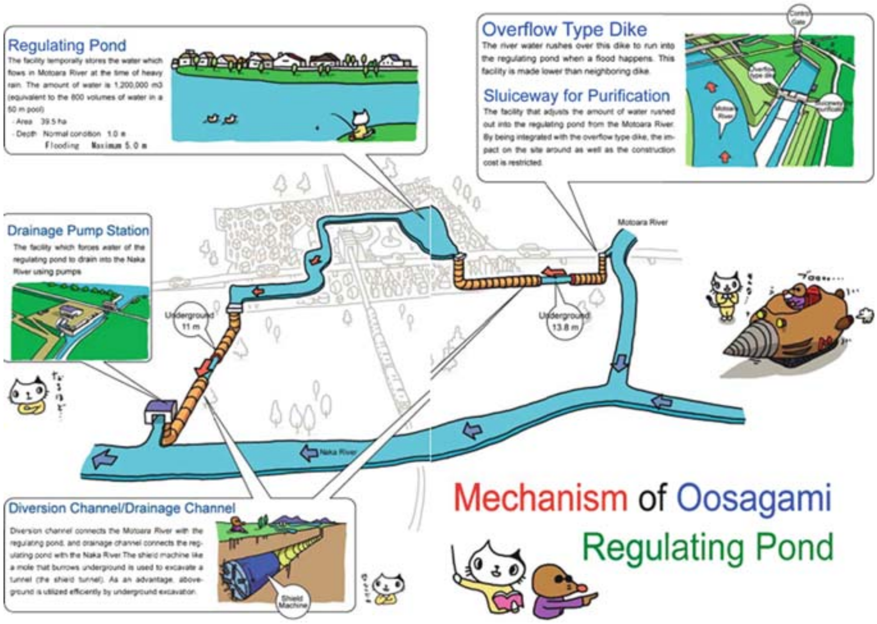


Fig. 4.19 Functioning of the system with facilities (Source: Koshigaya Land Development Office, 2005)

The mechanism of the regulation pond works as follows (Fig. 4.20). Before a flood occurs the water level is kept low. During a flood the water flows over the overflow dike and the control gate is open. The drainage gate is closed to prevent that the water flows immediately in the Naka-river. After the flood happened the control gate is closed and the drainage gate is opened in order to let the water flow in the Naka-river and he water level is brought down to the original level.

Another mechanism is also used. In order to keep the water quality high, the regulation pond needs to be flushed through once in a while. The tidal differences are used to operate the system. In times the tidal level is raised the drainage pond is closed in order to raise the water level in the regulation pond. If the tide is falling, the gate is kept open to flow the water through the system.

4.4.3 Types of Houses

The houses typology is based on possible adjustments in building techniques and adjustments in the installations. Water deserves a structural function starting in the initiative phase and ending with the usage phase, and maintenance. Water is allowed in the house, beneath or under it. Two categories types of houses are distinguished (Fig. 4.21): the independent and dependant house. The dependant waterproof house requires human support to become waterproof during inundation (for

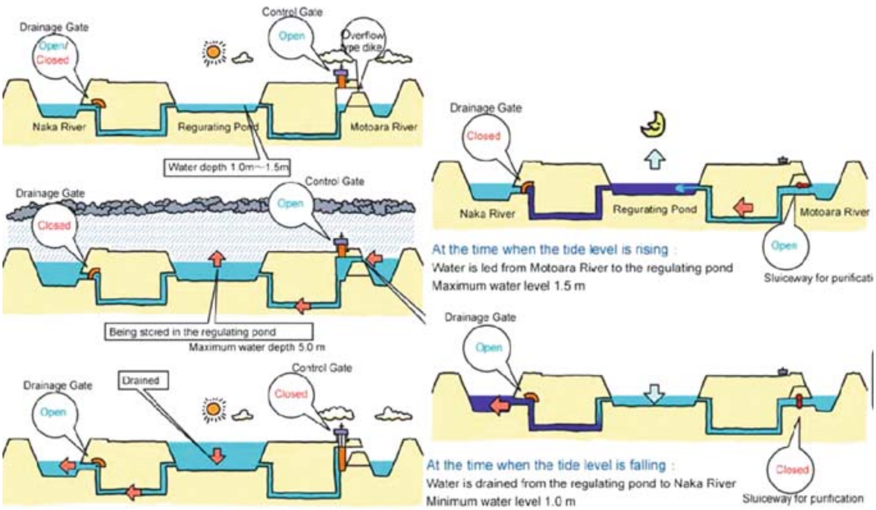


Fig. 4.20 Functioning of the pond in times of flood (*left*) and cleaning the system using tides (*right*) (Source: Koshigaya Land Development Office, 2005)

instance: placing of waterproof particions in front of façade openings), while the independent waterproof house is waterproof by itself.

4.4.3.1 Wet Proof House

During a flood, water is allowed to enter the house until a certain height, 1,5 metres above the floor. Inside the house the damage is minimised by using waterproof floor, walls and other amenities inside and outside the house. The furniture is by preference removable and waterproof. The house needs to have enough openings in order to give the water the space to flow through (Fig. 4.22).

4.4.3.2 Dry Proof House

This house has a waterproof ground floor and outside walls and these houses are waterproof until 90 cm height. Recent research (Bowker, 2007) advises to use waterproof measures, meant to protect the building skin, up to 60 cm, because the chance at tears in the wall, shrinkage and leakages increase above that height. Furthermore, this research states that above a flood level of 90 cm higher risks are apparent at floating rubbish, trees and branches. If other materials than bricks are used it is possible to make the construction waterproof. The decisions and choices depend on the costs and benefits of different solutions. If a flood takes place open parts of the façade and the ground floor are closed by hand (Fig. 4.23). If this is done the house is prevented – up to 90 cm – from entering water. This house does not have free space under the ground floor. This prevents water to enter the house from beneath during a flood.

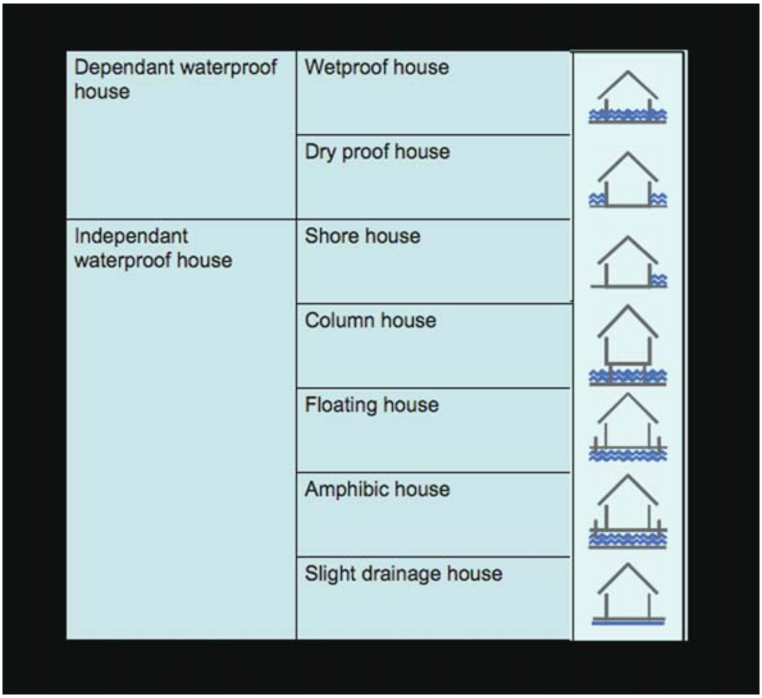


Fig. 4.21 Typology of houses (Source: www.waterbestendigbouwen.nl)

Fig. 4.22 Wet-proof house, example of measures inside the house: waterproof floor, waterproof walls and electricity above maximum water level (Source: www.waterbestendigbouwen.nl)

Fig. 4.23 Dry proof house measures outside the house keep the house dry (Source: www.waterbestendigbouwen.nl)

4.4.3.3 Shore House

One side of this house – the waterside – is waterproof. The entrance is on the opposite (land) side. The ground floor is made waterproof and the walls are waterproof up to 1.5 m above ground level at the waterside. Above this height space can be used for windows in order to provide enough daylight to enter the house (Fig. 4.24).

Fig. 4.24 Shore house, Amersfoort (Source: www.waterbestendigbouwen.nl)

4.4.3.4 Column House

This house is built on columns, anchored on the fundament poles. The columns and ground floor are above ground level and water level. Despite the fact that the water level fluctuates, the house will be dry any time, because the columns provide dry circumstances – the ground floor is high enough (Fig. 4.25).

Fig. 4.25 Column house (Source: www.waterbestendigbouwen.nl)

4.4.3.5 Floating House

The underground of this house is water. Fundament is not necessary. The house is fixed horizontally, by means of mooring poles, which allow the house to move vertically along with the water level. The floating house is put on a floating body, which can be a hollow concrete reservoir (www.goudenkust.nl) or a plate, made from EPS (exponant polystyrene) as heart. FlexBase (www.flexbase.eu) is an example of this (Fig. 4.26).

Fig. 4.26 Floating houses (Source: Dura Vermeer Buiness Development)

4.4.3.6 Amphibic House

The amphibic house consists of a traditional fundament as well as a floating body. In dry circumstances the house rests on the fundament, but in case of the rise of the water level the floating body enhances the loosening of the fundament and the house is capable of floating. This house is connected horizontally with mooring poles as well and is able to move along with water level fluctuations (Fig. 4.27).

Fig. 4.27 Amphibic houses (Source: Dura Vermeer Business Development)

4.4.3.7 The Slight Drainage House

This house has to deal with high groundwater levels and the ground floor and a part of the outside walls and facades, which are below water level, needs to be waterproof. This house does not have any free space under the ground floor, preventing the groundwater from entering the house (Fig. 4.28).

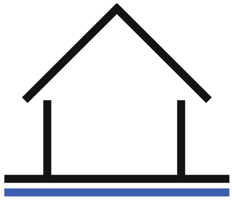


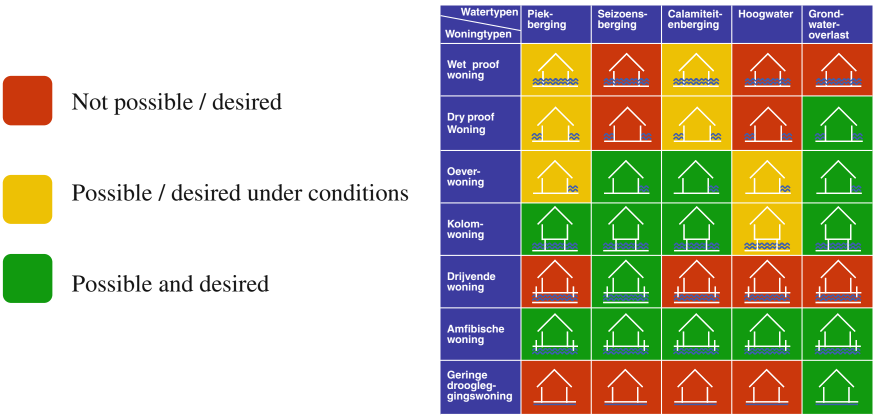
Fig. 4.28 Slight drainage house (Source: www.waterbestendigbouwen.nl)

4.4.4 Combination of House and Water Typologies

Different water circumstances require other types of houses. In the Table 4.1 is shown which combinations are possible.

For example, a floating house can be built in the relatively quiet circumstances of a seasonal storage, but to build this house in dynamical and fluctuating situations is not advisable. The slight drainage house is only suitable in situation with a high groundwater level, but will meet problems in any other circumstance.

Table 4.1 Matrix of water-house typologies combinations bron: www.waterbestendigbouwen.nl



4.5 Conclusion

Risk is defined as the chance × the effect of a flood. The way to deal with risk is in each country and at each scale different (Table 4.2). On a national scale general standards need to be defined to guarantee safety and spatial planning of national importance needs to be programmed, for example the planning for the rivers in the Netherlands. On the regional scale a combination of approaches can be distinguished. Spatial planning on a regional scale, the development of hazard maps or a catalogue of possible measures to deal with different levels of risk are options. The

Table 4.2 Overview over project characteristics

Scale	Project	Content	Instrument
National	National Safety Policy	Protection level dike rings	Safety standards Room for the River
	Water vision	Climate proof safety	Risk = chance × value
Regional	ELLA	Retention	Spatial measures
	SAFER	Safety	Flood hazard maps
	Flood Risk	Typology quick-slow and deep-shallow	Catalogue of measures
Local	Water typology	Water measures depending on environment	Spatial solutions
	Koshigaya	Regulating pond	Spatial measures
Building	Typology houses	Different measures for each house type	Catalogue of measures
	House × Water	Possible combinations of house types and water environments	Matrix

local level is suitable for spatial measures. The different water environments are spatially treated different and the Japanese example shows an innovative way to deal with shortages and surpluses in a spatial manner. The building level shows mainly a catalogue approach. A pallet of solutions for buildings in different circumstances is defined.

Water is steering the spatial order and is at the same time the central key in dealing with climate change. This is especially true for the Netherlands, but also important in many other countries.

At the same time, adaptation to climate change in spatial planning as far as water management is concerned is not a big issue yet. Many initiatives and policies from the water sector are focussing on risk standards, safety standards and water typologies. Not many integrated plans can be distinguished so far. Water still is not seen as an element, which can be integrated in spatial planning in a flexible way. For instance: the way a surplus of water is treated is not really contributing to the spatial quality of plans, but mainly seen as something, to which an area has to be protected. This is a missed chance, because if spatial plans can make use of the available water the spatial quality of the area as well as the resilience could have been improved.

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Commissie Waterbeheer 21ste eeuw (2000); *Waterbeleid voor de 21ste eeuw, Geef water de ruimte en aandacht die het verdient*

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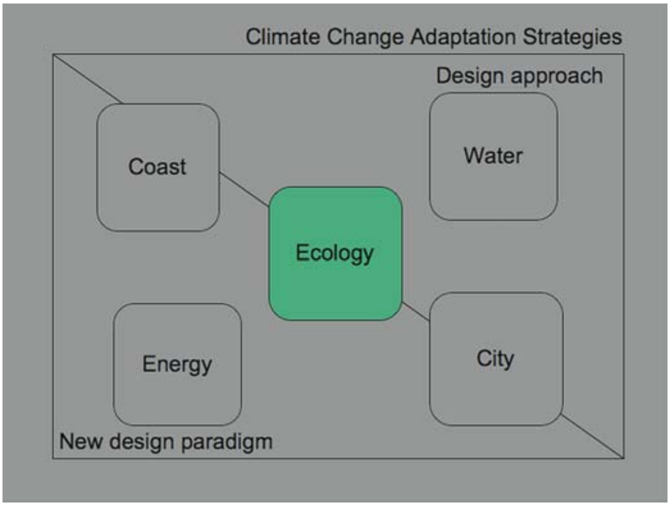
Chapter 5
Ecology



Abstract In order to preserve or regenerate ecological values throughout Europe the EU defines regulations and directives as well as the Natura 2000 areas. In the Netherlands the ecological policy not only consists of directives, but has a spatial focus also. The Ecological Main Structure defines where ecological values are to be protected and developed. At the same time a relatively rapid shift of climate zones and the accompanying ecological zones in a northeast direction can be observed.

The question is if existing policies are sufficient in dealing with the effects of a changing climate. It may well be that existing policies and regulations reach exactly the opposite of what they aim: they work restrictive and oppressive. Species and habitats, which need to move along with shifting climate zones, are bound within

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regulated zones and are not encouraged or it is not made possible to move outside existing preservations.

In order to make climate enforced movements of ecological systems possible new strategies need to be introduced. These strategies stimulate flexibility and increase the ecological capacity and connectivity. Larger and flexible areas emerge, in which the natural system is able to function in a natural way and space is created for natural landscape forming processes. If these strategies are implemented, existing species are supported to stay in their habitat and new species are given space to enter the habitats and survive. It becomes possible for these animals and plants to leave their existing habitat and replace it by a new one.

Up till now, there are not many examples of spatial plans, which incorporate these kinds of principles. Realisation of ecological zones is mainly based on existing species and habitats and current ecological values. Anticipation on the effects of a changing climate cannot be found back in spatial planning. Research carried out in the BRANCH project, and the use of this knowledge in the Groningen case, illustrates that it is possible to define ecological requirements in a spatial manner and to implement these in spatial planning and design. Natural processes, like illustrated by the climate buffers, can be given the required space and the improvement of the ecological dynamic is better possible. The resilience in the ecological system increases and the system is better equipped to deal with the effects of climate changes.

This chapter deals with the spatial possibilities to improve the ecological chances to cope with the effects of climate change. The impact of climate change on ecology as such is not taken into account.

5.1 Introduction

In the perspective that the natural resources and biodiversity on the globe under pressure is, a lot of policies are carried out to prevent further degradation of the natural qualities (IPCC, 2007). These policies aim to support threatened species and preserve nature reserves. In Europe, several directives, and in the Netherlands spatial policies are developed to do so. The question may be raised if these aims still can be reached if circumstances are changing due to climate change. And if not so, which alternative adaptation strategies can be developed. In this chapter the focus lies on possible *spatial* adaptation strategies. The shortcomings of existing regulations, the effects of climate change for nature and several spatial adaptation strategies, such as the connection and enlargement of nature areas as well as climate buffers, are described.

5.2 Directives

The EU established two acts regarding the preservation of birds and habitats (Jans et al., 2000). These directives outline which animals and plants and their living environment (habitat) needs to be protected by all member states of the EU.

5.2.1 *Bird's Directive*

The Birds Directive (79/409/EEG) as well as its amending acts aims to:

- Protect, manage and regulate all bird species naturally living in the wild within the European territory of the Member States, including the eggs of these birds, their nests and their habitats;
- Regulate the exploitation of these species.

The Member States must also conserve, maintain or restore the biotopes and habitats of these birds. Special measures for the protection of habitats are adopted for certain bird species identified by the Directives (in the so-called Annex I) and migratory species. In the beginning, the Annex I consisted of 74 species, but the number of bird species on the list increased over the years to 175. In order preserve all naturally living birds in the wild and the list of special birds, the member states are obliged to realise sufficient different and large enough habitats. The Member States shall create protection zones and take care of maintenance and spatial planning inside and outside these zones, which equals the ecological demands of the habitats.

It is prohibited:

- To deliberately kill or capture the bird species covered by the Directives.
- To destroy, damage or collect their nests and eggs;
- To disturb them deliberately;
- To detain them;
- To sale, transport for sale, detention for sale and offering for sale of live and dead birds or of any part of a bird or any product produced from it.

The Member States must encourage research and activities conducive to the protection, management and exploitation of the bird species covered by the Directives (Fig. 5.1).

5.2.2 *Habitat Directive*

The Habitat Directive (92/43/EEG) aims to maintain the richness of plants and animals (biodiversity) by protecting their natural living environments. Like the Birds Directive prescribes, the Habitat Directive enforces Member States also to define special protection zones and maintain these. The obligatory measures to be taken on the basis of the Directive aim to maintain or restore the natural habitats and wild

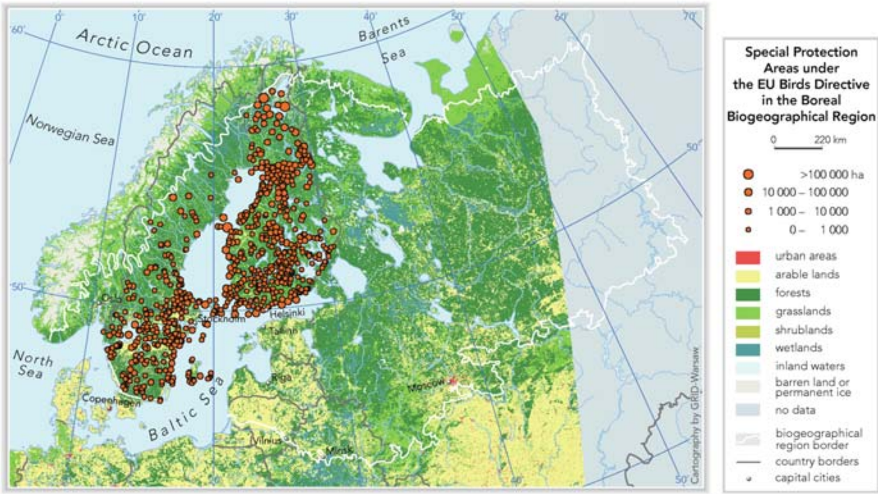


Fig. 5.1 Birds Directive locations in different biogeographical regions (Source: http://dataservice.eea.europa.eu/atlas)

species of Community interest. In this respect, a much larger number of plant and animal species are listed under the Habitat Directive than under the Birds Directive and consists of obligations on the protection of wild animals and plants as described in the Bern Treaty.

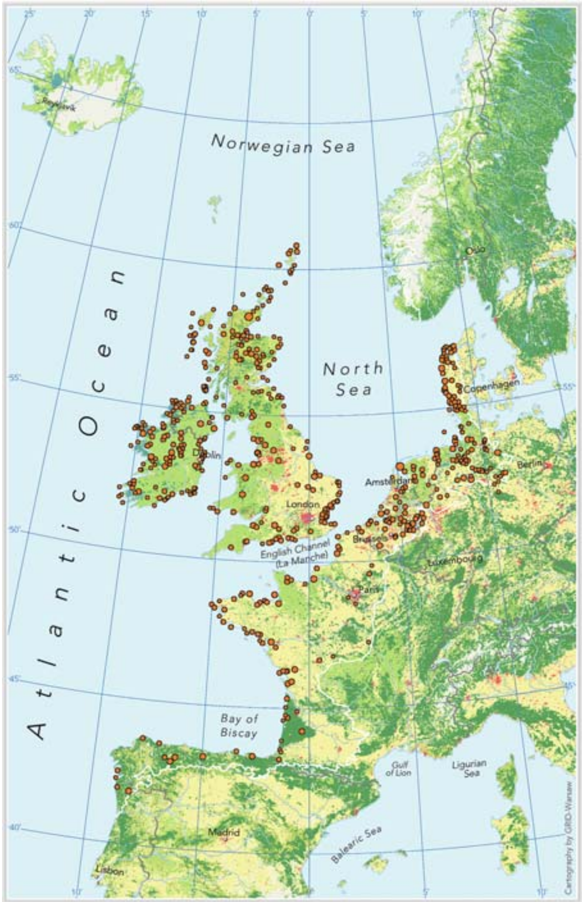
The obligations in the Directive can be divided in two categories: on the one hand side obligations that secure the preservation of natural habitats and habitats of species and on the other hand obligations regarding the protection of species. Both categories aim to maintain or restore a favourable status of preservation.

Natural habitats are defined as 'land and water zones, which contain special geographical, abiotic and biotic characteristics, which can be both natural as semi-natural'. Habitats of Community interest are habitats, which are in danger of extinction or under threat of minimising their natural dispersion area or are a special showcase for one of the five biogeographical regions within the EU (Fig. 5.2).

The definition of the habitats of species in the Directive is as follows: a, through biotic and abiotic factors determined, environment, where the species during one of its biological cycles lives. In Annex II of the Directive a list of plant and animal species of Community interest is included, for which the protection of their habitats is important for their preservation. These species are threatened, vulnerable, rare or indigenous and need therefore special attention

In order to protect species the Member States need to implement a 'system of strict protection' regarding species of Community interest. As far as animal species are concerned the system of protection includes prohibits:

Fig. 5.1 (continued)



- To deliberately kill or capture naturally wild living animals
- To destroy, damage or collect nests and eggs;
- To disturb them deliberately, especially in periods of reproduction, dependency of breed, hibernation and migration;
- To destroy or damage reproduction or resting places;
- To sale, transport for sale, detention for sale and offering for sale of live and dead animals.

The system of strict protection of plants contain prohibits:

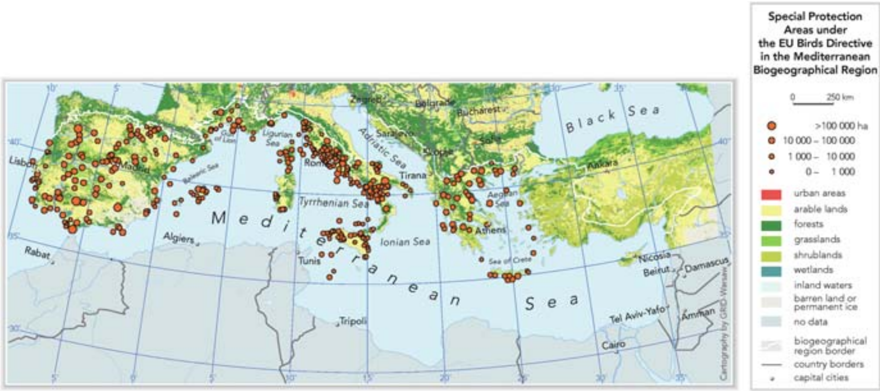
- To deliberately collect cut, uproot or destroy plant species;
- To sale, transport for sale, detention for sale and offering for sale of plants retrieved from nature. An example of a combined bird's and habitat directive for the Wadden Sea area in the Netherlands is given in Fig. 5.3.

Fig. 5.1 (continued)

Fig. 5.1 (continued)

5.3 Natura 2000

The Habitats Directive is intended to help maintain biodiversity in the Member States by defining a common framework for the conservation of wild plants and animals and habitats of Community interest. Together with the Birds Directive it establishes a European ecological network known as "Natura 2000" (Fig. 5.4). The network comprises "special areas of conservation" designated by Member States



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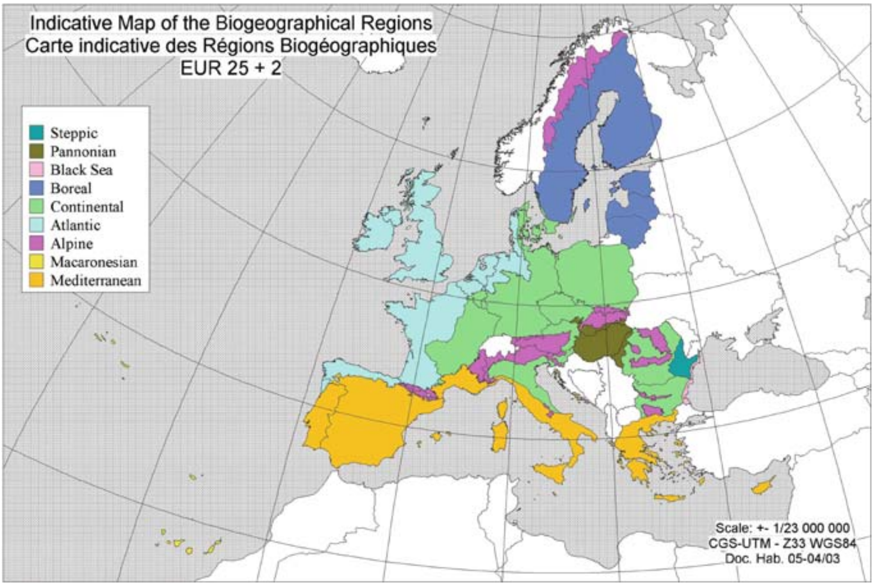


Fig. 5.2 The biogeographical regions within the EU

in accordance with the provisions of the Habitats Directive, and special protection areas classified pursuant to the Birds Directive on the conservation of wild birds.

Annexes I (Natural habitat types of Community interest) and II (Animal and plant species of Community interest) to the Habitats Directive list the habitats and species whose conservation requires the designation of special areas of conservation. Some of them are defined as 'priority' habitats or species (in danger of disappearing). Annex IV lists animal and plant species in need of particularly strict protection.

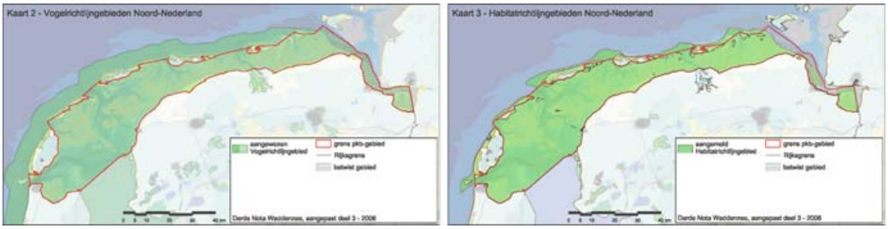


Fig. 5.3 Example of Birds Directive (*left*) and Habitat Directive in The Wadden Sea area (Source: Ministerie van VROM et al., 2006b)

Special areas of conservation are designated in three stages. Following the criteria set out in the annexes, each Member State must draw up a list of sites hosting natural habitats and wild fauna and flora. On the basis of the national lists and by agreement with the Member States, the Commission will then adopt a list of sites of Community importance. No later than 6 years after the selection of a site of Community importance, the Member State concerned must designate it as a special area of conservation.

Where the Commission considers that a site which hosts a priority natural habitat type or a priority species has been omitted from a national list, the Directive provides for a bilateral consultation procedure to be initiated between that Member State and the Commission. If the result of the consultation is unsatisfactory, the Commission must forward a proposal to the Council relating to the selection of the site as a site of Community importance.

Member States must take all necessary measures to guarantee the conservation of habitats in special areas of conservation, and to avoid their deterioration. The Directive provides for co-financing of conservation measures by the Community.

Member States must also:

- Encourage the management of features of the landscape which are essential for the migration, dispersal and genetic exchange of wild species;
- Establish systems of strict protection for those animal and plant species which are particularly threatened (Annex IV) and study the desirability of reintroducing those species in their territory;
- Prohibit the use of non-selective methods of taking, capturing or killing certain animal and plant species (Annex V).

The Member States and the Commission must encourage research and scientific work that can contribute to the objectives of the Directive.

The directives and the obligations in the Natura 2000 areas are very strict and relatively unchangeable. A detailed map of the Natura 2000 areas in the province of Groningen, the Netherlands, is given in Fig. 5.5. The basis for the regulations is formed by existing or threatened species and their habitats and not by future opportunities for in the area unknown species and their habitat requirements. Especially if climate changes rapidly shifting species meet a lack of suitable habitat to settle. This might cause ecological problems in the future, because unchangeable circumstances

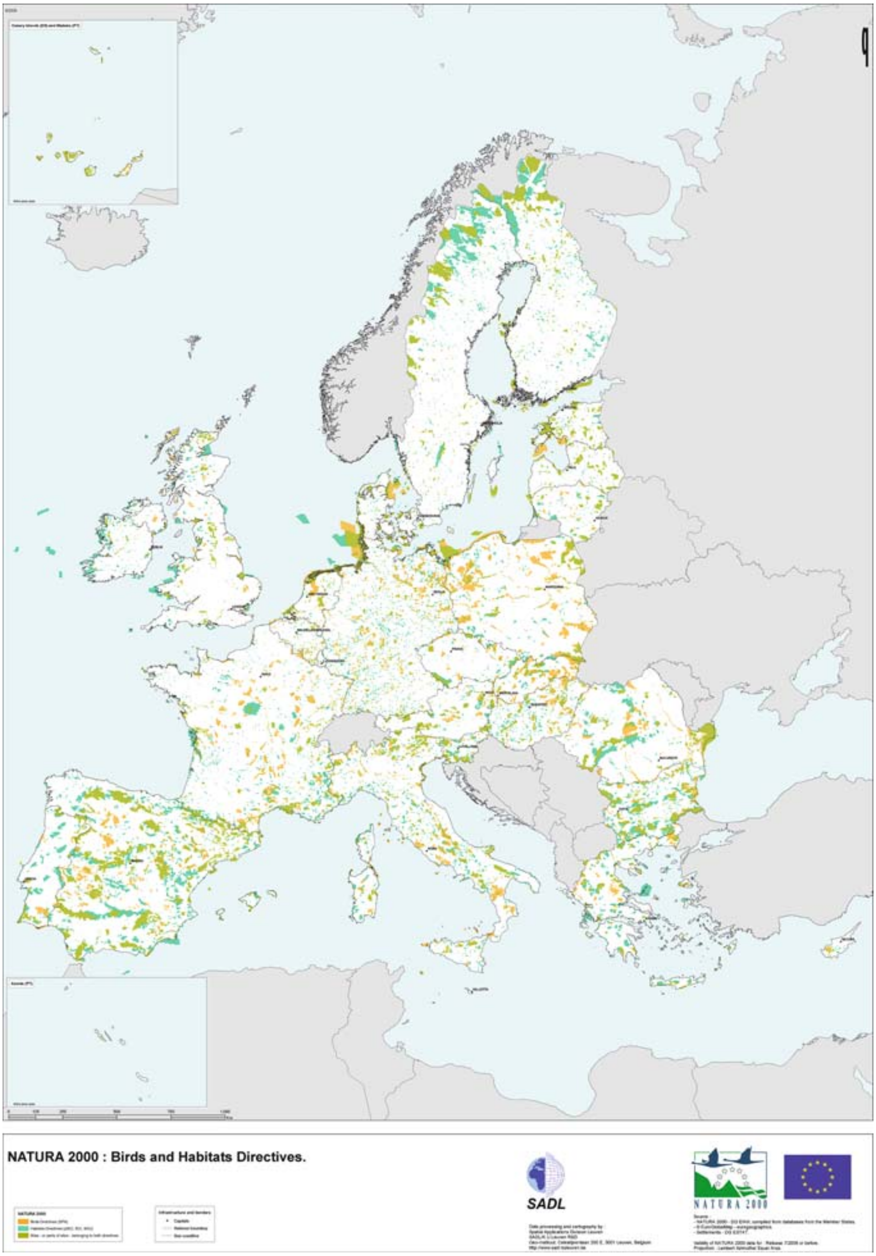


Fig. 5.4 Natura 2000, a combination of the allocated areas derived from the Habitats and Birds Directive

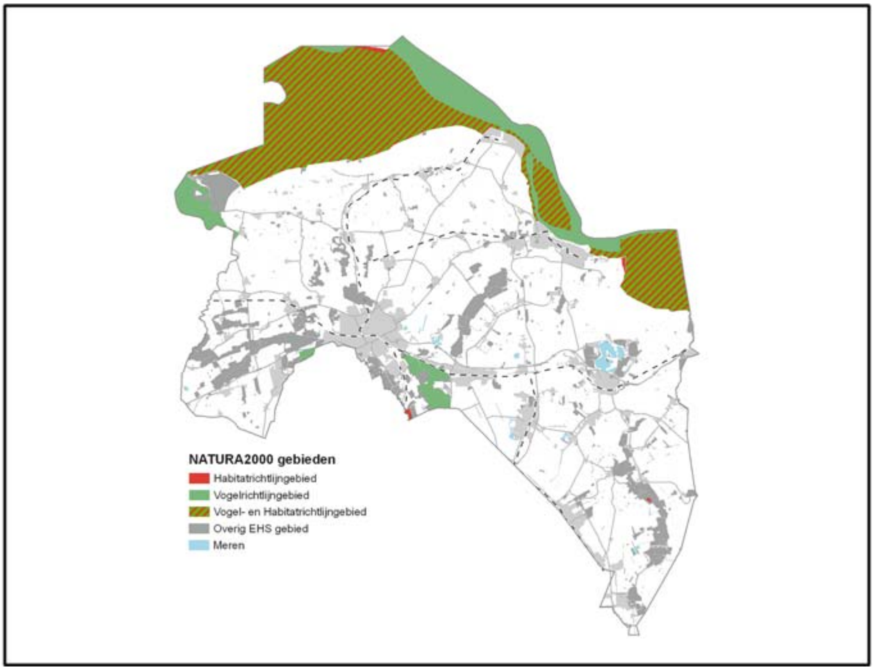


Fig. 5.5 Detailed map of the Natura 2000 areas in Groningen province, the Netherlands (Source, Provincie Groningen)

will prove a wrong basis for a changed ecological demand. Thus instead of preparing a network, which helps endangered species and habitats the stiff protective rules withstand an emerging climate adaptive nature.

5.4 Dutch Spatial-Ecological Concepts

5.4.1 Ecological Main Structure

The Dutch government decided in the nineties that spatial measures wee required to realise ecological goals. The nature in the Netherlands was in bad shape, degraded and of low quality, due to several environmental impacts, such as bad water quality and due to urban developments, which caused shrinkage of nature reserves and caused the cutting of nature areas in pieces. The decision was made to create a network in the Netherlands, which connects and enlarged nature areas: the Ecological Main Structure (Fig. 5.6). Because of the fact that nature areas are better connected, plants and animals are better capable of moving from one area to another and this results in a lower vulnerability of the species for environmental impacts. Larger areas favour greater diversity and are suitable for more species, which make them less vulnerable for disasters, weather extremes and environmental impacts.

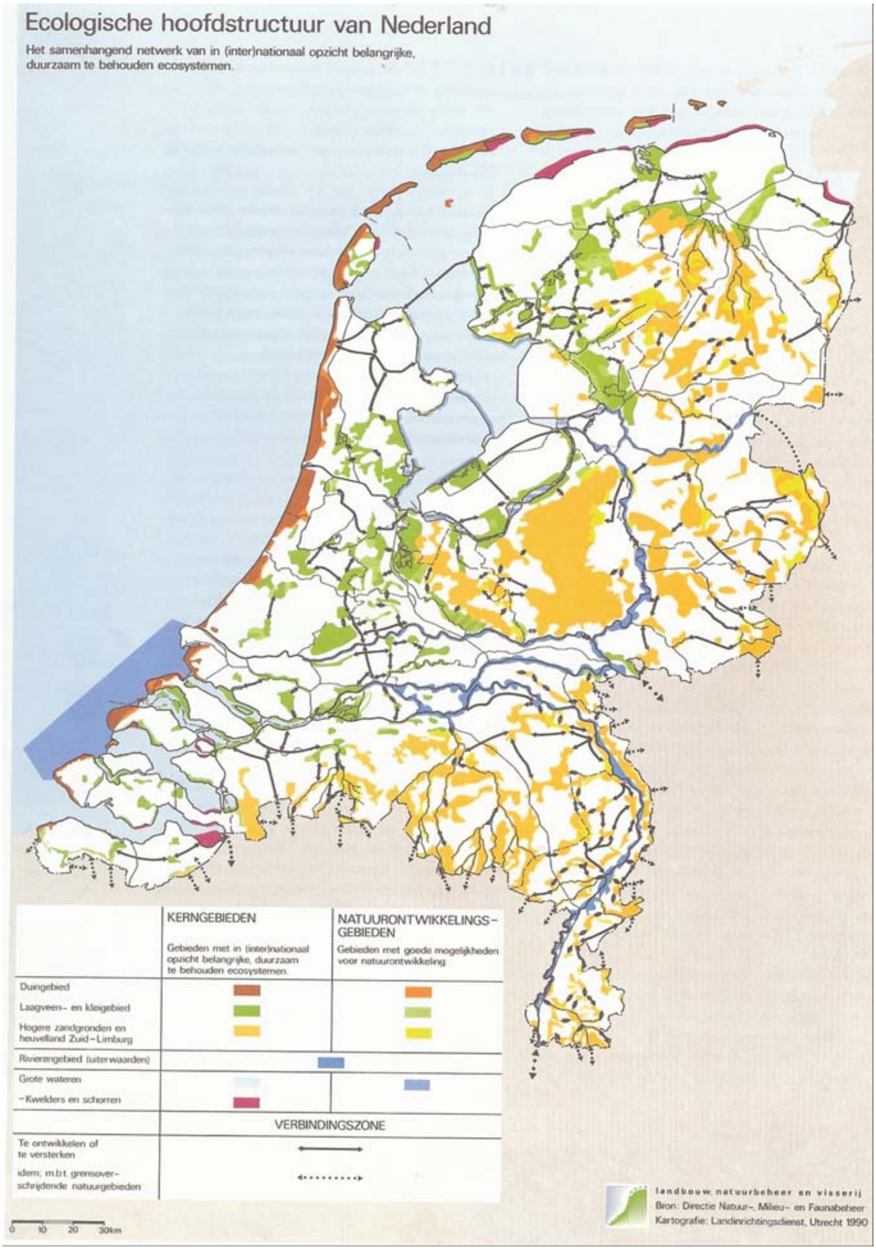


Fig. 5.6 Ecological main structure in the Netherlands (Source: Feddes et al., 1998)

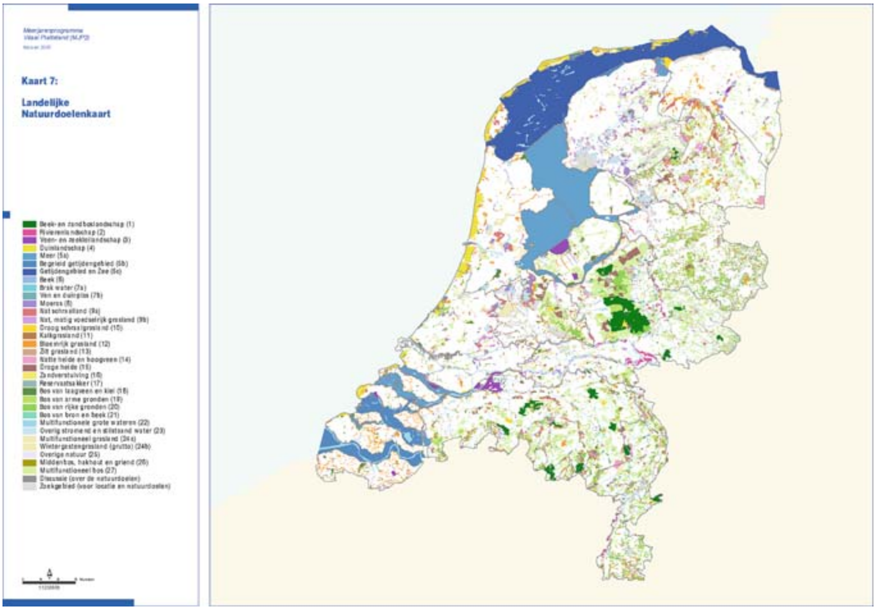


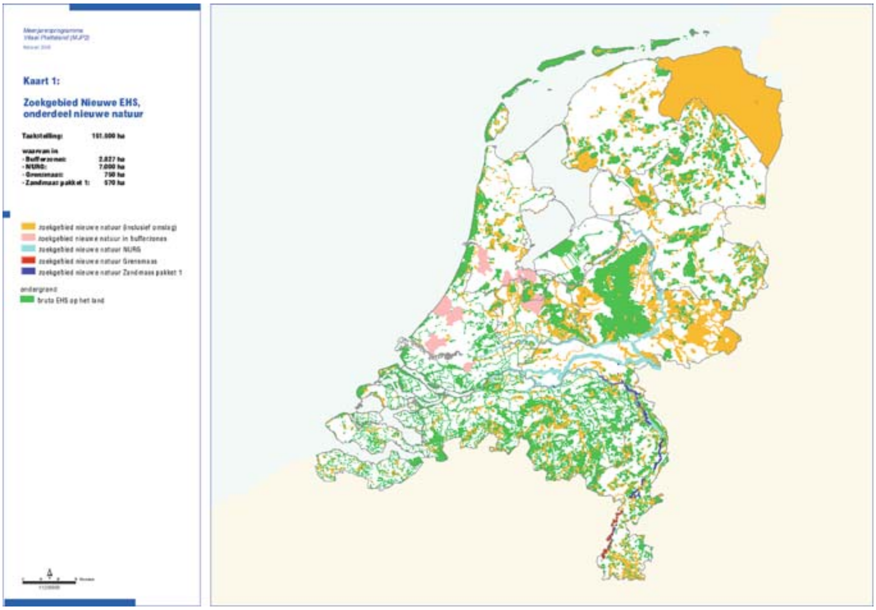
Fig. 5.7 Ecological goals in the Netherlands (Source: Ministerie van LNV, 2006)

Every area in the Ecological Main structure has its own ecological goal (Fig. 5.7), which describes the desired nature quality of the location. If the ecological goals are reached and the areas form a coherent system, the Ecological Main Structure is finished. In 2018 the Ecological Main Structure contains 728,500 ha, which is around 17.5% of the entire Dutch surface. The aim is to have realised in 2020 around 750,000 ha. Most of this Structure exists in the form of forests and nature areas, which will be added by new nature and wet nature (Fig. 5.8). According the regulations around the Ecological Main Structure more or less 150,000 ha of agricultural grounds are replaced with nature (Ministerie van LNV, 2006).

In order to prevent nature areas to become isolated, connections are necessary, which provide species the possibility to return after leaving an area due to illnesses. Connections improve the exchange of different species and it supports a good health. These robust connections add 27,000 ha new nature (Fig. 5.8).

The Ecological Main Structure is built up out of core areas, nature development areas and connections:

- Core areas are nature reserves, estates, forests, large water areas and valuable agricultural culture landscapes with a minimum size of 250 ha;
- Nature development areas are areas with good perspectives to develop natural values of national or international interest;
- Connections are areas, which connect core- and development areas with each other.



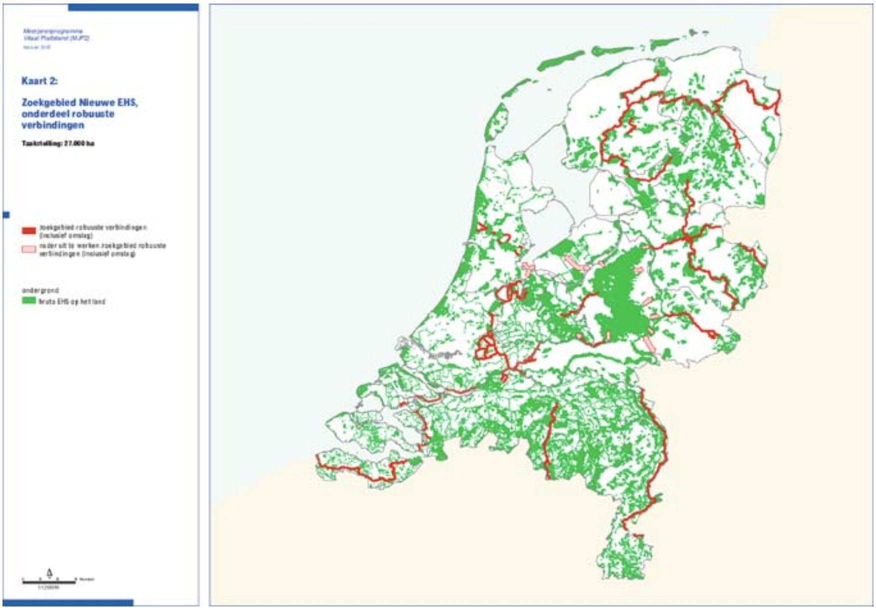


Fig. 5.8 Search maps for new nature (*upper*), robust connections (*middle*) and wet nature (*under*) (Source: Ministerie van LNV, 2006)

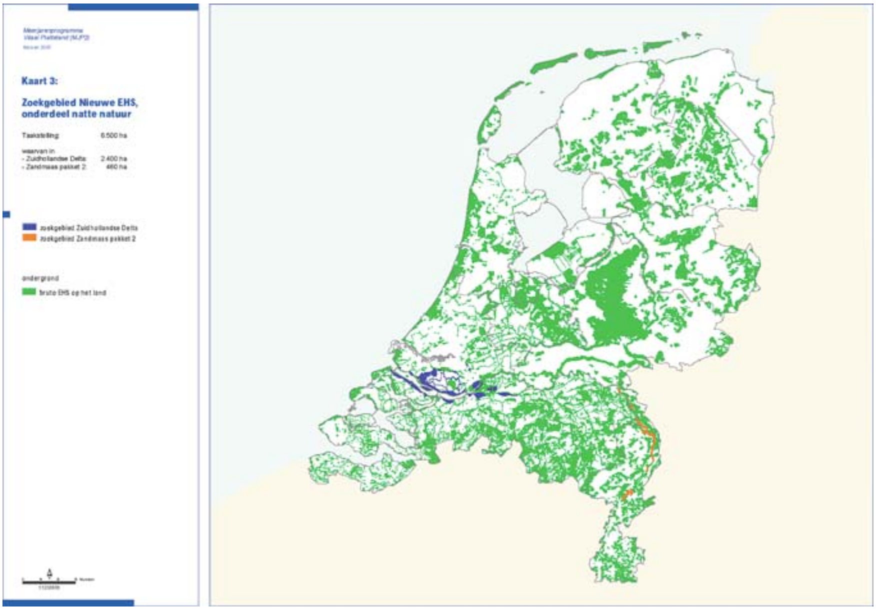


Fig. 5.8 (continued)

The aim is to connect the Ecological Main Structure with foreign ecological structures.

The realisation of the Ecological Main Structure is tough, due to landownership and debate on the exact boundaries of nature areas. Beside this difficulties in the execution, the question may be raised how the ecological structure as planned behaves under changing climatic conditions. If climate zones are shifting and new species enter a certain area, these ecological structures need to adapt as well. Probably, the Ecological Main Structure is not able compensate the negative effects of climate change entirely. In that case, added measures are necessary (Alterra, 2006).

5.4.2 National Landscapes

Natural landscapes are landscapes with internationally rare or unique and nationally characteristic landscape qualities. The landscape, cultural-historic and natural qualities must be safeguarded, sustainable maintained and, if possible, strengthened. Preservation through development is the slogan within the national landscapes (Ministerie van VROM, 2006a). The landscape qualities are steering the developments in the area. Spatial developments are possible, but only if the landscape qualities can be strengthened. The provinces are responsible for implementing the policies regarding the exact boundaries and core qualities of the national landscapes.

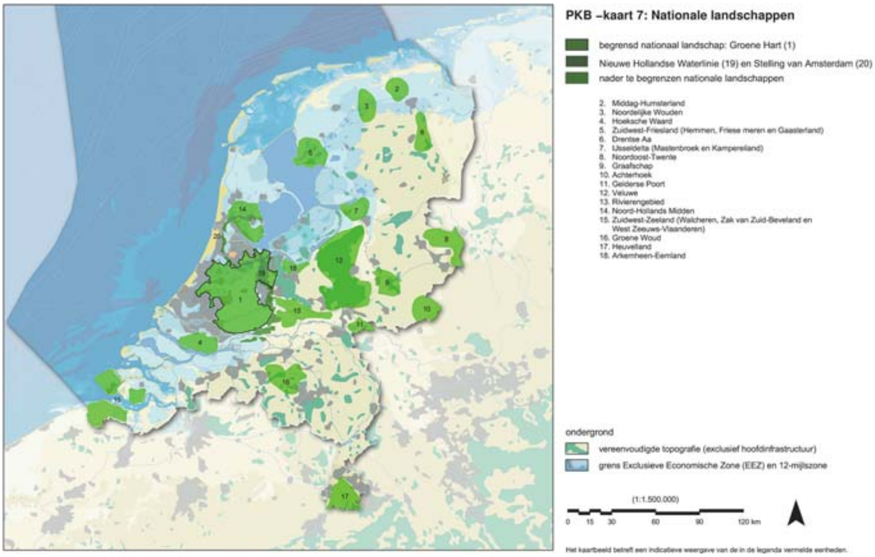


Fig. 5.9 Location of the national landscapes (Source: Ministerie van VROM, 2006a)

Nature areas contribute to the characteristics of the national landscapes and the recreational and experience values. The development of ecological structures takes place in harmony with the are-specific landscape qualities.

The central government decides on the choice for the different national landscapes (Fig. 5.9).

The Ecological Main Structure and National landscapes offer certainty on the future status of areas. The areas are exact bound and there is little doubt, once realised where exactly the areas are located. For current species this is a sound approach. Knowing which species seek for a certain environment, the connected Main Structure as well as supportive national landscapes helps protecting existing ecological values. However, if climate changes relatively rapidly, the same question can be posed as regarding the effectivity of the directives. A spatially fixed pattern of ecological structures might conflict with future demands of species, which move northeaster ward and enter areas, which probably fit suboptimal.

5.5 Effects of Climate Change on Nature

The effects of climate change are felt everywhere. The nature will have to deal with new species and several existing species will meet more difficult circumstances. Nature has always been dependent on the weather. Factors, like enduring rain, extreme heat or long droughts influence the ecological quality of nature. It is obvious that the changes in climate will accelerate the upcoming decennia. Nature will have to adapt more and faster than before. I history, nature has to deal with weather

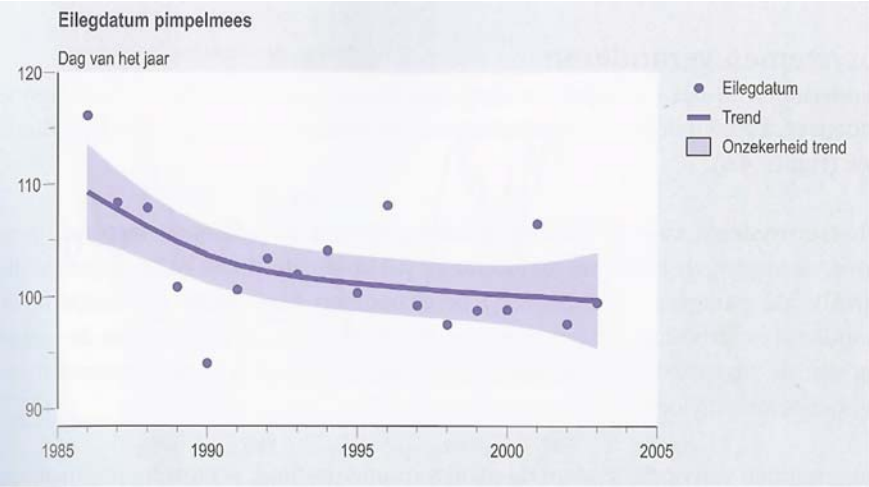


Fig. 5.10 Date of egglaying of the Blue tit (Source: MNP, 2005)

incidents. The changes in climate developed in a pace that big adjustments were not necessary. Nature copes with the incidents and went on functioning like it did before. With the upcoming expected fast changes in climate this attitude is no longer possible: the incidents of before ‘are’ the climate today.

Changes in climate might influence nature seriously. The rise of temperature and the increasing happenings of extreme weather events change the seasons: spring starts earlier and the winter starts later. Bird lay their eggs earlier (Fig. 5.10), migrating species arrive earlier and depart later and spring flowers will bloom earlier. Because the shift in spring is not for every species the same, the food chain might be disturbed. At the same time, species are shifting slowly towards the northeast (Fig. 5.11). In the Netherlands regular species and the species from the south will increase, while northern species and rare species will decrease. Many species are not capable of following a shift of climate zones of 400 m in a century. This results in a threat of extinction for several species.

5.6 Sensitivity

In the Netherlands the sensitivity for climate change for different ecological typologies has been mapped (Blom et al., 2008). Those sensitivities, which are especially important in relation to climate change, are drawn on these maps. Figure 5.12 gives the maps for the disconnections in the ecological main structure of the Netherlands and the existence of cold-loving species. The most disconnections can be found in the southern and eastern parts of the country. The same pattern is found for the existence of cold-loving species.

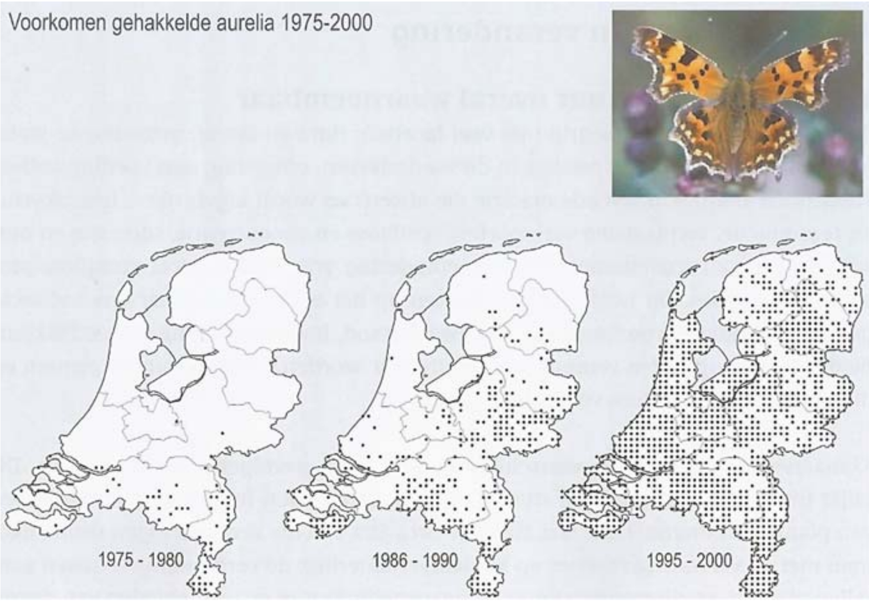


Fig. 5.11 Shifting of the presence of the butterfly ‘gehakkelde Aurelia (Polygonia c-album)’ between 1975 and 2000 (Source: MNP, 2005)

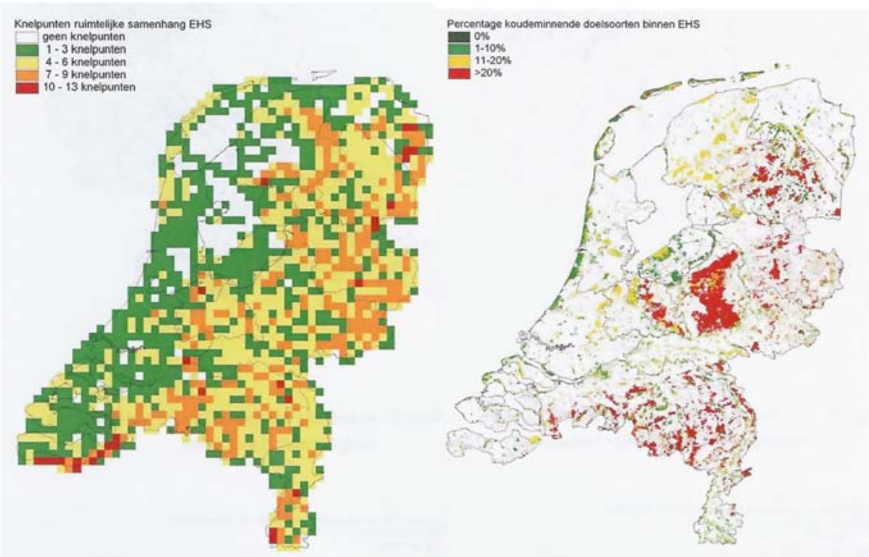


Fig. 5.12 Disconnections in ecological structure (*left*) and existence of cold-loving species (*right*) (Source: Blom et al., 2008)

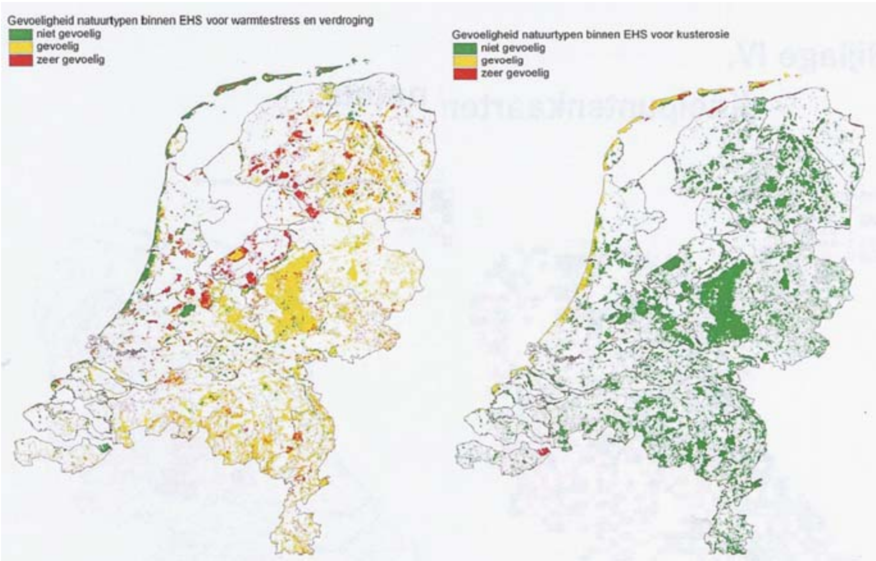


Fig. 5.13 Sensitivity for heat-stress and droughts (*left*) and coastal erosion (*right*) (Source: Blom et al., 2008)

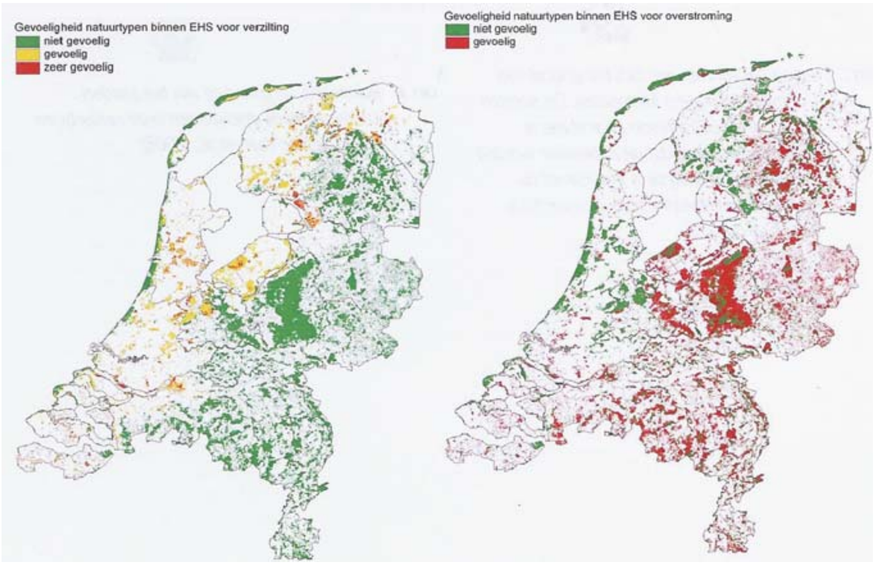


Fig. 5.14 Sensitive areas for salination (*left*) and floods (*right*) (Source: Blom et al., 2008)

The sensitivity patterns for heat-stress and droughts as well as sensitivity for coastal erosion is shown in Fig. 5.13. The most sensitive areas for heat and drought are found in peat bog and marine clay areas (Fig. 5.13, in red). Within the higher grounds especially the peat-moor, wet heather and brook-valleys are very sensitive.

The most sensitive areas for coastal erosion are limited to tidal zones (marsh and salting) and dunes.

The areas, which are most sensitive for salination and for floods are represented in Fig. 5.14. Peat-bog swamps and marine clay areas are very sensitive for salination, while the higher sandy grounds are sensitive to floods from surface water (brooks and rivers).

If all distinct sensitivities are integrated, the most sensitive areas for climate change in the Netherlands can be drawn on a map (Fig. 5.15). Examples of

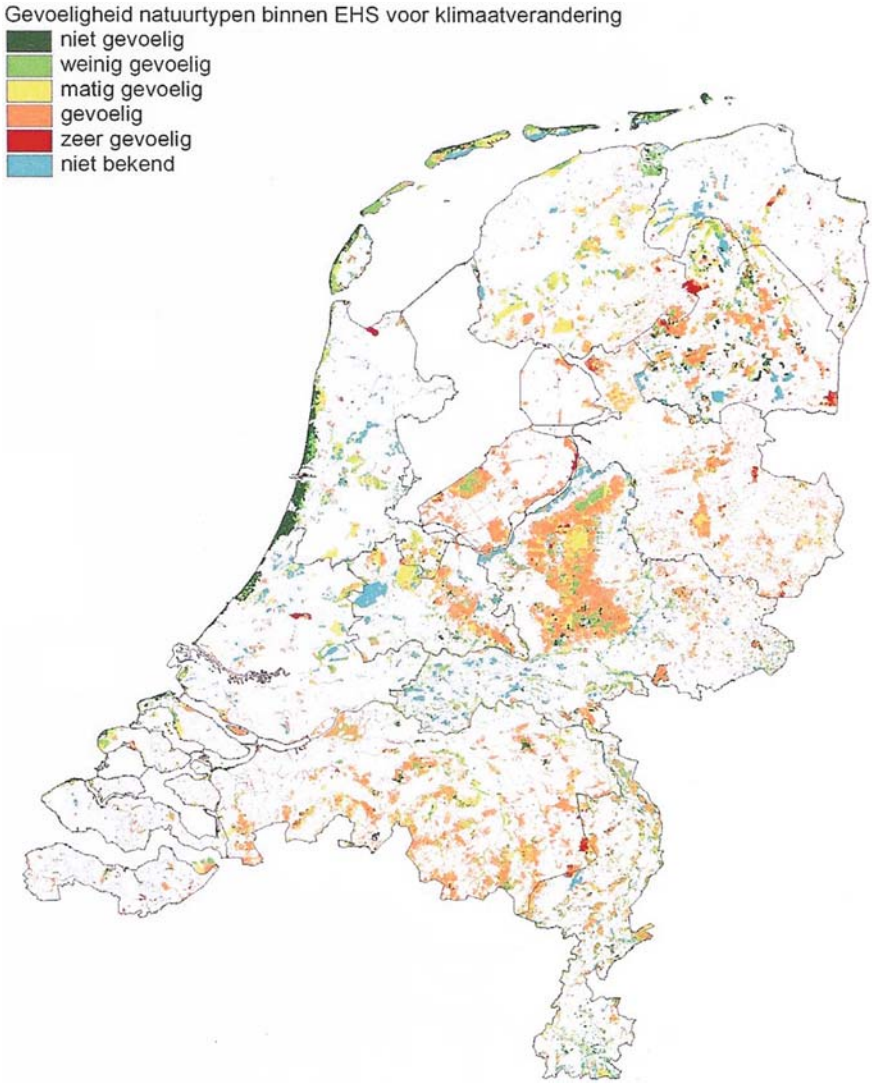


Fig. 5.15 Ecological sensitive areas for climate change (Source: Blom et al., 2008)

ecological types, which are very sensitive for climate change, are wet heather, peatmoor and freshwater lakes on marine clay. Furthermore, sensitive types can be found in large units at higher sandy grounds. The method of integrating sensitivities of different ecological types leads to a combinatory of sensitivities for different effects of climate change. Because of that, only types, which are sensitive to more effects, remain on the map. Types, which are very sensitive for only one effect of climate change are scored less sensitive on the integrated map and disappear. The question may be posed if it were not better to simply add up all very sensitive types in the map. The effect would have been that a larger area is sensitive for the effects of climate change.

5.7 Dilemma: Strict Rules or Flexibility

If the effects of climate change lead to shifting ecological zones, like illustrated in Fig. 5.16, the question may be raised if existing policies in the form of directives, Natura 2000 and a concept like the Ecological Main Structure are able to follow the changes and provide nature enough space and flexibility to deal with climate change.

If the directives, Natura 2000 and the spatial policies are analysed these instruments show little possibilities to constantly adapt regulations, standards or spatial outlines. And due to climate change this flexibility is exactly what is needed for species to be able to move along with shifting climate zones. The future location and habitats for moving species and ecosystems are to a certain extend unpredictable. And because the regulations use predictability, like the rule to protect the existing species and habitats and the exact definition of ecological spots, as a starting point a misfits appears between demands of the future and fixed rules of today. Therefore it is hard to create a climate proof ecological structure and obey the directives and spatial patterns at the same time. Hence, if the regulations are securely sustained, a climate proof development of the ecological system is obstructed. New strategies need to be developed in order to create the opportunity for nature to move along with changing climate zones.

The Netherlands seem the best example of a high density of people and functions, where it is necessary to formulate quite exact regulations and decisions on the strict defined exact locations for the Ecological Main Structure. In such a situation regulations need to be very exact and become oppressing. Here, the adaptation of nature to climate change is extremely necessary, but the space to do so is smallest. Therefore, the Dutch situation and solutions is taken as an example how a region can deal with this dilemma.

5.8 Adaptation Strategies

Spatial adaptation strategies aim to take advantage of the possibilities, which are provided by climate change as well as to increase the resilience and the ability to recover of nature. Therefore, it is necessary to shift from a static, protecting,

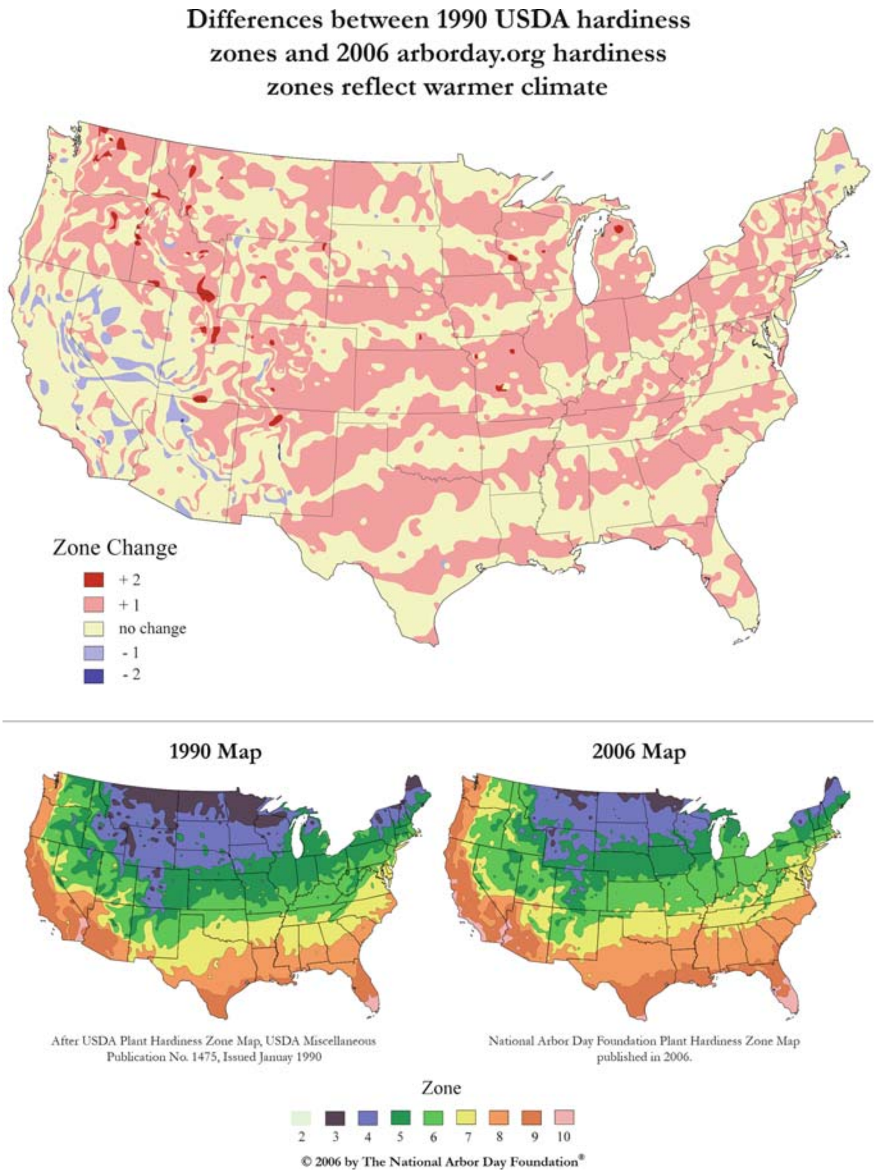


Fig. 5.16 Shifting ecological zones in the US (Source: Committee on Ecological Impacts of Climate Change, 2008)

ecological policy to a dynamic strategy, which focuses on the resilience of ecosystems and the capability of species to recover (Vos et al., 2007a). In this strategy resilience and recovery need to be translated into spatial dimensions. The ecological main structure and its surroundings need to be adjusted according these principles and the objectives need to be changed: from rarity of species to an approach based on the functioning of the ecological system. Then, a stronger and more integrated role of nature in spatial planning can be reached. Several spatial strategies are described (Vos et al., 2007b):

1. Improve the *spatial coherence* between the ecological main structure and Natura 2000 areas (nature reserves, which received a protected status at a European level, Bird directive and/or Habitat directive). The objective is to preserve species, for which climate becomes less suitable, in the best available areas and to provide areas where species, for which climate becomes increasingly suitable, can move to. Species are only capable of follow the shift of their habitats if new areas are within their dispersion range and if areas are large enough to support species in dealing with weather extremes. The spatial coherence of areas is very important to prevent species from regional extinction, which happens easier if areas are split up. The Natura 2000 areas do not form a connected network yet and this causes a difficult adaptation to climate change for many species. They are hindered to move and therefore they cannot follow the most optimal climatic circumstances (Change magazine, 2006a). The ecological main structure and robust ecological connections, which are additions to the ecological main structure in order to enlarge the spatial coherence between regions and offer less mobile species the chance to move (LNV, 2001), need to be connected with international ecological zones, areas need to be enlarged and small areas need to be connected with each other;
2. Spatial measures at area level in order to increase the *resilience* of ecosystems. The objective is to sustain biodiversity at current level. Ecosystems are better equipped to deal with changes in species interactions and increasing disturbing events. Enlargement of nature areas and internal heterogeneousity offers space to species and improves the ability to recover;
3. Adjust *abiotical conditions* in nature reserves. The objective is to offer more space to natural processes in nature reserves and to solve changes in water and nutrients availability. If climate change causes changes in the existence of nutrients, ecosystems become eutrophic and become rougher: biodiversity decreases. Climate change affects the availability of water also: droughts as well as inundation in case of extreme rainfall. Space needs to be created to provide area for increasing dynamic in water patterns;
4. Creation of a multifunctional *climate mantle* (Fig. 5.17) around the ecological main structure. The objective is to develop functional connections between the ecological main structure and the surroundings. The resilience and recovery capacity of the landscape is improved. The climate mantle provides the space to relief pressure from recreation or environmental hazards on the ecological structures. Finally the mantle offers flexibility to deal with unexpected climate change. The climate mantle is a zone around the ecological main structure, consisting of cultural landscape and capable of increasing the climate proofing of the ecological main structure. In the mantle nature is mixed with water functions, agriculture and recreation. The green-blue veined landscape offers risk reduction for the effects of climate change, like floods or plagues and is capable to store water;

Fig. 5.17 Example of a climate mantle (Source: Vos et al., 2006)

5. Nature as an integrated part of *multifunctional spatial developments*. Te objective is to integrate nature in spatial decision-making at all levels of scale. Nature is able to serve as relief bringing function in times climate change affects all other spatial functions, like living and working. This may lead to a flexible coastal defence using natural processes, control of water dynamic in catchment areas using nature as a sponge or nature in the city as bearer of the quality of life and the power nature has to fixate CO_2 and thus contributing to mitigation of climate change;
6. Increase the *learning capacity* and dealing with uncertainties;
7. A new *vision* on nature in spatial planning.

The National Environmental Assessment Agency formulated slightly different strategies (Groot et al., 2006):

a. Design and Implementation of *ecological networks* (green corridors and ecological zones). Considering the expected speed of future climate changes, there will be little time to adapt to new conditions within the present home range, both behaviourally and/or evolutionary. Without special measures, extinctions of local populations are very likely to increase. Often due to the isolation of most nature areas, migration and adjustment of distribution ranges will be difficult for most species. The establishment of green corridors and ecological zones are very important to support adaptation of species especially those with low migration capabilities (Groot and Ketner, 1991). Ecological networks are a set of ecosystems, linked through robust corridors, providing space for species and allowing them to easily shift their habitat. The Ecological Main Structure has been designed with the main purpose of restoring natural ecosystems lost during the past years as a consequence of human actions. Although the Main Structure was not originally meant as a climate adaptation measure, the creation of the Structure can enhance the adaptation capacity of species to climate change. The current design of the ecological network should therefore be reconsidered to take better account of the pressures imposed by climatic change. It is very important to improve existing corridors between green areas, and establish new ones, to allow plants and animals, especially those with low migration capabilities, to follow favourable environmental circumstances. New corridors can be created through rehabilitation of degraded areas or conversion of areas, which were used for other purposes (e.g. agriculture);

b. *Protected Areas* should be screened on their suitability under changing climatic conditions. In general, climate change will lead to more instability in nature, which requires more 'adaptive management' and more space for species to allow them to adjust their distribution and/or phenology to changing environmental conditions. The selection of sites should focus on areas, which have the highest potential to provide suitable habitats to threatened species under changing climatic conditions. In Europe, this will usually be to the north of the current distribution limit of the species (Groot and Ketner, 1991). In order to increase the robustness of ecosystems, it is also necessary to adjust management strategies for protected areas, e.g. to ensure certain environmental conditions, take into account pest-control measures or adjust water management. New protected areas can be developed through acquisition of land and change in land use;
c. Adjustment of *mix of tree* species. The dispersal rates of trees is very slow compared to the expected speed of climatic changes and corridors may not be able to counteract the negative effects on some tree species, calling for active afforestation measures. Afforestation can contribute to create new green areas and increase the robustness of existing forest ecosystems. New forest areas will also counteract the loss of forest caused by excessive drought in summer. When planting a forest, particular attention should be given to the selection of species. Adjustment of forest management can occur in already existing forests for the main purpose of decreasing the vulnerability of the ecosystem. For example a switch from single-stand to mixed forests, a switch from drought sensitive species to more resistant species and the use of a more broad range of species will help to spread the risk of possible negative effects.
d. *Artificial translocation* of plants and animals is proposed as a way of preserving species under climate change. They also emphasize the importance of using various management approaches according to specie's climatic tolerances and dispersal abilities. For example, for the conservation of many mammals, artificial translocation may be more useful than the creation of large-scale migration corridors; whereas wind-dispersed plants may be best conserved in disjunctive reserves aligned in the direction of projected climate change.
e. Although not meant as an adaptation strategy to climate change, *agri-environmental schemes* could contribute in maintaining a variety of valuable semi-natural habitats, maintaining or increasing species richness and thus enhancing the resilience of the natural system against climate change. These measures, however, are not always effective in conserving and promoting

biodiversity. A more accurate design of the measures is needed in order to obtain positive impacts on biodiversity. Kleijn and Sutherland (2003) suggests that in some cases agri-environmental schemes that aim to protect biodiversity in extensively farmed areas can be more effective than those aiming to improve biodiversity in intensively farmed areas; in some cases the success of the scheme may depend on the motivation of the farmers and on the amount of support, feedback, encouragement and supervision that they receive.

f. *Integrated water management* for ecosystems. The Dutch water policy recognizes the necessity of dealing with changes in water levels. Sea level is expected to rise as well as peak discharges of the rivers. Moreover, there is the necessity of storing water from heavy rains and counteracting drought, both likely consequences of climate change. Next to safety issues, conservation of the ecosystems is considered an important goal. After the major floods of 1993 and 1995, traditional ways of managing water (i.e. building higher dikes) are not considered the best options. The notion of fighting against possible events like flooding is been replaced with the notion of adapting to changes. Instead of thinking of creating new heavy infrastructures, which have severe consequences for the environment, a new vision started to develop. Creating more space for water, besides increasing the water storage capacity and benefiting landscape, can offer space to plant and animal species. Appropriate water management can allow adequate storage of water from heavy rains and can help in counteracting drought, both likely consequences of climate change. However, it should be realised that existing natural habitats are likely to disappear when faced with increasing incidence and/or magnitude of inundations.

g. *Integrated Coastal management*. Sea level rise and flooding are main threats in the coastal areas, especially in low-lying areas. The following adaptation strategies can be considered:

- Re-establishment of the natural dynamics of the dunes. This can create opportunities for nature development and can reduce the risk of flooding, thus can prevent damages to the ecosystems;
- Use of natural areas (e.g. peat lands). These natural areas, besides enhancing the natural functions of the coastline, can increase the water retention capacity of the coastal zone, reduce the risk of salt water intrusion caused by sea level rise (Ierland et al., 2001) and prevent damage to the natural system.
- An expert group (CPSL, 2005) investigated some solutions for coastal protection and sea level rise in the Wadden Sea. Some of the measures combine the social and economic requests with the ecological function. They can protect valuable habitats and biodiversity enhancing resilience against climate change. Some measures considered are:
- Enhancement and maintenance of salt marshes. Salt marshes have a high ecological value since they constitute the habitat for several types of birds, for halophytic plant species and partly highly specialized invertebrate fauna (e.g. arthropod species).
- Development of mussel beds and sea grass fields. Besides helping to safeguard, on a local scale, inter tidal areas from drowning, this measure can

provide favourable conditions for other species and is therefore enhancing biodiversity.

8. *Restoration of ecosystems* directly depending on water quantity or quality. In autumn 2000 the EU Water Framework Directive (WFD) was published. The WFD does explicitly state that: '[it] contributes to mitigating the effects of floods and droughts'. Moreover, it also aims at 'preventing further deterioration and protecting and enhancing the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems'. Thus the WFD may be considered to be one of the means to enhance resilience of nature against any change, including impacts of climate change.

In order to increase functional connectivity, which aims to reduce further fragmentation across ecological networks in Europe, the following framework is proposed to implement the Birds and Habitat Directive (Kettunen et al., 2007):

a. Identify species and habitats of Community interest that are already impacted by or vulnerable to fragmentation and/or changes in climate space (using a proposed risk assessment framework);
b. Assess the functional connectivity requirements of vulnerable species and habitats, taking into account likely habitat fragmentation and climate change impacts where necessary;
c. Integrate functional connectivity requirements into ecological networks and generic habitat measures across the wider environment;
d. Implement connectivity measures through existing mechanisms, such as protected area management processes, planning regulations and policies, land-use policies and EU funding mechanisms.

It may be concluded that several adaptation strategies can be used to increase the adaptive capacity of the ecological system and create the possibility for species and ecosystems to move with shifting climate zones. In general the proposed adaptation strategies can be divided into two types of measures: measures to improve the quality and management within existing ecological areas and measures that are aiming to expand and connect ecological areas.

If the different adaptation strategies are summarised the following connections become visible:

The aim is to develop coherent ecological *networks en corridors*, which *connect* the *fragmented protected areas* within the Ecological Main Structure with those of Natura 2000. The *abiotic conditions* need to be improved, which are able to *increase resilience* of the areas and are able to *restore ecosystems*, depending on *water* quality and quantity, *forests*, *coasts* and as part of *agricultural schemes*. A *clear vision* on nature as part of spatial planning enables to formulate the areas where the ecological system need to expand, as a *climate mantle*, as part of a *multifunctional zone* or as space where *artificial translocation* may take place. Constant alertness on an ongoing adaptation to changing circumstances stays necessary. Therefore, increase of the *learning capacity* needs to be improved constantly.

5.9 The BRANCH Project

In the BRANCH project research is carried out on the required spatial adjustments to provide nature the chance to adapt to climate change. The main questions in the project focuses on the way climate zones are shifting and what the desired dispersion of biotic communities and species is. What are the bottlenecks if species shift? And how can the landscape be adjusted in order to increase the spatial coherence of nature?

In the project models were developed about the reaction of nature to climate change (Change magazine, 2006b). Potential living areas are put on maps and this makes it visible which area stays suited for a specific species, which area is a potential area for domestication and which areas will be abandoned by this species (Fig. 5.18). In the next step can be determined which part of the ecological network is climate proof and where adaptation measures are necessary (Fig. 5.19).

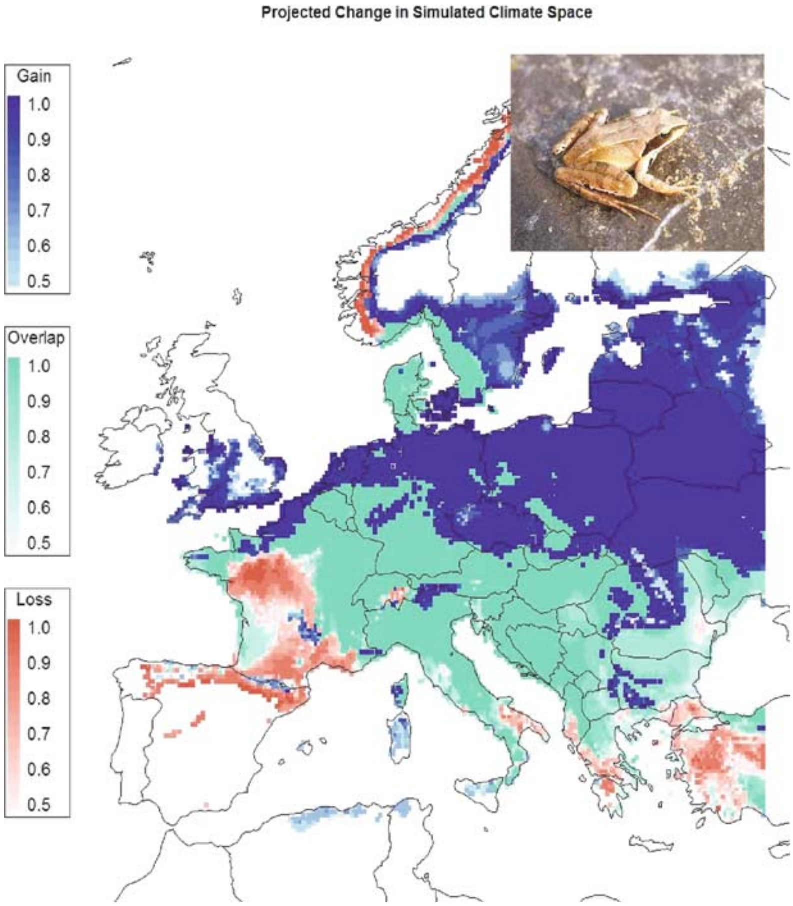


Fig. 5.18 Shifting of suitable climate zones for the Agile frog ('springkikker') (Source: Berry et al., 2007)

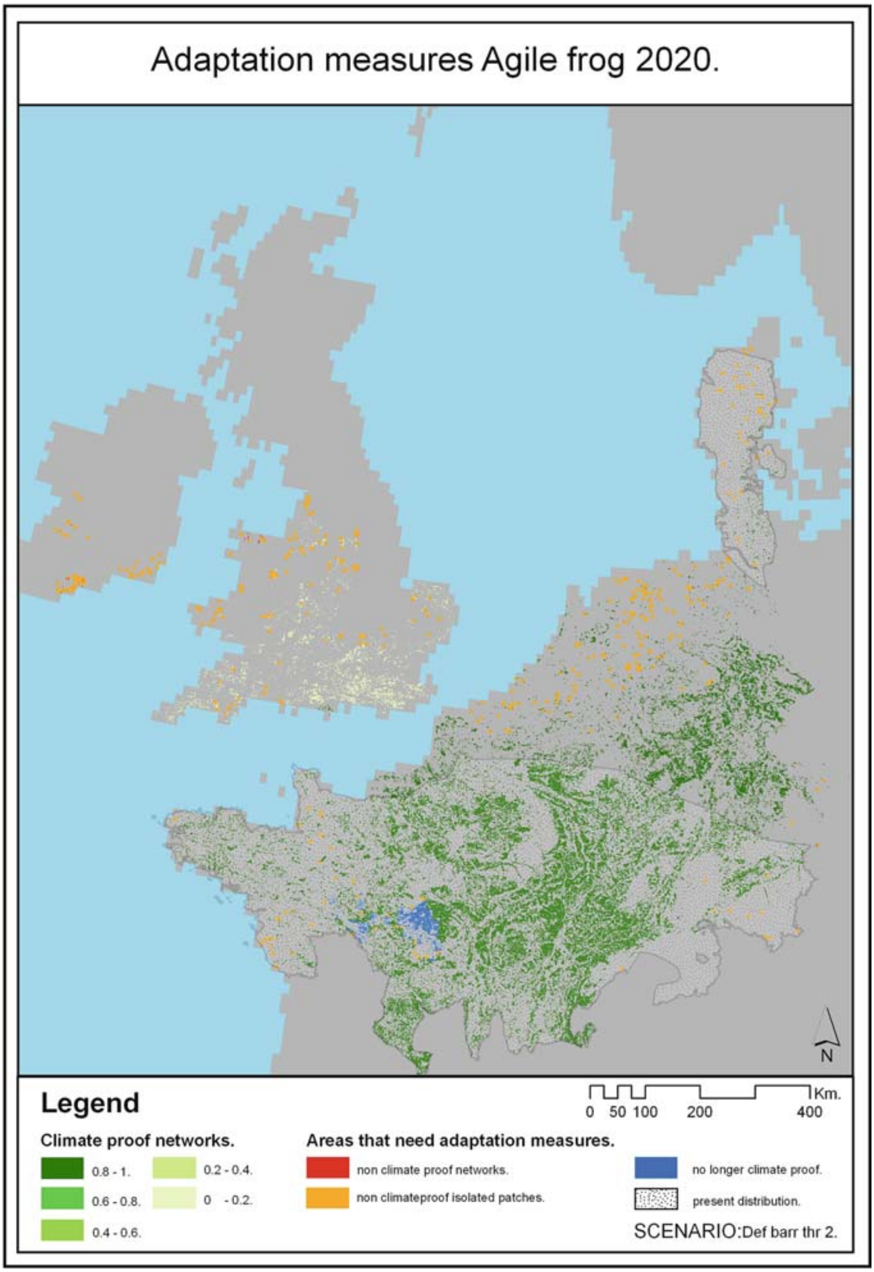


Fig. 5.19 Climate proof networks and required adaptation measures (Source: Berry et al., 2007)

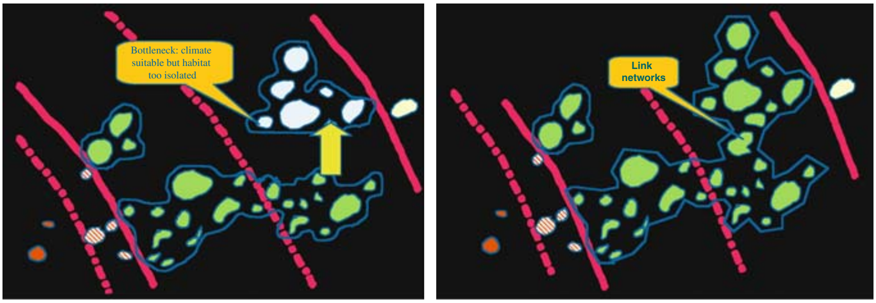


Fig. 5.20 Connection of networks (Source: Vos et al., 2007)

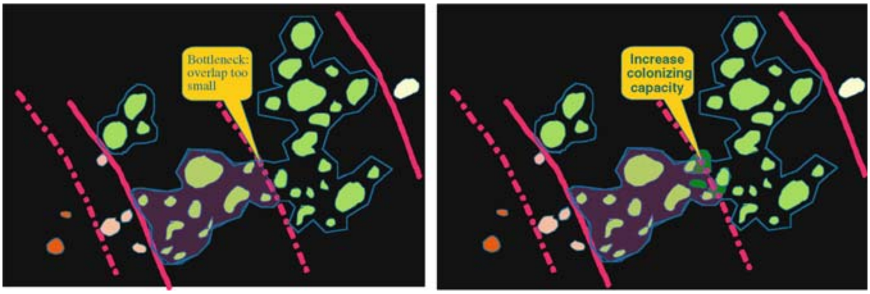


Fig. 5.21 Increase of capacity (Source: Vos et al., 2007)

Depending on the situation, planning options are developed in order to give nature the best chance to adapt to climate change. In a situation where climate is suitable but the area is too isolated networks are connected (Fig. 5.20). If the connection is there but the capacity of the area is too low to jump to a ‘climate suitable’ area, the capacity of the areas in the ‘link’ must be enlarged (Fig. 5.21).

Both strategies make it easier for species to move to new areas if the climate changes. The robustness of the ecological network and the amount and quality of connections determines the chances to survive.

The most important results in the BRANCH project are (BRANCH partnership, 2007):

- More flexibility is required in the Habitat directive;
- The connectivity between Natura 2000 areas needs to be increased;
- In spatial planning long-term developments need to be incorporated more strongly;
- At a regional level landscapes need to be created, which enhance species to adapt to climate change;
- At strategic locations new habitats need to be created as compensation for abandoned areas, due to climate change.

5.10 Use of BRANCH Principles in Groningen Province

The BRANCH principles were sustained in the province of Groningen. The objective was to define an ecological structure, which has de ability to adapt to climate change and compare the results with the existing ecological main structure in the region (Roggema et al., 2008). The first step in the planning process consists of defining the unique existing and potential nature reserves. The specific habitats for the area were chosen and for each specific habitat a so-called guiding species was picked. Not the species as such is important, but it needs to represent the ecosystem and habitat it is derived from. For every guiding species the required area and connections were calculated and positioned on a map of the region (Fig. 5.22). In some occasions the available area is not big enough to create enough habitat for an existing species under threat of changing climate or for a new entering species. In most occasions there is a lack of connections. The required measures to deal with a changing climate were sketched on the maps.

The next step is to link the desired measures for every guiding species with the existing water system. The specific situation and desired climate proof measures from a water point of view are easily combined and most of the time compatible with the proposed ecological measures. Every part of the water system is approached separate in order to define the best possible measures for the rarity and the role in the entire water system. Measures are defined for the Sandy brooks and ridges, Former peat-moor, Lower grounds and Marine clay area (Fig. 5.23). In the Marine clay area the main objective is to discharge water into the sea. This is easily combined with ecological aims to restore the marshes and to let water re-enter inland to start the natural process of a rising ground level. In the Lower grounds the main objective

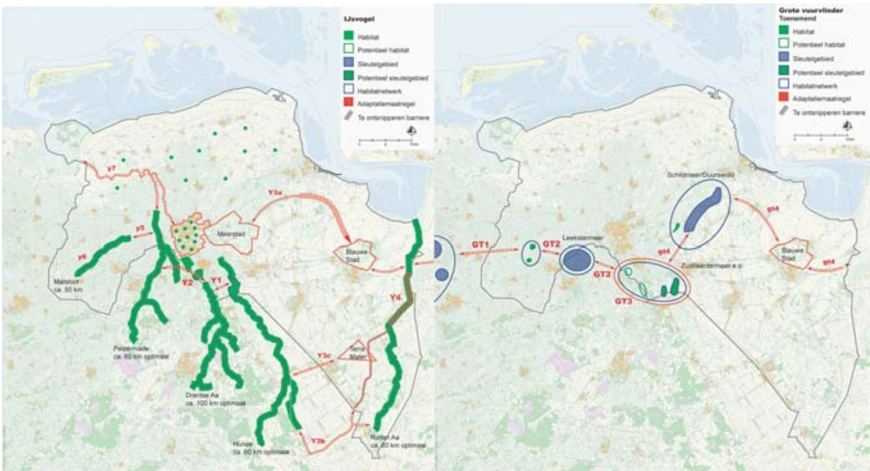


Fig. 5.22 Climate proof measures for the guiding species Kingfisher (Alcedo atthis, *left*) and Large Copper (Lycaena dispar, *right*) (Source: Roggema et al., 2008)

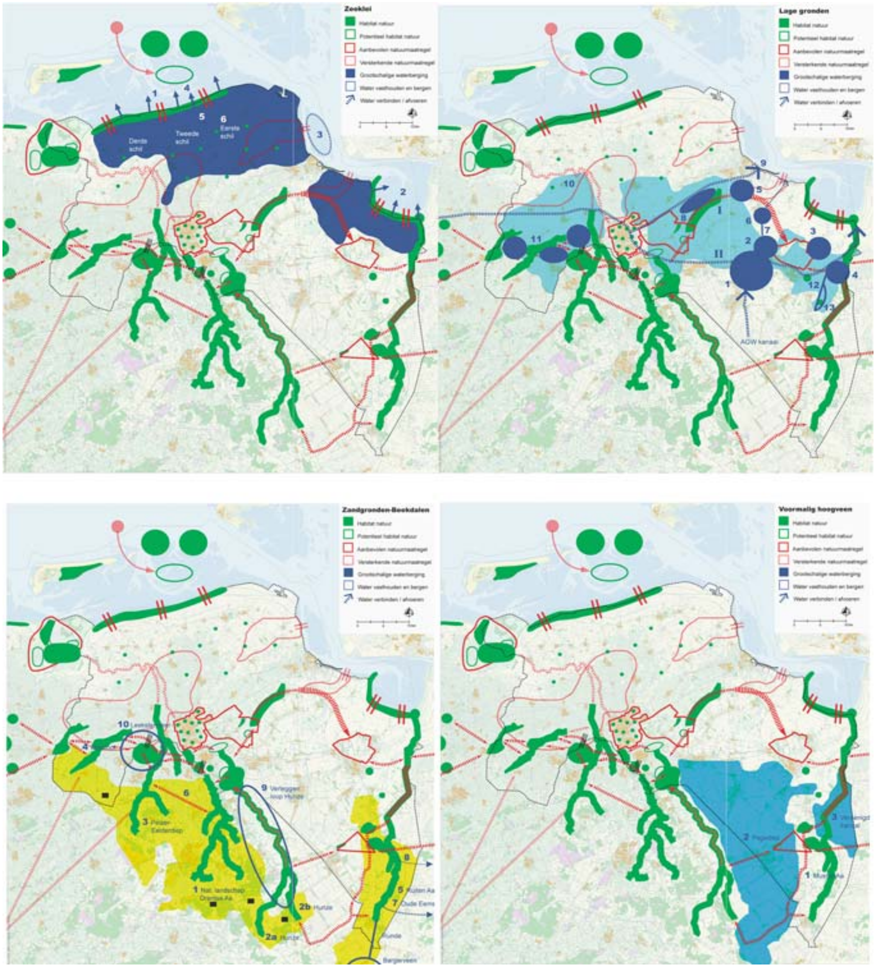


Fig. 5.23 Climate proof ecological measures connected with existing water system: Marine clay (*top left*), Lower grounds (*top right*), Sandy plateaus of brooks and ridges (*bottom left*) and Former peat-moor (*bottom right*) (Source: Roggema et al., 2008)

is to store as much water as possible. This can be combined with the ecological desire to create larger and more areas and connection of wet nature. The area of Former peat-moor is treated with a rational controlled water management system in order to provide the agriculture with enough water at the right moment. The most valuable areas of the Sandy brooks and ridges are treated as a sponge: keep as much water in the area and discharge it as slowly as possible. In these areas the ecological objectives to create wet brook nature and gradients are cooperative with the water aims.

If the climate proof ecological measures are integrated and drawn on the map they can be compared with the existing policy of the ecological main structure in

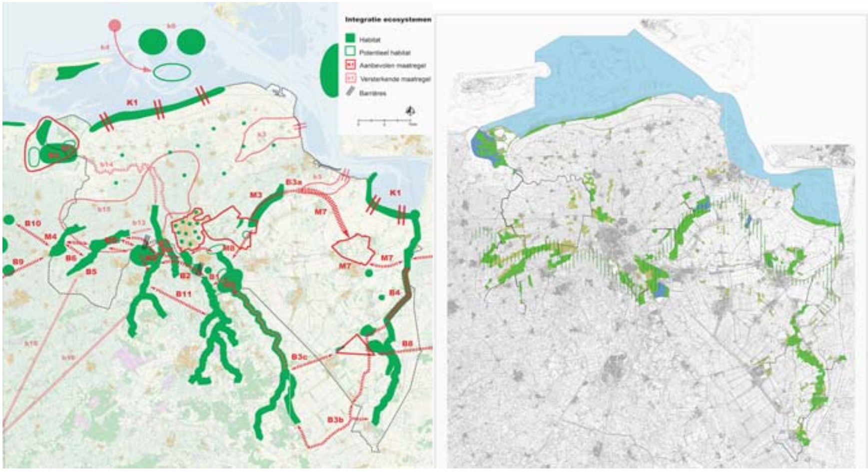


Fig. 5.24 All climate proof ecological measures (*left*) compared with the ecological main structure in Groningen (*right*) (Source: Roggema et al., 2008)

Groningen (Fig. 5.24). The similarities are visible, but there are also quite some differences between both maps. Especially the amount of connections is much higher in the climate proof map and generally the size of areas is larger.

The final step in the planning process is to overlap both maps in order to find out which additions must me made in future policy (Fig. 5.25). Again, connections and additions become visible.

The use of BRANCH principles in the province of Groningen illustrate that a climate proof ecology needs to be extended with square metres as well as with connections in order to provide both enough ecological capacity as well as increase the connectivity between areas. Taking these measures support species to shift along with climate zones, provide better chances for existing species and prevent species from extinction.

5.11 Climate Buffers

A specific adaptation strategy, which aims to define spatial solutions in the form of natural landscape shaping processes, which are able to increase the resilience of urban areas as well as the countryside and thus forming a buffer against climate change, protecting and sustaining existing functions and offering chances for new functions (Andriesse et al., 2007).

The cooperative nature organisations in the Netherlands developed a concept how spatial lay out and water can be adapted to climate change: the natural climate buffers (Bureau Stroming, 2006). This concept aims to anticipate on climate change. The changes that require most measures are in the Netherlands mostly related to water: protection against the sea and rivers and dealing with

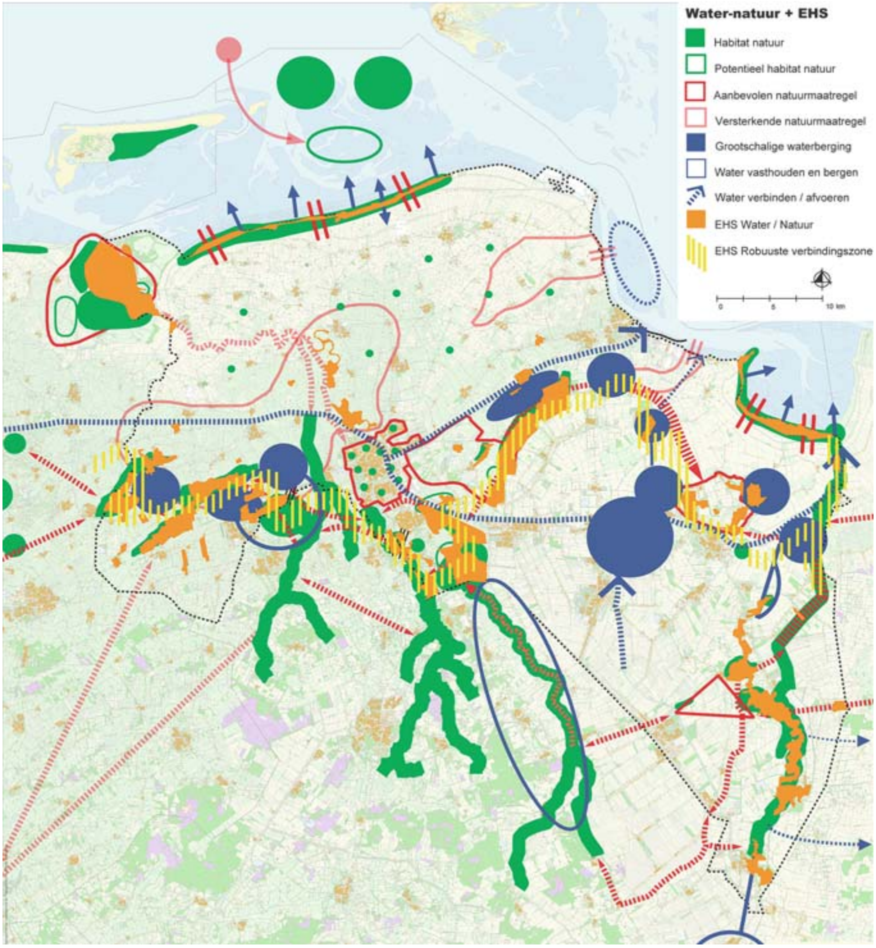


Fig. 5.25 Differences between all adaptive measures and ecological policy (Source: Roggema et al., 2008)

surpluses or shortages. A technical approach will become increasingly dissatisfying. The solutions of the future need to include the acceptance of risks and need to offer spatial changes. Safety measures need to strengthen the vitality of ecosystems and at the same time offer chances for economical developments. Climate buffers aim to provide such a solution, which add high qualitative multifunctional spatial measures to the landscape (Bureau Stroming, 2006). Climate buffers reactivate or revitalise natural landscape forming processes. They offer space for nature, housing, working and recreation and are capable of growing with the changes and the pace of climate change. They are applicable in any landscape type. In the Netherlands five different landscapes are distinguished: River landscapes, Estuaries, Dune landscapes, Lower

Table 5.1 Probable effects on landscapes without climate buffers

Landscape type	Natural functioning	Without climate buffer
River landscapes	Natural erosion and sedimentation lead to meandering rivers, with room for rivers	Room for the river is a good start, but more space is required
Estuaries	Recovering natural erosion and sedimentation and enough deliverance of sediment the estuaries can grow along with sea level rise	Dissatisfying deliverance of sediment causes lack of resilience against sea level rise and the existing buffer function
Dune landscape	Restoring of the natural increase of dunes contributes to the strengthening of the coastal defence	A fixed coast line diminishes the resilience of the coastal defence
Lower peat landscapes	Increase of groundwater levels supports the grow of lower peat and withstands soil subsidence	Increased soil subsidence, flood risks and salination
Higher sand and hilly landscapes	High water storage ability (sponge)	Less water is stored, increase of high river discharges and less water available in dry periods

Source: Andriesse et al. (2007).

peat landscapes and Higher sand and hilly landscapes. In Table 5.1 is shown for every landscape what would happen if climate buffers were not realised.

5.11.1 River Landscape

In the river landscape the measures consist of de-poldering and the removal of summer dikes, the creation of high tide channels and the lowering of the shore. This results in a flood plain. Upstream flowing storage can be used and new rivers may be developed. At the spring of the river measures, which increase the sponge function need to be realised. This requires international cooperation, because most of the time these areas are located outside the Netherlands.

Near the Biesbosch the river meets the tides of the sea. Originally, this area functioned like a huge and resilient sweet water tidal zone with creeks and channels. This made it possible for the area to move along with the natural dynamics and adapt to a rising sea level and increased river discharges. Because the tidal influence has disappeared, due to the disconnection of large parts of the Biesbosch from the sea, the area became static and loses its function to buffer for high tidal discharges. The natural dynamic of the area can be revitalised by creating a new high tide channel or the emergence of creeks and little channels in a natural way (Bureau Stroming, 2006). An example, where these principles will be realised is the Zuiderklip, which used to be the fourth dinking water basin in the Biesbosch area. The flood and tidal dynamics will be restored by the creation of a robust flowing channel (Figs. 5.26 and 5.27).

Fig. 5.26 Lay out of Zuiderklip (Source: www.dezuiderklip.nl)

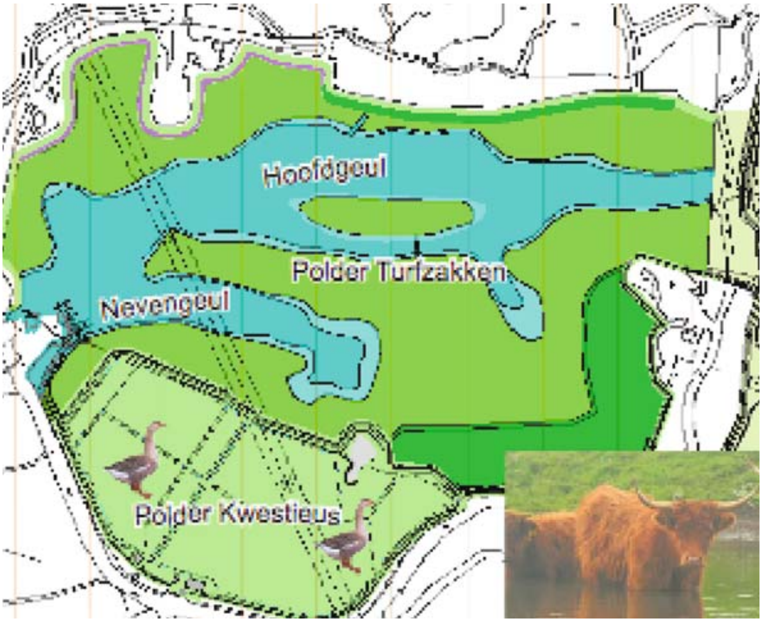


Fig. 5.27 Detail design Zuiderklip (Source: www.dezuiderklip.nl)

5.11.2 High Parts of the Netherlands (Higher Sand and Hilly Landscapes)

Even in the higher parts of the Netherlands climate buffers are applicable. For example by closing the ditches of the brooks in the spring area and regeneration of the natural vegetation, the sponge function increases. This way, the peak discharges in the brooks can be lowered. Downstream, the natural flooding dynamic of the brooks can be restored if the land use at the edges of the brooks is made flood-proof. Beside that the brooks can be re-meandered in order to revitalise the natural erosion and sedimentation processes.

The Weerter forest is an example, where these principles are applied (Fig. 5.28). The drainage ditches are filled up and the discharge of water is hindered as much as possible. This will result in the storage of water upstream the brooks and a high quality peat and marshland nature will emerge. On top of that, much water is buffered in the area in case of extreme precipitation, which leads to less water annoyance in Den Bosch and Eindhoven downstream.

5.11.3 Lower Parts of the Netherlands (Lower Peat Landscapes)

The lower parts of the Netherlands used to be characterised by growing solid by peat-formation and becoming dry land. This is why these areas were capable of growing with the sea level. Because of draining and poldering these natural process

Fig. 5.28 Weerter forest: existing situation compared with climate buffer lay out (Source: Ecobus, 2005)

Fig. 5.29 Polder Schieveen as climate buffer (Source: Bureau Stroming, 2006)

was turned off. The landscape was no longer capable of functioning as a sponge and of keeping the water in the area (Bureau Stroming, 2006), while this is even more important in times of climate change. A climate buffer is able to increase the sponge function in the landscape. If a large area of reed and sedge marshland is developed, the landscape is made capable of storing water and discharging it slowly. These marshlands function as a water resource in summer. An extra advantage is that the marshland cleans the water as well, which improves the water quality. The existing peat-meadows and the reclaimed marshland are the most suitable parts in the landscape to function like this. In these areas the functions follow the water levels instead of a water level that is adjusted to a desired function. More water can be stored and the landscape is capable of growing with a rising sea level again (Bureau Stroming, 2006). An example of this is polder Schieveen (Fig. 5.29), but there are huge possibilities in the eastern part of Groningen also, where the ground level is dropping as a result of gas depletion, by a partial inundation of the Dollard. The process of deposition is happening very slowly and it can be questioned if the pace is fast enough to compensate or reverse the dropping of the soil. In clay polders the supply of mud is stagnated and these areas are drained as well. This is the reason why here a fast soil dropping takes place. Water management is completely artificial and becomes increasingly complex. These areas profit from re-coverage of natural deposition, which enhances the ground level to keep up with the sea level. It is desired, if possible, to connect some polders with the sea and rivers. De-poldering is able to start this process.

5.11.4 The Coast, the Wadden and Estuaries (Estuaries and Dunes)

In the coastal zone the rise of the sea level has a huge impact on the ability to protect land behind the dikes. Beside that, it hinders the free discharge of river-water towards the sea. On top of that, saline seawater penetrates deeper into the land by sea-arms and groundwater flows. Finally, the saltwater quality decreases because the supply of fresh water is hindered by sudden fluctuations, due to the increase of extreme peak showers. At the same time less sediment is available because the relation between river and sea is disconnected and the sea level rises faster (Bureau Stroming, 2006).

If climate buffers are realised these areas would be capable again to keep up with the sea level rise. To make this possible the areas need to gain net sediment, for example by the introduction of dynamic coastal management, restore tidal functions or create new dunes. Between the dunes a plain emerges, where the sediment is able to settle down. A coastal zone evolves instead of a coastline. Opening the coastline enhances the supply of sand and clay and therefore the land is capable to grow in the same pace as the sea level is rising. If living is required here, this needs to be realised on artificial hills (*wierden*). Spin-off of thinking in a coastal zone is that the strict separation between salt and sweet water is left behind and a rich variety of salty environments will emerge. Sweet water can be stored in sweet water basins in the dunes and by means of a brook-system can be transported to end-users. The Wadden Sea functions more or less in this manner already. However, Bureau Stroming states that the circumstances in the Wadden Sea need to be strengthened in order to improve the sedimentation process (Fig. 5.30). The flood dynamic may return if kwelders are restored, the living conditions of sea-grass fields, mussel and cockle banks are increased or free the development of dust dikes on the Wadden islands. Changing like this, the Wadden area is capable to keep up with the changes in climate and able to improve safety at the same time.

As Table 5.2 illustrates, climate buffers provide on many criteria very positive scores in contributing climate proofing the Netherlands. Not only the logical themes, like safety, nature and water benefit from the concept; also the economic and living conditions improve.

5.12 Conclusion

In order to protect ecological values European and National directives and policies focus on the protection of existing species or the preservation of the habitats they live. The directives are described in detail and the spatial translation of these policies are described exactly and localised in great detail. The result of this approach is a system, which seem definitely established and difficult to change. The future development of a certain area is determined by a once defined surface or the amount of animals. Politicians find it difficult to deviate from once made decisions, especially if these decisions were made with a lot of effort.

The attempts to fixate a certain future ecological value in a certain area, based on existing habitats and species becomes, with an increasing pace of climate change

Fig. 5.30 The Wadden as climate buffer (Source: Bureau Stroming, 2006)

more and more inappropriate. Other adaptation strategies are necessary in order to deal better with uncertainties. Alternative strategies, which facilitate flexibility and aim to strengthen the natural functioning of the ecological system, need to be used. These strategies focus on internal consistence and improving the ecological quality by the increase of the capacity and the strengthening of the connectivity. If the total capacity can be enlarged, for instance through a better connectivity, the chances are larger for ecosystems to survive under changing conditions and the chances are larger that areas are able to function in a natural way: natural landscape forming processes get the chance to develop the area and make valuable areas resilient against climate change, no matter which species makes use of the area in the future. Strong and strict regulations prevent this development from happening.

Table 5.2 Contributions of the landscape types to a climate proof Netherlands

		Type climate buffer				
Criteria		River landscapes	Estuaries	Dune landscapes	Lower peat landscapes	Higher sand and hilly landscapes
Primary effects	Water system	+	+	+	++	++
	Nature	++	++/+	++	+	++
	Safety	++	+	++	+	++
	Economy	0	0/+	0/+	0/+	+
Living environment	+	0	0	–/+	0/+	
Secondary effects	Living	+	+	+	+	+
	Recreation	+	+	++	+	+
Cultural-history	+	0	+	+	++	
Adaptability	Scale	0	0	+	+	++
	Time	0/+	+	+	+	+

Source: Andriesse et al. (2007)

References

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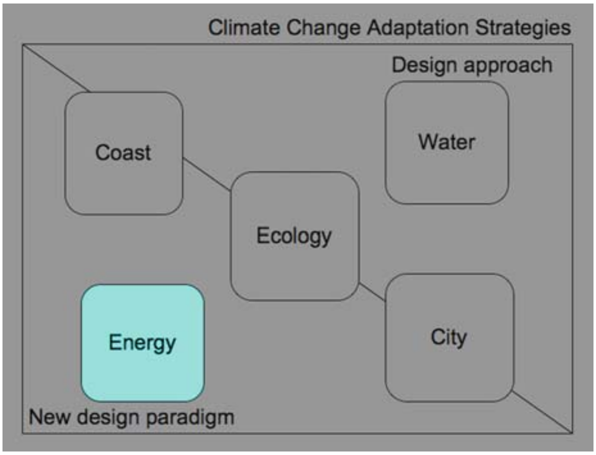
Chapter 6
Energy Potentials



Abstract The prices of energy are increasing and will do so in the future, mainly caused by a growing scarcity of fossil resources. High energy-prices will have severe impacts on society. For instance, the heating of a house or the costs for transportation will increase to a level, which affects daily life of all people. Those people, who live a long way from their work, own badly insulated houses and have low incomes are the first to notice difficulties. Part of the solution is to decrease the dependency on fossil energy resources. Only then the forces relation with high prices can be loosened. The way to decrease dependency on fossil resources is the production of sustainable energy at a local level, use this energy and, if there is a surplus deliver energy to the grid and earn money with it. In order to optimise the local energy production knowledge on the local energy potentials is required. The methodology of

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energy potential mapping (EPM) gives insight in the most efficient combination of sustainable resources, which can be used at a certain location. Because this mapping is area specific and gives the combination of energy resources, it is the key to spatial planning and design. Based on the energy-mix the design of landscapes and urban areas can be conducted.

6.1 Introduction

6.1.1 Towards a Sustainable Provision of Energy

Climate change and depletion of fossil fuels demand for a sustainable energy provision. According to the Dutch Ministry of Housing, Spatial Planning and the Environment (VROM, 1998) this will be the case if:

- All energy sources used are sufficiently available, now and in the future;
- The effects of energy consumption lastingly harmless to nature and mankind;
- Everybody has access to energy for a reasonable price.

These criteria demand for an energy system that is based on renewable or abundantly available sources, where affordable energy is generated by means of clean processes. One of the possibilities to do so is better deployment of local opportunities. This chapter will demonstrate the need for a more regional approach to energy and how local energy potentials can be systematically analysed. The main focus thereof is Sun, wind, water, biomass, waste heat and cold yet also clean types of fossil energy. The energy potentials – at which spot can which type of energy be yielded – can be charted. If they are subsequently superposed regional energy landscapes will evolve. These may form the basis for an energy-directed regional plan, proposing spatial interventions derived from energy potentials.

Energy in the Future City

At the conference Future City (6th of December 2006, The Hague) the following conclusions were drawn:

- It is recommended to become less dependent from other regions in the world, but entire self-provision is not necessary or desirable. Most achievable seems a ubiquitous grid that not only is based on central generation or distribution yet that can also be fed by decentralised, self-sufficient units.[1]

[1] In his speech to the Dutch industry – Aalsmeer, 14th of October 2008 – former US Vice-President Al Gore referred to this by 'the super grid' onto which everyone can upload and download energy and which should be connected to centralized solar plants in deserts.

- Centralised energy systems are suited for areas with high densities and a good infrastructure. However, we should also dare to develop decentralised systems at the scale of cities, districts, neighbourhoods and even individual buildings.
- We should shift from mono-fuel towards multi-fuel systems, for independence, operational safety and in order to gain more out of local potentials.
- Spatial planning should be directed by energy potentials on a local level and by considerations of exergy ('heat cascading').[2] Energy demand and supply should be functionally tuned and balanced.
- Hydrogen is a better medium for energy storage and transport than present alternatives. An economy based on hydrogen can be clean and efficient, as well as sustainable if hydrogen is sustainably produced. It is costly, though.

These conclusions for an important part converge with other studies (Timmeren, 2006; Noorman et al., 2006; Roggema et al., 2006b).

6.1.2 The Oil Price

Climate change is influenced strongly by the amount of greenhouse gases in the atmosphere. Especially, the concentration of CO_2 has increased over the last decades. This increase is mainly caused by the extensive use of fossil resources, such as oil and gas. The way the energy supply is currently arranged, on the one hand causes higher concentrations of green house gases, and because of this higher temperatures on earth, on the other hand our energy system is fully based on the use of fossil sources.

Depletion of the main reserves, additional to the demand explosion from countries as China and India, leads to uncertainty and, more importantly, a fast increasing price of energy. Figure 6.1 presents the historical development of the price of crude oil. A peak is visible following the two 1970s′ oil crises, but the recent climb is surpassing that one.

Figure 6.2 gives a more detailed image of the previous years. In 2005 oil prices were on a level of $ 50–60 per barrel and in 2007 experts debated whether the $ 100 barrier would ever be reached (Fig. 6.2). This graph does not show the devastating course after 2007. The steep increase continued and in May 2008 the price of crude oil peaked at $ 135. Due to the financial crisis that followed after the summer of that year prices dropped again, but experts expect a renewed climb to new heights within a year.

[2] This will be discussed further on.

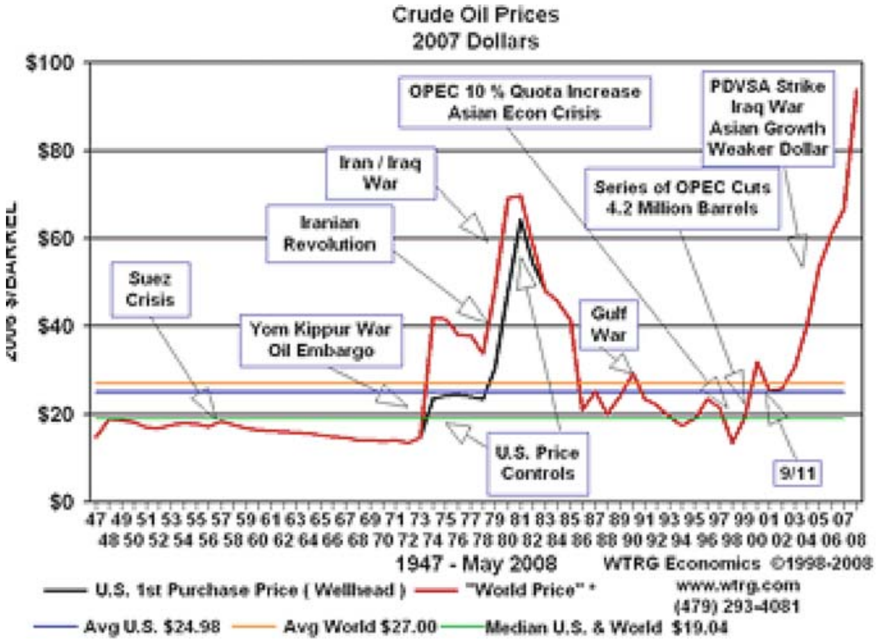

Fig. 6.1 The price of crude oil during the last 50 years (www.wtrg.com)

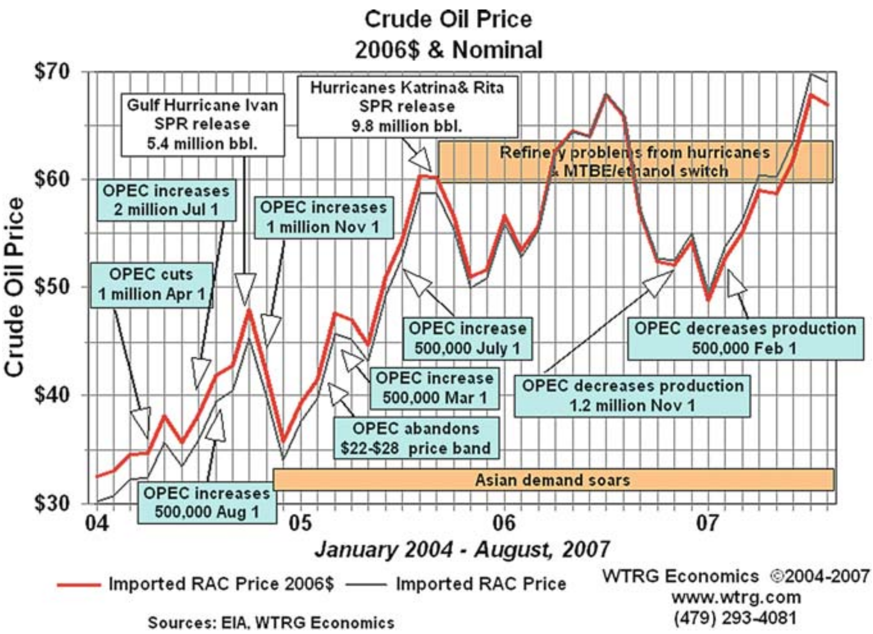

Fig. 6.2 The price of crude oil between 2004 and 2007 (www.wtrg.com)

These developments urge for answers. Development of a sustainable energy system is essential and becomes more urgent in the near future.

In their article, Williams and Alhaji (2003) argue that current times show strong similarities with the periods just before the energy crises in 1973 and 1979. Common elements include:

- Low oil stocks
- Declining US petroleum production
- Limited US policy options for Middle East
- Low level of oil industry spending
- High dependency on oil imports
- High import from a small number of suppliers
- Political turmoil in oil-producing countries
- Speculation
- Economic downturn

These elements can be seen in international developments of today. The rapid rise of oil prices makes it even resembles a crisis more (Fig. 6.3). In day-to-day practice these developments are underestimated and put aside as a future problem. Aims and goals of European, national and regional policies are moving in the right direction. The question is whether the objectives are ambitious enough or not and if they will be achieved in time.

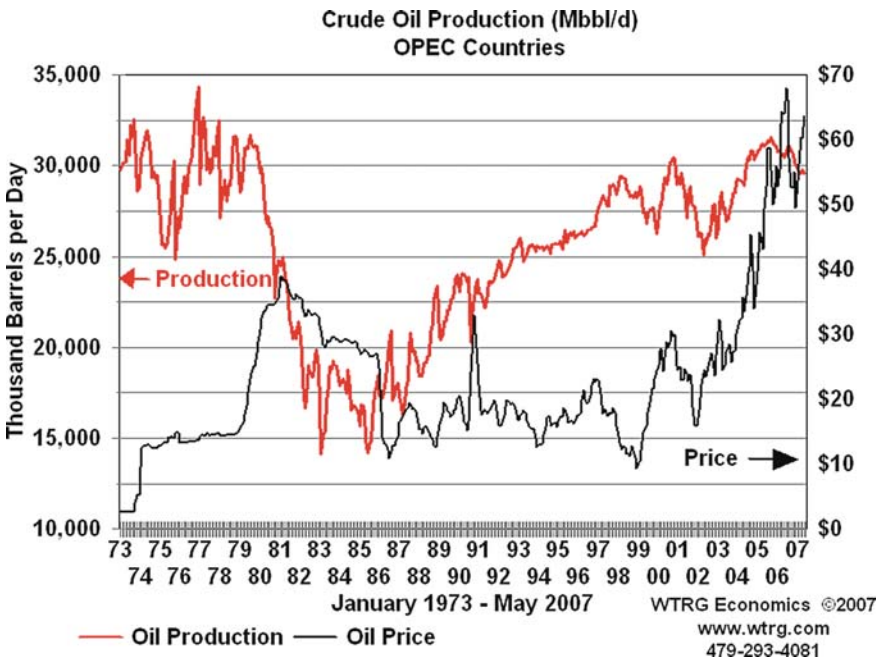

Fig. 6.3 Oil production and price since 1973 (www.wtrg.com)

6.1.3 Predicting the Price of Oil

The fluctuating prices of oil can be considered to be one of the most important issues of political and economic analyses during the last years. It is practically impossible to find any natural resource, which future price is as hard to predict as the price of oil. Unfortunately the prediction's hardness concerns not only the long-term perspective of the prices, but also the short term one.

According to the *International Energy Outlook 2002* the oil prices until 2020 would not exceed *$ 40* (International Energy Outlook, 2002. p. 26). After 3 years the *International Energy Outlook 2005* stated that in 2020 the maximum price for crude oil would be around *$ 50* (International Energy Outlook, 2005. p. 28). Finally, the *International Energy Outlook 2007* predicted an *$ 80* price for one barrel of crude oil in 2020 (International Energy Outlook, 2007. p. 30)

The main problem here is not the inadequacy of the predictions for 2020, but the fact that this article is written at a moment, when one barrel of crude oil costs more than $ 140 and that it is not possible to find data or analyses in 2007, which predict a $ 140 a barrel price for 2008. The inadequacy of price prediction has many explanations: the technical methodology used in energy outlooks and prediction studies, the instability of politics in the Middle East, speculations in world energy markets, etc. At the same time these explanations can not change the fact that producers and consumers of oil as well as scientists, who study the actual problems of energy policy and security, at best have only a rough notion about the future price of oil – a resource that plays an unprecedented important role in the modern world.

6.1.4 Consequences

It is obvious, that the accuracy of price predictions from the possible growth or decrease of world consumption is more than limited. The International Energy Outlooks mentioned above more or less succeed in the prediction of possible growth of consumption and in drawing up future prices from available data of the upcoming demand and production of oil. Even if the Energy Outlooks approximate future consumption exactly, the same Outlooks predict a price, which is far from being precise and practically realised.

This implies one very important thing: market mechanisms of pricing do not or almost do not work in the case of oil prices. This is a very serious problem in a situation when:

1. The market economy and market mechanisms of price regulations are considered to be the foundation of modern world economy
2. Oil remains a natural resource, which plays one of the most important roles in the functioning of world economy and modern society

One may call the modern economy transactional, post-industrial or capitalistic – which is a matter of methodology and ideology – but at the same time, everyone accepts that our modern economy's functioning is directly connected to energy resources and the most important of them: oil. This leads to a very frightening picture: the future price of this resource, which influences our lives and severely creates *the environment* of our existence, is not known.

It may be challenging to state here that the modern mechanism of oil pricing is mostly a stock-jobbing one. It is very important to understand why. Speculations in the world energy markets are not a new phenomenon and a speculative influence on pricing mechanisms has always been present and had many injuring results. However, speculations can hardly influence the pricing mechanisms if in one year the oil price rises by $ 40 or 50. The uneven pricing of oil must be considered a result of a more objective and more dangerous reality: the oil demand itself is stockjobbing. This means that the demand is out of market, predictions, growths and decreases. This stock-jobbing demand may be a result of two important realities of the modern international politics and economy:

- Absolute uncertainty about oil-producing regions. What will happen in Iraq? Will Washington attack Iran? Will Iran close the Hormuz Strait? Will Islamists take over power in Saudi Arabia? What will happen with Russian-American relations? Etcetera, etcetera. . .*Transferring the current situation from the oil market, for example, to the wheat market: wheat is bought without having any clear information about the situation, for example, in Canada, which is one of the most important exporters of wheat in the world.*
- The perception of oil resources exhaustibility became a reality. There is a clear perception that oil is an exhaustible resource. *Transferring this situation again to the wheat market: it seems that the buying of wheat includes scientific and speculative information on future perpetual droughts in world's wheat fields.*

This is what we call a stock-jobbing demand. It is hardly possible for the market to regulate this kind of demand. It is out of market. The market economy scheme – consumption decrease will bring about the decrease of demand and price – does not work and will not work here. This creates sound doubts, that national governments' steps to limit the consumption growth will not stop the rise of prices. This situation is a really great challenge, not only for the national or international economy, but also for social systems of the modern post-industrial part of the world.

The question may be posed here what is the best way to act in a situation when the price of an important natural resource is being formed not inside the market field? How should be acted, when the price of an important resource cannot be predicted? And one more important question: are national governments of developed and democratic countries around the world going to act pertaining the ideology, philosophy and methodology of the market economy, or should they regulate the prices with non-market instruments? These questions require adjusted answers, because these answers not only concern energy markets yet influence other spheres as well – governance, spatial planning and law.

6.1.5 Capitalisation of Land and Real Estate

Land and territories are not imported from the Middle East or from anywhere else. These are constant resources, which have their own price. Perhaps land,[3] territories and also real estate are limited but we know that they will never be final. Land and territorial resources are not exhaustible, and there is no rush over the willingness to get more land and houses as soon as possible, because soon there will be no land property or cottage to buy.

At the same time the price of the land and of a house depends on several factors. The most important ones include ecology of the area, the distance from an important centre for the buyer or a residential place, the social context, the correlation between prices in other places, comfort and prestige. These factors play an important role in every country and every region.

Prestige and (to a lesser degree) ecology are factors to be considered partly subjective and concerning people who have a high property qualification. *The middle class*, different in every country and having different incomes, *pays more attention to comfort*. The middle class buys houses, taking into consideration the income situation of the household and the expenses, which the housekeeping will provoke. For the majority of countries the main expenses are hut taxes and public utilities (electricity, gas, water, sewage, heating). It is well-known that these public utilities are power-consuming, and thus strongly energy-related, in every country. Hence, the cost of housekeeping and the *cost of life* in a house depend emphatically on *the cost of energy*. The oil component plays a huge role in electric power production and regulates also the price of the other important resource for electric power production – natural gas. This regulation will remain until an independent mechanism of gas pricing will be created. It is very doubtful if such a mechanism will ever be the case, since the main exploiters of natural gas want to keep the oil price mechanism connected to that of natural gas, especially when the prices of oil are rising.

With the current rising of oil prices domestic costs can be presumed to be undergoing an active transformation phase. This transformation will touch the interests, first of all, of the middle class, which consists of the majority and forms the backbone of developed societies and democratic states.

At the same time there are serious reasons to assume that the rising cost of housekeeping must be studied as a factor, influencing the real estate markets and the *mortgage services of the banking sector.* So far, no data are available on the changes in public utilities costs in the USA or EU during recent years. This kind of data is useful to assess the probable component of public utilities costs in the 2008 mortgage crisis in the USA or a sudden failure of the real estate prices in some European countries.

[3]Here we talk not about agricultural or industrial land, but about the one, which has spatial purposes.

6.1.6 Implications to Commuters

Oil prices influence also another aspect of real estate – its location. The costs of transportation also increase because of a high price of gasoline. The development of the oil price will influence every means of transportation - private car, public bus, train, taxi or other. The only way to become independent from gasoline prices is to walk or use a bicycle for commuting. But the majority of the people uses cars and cars use gasoline, which rapidly becomes more expensive. Higher prices of oil may limit the interest of people to drive, as it becomes too expensive. Late June 2008 the price of a gallon (3.8l) of gasoline in the USA was approximately $4 – a little more than 1 dollar for a litre (http://www.eia.doe.gov/oil_gas/petroleum/data_publications/wrgp/mogas_history.html). In June 2004 this price was half as high and in June 2002 one third. The International Energy Administration states that the average use of gasoline in the USA is approximately 7l per car per day (International Energy Administration – 2008 Annual Energy Outlook. June 2008). Thus, each car spends about $ 7 per day for a gasoline, which is more than $ 200 every month. But 7l a day is an average, including the consumption of people who rarely use their car and including cars of people from little towns, who drive only several kilometres a day. Far more relevant is the question how much a New York suburb resident, who works in the business centre or in a supermarket in the city, pays for gasoline every day. People, who use 20–30l for commuting, are far more common. These people spend $ 600–800 on gasoline every month. What do they need to pay if a barrel of oil will cost $ 250?

What are the possible effects of this situation? The car industry may face a real challenge, one such as GM faced during 2007, losing around 40 billions due to sales decreases. But this is not the only effect. The other – the more important one – is that it becomes ever more significant where you live, how far you are from your office and how much you pay for your transport to and from the city. For a person who lives in a small town around 30 km away from New York City and who works in the city and earns $ 5000 a month, it is more than inconvenient to spend $ 800–1000 for commuting. $ 1000 equals a mortgage loan interest payment each month for a $ 200000 loan from a bank at an incredibly favourable 5% a year for 20 years. The price for gasoline can be compared to the same sum of money you pay to the bank as a mortgage loan interest. It is a very interesting picture, because you indirectly pay a double interest cost for your house – *to a mortgage structure* and *to a gas station*.

The first study on this issue will be carried out in the Netherlands soon. For the province of Groningen the first version of a transport map (Fig. 6.4) depicts the socio-economic consequences of rising oil prices in a spatial way. The map visualises that certain regions, which are farther off from the central city, will face serious trouble. In these areas it will become too expensive to commute to the city on a day-to-day basis. This will affect real estate prices and migration from these places. The collapse of these areas, which in the case of the Groningen province are already relatively unfavoured sites for living, may be a serious issue for the coming years. The fact hat this has severe consequences for lower and middle class people makes it an important political issue.

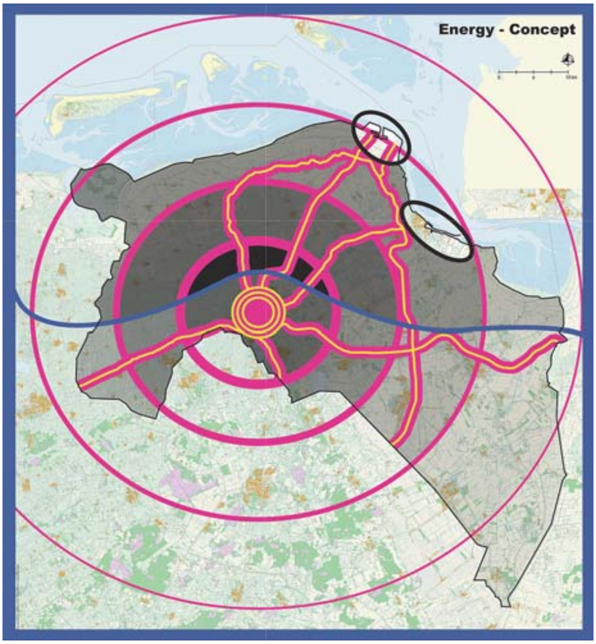

Fig. 6.4 A map of the province of Groningen, spatially showing the socio-economic effects of travelling distances to and from the city of Groningen (Source: Roggema et al., 2008)

6.1.7 Spatial Solutions

What can be done in this situation? There are some options for the mobility problem described. People may find a job in their own town, start to produce energy locally, as the American Institute for Contemporary German Studies recently suggested (Ochs, 2008), or they can *move to a village closer to the city*?

It is understandable, that this question becomes current for millions of people around the world. Not just in big countries, as the USA, yet also in the European Union – a region without borders and with extremely high gasoline prices. What will happen with the real estate prices in rural towns, if millions of people start to realise that they no longer want or *will be able to live* there any more? What will be the effect on the capitalisation of real estate and land? Certainly, the market mechanism will work better here than in the case of oil prices. A cut in demand will result in a collapse of prices, of the mortgage sector, constructional business and transport infrastructure, all of which play an important role in the life of cities and regions.

Gasoline prices in the EU are higher than in the USA, which deprives the European spatial planning advantages. In contrast to the USA, in the EU housing estates are closer to big cities but people have to pay more money for a gasoline. The data of June 2008 show, that one litre of gasoline on average costs € 1.40. Finland has the honour to bid the highest price (€ 1.53), whereas Romania demands the lowest (€ 1.10, still more than in the USA) (European Commission, Directorate-General for Energy and Transport). What will happen to the gasoline prices in Europe if the price of crude oil rises to $ 250 a barrel?

The question for the EU is probably of higher importance, because within the boundaries of the European Union there is a lack of common spatial planning or of a city-town relationship model. Every country features its own models and the western and eastern parts of Europe are quite different. In the Netherlands there are a lot of people driving over 20 km to and from Amsterdam or Groningen every day. There are less of such people in, say, Romania. Common and shared spatial models and visions for Europe have not been developed yet. It is probably better not to have a strict common model since this offers more freedom for specified changes in European spatial planning in the context of high oil prices.

It is important to understand that there is an strong interconnection between oil-prices and spatial planning. In documents and studies of the EU hardly any attention is paid to this issue, neither in the serious report '2030. Territorial Futures. Spatial Scenarios for Europe', published by the *European Spatial Planning Observation Network (ESPON)*. Another ESPON document – 'The Territorial State and Perspectives of the European Union Document' – tackling the problems and challenges of the spatial planning in the EU, pays no attention to the challenge of high oil prices.

6.1.8 Different Energy Resources

The tendency, in the process of mounting oil prices, to widely use coal again for the generation of electricity – in China and the Western world – will have a devastating impact on greenhouse emissions and pollutions that seemed to have been banished. Many countries now seek refuge to nuclear power but uranium is also depleting. Meanwhile, sustainable energy may be expensive yet abundant: based on the potential for energy from the sun, wind and water, Jong et al. (2006) calculated that the Netherlands alone could already sufficiently provide the global economy with energy. However, at this instant local potentials are not effectively seized.

6.1.9 Sustainable Development

This problems and challenges discussed require a multidisciplinary and serious study, not only taking economy into account. It needs an integrated approach on economy, politics, ecology, social stability, sustainability and spatial planning. The method of energy potential mapping can be an important means to do so.

The threats of climate change and energy depletion can be used as a catalyst for sustainable redevelopment by founding spatial planning on climate change and local energy potentials, in accordance with an optimal usage of the energy cycle by means of the low-exergy principle. The local potentials for the generation of energy can be investigated by means of analyses of climatic conditions, landscape and land use typology, local natural, cultural and technical features, and existing 'hotspots' of energy and heat generation.

6.2 Energy Potential Mapping

6.2.1 Background

The methodology of energy potential maps evolved during the research process of the Grounds for Change project (Noorman et al., 2006; Roggema et al., 2006a).[4] Main aim of this project was to find a sustainable energy system for the Northern Netherlands (Frisia, Groningen and Drenthe) for the year 2035 and the spatial consequences of this.

The northern region has always played an important role in the energy provision of the Netherlands: during the 19th century large areas of peat were colonised and excavated, and after World War II the discovery of oil and natural gas made it one of the most significant contributors to the national treasury. Although originally huge in size, the gas reserves are expected to deplete within 25 years, forcing gas-related companies to concentrate on import and storage of gas from elsewhere. Nevertheless, this will only postpone depletion.

Despite its natural riches, the North is relatively weak, economically, subject to emigration of young people to the Randstad, the Dutch economic centre cornerstoned by Amsterdam, Utrecht, Rotterdam and The Hague. This, together with the increasing water threat due to climate change and the problem of energy depletion, made the Northern Netherlands an interesting case for drastic measures needed for a sustainable future.

With the Grounds for Change assignment, energy had to be linked with the planning process, for which the charting of energy characteristics of the region became a practical means. The *energy potential maps* depicted energetic strengths or weaknesses. These were base don climatological, geophysocal and cultural-historical-technical properties of an area. The Grounds for Change project spawned potential maps for solar energy, wind, water, biomass and the underground. The superposition of these maps led to the *energy mix map*, which presented an overall picture of all energy potentials in every part of the region. See Fig. 6.5.

In particular the energy mix map gives a good impression of the energy richness of parts of the region. In this respect, the northeast of Groningen turned out to be the richest, offering good potential for solar energy, wind, biomass and gas from the underground. Large parts of Drenthe in contrast need to restrict them selves to biomass only.

Grounds for Change continued with the development of a new environmental plan (POP) of the Province of Groningen. During this POP energy research project (Dobbelsteen et al., 2007a) the methodology was enhanced and not anymore based on the energy source (Sun, wind, water etc.), however on the energy type (the

[4] Various parties were involved in this project funded by Energy Valley, such as the Dutch provinces of Drenthe, Fryslân and Groningen, Delft University of Technology, Groningen University, Bosch Slabbers landscape architects and Stegenga Workshop for Urban Design.

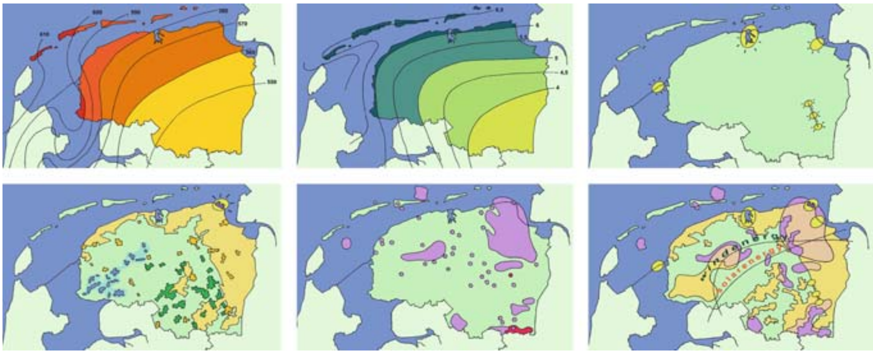

Fig. 6.5 Energy maps from the Grounds for Change project: *left* to *right* and *top* to *bottom*: the potential maps for the Sun, wind, water, biomass and underground, plus the energy mix map (Roggema et al., 2006a)

provision of electricity and heat, for instance, regardless of the original source). In fact, the energy mix map of Grounds for Change was split to real potential maps.

After the regional and provincial level, the methodology was zoomed in on the meta-urban scale of Delfzijl and its environs in a master's project at the universities of Delft and Leiden (Vernay, 2007).

Ever since, the method of energy potential mapping has taken off in various projects at different scales: the municipality of Almere and districts of this city (Dobbelsteen et al., 2008a, b, c), districts andneighbourhoods of Rotterdam, and Amsterdam Schiphol Airport (Dobbelsteen et al., 2008d), even linking in with the comparable approach to 'smart and bioclimatic design' (Dobbelsteen et al., 2008e), on the building level. In the mean time, many scientific papers have been published on energy potential mapping (Dobbelsteen et al., 2008f; Dobbelsteen, 2008; Dobbelsteen et al., 2007b, c; Gommans and Dobbelsteen, 2007; Dobbelsteen et al., 2006a, b).

6.2.2 The Methodology of Mapping Energy Potentials

Energy potential mapping is founded on an incremental approach of steps (Fig. 6.6):

- First an inventory of general information related to the history, topography, climate, landscape and the current energy system.
- Subsequently more information can be gathered from climatological and geophysical maps: Sun, wind, water, soil, nature and agriculture, buildings and industry and finally infrastructure. Each of these maps offers opportunities to generate or store energy.
- These opportunities are then elaborated on vertically in energy potentials for fuels, electricity, heat and cold and possibly CO_2 capture. The potential maps

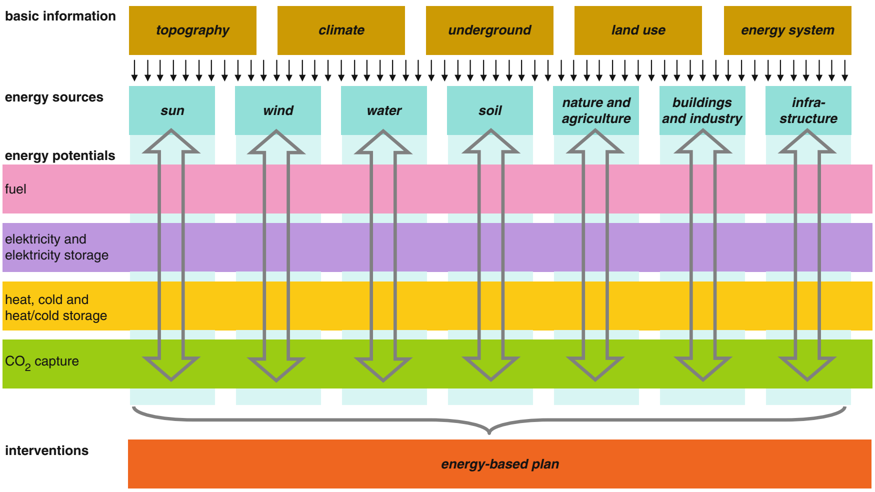

Fig. 6.6 Schematic overview of the methodology of energy potential mapping

are elaborated horizontally, thereby depicting that all aspects of the climatological and geophysical basis maps are converted in terms of energy.

- All potential maps together culminate in (a map of) proposed spatial, functional or technical interventions. These are a reasoned selection of most urgent and effective measures resulting from the charted energy potentials.

6.3 The Local Energy Toolbox

6.3.1 Climate and Energy

With the cheap and once over-abundant presence of fossil energy, generic design of buildings and cities could be copied everywhere (Fig. 6.7) across the world, ignoring local characteristics and thus causing an enormous increase in consumption of primary energy.

Mankind has almost lost the ingenuity of optimally deploying vernacular qualities and site-bound features and peculiarities in the design of the living environment. Startingpoint for an effective use of energy should be the fundamental knowledge of the climatic zone in which a plan is developed. Figure 6.8 shows the climatic zones of the earth.

Temperature and its diurnal and seasonal differences define the boundary conditions and constraints to planning and design. Examples are the desirability of solar irradiation in cold climates and the reflection and obstruction in warmer climates, the use of the soil or building mass to stabilise great temperature differences and the necessity of inter-seasonal storage in cases of excess and shortage of heat or cold.

Fig. 6.7 Copy-pasting generic designs, regardless of the local climate (Hellman, 1994)

Humidity defines the perception of heat and the (im-) possibility of certain passive cooling techniques. These differences are clarified by the extreme climate difference of the cities in Fig. 6.9.

6.3.2 The Sun

The sun is the source of all energy on earth; although some places are sunnier than others, solar radiation is abundant and ubiquitous, so its potential should always be taken into account. The sun can be reaped everywhere, but its precise yield is strongly dependent on the latitude, season and local obstructions such as building, green and pollution in the air. Figure 6.10 gives the solar intensity for the Netherlands, expressed by Joules per cm^2.

Joule/cm^2 can be converted to kW/ha, determining the energy potential of entire pieces of land. In summer this country receives the most solar energy and longest solar hours; in winter the percentage of total possible solar radiation is smallest.

6.3.3 Electricity

In the Netherlands the energy intensity of the sun is too low to produce electricity from the sun on a large scale. The large-scale, centralised solar power generation is more obvious for countries with an abundance of solar hours, under the assumption of efficient facilities for transportation through high-voltage lines or hydrogen. Therefore, western countries could consider investments in solar power plants and hydrogen production utilities in other (developing) countries, thereby contributing to better-spread welfare.

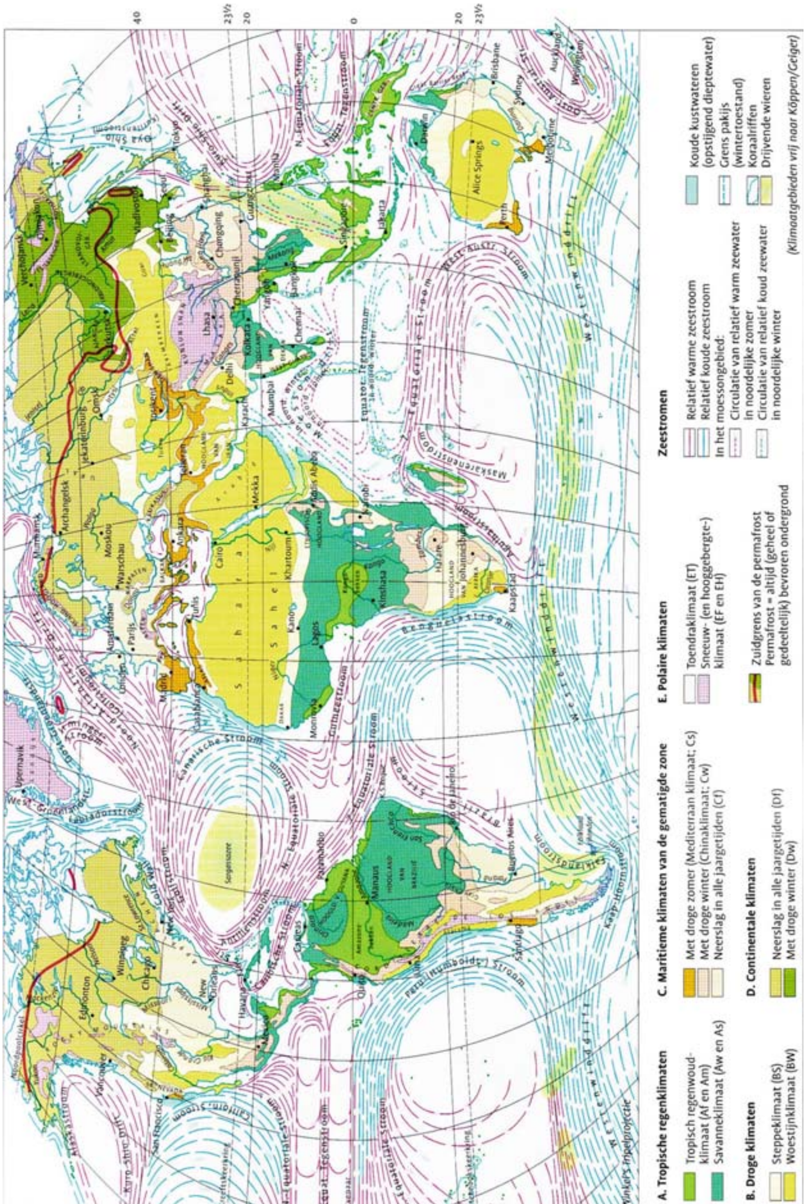

Fig. 6.8 Climatic zones of the earth (Wolters Noordhoff, 2007)

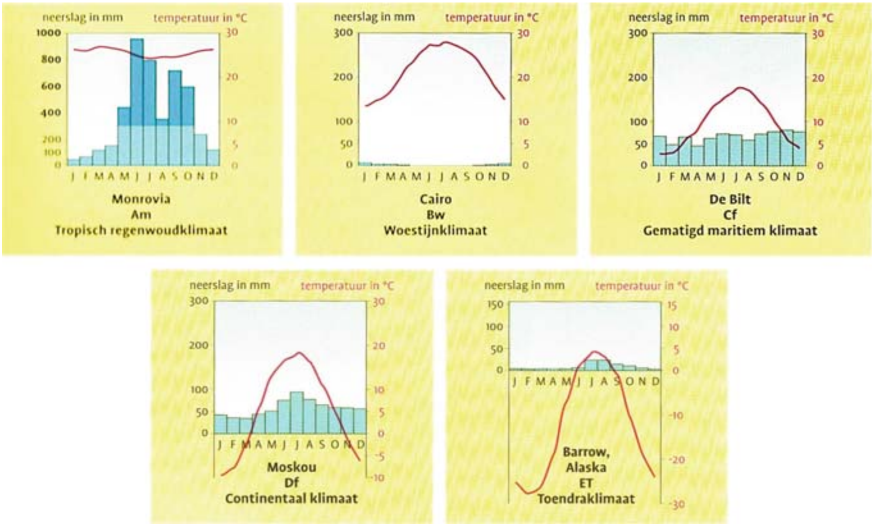

Fig. 6.9 Extreme climates and their temperature and precipitation differences (Wolters Noordhoff, 2007)

In spite of current conversion efficiencies of photovoltaic (PV) systems and a limited energy content of solar radiation in the Netherlands and other countries from the northern hemisphere, electricity from the sun can play a significant role in the energy provision of dispersed, small-scale clusters of buildings and individual buildings. For isolated villages a combination of PV and small wind turbines could already largely or completely provide the need for electricity. With PVT (PV thermal) panels heat can also be generated.

6.3.4 Heat

The solar energy that reaches the surface of the earth (around 100 W/m^2 in Western Europe) can also be used for heating purposes, via passive (the capture of irradiation via windows and building mass) or active technology (e.g. solar collectors).

The functionality of solar heat depends strongly on the local circumstances (orientation and angles of obstruction by the natural and technical landscape, greenery and buildings) and hence, can only be charted on small-scale potential maps. In relatively cold climates (average temperature below 20°C) the use of solar heat is recommended: it is available everywhere and cheap.

6.3.5 Wind

Energy can be reaped from the wind almost everywhere, but in contrast to the sun, geomorphological aspects play an important role in local wind characteristics. A

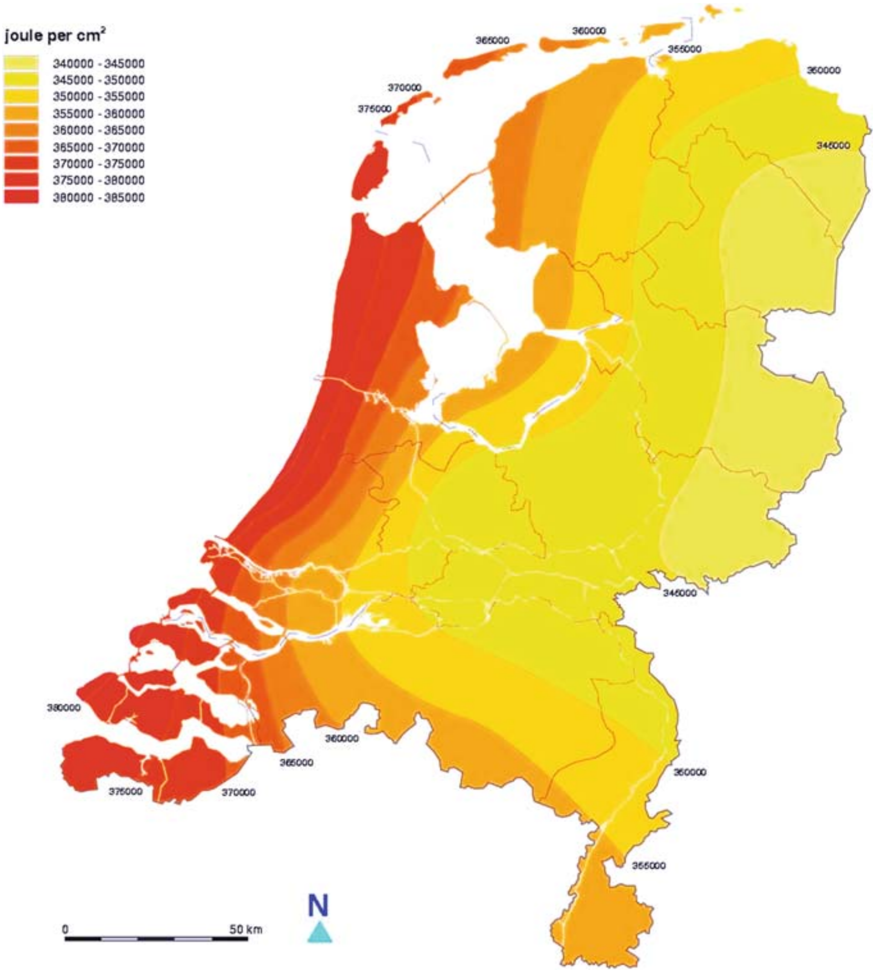

Fig. 6.10 Energy intensity of solar radiation in the Netherlands (KNMI)

generic image of the wind speed can be drawn from maps such as Fig. 6.11. At lower heights impediments of greenery and buildings define wind patterns and its strength, which can locally be accelerated or extinguished.

In the case of wind the direction is also an important factor that in combination with the building characteristics determines whether a lot of energy can be locally generated or not. Most areas in the world have an omni-directional wind pattern, demanding for rotatable wind turbines for optimal yields. There are also regions in the world that show bi- or even mono-directional patterns. A large part of China for instance has bi-directional wind features (NW-SE), offering opportunities to either obstruct or allow wind flows through the built environment. Figure 6.12 depict the wind roses in Canberra, Australia. It is omni-directional and

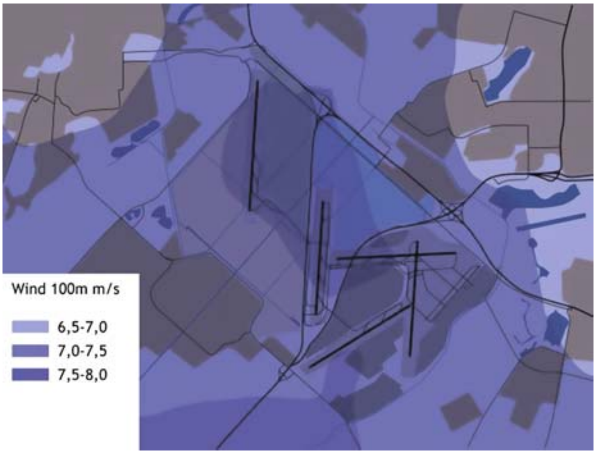

Fig. 6.11 Wind speeds around Amsterdam Schiphol Airport, at a height of 100 m, showing an area of relative strong winds around the two landing strips in the empty polder north of the terminal (based on SenterNovem, 2006a)

very different in the morning and afternoon, but with a predominant occurrence from the north-west. Since this is where the outback desert can be found, this wind brings drought and heat in summer and freezing cold at night. Hence, an example of wind to be obstructed although some of it can be useful for cross-ventilation of urban areas.

Table 6.1 gives the potential yield at different wind speeds per unit of area (km^2 or hectare, with a rotor diameter of 50 m) or per m^2 of rotor area (the circular area of revolving rotors). As can be seen, planning turbines at the most appropriate locations (9 m/s on average versus 7 m/s, which is not to bad either) rapidly causes differences in yield by 70%.

High wind turbines require adaptation of the low-voltage power grid and upgrading of transformers, or a direct connection to the medium-voltage grid. Therefore, the presence of the medium-voltage network defines the potential of solitary large wind turbines. For wind parks a separate connected is usually arranged for, which economically is more feasible.

Just as with solar energy, decentralised generation of wind power enables becoming energetically self-sufficient. Some smaller turbines that are suitable for the built environment – such as the Turby – can produce the annual amount of electricity needed by a household if they are installed at favourable positions.

6.3.6 Water

Water can be deployed in the energy system in various ways. Firstly, Electricity can be produced from gravity: potential and kinetic energy of falling or flowing water. This can refer to hydro-electric plants in mountains and rivers, tidal differences or

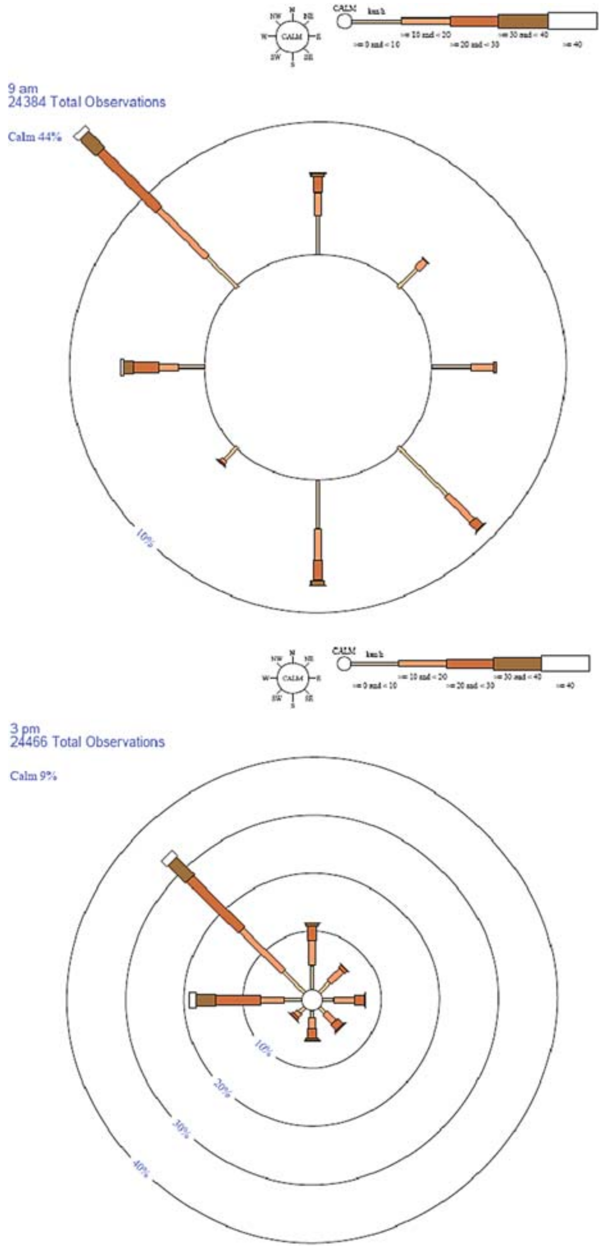

Fig. 6.12 Wind roses of Canberra, Australia, at two different times of the day: 9AM (*left*), 3 PM (*right*); the morning brings 44% of wind calm; wind forces are much strongerand predominantly from the north to west in the afternoon (Bureau of Meteorology Australia)

Table 6.1 Potential yields from wind at different speeds

	Per km^{2a}		Per ha^{a}		Per m^2 of rotor area	
Wind speed (m/s)	Yield (GWh)	Power (MW)	Yield (MWh)	Power (kW)	Yield (kWh)	Power (W)
9.0	52	593	520	5.93	1434	163.6
8.5	46	525	460	5.25	1250	142.6
8.0	40	456	400	4.56	1100	125.5
7.5	35	399	350	3.99	950	108.4
7.0	30	342	300	3.42	830	94.7

[a]with a rotor diameter of 50 m.

wave energy. In coastal areas, old sea inlets can be used for tidal power generation if the height difference is big enough. Inundation plants are a possibility to simultaneously protect the land from to great pressures on the dikes of a low-laying country and generate power from the influx of seawater. This of course has stark effects on the hinterland. The specific type of polderland beneath the sea can enable continuous production of sustainable energy when water from outside the polder is continuously let into the polder and pumped out again through solar and wind power, which are discontinuous and often switched off when they interfere with common power plants (see Fig. 6.13). This principle of inlet plants should allow open water fluctuations.

A different means of extracting electrical power from water relates to the chemical differences between salty and fresh water. Where fresh water runs into the sea, chemo-electrical exchange through membranes can produce electricity: ‘blue energy’, of which there are two principles: osmosis and reversed electric dialysis.

6.3.7 Biomass and Waste

6.3.7.1 Fuel

Biomass itself can be considered a fuel, but in this form, apart from fuel for furnaces, it is hardly usable for modern function. Therefore it can be processed in biorefineries – producing e.g. bio-diesel – or bio-ethanol factories. Green algae that purify water can also function as fuel since they contain oily substances, which can be refined to bio-diesel as well.

6.3.7.2 Electricity

Power can be generated from biomass and (organic) waste through incineration of biomass and waste in power plants (bio-plants or multi-fuel plants), which is the traditional way, and through bio-fermentation, which produces biogas, which subsequently can be incinerated in power or co-generation plants for both power and heat. Bio-fermentation can be applied to biomass from woods, greenery, agriculture

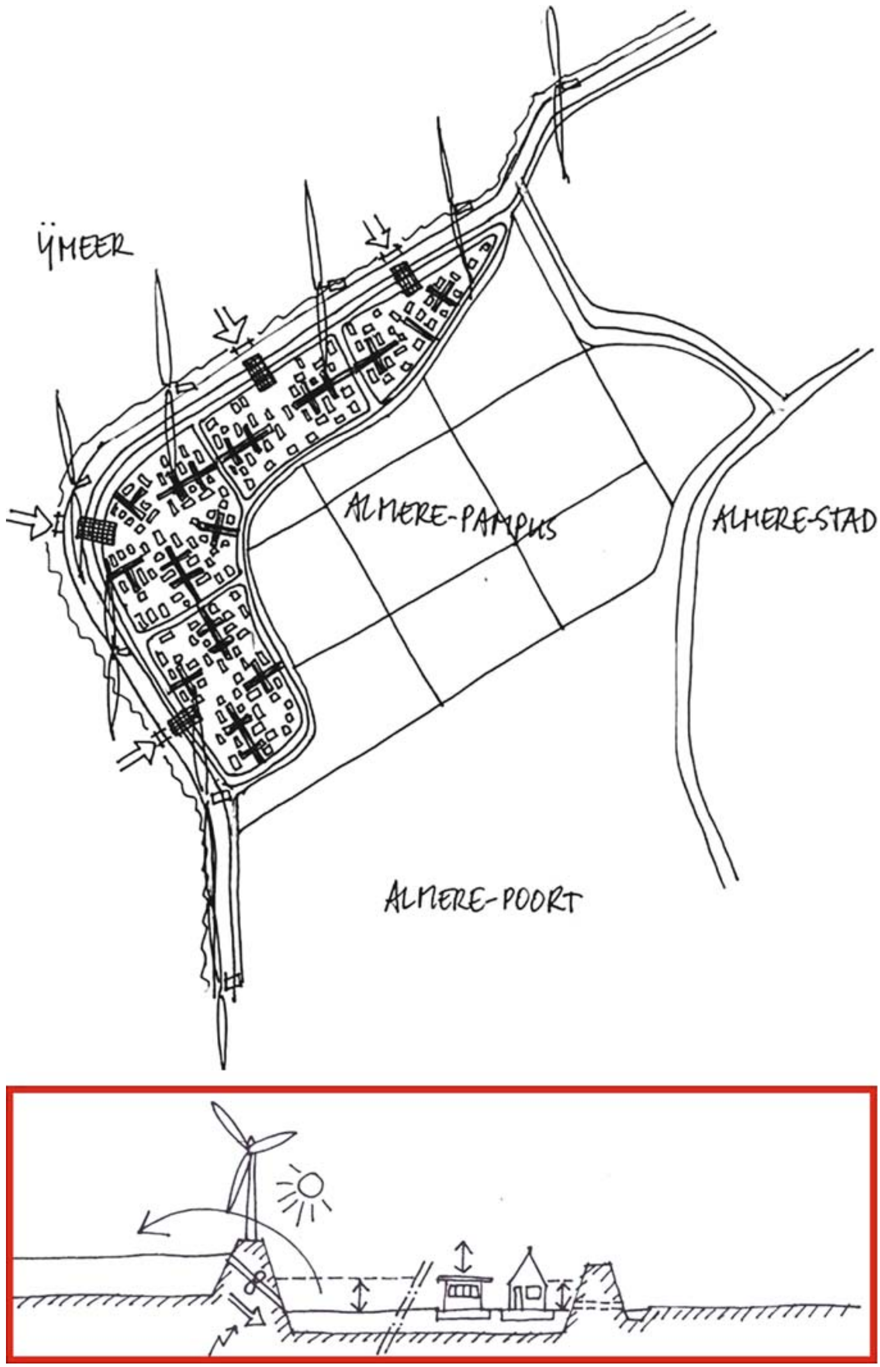

Fig. 6.13 Idea of an inlet plant for the polder of the city of Almere, Netherlands

and so-called second-generation biomass (e.g. wood pellets), organic waste, manure and wastewater. Especially the latter is a promising source, produced at the places where energy is needed. It only requires decentralised facilities at the neighbourhood or district level: the building scale is too small and the urban scale too big.

6.3.7.3 Heat

As a traditional technique, heat can of course be won from the burning of biomass. Here again this can be achieved directly or via fermentation of manure and organic material. Combined heat and power generation is then most efficient. The deployment of biomass in the energy cycle of the built environment suggests mixing of agricultural businesses with housing developments. For the environment of Almere in the Netherlands we calculated that an average agricultural company could make 30 dwellings energy neutral by means of a fermentation plant and co-generation. An inventory of heat excess of shortage, such as in Fig. 6.14 is worthwhile in this case. Where there is excess of heat, housing developments may be viable.

6.3.8 The Underground

Figure 6.15 gives an overview of possibilities to use the underground in the provision of energy, water and other resources. There are various opportunities for heat exchange with the underground:

- Heat and cold from open water, ground water, or soil to approximately 50 m of depth
- Heat and cold storage in aquifers in the shallow underground from 50 to 250 m
- Geothermal heat (20–60°) from aquifers in the intermediate underground (between 100 m and 1 km)
- Energy and CO_2 storage in salt cavities in the same intermediate underground
- Geothermal heat (60–140°) from aquifers, gas and salt cavities in the deep underground ondergrond (1 km and deeper)
- Gas and CO_2 storage in empty gas fields in these deep layers

The potentials of a specific region depend on local geophysical properties.

6.3.8.1 The Deep Underground

Heat can be won in all places with good potentials for geothermal heat from the deep underground, but in particular where emptying, in-watering gas fields (permeable to aquifers) are present. At the depth of gas fields, the water can reach 100–140°C, a practical temperature for all domestic and many industrial purposes. Lower temperatures (from shallowers) are still useful for heat-demanding functions (washing, showering, heating, swimming pools etc.).

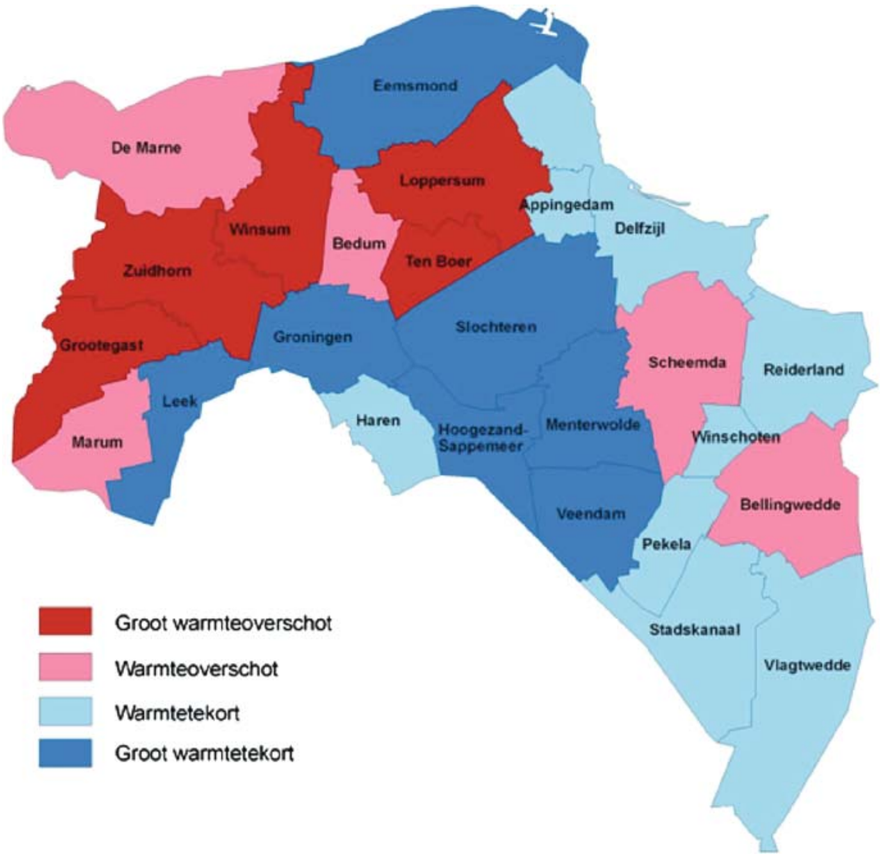

Fig. 6.14 Heat balance of different municipalities in the province of Groningen, Netherlands, for manure fermentation applications (Source: KNN Milieu, 2006)

6.3.8.2 The Intermediate Underground

The potential for storage of heat and cold in shallow aquifers down to a depth of 250 m is partly dependent on the thickness of the aquifer. Storage of this heat and cold is particularly suited for functions with a changeable pattern of heat and cold demand and supply, necessitating seasonal storage. Instances of this demand are dwellings, holiday homes, recreational facilities and season-bound industrial activities. Unsuitability for heat and cold storage, in reverse, indicates that patterns of supply and demand should be tuned optimally through a well-deliberated mix of functions. A second solution would transportation of heat and cold to areas with a reversible demand pattern. The third solution is storage of heat and cold in the underground without the use of aquifers, so in closed storage systems.

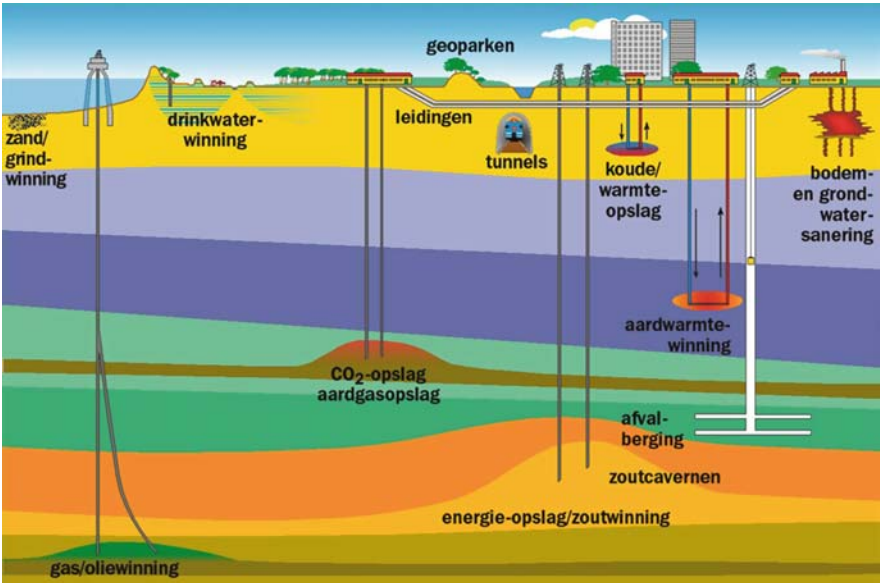

Fig. 6.15 Possibilities of the underground (Source: TNO/Built Environment and Geosciences)

6.3.8.3 The Shallow Underground

By means of heat pumps and heat exchangers, heat and cold can be exchanged with the underground, ground water, openwater and outside air. In the shallow underground the potential to exchange heat and cold is many restricted by other concessions. Figure 6.16 is a map of the suitability of the soil for the application of vertical heat exchangers, with a conversion to energy potential.

6.3.9 Exchanging and Cascading Heat and Cold

6.3.9.1 Exergy

The First Law of Thermodynamics states that energy is never lost, whereas the Second Law describes that processes develop towards a state of increasing entropy. Hence, entropy embodies the non-useful waste energy evolving during processes. Exergy is the useful part, the part that can perform work. It is a measure of energy quality.

Processes can be energy-efficient, but in terms of exergy this efficiency can be totally different if the initial exergy level is predominantly converted to entropy. For instance, a boiler may have an energetic efficiency of 95%, but considering the gas flame of 1500°C, a lot more can be done with it than just heating up houses to 20°C. The exergetic efficiency is approximately 15%. If the gas flame heat were used in the

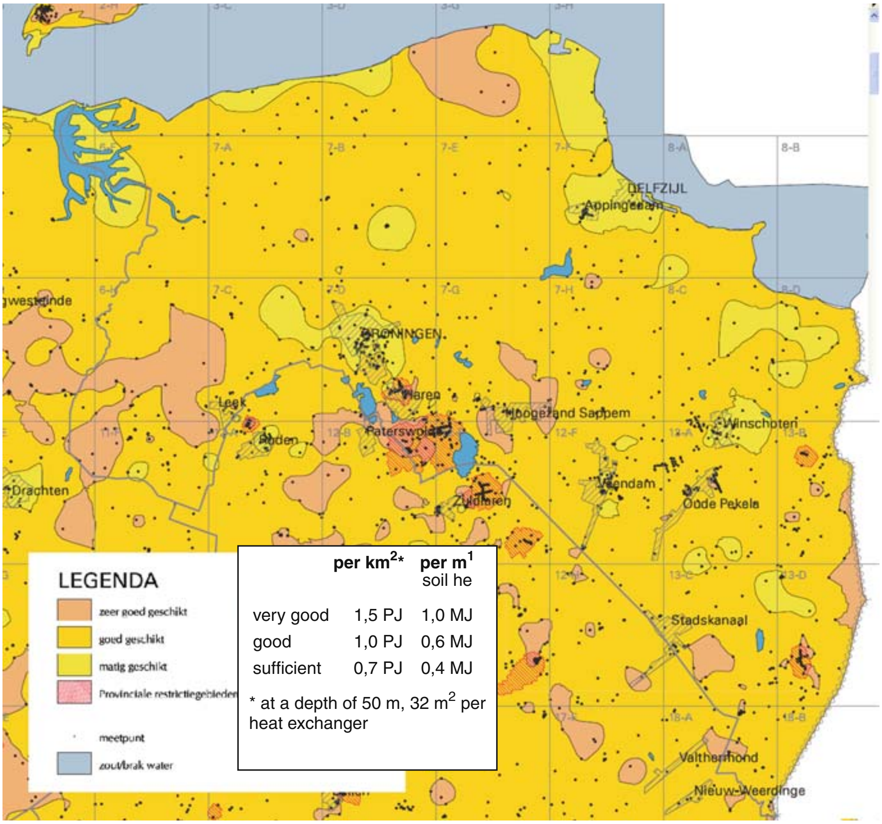

Fig. 6.16 Suitability of the soil in the province of Groningen for vertical heat exchangers (IF Technology, 2005), and the energy yield that it can produce (1 PJ = 278 GWh)

metal industry, the exergetic efficiency would approximate 100%. Therefore, energy of a high-quality level should be used for high-grade functions before it transforms into a lower-quality state, which can still be useful to low-grade functions.

6.3.9.2 The Low-Ex Approach

The current energy system in a region (Fig. 6.17) is characterised by an influx of primary energy – fossil fuel – into every function present in the area. A power plant, which is also fuelled by fossil energy, generates electricity and every function produces waste and waste heat. The latter is emitted into the air and water.

The low-exergy (low-ex) approach strives for limiting exergy losses between and during process steps. This would imply feeding an exergy quality close to the required level, losing little exergy during the process step and finding a secondary function that can make use of the output level. High temperatures would only be

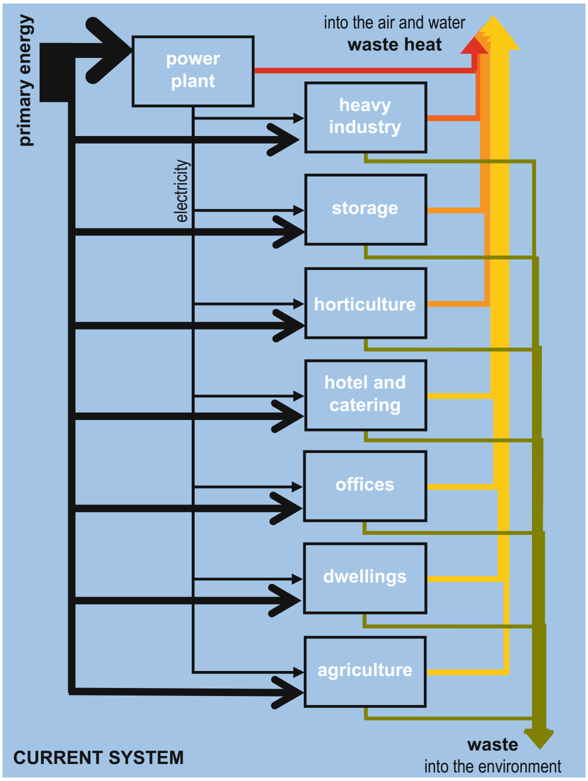

Fig. 6.17 Graphical example of energy provision in the current system (Source: (jij) even Vastleggen?)

used in heavy industrial processes, of which waste heat could be used in lower-grade functions as manufacturing processes, horticulture, and subsequently for residential heating (the cascade of Fig. 6.18). Residences and agriculture can eventually again ‘feed’ the power plant with biomass and waste.

Thus, four instead of just one function would be served by the same amount of primary energy. In our current system each step requires high-quality input of exergy.

On the regional scale the low-ex principle has implications for planning. Low-caloric heat cannot be transported over long distances: heat losses would be too big. Therefore, spatial functions should be concentrated and mixed: horticulture near industry, residences near horticulture. Before this can be established, the energy potentials of the region should be investigated.

Figure 6.19 presents an inventory of heat produced in the environs Delfzijl. The amount of heat is defined by size of the respective circle and the temperature is defined by the colour. In this figure, heat demands are also depicted at the darkest colour of red, 90°C, which is the traditional temperature for conventional heating systems. As can be seen, industrial waste heat is at a lower level. Nowadays,

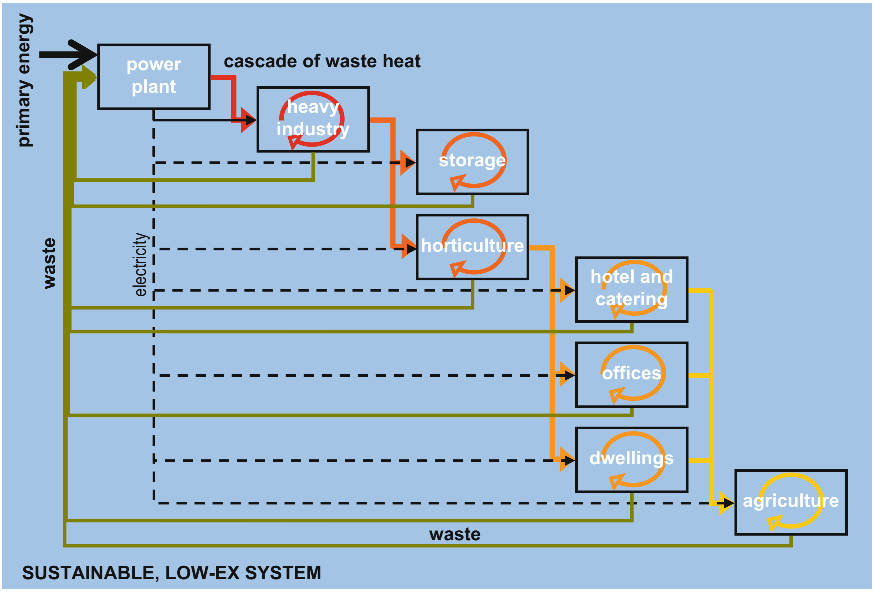

Fig. 6.18 A more sustainable, low-exergy system that uses heat cascading (*right*)

however, we are able to design buildings that require low-temperature heating systems, enabling reuse of industrial waste heat.

6.3.9.3 Tuning Heat and Cold Supply and Demand

A better tuning of excess and shortage of heat and cold can save a lot of energy. In most urban settings in temperate climates there is simultaneous demand for heat and cold in a significant part of the year: dwellings need heat from October to April, whereas modern offices already require cooling from March to December. By the selection of specific functions, balance can be established. This commences with the analysis of daily patterns: dwellings of families with working parents and kids at school need a comfortable indoor climate in the morning and evening, whereas this applies to offices, schools and retail during the day. A well-deliberated mix of functions with utilities that enable exchange and storage of energy would to the extreme only require a resuming demand for heat or cold (not both), which can be solved with a function that only needs this heat or cold (swimming pool, skating rink etc.).

6.4 Example: Energy Potentials of the Province of Groningen

The methodology of energy potential mapping will be exemplified by the energy study for the provincial environmental plan of Groningen.

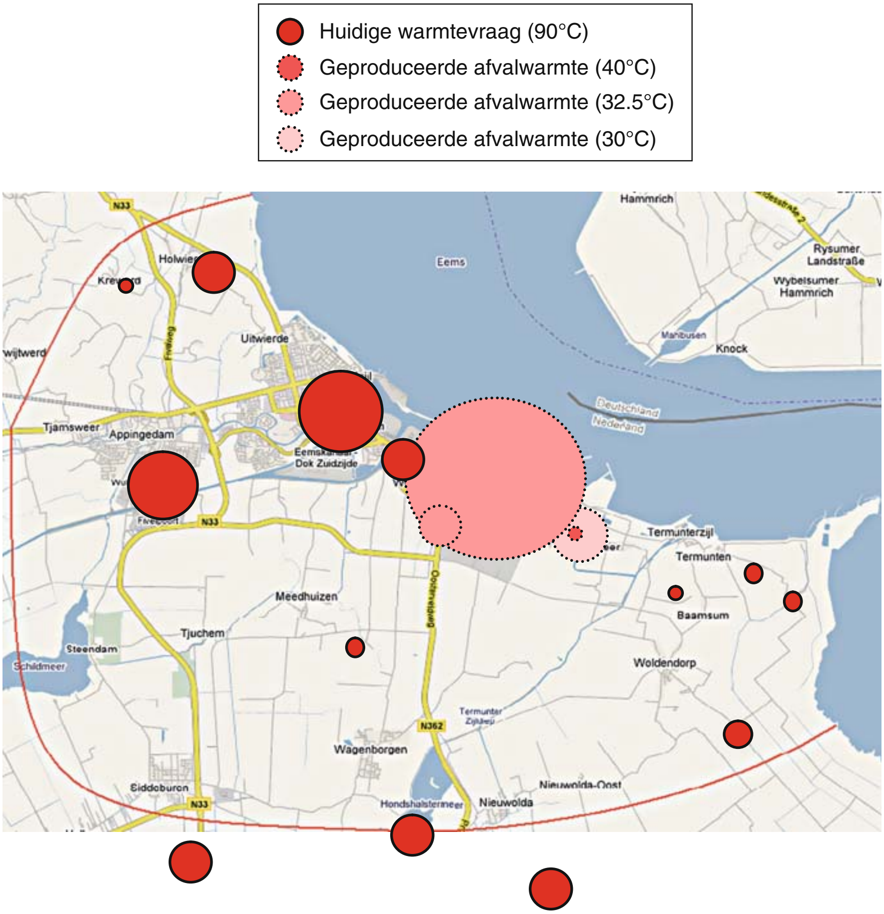

Fig. 6.19 Demand for heat and production of waste heat around Delfzijl (Vernay, 2007)

6.4.1 Electricity

Figure 6.20 shows the map of all potentials for electricity generation. It gives the best location for wind parks, a tidal plant and a few ‘blue energy’ plants along the coast, for a biomass-based industrial cluster in the centre, and for a new type of plant: an inundation plant for occasional flooding of the deepest polders in case of emergency. Furthermore, there are small, decentralised bio-digestion installations with combined heat and power (CHP) generation, spread through the countryside, which contains many isolated farms and villages. Energy values of solar radiation showed little variance over the province, so use of photovoltaic panels is possible anywhere. For large-scale solar plants, the energy properties of a northern place as Groningen are unfavourable. However, solar panels, as well as small wind turbines, can support local selfsupply.

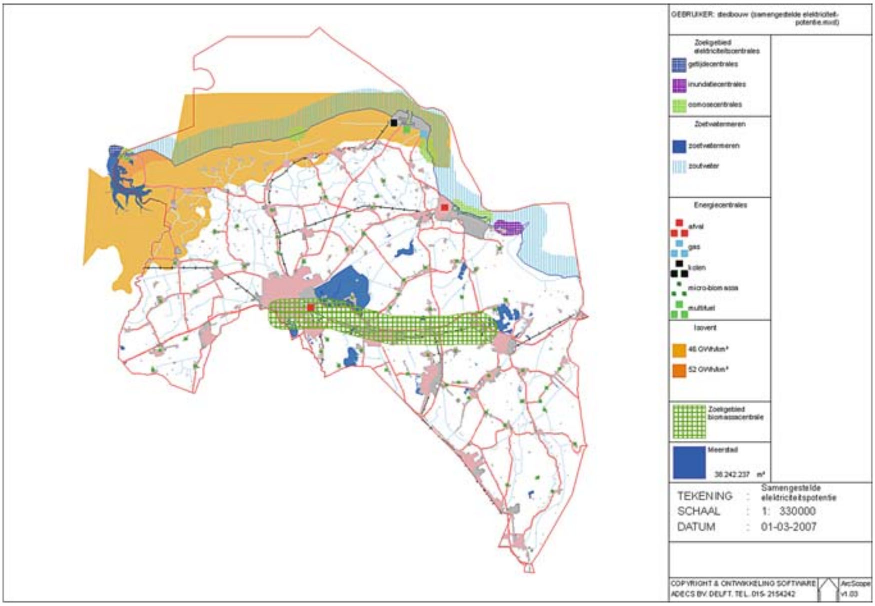

Fig. 6.20 Overlay map of energy potentials of Groningen for the generation of electricity (Source: Dobbelsteen et al., 2007a)

6.4.2 Heat and Cold

Figure 6.21 is the overlay map of heat and cold potentials. The map depicts the potentials of geothermal heat from aquifers at 3000 m of depth, to be deployed through empty gas fields, shown as grey grids. The drill-holes of gas locations are indicated by small blue triangles. The small dotted areas depict reasonable to good potential for heat and cold storage in shallow aquifers (50–250 m deep). The hollow circles are centres of heat (red) and cold (blue) demand, whereas the full circles mean supply of heat and cold. The excess of heat in industrial areas is evident. Nevertheless, the largest producer of heat, the Eems Harbour area, now has no heat-demanding function close to it. This can be altered through spatial planning that takes heat potentials into account.

Solar heat, again, is available anywhere and should be seized when possible. This also applies to local exchange of heat and cold with exhaust air, the soil and open water.

6.4.3 CO_2 Capture

The principle of human influence on the climate is quite simple: prehistoric lush jungles that captured carbon dioxide (CO_2) over millions of years evolved into fossil fuels, which are again converted into CO_2 in a time period of two centuries. To

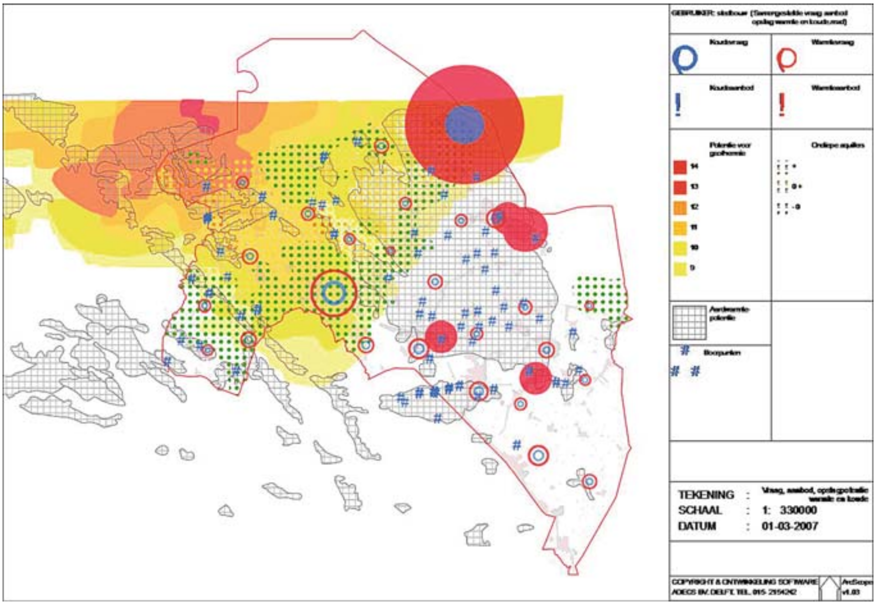

Fig. 6.21 Overlay map of potentials for the provision of heat and cold in Groningen (Source: Dobbelsteen et al., 2007a)

compensate for that, new jungles should thrive another couple of million years, but this time man obstructs the natural regeneration of plants. A 4-steps strategy may be

1. Avoid emission of CO_2 by energy-saving and sustainable energy resources;
2. Make CO_2 useful in industrial and horticultural processes;
3. Compensate for CO_2 emissions by planting trees and other green absorbers;
4. Storing CO_2 underground

This last option is possible in emptying gas fields that are not watered out after abandonment. Figure 6.22 summarises the last three options for the province of Groningen. The gas drill-holes are again given.

6.4.4 An Overlay of Potentials

All energy potentials discussed previously were superposed in Fig. 6.23, indicating areas of great energy potentials, either natural or technical. New developments in the region could be directed on the basis of these potentials, at least in they need to energy-effective.

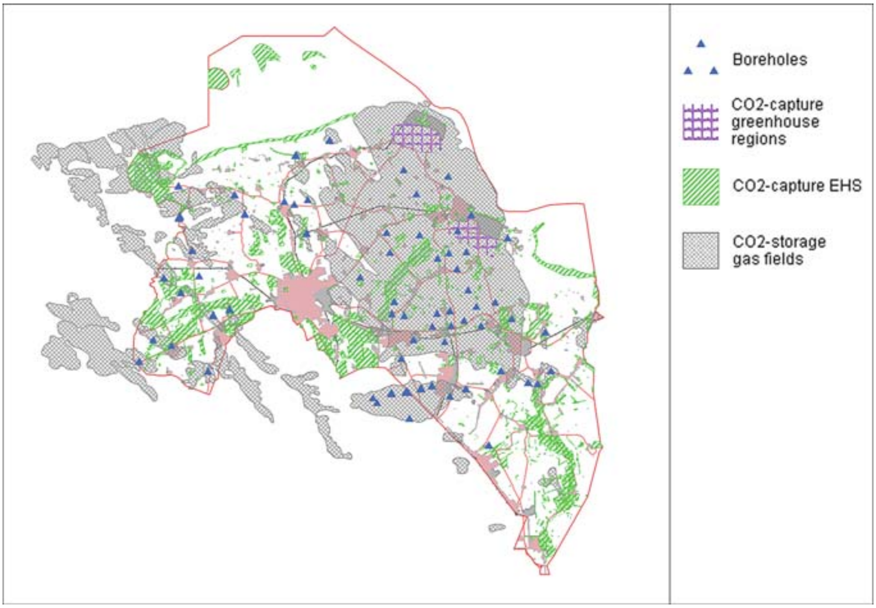

Fig. 6.22 Overlay map of potentials in Groningen for CO_2 use in greenhouses, compensation by plants and storage in gas fields (Source: Dobbelsteen et al., 2007a)

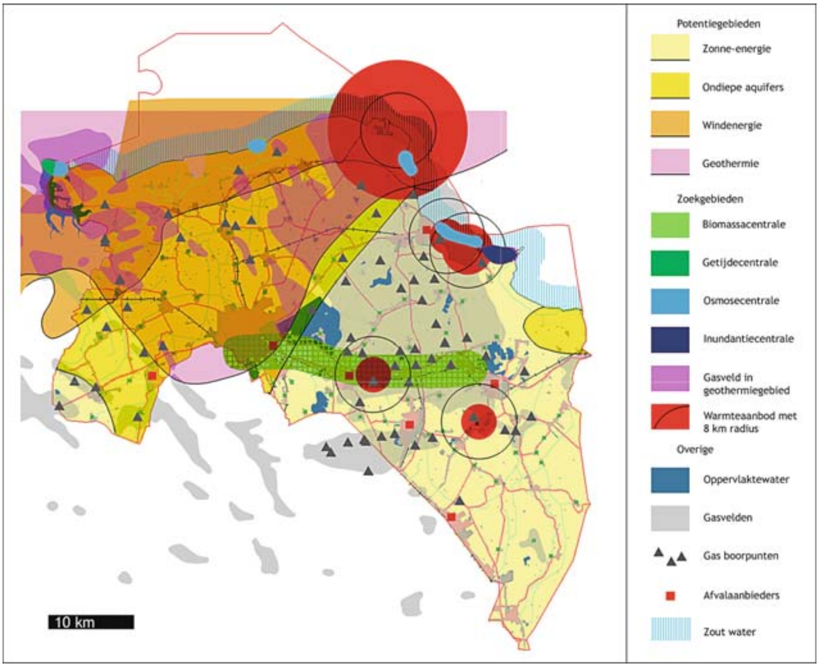

Fig. 6.23 Overlay map of all energy potentials of Groningen (Source: Roggema et al., 2008)

6.4.5 Towards a Sustainable Provincial Plan

For the POP of Groningen a map of proposed spatial interventions based solely on energy considerations evolved directly from the energy potentials study (Fig. 6.24). A few examples of interventions from this map are: again opening the Lauwers sea inlet for a tidal plant and a blue energy plant behind this barrier, the establishment of a biomass-based industrial cluster, and the location of new greenhouse and residential developments near industrial hotspots of heat production.

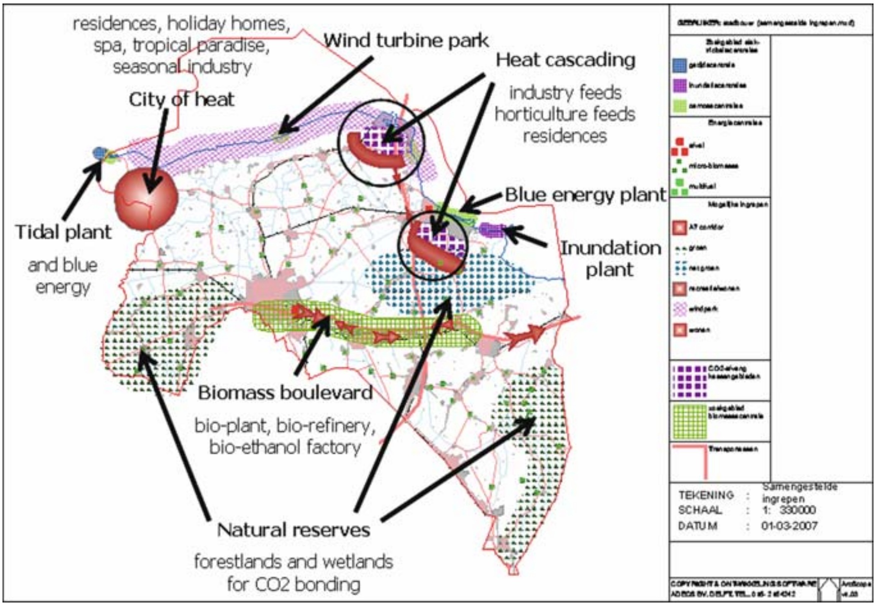

Fig. 6.24 Proposed interventions (Source: Dobbelsteen et al., 2007a)

6.4.6 Outcomes of the Groningen POP Study

On the basis of the POP study of Groningen, a realistic potential of provincial resources could be calculated. It turned out that the proposed local solutions can solve approximately 50% of the current demand for energy. The 50% provision of sustainable resources still implies the necessity of saving the other half of energy. Nevertheless, it would still embody a more resilient solution as opposed to a future situation, where 95% of the energy resources needs to be imported from other regions in the world that are not always stable.

6.5 Conclusions

Energy potential mapping enables sustainable spatial planning based on effective use of local energy potentials. It visualises sustainable ambitions for the future and the consequence of it to planning. It has proved to be an ideal catalyst for discussions, as opposed to written policy plans. The new approach can be used anywhere in the world, most probably leading to different solutions. A sustainable future has different faces, depending on local potentials and local demands.

Planning based on local potentials and energy cascading would imply spatial interventions that deviate from the current paradigm. Combining functions in particular will require delicate planning and a focus on quality of living. On the other hand, the pragmatic look at the characteristics and qualities of a region will bring the problem and solution closer to citizens en enhance their individual feeling of responsibility. Not least, it will inspire to innovate, which is needed in a world facing climate change and energy depletion.

6.5.1 Considerations

For the energy potential studies discussed in this chapter, many factors that influence spatials planning could be left out of the equation, allowing an almost autistic concentration on the aspect of energy and a pure translation of energy potentials into spatial interventions. In order to achieve these changes, making savings attainabl, one should be prepared for a different form of spatial planning. Spatial planning by definition is policy of finetuning, in which energy hardly has had any influence. At the moment, the energy provision is implicitly serving spatial planning, but methodology presented may bring a reverse paradigm. Apart from leading to a better energy performance, this approach is necessary to respond better to climate change and become less dependent on other regions in the world.

A remaining question is whether the persistence of the hydrogen economy would obstruct the location-bound approach of energy potentials. Nevertheless, even then it will be useful to optimally deploy locally available energy of sun, wind, water, biomass and the underground, as well as waste flows.

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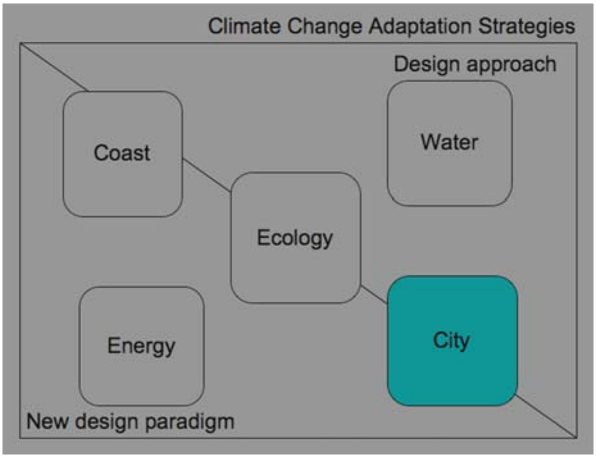
Chapter 7
The Urban Environment



Abstract The main effects of climate change in urban environments are heat-stress and flooding. In order to mitigate these effects the city needs to adapt and anticipate. The most fundamental solution would be to relocate urban areas towards places that are less likely to suffer from heat or rainwater. However, although this rigorous solution might be effective from a heat and water point of view, replacement of large groups of people is not as easy. The solutions to keep a comfortable living environment in the city at a high quality level needs to be found in the creation of space for green and water. Green and blue structures in the city pattern not only create a pleasant environment, they also solve excessive heat problems and water surpluses. It is clear that in times of extreme weather events like heavy rains a city with large spaces where the water can be stored is far more flexible and will face less problems than a dense and paved one. The effect of green spaces with water on the temperature is positive. A city with large green spaces is much more comfortable during

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a heat wave than a city without these spaces. The temperature rise in green cities is much lower than in other ones. In the design for new urban areas and for urban regeneration areas the integration of space for green and blue elements is essential for a future urban climate in which people are not to suffer from uncomfortable circumstances or even become victims of the city.

7.1 Introduction

The urban environment is vulnerable to climate change. For example, a rising temperature leads to more heat problems than in the countryside, and extreme precipitation causes more flood problems in built-up areas than in the landscape. The choice of urban development locations also influences the effects and vulnerability of urban areas for the changes in climate. An anticipative strategy is required to minimise effects in the long-term.

In cities both the government and inhabitants will take measures to minimise the effects of climate change. If this anticipation is too late or not enough these measures may work counter-productively and increase the climate-related problem or cause other negative effects. If heat is enduring, people will react with buying more air-conditioning. This leads to an increase of greenhouse gas emissions and thus the increase of the climate problem. If the extreme precipitation increases municipalities will react with the realisation of larger sewage systems and rainwater discharge systems. These systems cause problems in sewage treatment plants or cause water annoyance elsewhere. In order to prevent these problems the government needs to anticipate climate change if urban functions are developed. It would be wise to take a period of 100 years in mind, because most buildings and neighbourhoods last the same length of time at least.

7.2 Occupation Strategy

In case new space for urban functions needs to be found and the period of anticipation is set at 100 years or more, two occupation strategies can be distinguished.

In the first strategy new building locations are positioned where floods are not impossible. The building techniques and urban patterns are adjusted in a way that minimises the climate effects.

In the second strategy those locations are chosen where the effects of climate change are already minimal: thus, not in the deepest polders or in outer marches.

The first strategy focuses on existing spatial mechanisms and interests. Location choices are made, bearing in mind economic motives, distances to city centres or prevention of open space from being occupied. Once this choice has been made, the developments at location level need to be made climate-proof. Projects in the national spatial plan use this strategy and need to perform excellently re climate adaptation. Therefore, strict requirements are formulated for Zuidplaspolder, Haarlemmermeer and Almere, coincidentally all deep polders. The answer from the Ministry of Housing (Ministerie van VROM, 2007b) on questions formulated by motion of Bochove/Depla (TK, 2006), illustrates that climate change in the Netherlands is not seen as a factor that will change the existing occupation strategy for the next 100 years. The government is supported in that opinion by the National Environment Agency (MNP), which states in the second sustainability reconnaissance – Nederland Later (MNP, 2007) – that in case of a sea level rise of maximal 1.5 m in the upcoming century the Netherlands can be adapted, without changing its occupation pattern. In this vision, current concentration areas are the development areas of the future as well. Thus, in the national spatial plan most investments and spatial developments are foreseen to take place in Randstad Holland. Because these areas contain the highest economic values, they should keep it safe. The newly developed urban areas should be planned as the showcases of climate proof building and planning, because these developments would have to be very well adapted, due to their vulnerable location. If people and values are added to these areas the vulnerability and the risk of damage and casualties increases as well. Therefore the safety level in these areas is said to be higher than regions where less people and economic value is apparent.

In the second strategy the choice for a new urban development is based on the chance of a natural disaster, like flooding. Especially if land ice on Greenland and Western Antarctica melts at an accelerated pace and the sea level rises accordingly, it will be necessary to change the occupation strategy. Relief becomes the main steering factor, which steers urban developments to higher altitudes of the country. Independently of the existing situation, the spread of people and economic value over the country should change towards a concentration of most people and value towards higher altitudes, typically in Drenthe, the Veluwe and Northern Brabant. The invitation of mayor Leers of the city of Maastricht to host the majority of the Dutch people in his city (Trow, 2007), is based on this strategy. However an invitation of a mayor is not sufficient. A possible shift of economic values towards the higher grounds shall not be completed tomorrow. The national investment-patterns need to shift also (Roggema, 2007) towards these higher areas (Fig. 7.1).

However, current national policy is focused on the Randstad Holland, the part of the country, which is most vulnerable to climate change. Beside this, historically and culturally the national focal points are positioned here. The delta is historically the place where the living conditions proved to be the most profitable. Cities like Delft, Amsterdam, Utrecht and The Hague all originated at the most favourable places. This repetitive dynamic of settlements and resettlements at these exact places can only be changed by planning cities in a top down manner and at safe locations. In the Dutch context this seems not to be realistic.

Such an approach to organise the regional layout could be beneficial if the regional housing market, population densities and economic centres were connected with flood risk. The image for the province of Groningen (Roggema, 2007) shows urban developments at the higher areas of the province. The adjusted layout shows the economic activities in the existing and higher lying harbour areas of Eems

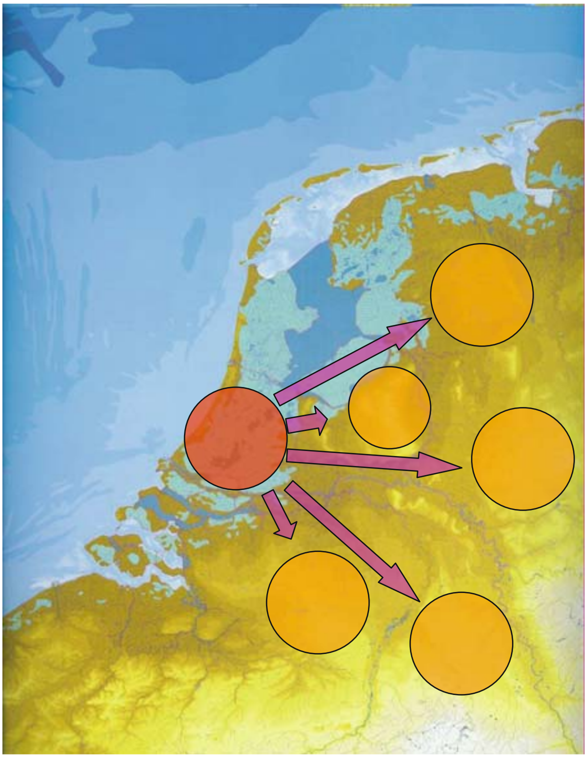

Fig. 7.1 Shift of investments towards the higher areas of the country (Source: Roggema, 2008)

harbour and Delfzijl and the concentration of living areas in the peat colonies and the southern Westerkwartier (Fig. 7.2).

Besides concentrating most activities at higher levels, at the same time lesser houses can be built in the lower parts. These houses need to be adjusted to possible floods. Making the houses floating, floodable or position them on modern forms of *wierden* (artificial hills) could meet these requirements.

7.3 Precipitation

It is expected that precipitation will occur increasingly in extreme heavy showers, especially in summer. This causes more often water annoyance in urban areas (Fig. 7.3).

The capacity of the urban water system is mostly not prepared to discharge extreme amounts of rainwater. Beside that, space in the public space is limited. Cities on sandy soils do have the ability to infiltrate large amounts of water and solve the water-problems, but lower areas do not have these opportunities, due to the wetter and less impervious clay and peat soils. In these areas spatial solutions

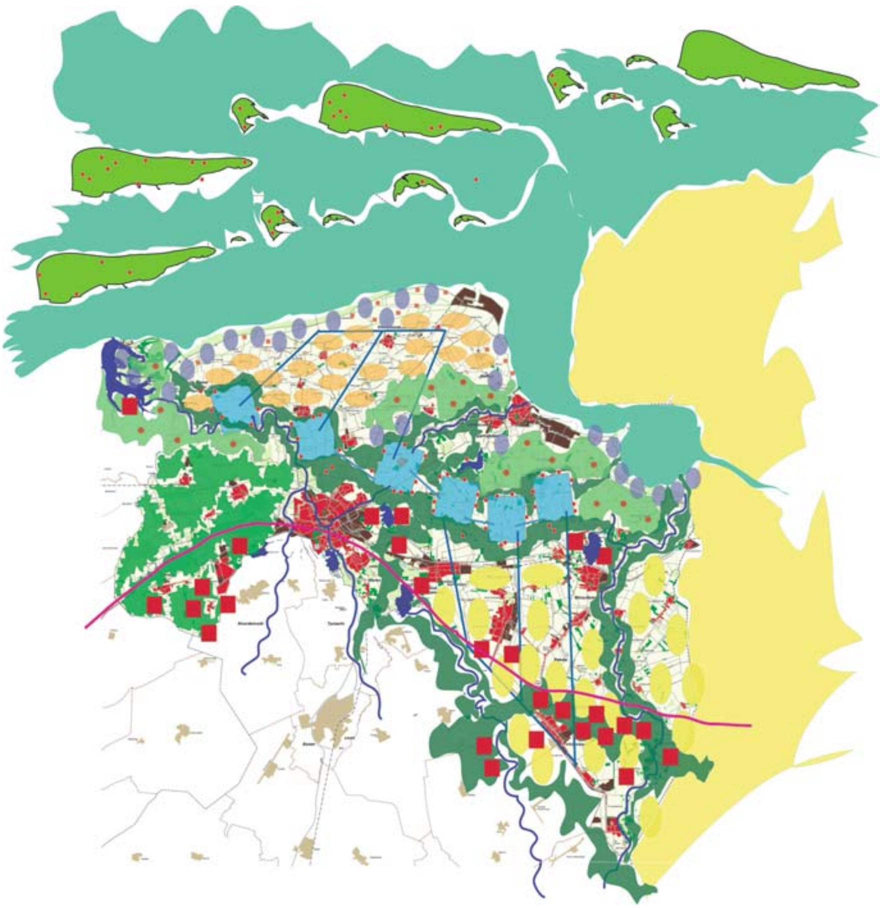

Fig. 7.2 Living and economy in Groningen, based on relief (Source: Roggema et al., 2007)

need to be found to store rainwater. In more dense urban areas with a lack of public space it might be necessary to demolish small parts of the existing city. The concept that has been developed for Delfzijl (Klap, 2007), where parts of the existing city were kept free for natural processes of sea, water and nature (Fig. 7.4) is as inspiring as unusable. Cities in a shrinking situation may see this as an option, but in growing cities this kind of solution is hard to realise. There, the solution needs to be found in an increased flexibility in the urban water system (Fig. 7.5). The public space needs to have a dual function: in normal circumstances it functions as park or green space, but during extreme wet periods the same space is used as storage basin. However, this offers chances to design a dynamic city image and special buildings (Fig. 7.6).

Fig. 7.3 Water-annoyance in the city, England, Summer 2007 (Source: www.bbc.co.uk)

7.3.1 Thames Gateway

The English office Baca Architects design plans, which contain a central role for the adaptation to climate change (Baca Architects, 2007). The analyses, they produced for the Thames Gateway illustrates that in an estuary with tidal processes a serious percentage of the newly built houses is at flood risk (Fig. 7.7). Strengthening the dikes and fortifications only moves the problem upstream (Fig. 7.8). Moreover, one breech in the single defence line may lead to a catastrophe.

Therefore, the design for East Tilbury proposes to incorporate a floodable zone in the design for the location instead of a single dike. This floodable zone is used for a combination of new dwelling types, water storage and nature development. The fact that water is allowed to flow out of the river basin prevents the water from being pushed upstream. In the design the dike is positioned as far from the Thames as possible (Fig. 7.9) and the buildings in the floodable zone can be lifted above flooding water, which makes them safe (Fig. 7.10). New small dikes protect the existing buildings. Furthermore, the water system in the urban design functions as a secondary storage for high tidal water, which will flow back into the Thames after the flooding is withdrawn (Fig. 7.11). In the urban green space the flooding water – as long as the quality is good – is infiltrated in the soil.

Fig. 7.4 Room for natural processes and storage of surpluses of rain in three steps in Delfzijl (Source: Klap, 2007)

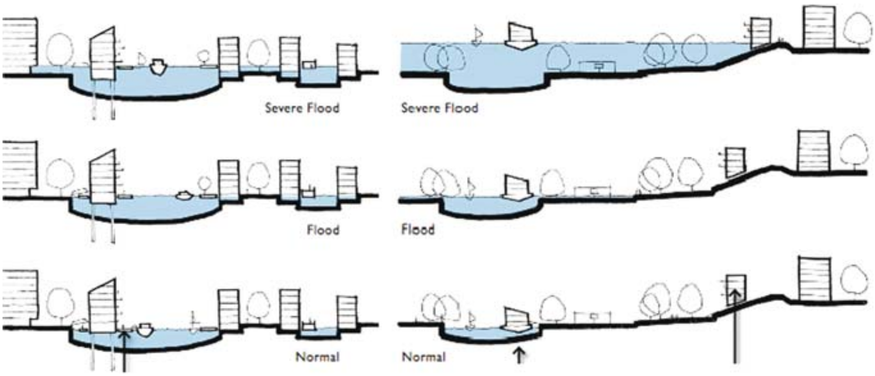

Fig. 7.5 Possibilities to increase the flexibility of the urban water system (Source: Baca Architects, London, 2007)

7.3.2 Urban Flood Management in Dordrecht

The municipality of Dordrecht is partner in the international UFM (Urban Flood Management) project, together with Hamburg and London (Herk, 2007). The objective of the project is to adjust spatial designs to deal with a possible flood. As the

Fig. 7.6 Increase of the flexibility of the urban water system and extraordinary buildings (Source: Baca Architects, London, 2007)

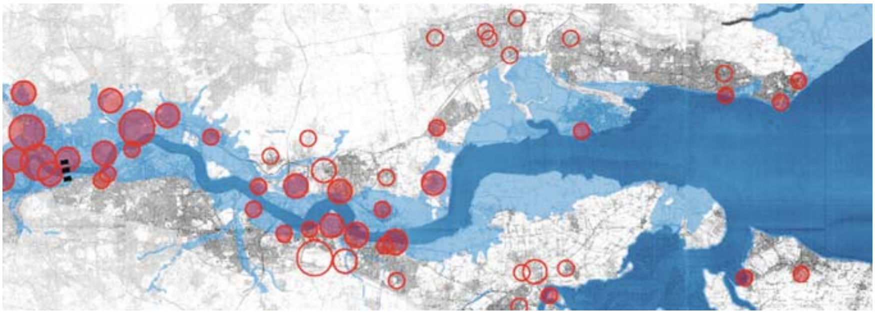

Fig. 7.7 New building locations in the Thames gateway (Source: Baca Architects, London, 2007)

Dordrecht pilot the project Stadswerven was chosen, a revitalising project next to the inner city.

In the project the probability of a flood is compared with the effects of a flood. If the probability can be decreased by a better protection, the effects – damage and casualties – will increase in case of a flood (Fig. 7.12). Wouldn't it be more desirable to accept that certain areas will flood if, in that case, the effects could be minimised? The urban areas can be laid out in a flood-proof way and measures could be taken in order to make the effects of a flood acceptable. The decision to accommodate floods in urban areas becomes a building block in the design process. The closure of the city with a mountain high wall leads to a completely different design assignment than an interwoven city with water

The project improves climate proofing at two levels: the Master plan and the individual building (Fig. 7.13). In order to do so, the flood itself as well as the possible damage is modelled and used as input in the design for the neighbourhood and buildings. The design is adjusted if measures decrease the chance of a flood and increase the flexibility of the area.

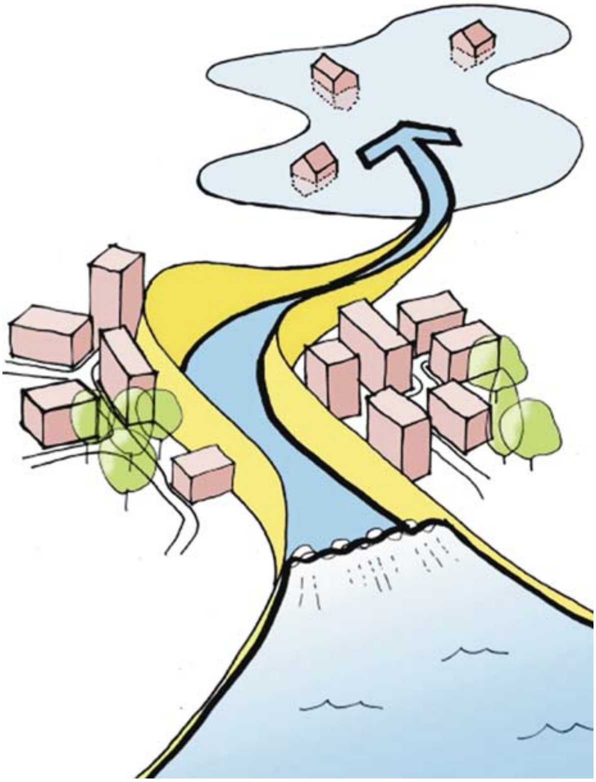

Fig. 7.8 Dikes enforce the water to be pushed upstream (Source: Baca Architects, London, 2007)

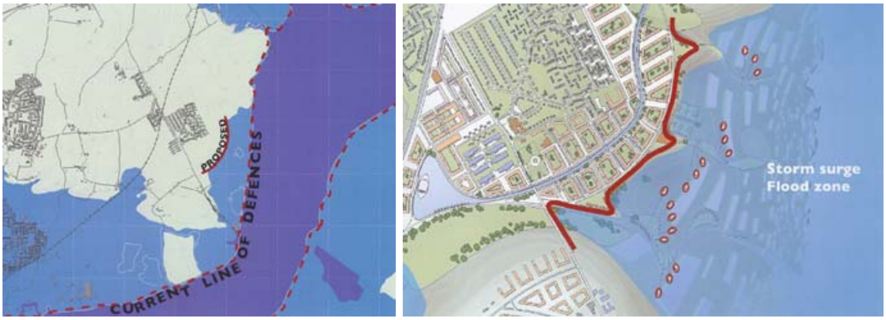

Fig. 7.9 Proposal for an alternative flood defence (Source: Baca Architects, London, 2007)

In the Master plan the flood strategy is introduced (Baca Architects, 2007), in which water – if apparent in large amounts – is used as a temporary quality in the urban design. By giving water a role in the city it becomes an archipelago (Fig. 7.14). The new 'inlets' for water are combined with parks, recreation and artificial flood plains (Fig. 7.15).

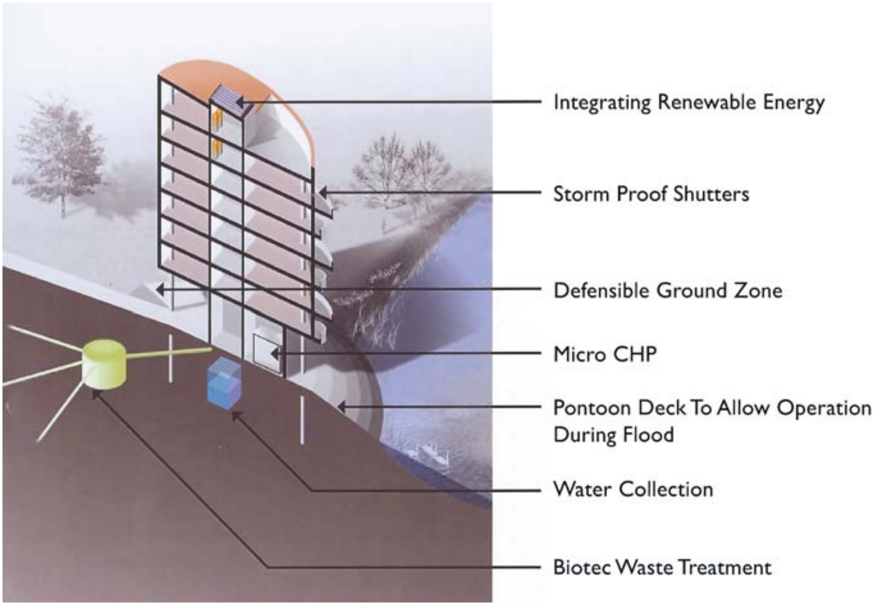

Fig. 7.10 Lifted building (Source: Baca Architects, London, 2007)

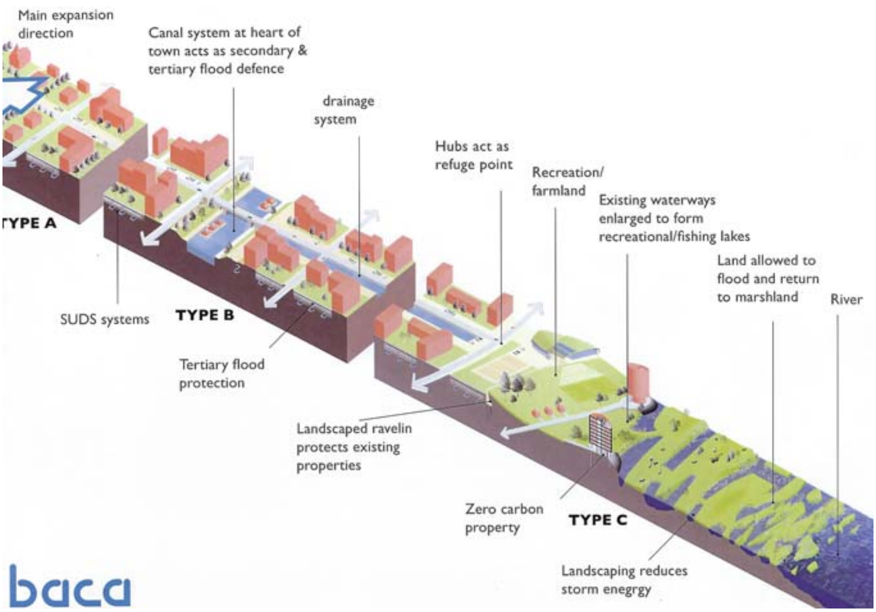

Fig. 7.11 Urban design (Source: Baca Architects, London, 2007)

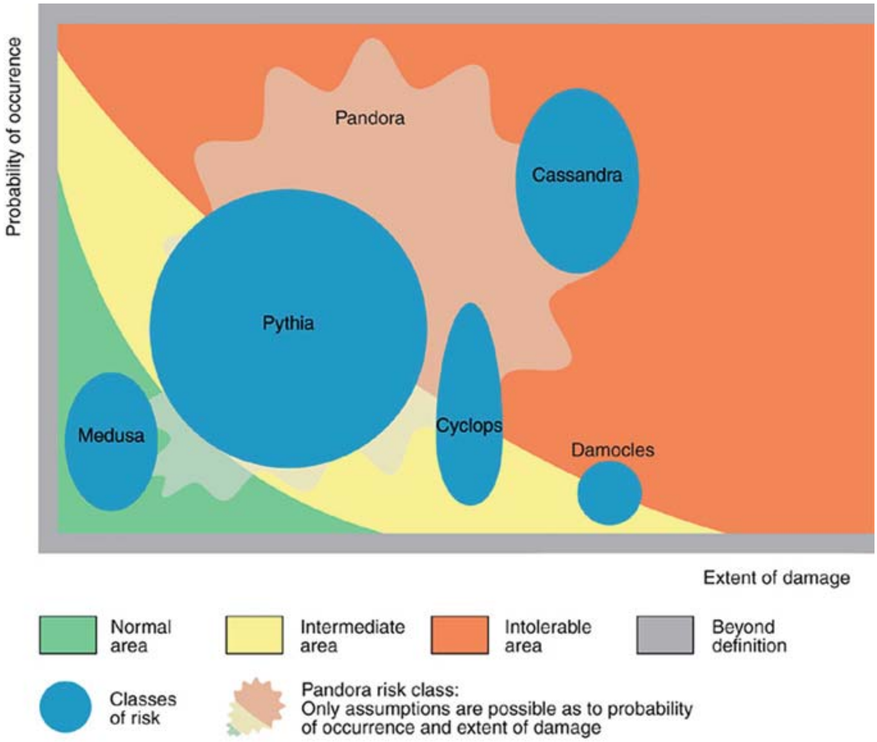

Fig. 7.12 Risk classes (Source: Renn, 2002, (Klinke & Renn, 2006))

Fig. 7.13 Climate proof buildings (Source: Baca Architects, London, 2007)

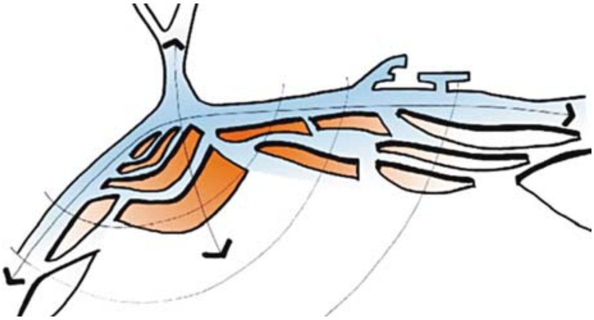

Fig. 7.14 Archipelago Dordrecht (Source: Baca Architects, London, 2007)

Fig. 7.15 Flood strategy (Source: Baca Architects, London, 2007)

The translation to an urban design leads to different dwelling types and public space, designated by whether floods occur frequently, regularly or seldomly. The public space and the buildings are adapted to the specific situations (Fig. 7.16). On top of this, in the design, integration takes place with a sustainable energy supply, transport and socio-cultural amenities (Figs. 7.17and 7.18).

7.3.3 Zuidplaspolder

The Zuidplaspolder is one of the deepest polders in the Netherlands and contains the lowest point to be found in the country (– 6.76 m below sea level). The polder is a typical Dutch landscape. The peat is dug off and the groundwater level is kept artificially low to suit agricultural purposes. The rest of the peat oxidises and this causes a further reduction of the ground level. These problems are exacerbated by climate change. It becomes increasingly difficult and costly to pump water out of the polder. This problem is exaggerated by the changes in climate, i.e. increased winter precipitation and shortage of water in summer. An added problem is sea

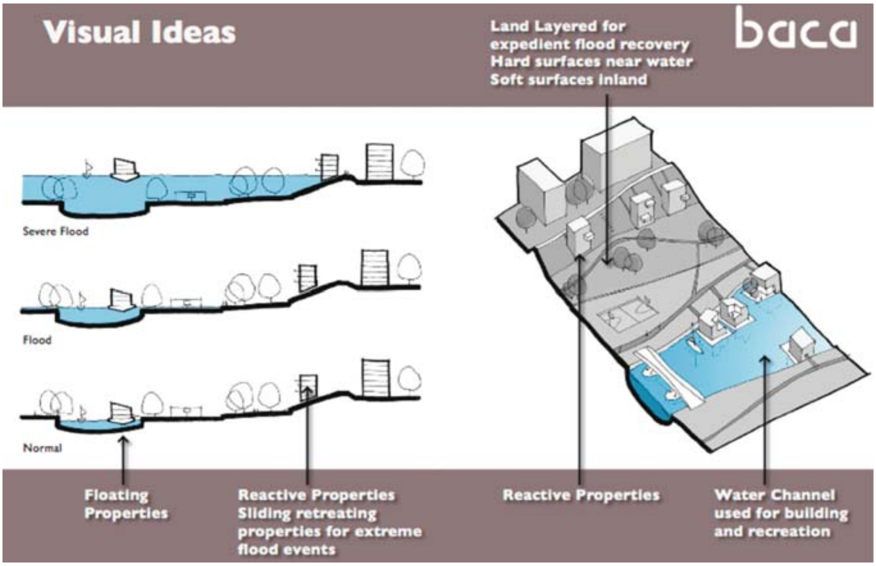

Fig. 7.16 Spatial proposal for a flood typology (Source: Baca Architects, London, 2007)

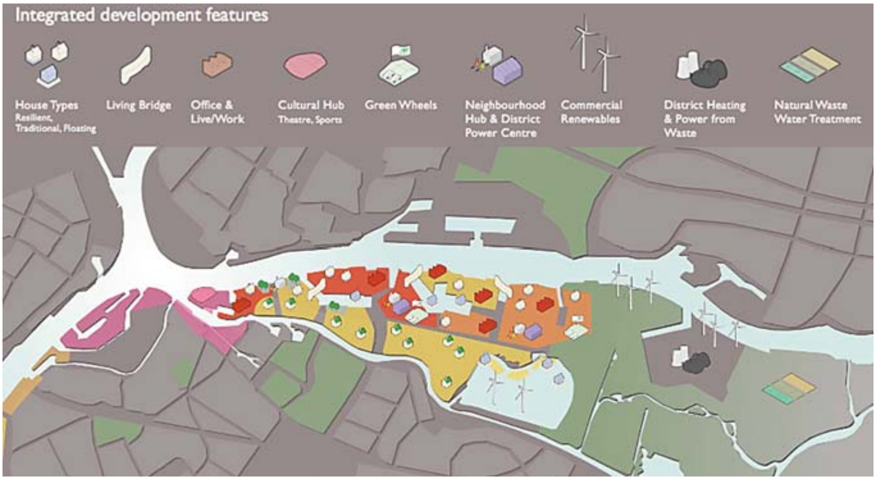

Fig. 7.17 Integrated proposal (Source: Baca Architects, London, 2007)

level rise, which increases saline seepage through the ground, which leads to saline groundwater (Fig. 7.19).

For the polder, a Master plan has been developed (Fig. 7.20), where in the ten years from 2010 between 15,000 and 30,000 new houses are intended to be built, 125 ha of business space, 280 ha of greenhouses will also be developed and 500 ha of nature will be realised. The question is how to realise all this in a climate-proof

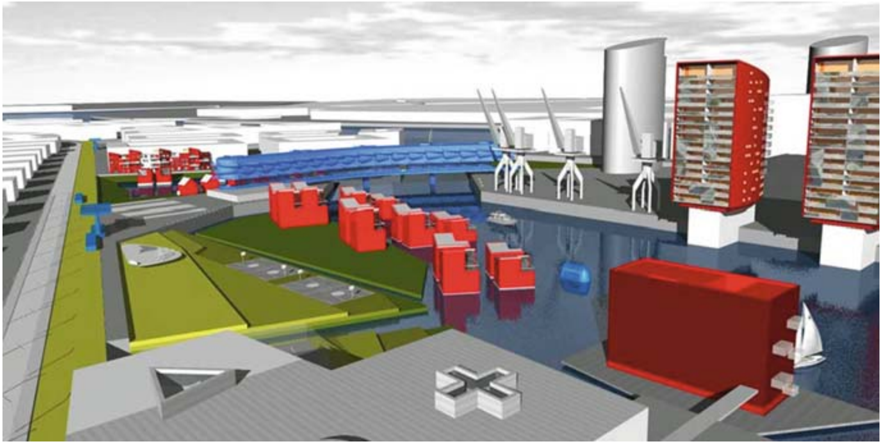

Fig. 7.18 Visualisation of the plan (Source: Baca Architects, London, 2007)

Fig. 7.19 Depth of the Zuidplaspolder (Source: Provincie Zuid-Holland)

manner. Therefore, Zuidplaspolder is given the special status of a hotspot in the ‘climate changes spatial planning’ program (www.klimaatvoorruimte.nl).

The hotspot project consists of three phases. In the first phase research is conducted on the changing conditions due to climate change and looking specifically at repetitive times of water annoyance. The possible changes in land use are mapped, using the spatial scanner (Schotten et al., 1997). This results in the envisioning of future perspectives. These perspectives are translated into design challenges in the second phase of the hotspot. Design research provides the challenges with solutions, making use of the back casting method, in which the most extreme expected future changes form the input for design at all levels, from building to region. The first area is designed climate proof (Fig. 7.21). In the third phase a costs benefits analyses is

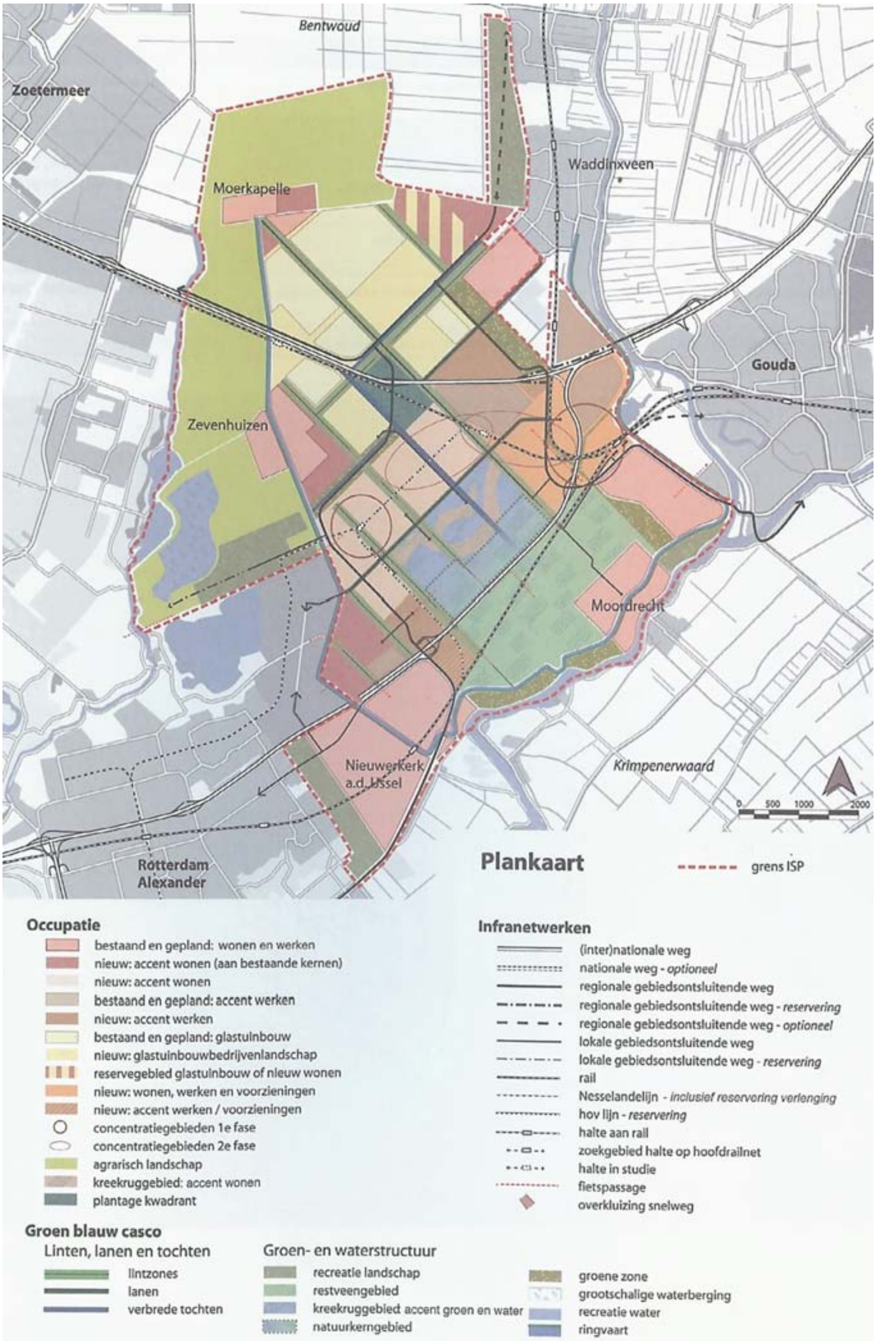

Fig. 7.20 Masterplan Zuidplaspolder (Source: Pelt et al., 2006)

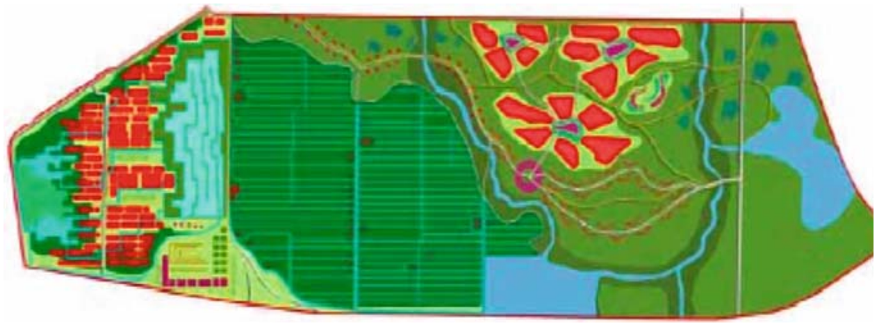

Fig. 7.21 First climate proof design (Source: Xplorelab, provincie Zuid-Holland, 2007)

carried out and finally, the climate proof quality of Zuidplaspolder is laid down in a covenant signed by all the partners involved.

7.3.4 Building with Water in Haarlemmermeer

Haarlemmermeer is an area under pressure of several spatial claims. The low lying polder is almost the lowest part of Randstad Holland, where all water is collected naturally and needs to be pumped out again. Moreover, the soil is compacted, which causes the lowering of the ground level. Salinity strikes hard during the shortage of precipitation in summer. The changes in climate urge for substantially more water to be stored, while the existing spatial claims of housing, urban developments, noise barriers, the safeguard contours of Schiphol airport, nature and landscape does not all fit in the space available. If all spatial claims were added up the polder is circa 15% too small. There is not enough money to realise green space and nature, the existing building techniques have a negative impact on water, salination and compacting of the soil. Yet, a sustainable water system, ready to meet the challenges of climate change, requires more space (Kuypers, 2007).

The task is to design an innovative landscape, where green, red and blue functions can be combined. Only then can spatial wins be realised. The plan is developed from three points of view: Controlscape, Mindscape and Landscape.

Technical research is conducted on market developments and water. This research is part of Controlscape. The research topics are the storage of water in extreme situations, dealing with safety and dynamics, the details of slopes and the natural circulation. The market study answers questions about target groups, the things to which they are attracted and if a competitive offer can be developed.

Mindscape focuses on the involvement of stakeholders, the feasibility, organisation and finance. The aim is to create a structure and cooperation, based on trust, for the long term. Landscape focuses on the integral design for the area (Fig. 7.22).

Green and blue structures steer the spatial plan. The houses are projected at the edges where land and water meet. The designed framework offers possibilities for

Fig. 7.22 Integral design for the pilot location (Source: Kuypers, 2007; © PPP Bouwen met water (www.bouwenmetwater.nl))

high and low densities. The infrastructure and space for parking is reduced to a minimum. The only way to reach the islands is by boats. The market risk is spread out because of the flexible phasing, in time as well as in space. The net spatial win is around 15% – surface water even 50%. The storage capacity in the design is enlarged in order to store more rainwater. The financial return in this plan is 15% higher than in comparable plans, even without counting in the profit in water management.

7.4 Heat in the City

In the last century 38 heat waves have been recorded of which 11 occurred after 1990 and 6 after 2000. A heat wave is in the Netherlands defined as a period with minimal 5 consecutive days above 25°, of which three above 30° (KvR, 2007). It is expected that heat waves will occur more often in the future (IPCC, 2007). Due to the rise in temperature, due to Global Warming, the average temperature in 2050 is predicted to equal the temperatures during the heat wave in 2003 (Fig. 7.23). This heat wave is one of the most extreme last century and many mortalities were recorded throughout Europe. During the two heat waves in 2003 several hundreds of deaths were recorded in the Netherlands. Robine (Robine et al., 2007) states that the number of mortalities in Europa reached 80,000. In cities the effects were especially severe. Vulnerable people, like the elderly (Fig. 7.24), people with heart diseases and breathing problems were harmed the most. Under the deaths only a small number could be explained by the so-called harvest effect (Pirard et al., 2005). The harvest effect means that people die a few months earlier then they would have naturally.

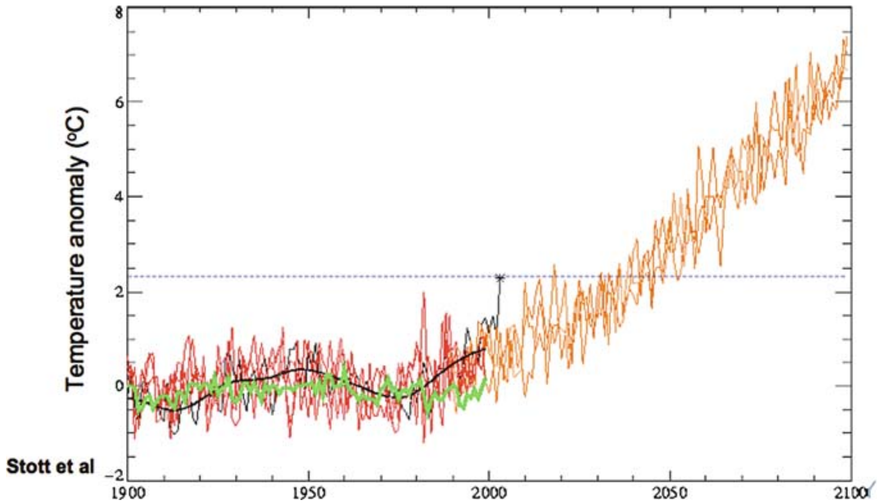

Fig. 7.23 In 2050 the average temperature equals the temperature during the heat wave in 2003 (Source: Nickson, 2007; © Greater London Authority)

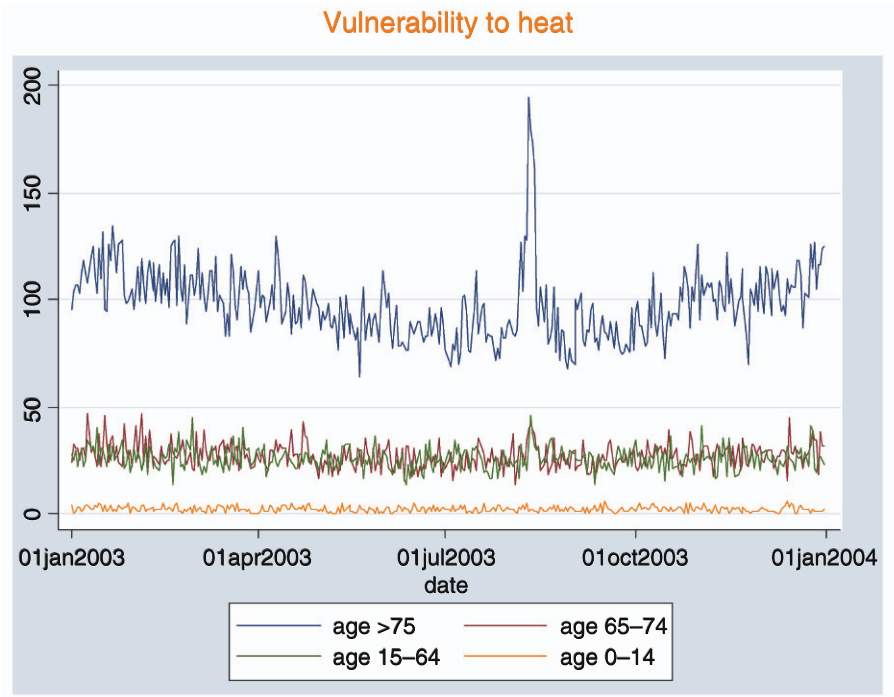

Fig. 7.24 Sensitivity of elderly for a heat wave (Source: Nickson, 2007; © Greater London Authority)

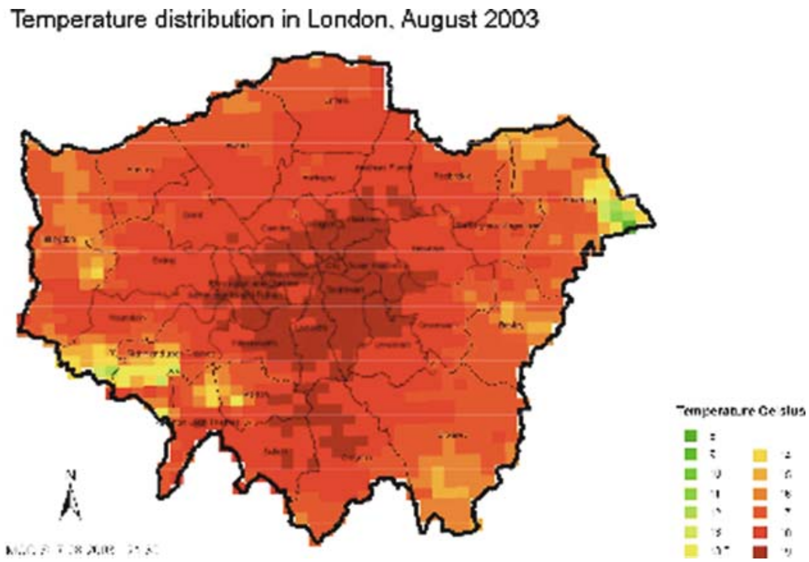

Fig. 7.25 London in *red*, temperature during the heat wave of August 2003 (Source: Nickson, 2007, © Greater London Authority)

The effect of a heat wave is greater in the city than in the countryside, because cities heat up faster, due to the large amount of stone and pavement. During the night the temperature stays high. In an urban area like London the temperature can be 8–10° higher than the surrounding countryside (Fig. 7.25). This is called the Urban Heat Island effect (UHI). The city needs to be adjusted to minimise the effects of heat waves in order to prevent the population from buying air-conditioning units, which use large amounts of energy and thus exacerbate the climate problem.

Adaptation of the city and buildings to higher temperatures and heat extremes is very important because the following developments increase in the future:

- The number of heat waves;
- Urbanisation in high densities;
- Air pollution due to traffic;
- The number of air-conditionings;
- Less cooling because of droughts;
- Elderly people.

The air temperature is not the only factor that influences the heat effect in the city. The long and short wave radiation, humidity and wind speed also influences the experience of heat by the people. In order to weigh these aspects the PET-index (Physiological Equivalent Temperature) has been developed, which makes it possible to measure the thermic component of climate and thus the experienced comfort

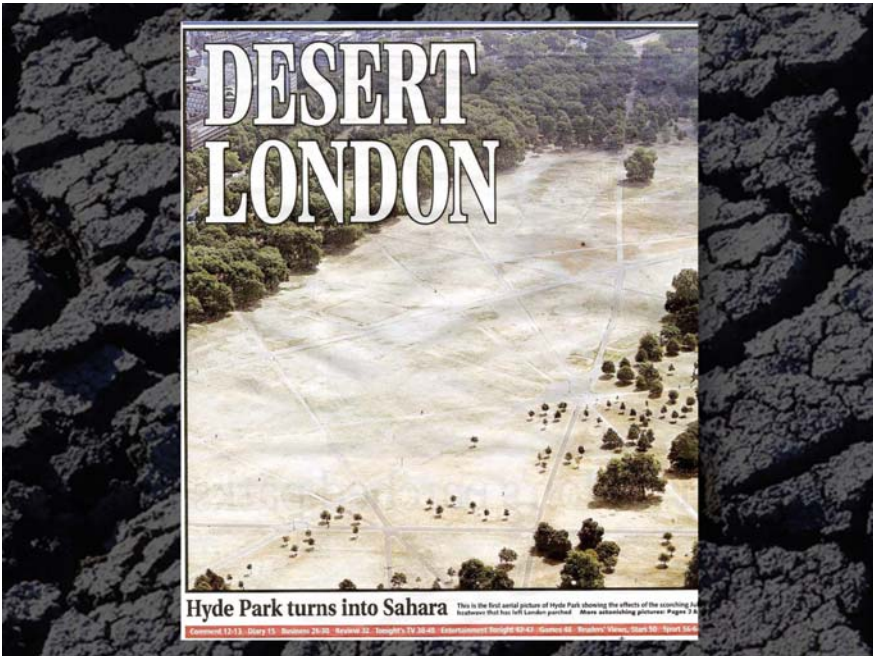

Fig. 7.26 Heat stress in London, 2003 (Source: Gilbert, 2007)

by the population (Kratschner, 2007). The PET can be used as a standard for heat stress in the city (Fig. 7.26).

Several measures can be used to deal with heat stress (Based on Nickson, 2007):

1. In case of large-scale urban developments the ventilation can be improved by a smart design. For example the shape of buildings needs to be high and small preferably, but the positioning of the buildings is also important. The city may be ‘greened’ and the number and variation of microclimates needs to be increased to give a choice for a specific environment depending the climate and find suitable cooling. Seasonal shadow can be introduced – like parasols- or sprinklers can have a cooling effect in public space, both of which are realised temporarily. In general, it is useful to realise pavements with a cooling effect – material that absorbs heat without getting hot – and plant climate proof trees, which are able to survive during heat periods;
2. In designing buildings the first win is to save energy. The saved energy will not contribute to the heat in the city. The use of white façades – which reduce radiation – the planting of trees and the use of ‘cooling’ materials can reduce the heating effects of buildings as well.
3. It is diligent to create a cooling-cascade: firstly minimise heat production, secondly prevent heat from entering the building, thirdly take care of ventilation and

design the heat balance inside – minimal thermal mass, high ceilings and the use of vegetation – and finally use city heating and cooling;

4. Ultimately, a emergency plan in case of heat waves must be developed, which focuses on minimising traffic, encouraging clean cars (not restricted to heat wave times only) and communicate the availability of cool buildings in the neighbourhood, where people can shelter in case of high outside air temperatures

7.4.1 Non-physical Heat Effects

Beside the spatial-physical heat effects in the city – the heat island effect – heat also influences the productivity, behaviour, electricity demand and lifestyle (Drunen and Lasage, 2007).

The average labour productivity deceases during high temperatures. If the temperature rises slightly, simple tasks can be done more easily, but complex ones become more difficult. If people stay one hour or more in a temperature of 32ºC physical tasks are conducted less well, while the quality of mental tasks decreases if people stay longer than 2 h in these temperature. And despite the fact that humans can get used to higher temperatures, the illness rate in the Netherlands during the heat wave in 2003 illustrates the impact: 11.5% against 3.4% normally.

If temperatures rise above 32ºC, people who do not know each other dislike each other more than normally. This might lead to more aggression. It is expected that if temperatures rise more this aggression will decrease because the general laziness increases, but no research is available on this issue yet.

In order to supply energy the power plants are dependent on surface water temperature, because the plant drains its cooling water and this is problematic if temperatures rise above 23ºC. The capacity to deliver electricity is under pressure and the consequences for the aquatic ecosystem increases seriously. If temperatures rise, the problems increase, while during heat waves the demand for cooling increases as well.

Life style changes with rising temperatures, because people will spend more time in the open air and parks and public spaces will be used more intensively. Because more people spend time outside the social interactions increase and the leisure possibilities do so as well.

7.5 Good Practices Guide (UK)

In the United Kingdom a good practices guide has been collated (Land Use Consultants et al., 2006), in which guidelines and examples on adaptation measures in the urban environment are presented. These examples are meant for project developers and designers and focus on different levels of scale and different phases of the design process. In the guide, design examples are conducted for three illustrative areas: a town centre (Bedford), a location in the city of London and for an expansion area (Isle of Sheppey).

7.5.1 The Centre of Bedford

The problems in the centre of Bedford, which are caused or intensified by climate change, are river flooding, sliding of soil – under buildings, shortage of water and the heat island effect. The measures in the Master Plan (Fig. 7.27) are meant to minimise these effects. A connected system of public spaces is created, which is

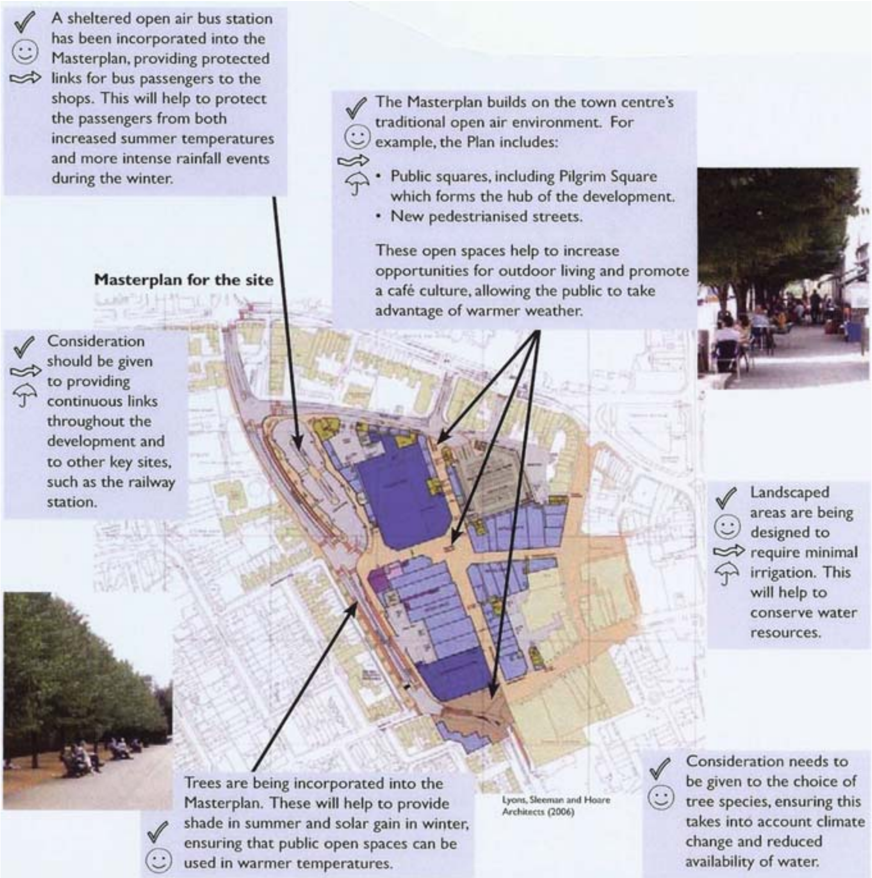

Fig. 7.27 Adaptation measures in the design for the centre of Bedford (Source: Land Use Consultants, 2006)

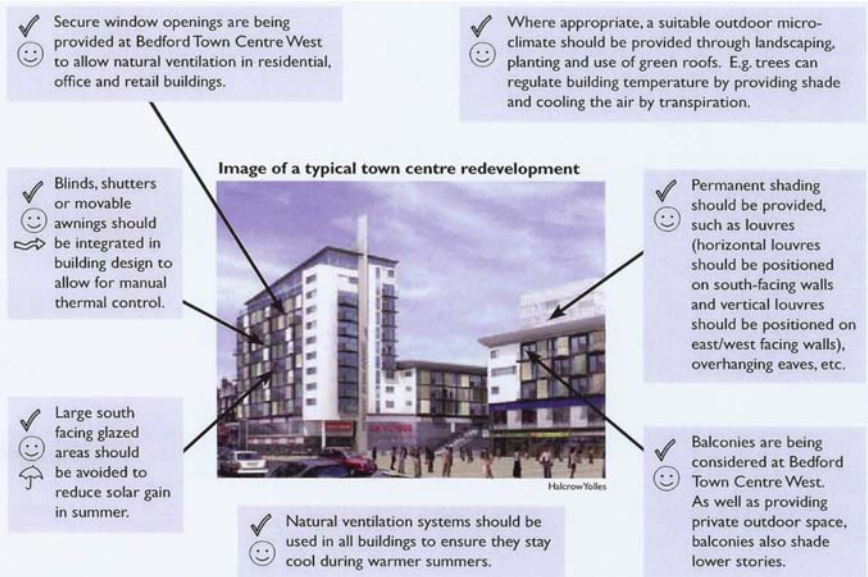

Fig. 7.28 Adaptation measures in buildings in the centre of Bedford (Source: Land use Consultants, 2006)

also connected to other urban structures. Open-air amenities are introduced, the area is landscaped and many new trees are planted, which are able to withstand changes in climate, like droughts.

The design of the buildings is climate proof as well (Fig. 7.28). Inside the buildings natural ventilation is used, enough shade is created by solar prevention and large projections outside the buildings and in the southern façades small windows are used. Balconies offer not only shade for the level below, but create also outside space for the dwellings. Finally, green planting optimises the microclimate.

7.5.2 Isle of Dogs in the City of London

In the city of London, at the Isle of Dogs climate problems like river flooding, heat island effect and water shortages converge. In the design for the area (Fig. 7.29) measures are proposed to minimise or reduce these effects. Water basins and enough public spaces are realised and in the urban design shade is created.

In and around buildings (Fig. 7.30) an attractive public space, with many cafes and vegetation is designed. In order to guarantee a pleasant climate during hot summers shopping and leisure is realised half under ground level.

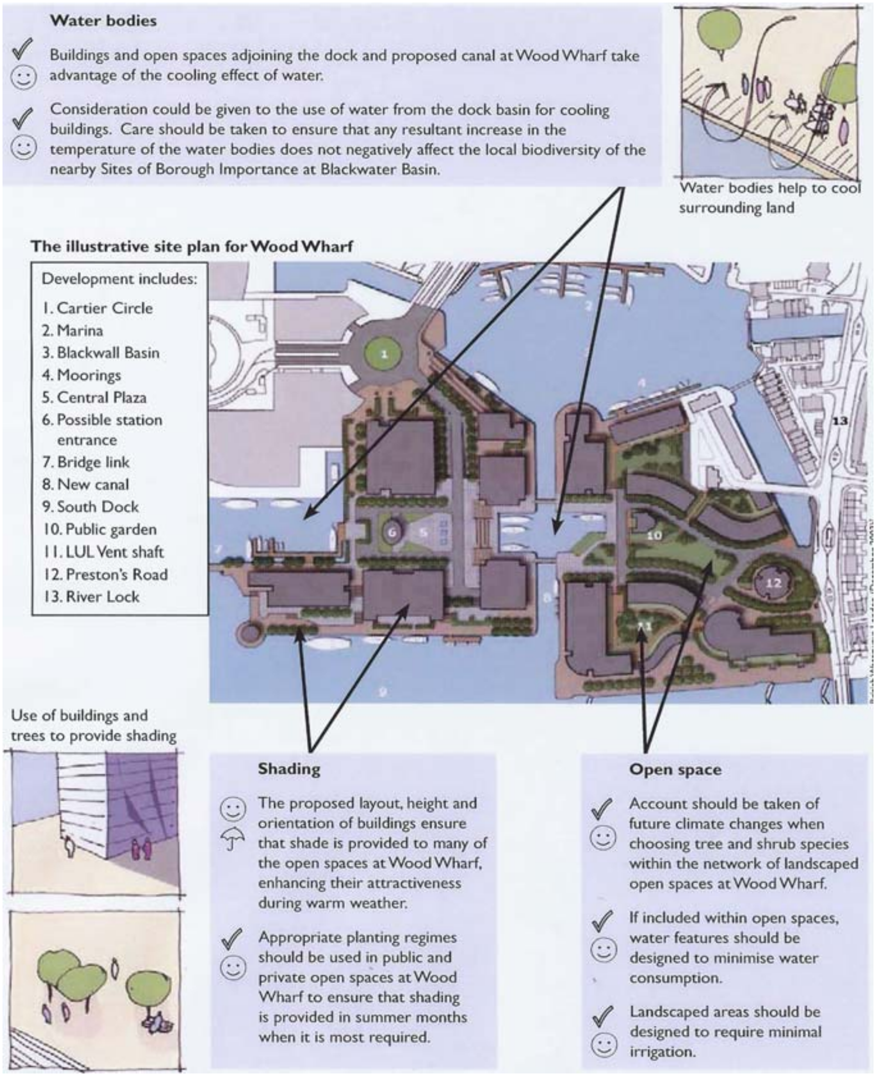

Fig. 7.29 Minimising the heat island effect in the Isle of Dogs, London (Source: Land Use Consultants, 2006)

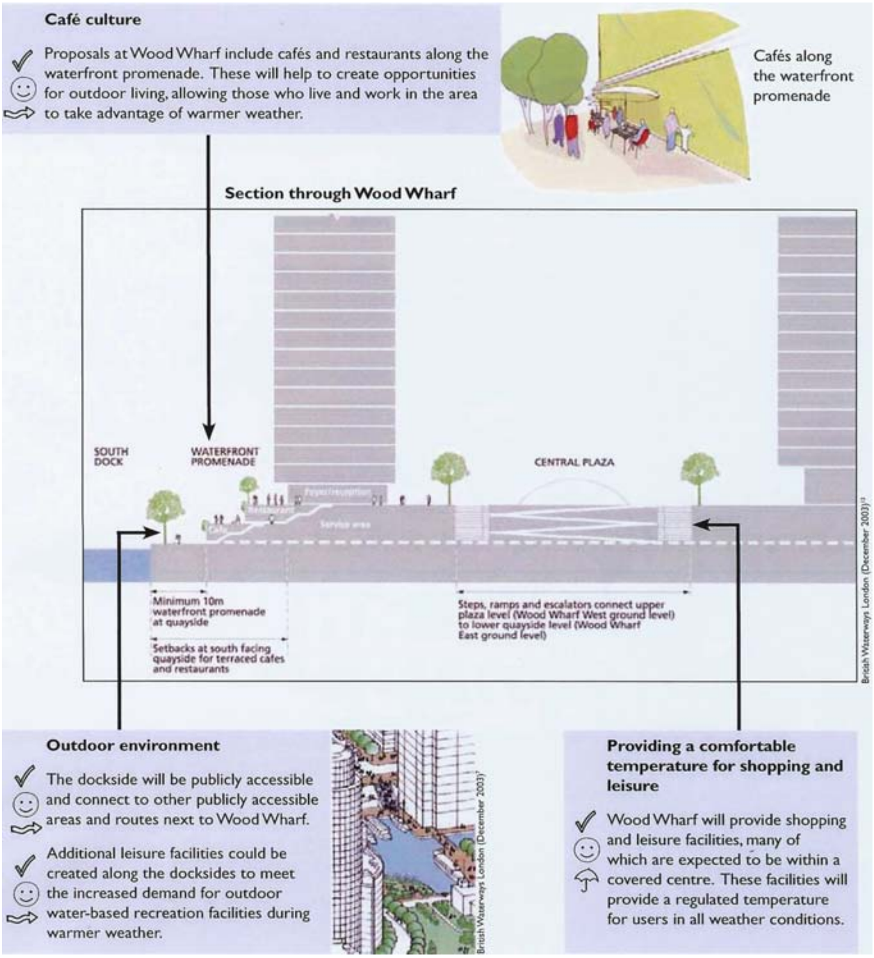

Fig. 7.30 Adaptation measures in high-rise and public space, Isle of Dogs, London (Source: Land use Consultant, 2006)

In high rise buildings shade is provided with lamellae and balconies and materials, which are absorbing heat minimal are used. Inside the buildings energy saving leads to as low as possible ambient heat gain (Fig. 7.31).

7.5.3 Urban Expansion: Isle of Sheppey

The subjects that are important with respect to a changing climate in the expansion plan for the Isle of Sheppey are river flooding, reduction of biodiversity, infrastructure, like bridges, under threat, the heat island effect and the availability of water. At an urban level dealing with flood risk is managed (Fig. 7.32).

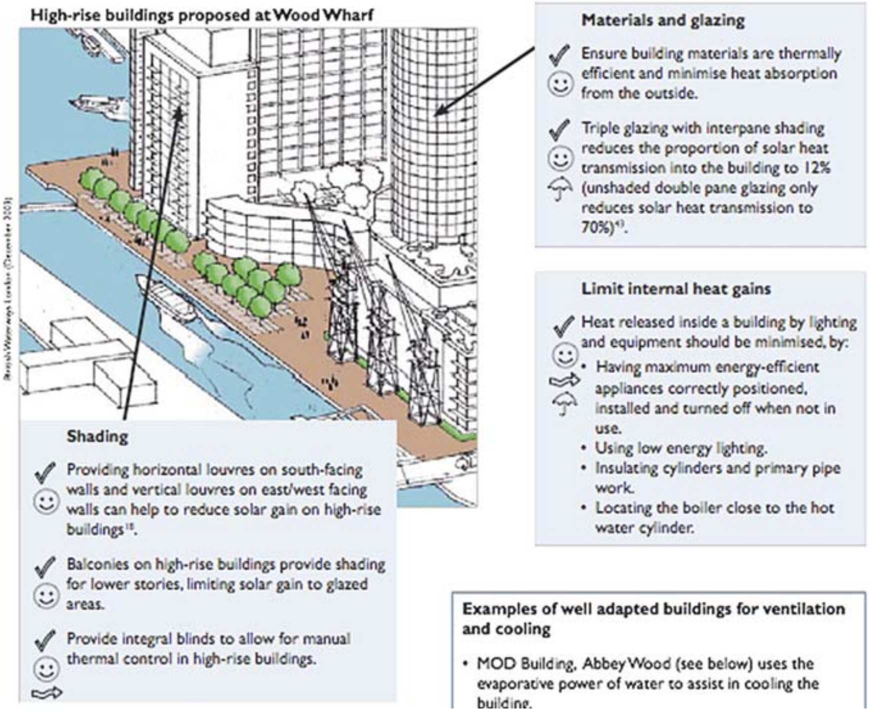

Fig. 7.31 Adaptation measures in high-rise buildings, Isle of Dogs, London (Source: Land Use Consultants, 2006)

The most vulnerable functions and common amenities are planned where flood risk is lowest. The defence against floods is soft and created in different steps. The functions at different places are adjusted to the risk profile. Lowest risk areas are developed with the highest densities and existing buildings are separated and individually protected. The urban water system is over dimensioned in order to collect rainwater and large spaces are designed to store temporary water during floods.

In the design, much space is created to keep biodiversity at the same level as previously or improve it (Fig. 7.33). The ecological networks are used to decrease the vulnerability of the system and increase the biodiversity by connecting the ecological networks. If certain areas are under pressure a flexible approach can be chosen, where the function changes in time, say from a playground initially to a nature reserve and water storage area later on. In addition, some species use linear elements 'ecological corridors' alongside existing and new urban structures.

Important functions are realised above the highest imaginable flood level and the functions at ground level are lifted in order to minimise the effects of a flood (Fig. 7.34).

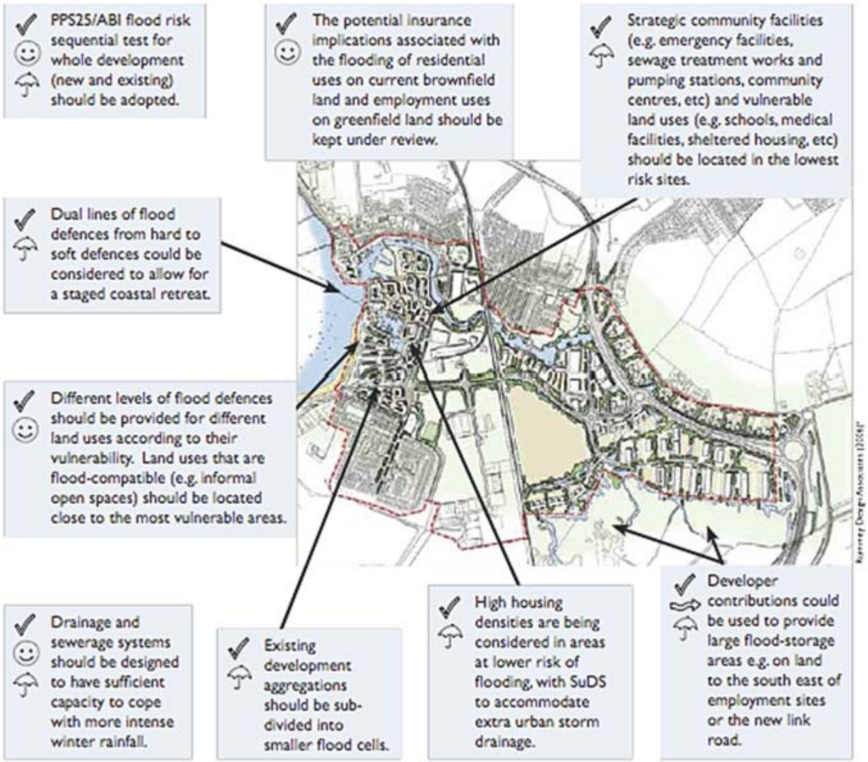

Fig. 7.32 Adaptation measures in the expansion neighbourhood Isle of Sheppey (Source: Land Use Consultants, 2006)

7.6 Concluding Remarks

The feasibility of adaptation measures does not only depend on good research, designs and plans. The economic, social and institutional complexity plays an important – may be decisive – role (Buuren et al., 2007).

The technical difficulties and challenges of realisation of measures are determined by the nature of technical amenities, the technical uncertainties around realisation and the probability assessment of the proposed measures and risks. The measures can be scored on a scale between hardly possible to realise and very simple realisation.

The social complexity is met by this set of values, which are accepted by stakeholders at the time the measure is to be implemented. The following factors play a role: number of involved partners, the amount of different standards and insights partners have, how controversial the measure is and recalls hinder and the necessity

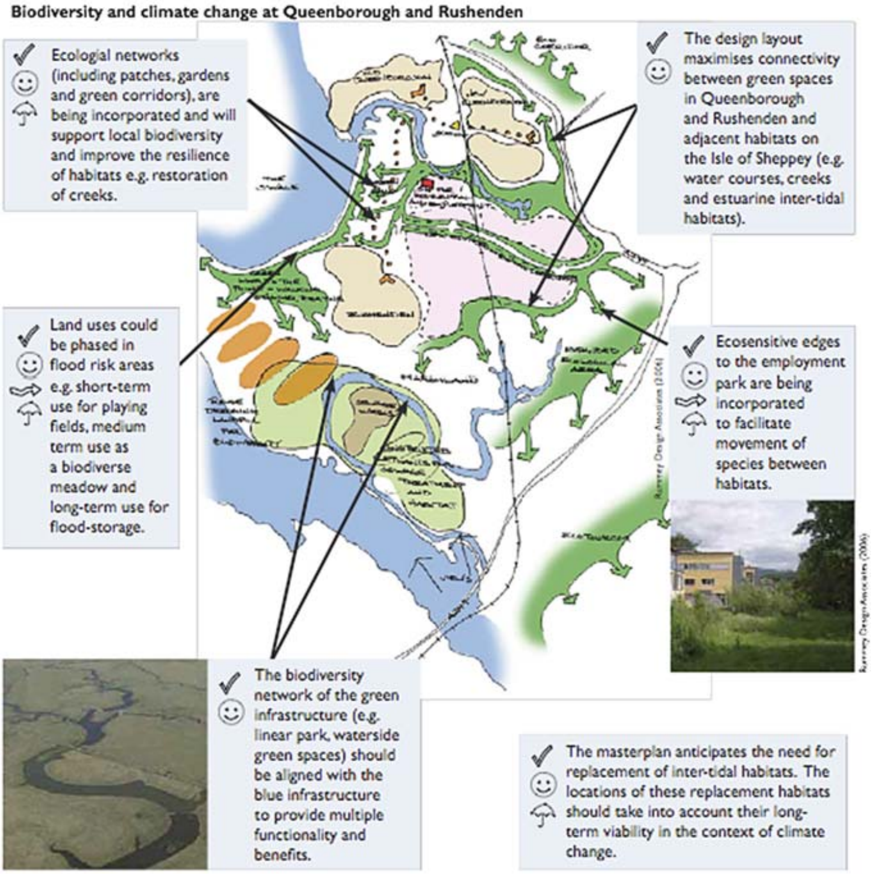

Fig. 7.33 Measures to improve ecological qualities Isle of Sheppey (Source: Land Use Consultants, 2006)

to reach consensus and converge. Measures can be scored on the scale of consensus: from complicated to easy.

If the institutional complexity of implementing the measure increases this needs to adjust the official bureaucratic organisations, existing procedures and arrangements. Increased cooperation between institutional domains, which were separated before, is necessary. The tension between existing practice and structures increases. Institutional complexity is expressed by a confrontation between institutional rules, organisational adjustments, cooperation and the level of innovation compared with existing arrangements. The institutional scoring card to realise adaptation measures is between radical institutional changes to hardly any change required.

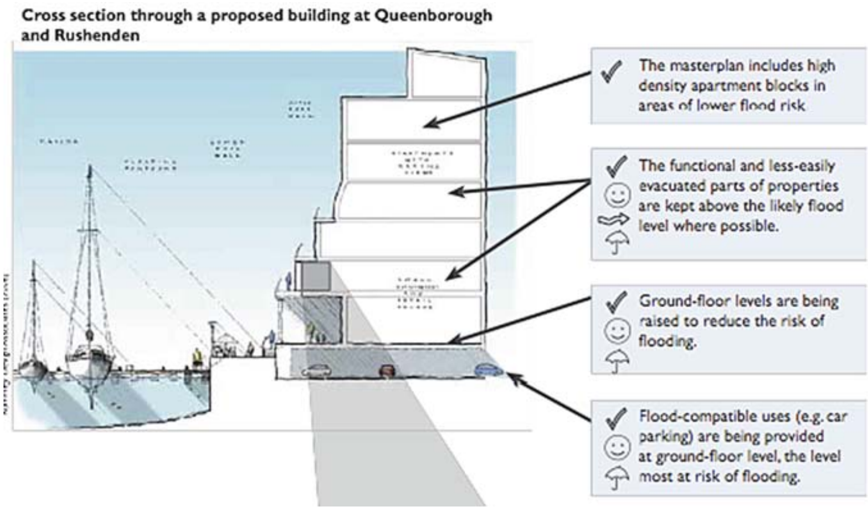

Fig. 7.34 Dealing with flood risk, Isle of Sheppey (Source: Land Use Consultants, 2006)

Buuren et al., (2007) states that the social complexity is more important than the institutional and technical complexity. Scoring and comparing the measures delivers insights into the difficulty of realising the different adaptation measures.

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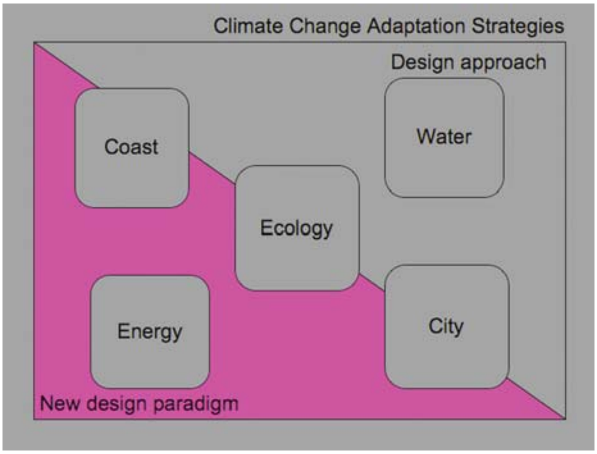
Chapter 8
Landscape 2.0



Abstract In order to anticipate on climate change and to adapt better and better to it the landscape en urban plans will have to implement adaptation measures in the designs or the planning will need to be adaptation-inclusive. These new typology of plans for spatial programmes and projects will emerge if changes in society are rapid and there is a need to anticipate on changes, which are foreseen on the long-term. A new landscape evolves in which people work together and anticipate on changes in a network-based way. Especially, in spatial planning and design the changes and adaptation measures will be incorporated. Because of the fact that long-term developments are unpredictable, the spatial planning no longer defines end images of the future but aims to define strategic interventions, which steer and initiate future developments in a more resilient direction. A new spatial planning paradigm emerges.

Reviewed by Prof. Dr. Pavel Kabat, Wageningen University and Research Centre, Earth System Sciences, the Netherlands

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8.1 In Patagonia

Ten years ago I was in Patagonia. Ushuaia, the southernmost city in the world, consists of one main street, full of souvenir shops, meant for the rich Americans, who leave their cruise ships for one afternoon to shop the shops empty. In the town contains some side streets also, less fancy, but where some special places can be found. One of the houses in such a side street, a somewhat large living room of an ordinary family house, contains some computers. ‘Internet-cafe’ was written in amateurish letters on the façade. Some friends of mine had an e-mail-address already. Thus, this seemed to be an excellent opportunity to send them a message from the other side of the world. It was possible, the strange lady of the house told me. After half an hour of typewriting I asked the lady how I could receive answers to my just send messages. She answered me to return two days later to find out if any messages were delivered on her home computer. Two days later several friends had checked their mailboxes and answered me.

Tomorrow, I leave for China. The trip is bringing me to Guiyang, a provincial town of 3.5 billion people (Fig. 8.1). The blackberry travels with me. After touch down in Guiyang I send an sms-message back home that the travel was ok and I landed safely at my destination. In the city I am able to read my e-mail and if necessary answer them. In case of an emergency they can reach me by telephone.

Fig. 8.1 Guiyang (Photo: Tracy Zheng)

With a blackberry I am ages behind, because real world travellers is on the Internet permanently, keeps up b-logs and is part of several networks at the same time. Everyone is not only consumer of news, messages or products, but becomes a provider also by supplying information in the net, which may be used by others. This free world of exchange, where everyone is consumer and producer at the same time is going to effect the spatial lay out of the country.

The adaptation to climate change and the sustainable energy supply are developments, which might cause problems on the long-term. If fossil resources are depleted in 50 years from now and the sea level and temperature is changed in 100 years fundamentally, society needs to have adapted itself. Because the changes are fundamental and are expected to be irreversible, it is necessary to take measures now. These measures need to be capable to initiate developments, which are desired on the long-term, at short-term. Existing planning methods – which mostly fix the future on a term of 10 years – and the existing political timeframe of four to 8 years need to be connected with the far future (Fig. 8.2). A new planning and design paradigm will emerge, which – in order to be successful – needs to connect to developments in society. And the new paradigm shall consist of the characteristics of an Internet society (Toffler, 2006) and Web 2.0 (Eye, 2007).

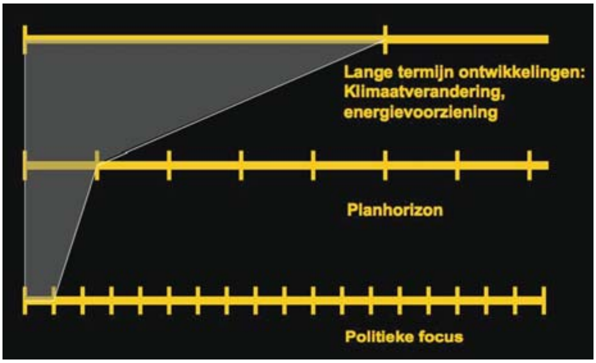

Fig. 8.2 Connecting long and short term (Source: Roggema, 2007b)

8.2 Web 2.0

The new net –Web 2.0 – is all about connecting. Aslander (Eye, 2007) states that the connection of people, ideas and information will be the new economy, in which hierarchical organisations no longer are leading, but where flexible network organisations become the standard. In this future it is more important to be a connector than the owner of knowledge or raw materials. Internet becomes a forum of exchange – via web-logs and on Hyves – instead a collection providers on websites. This new economy it is less important to make money out of your services, but it is all about the value that you contribute to something else: the economy of giving. Give and share leads to an endless return. Money is handy, it is limited also: you can give it away only once, while knowledge stays forever and can be divided endlessly (NRC Next, 2007).

The Internet revolution takes place now. After the transition form an agricultural towards an industrial society, the next revolution is becoming a fact (Toffler, 2006). In the old days it was important to have power over labour and posses land, later it was decisive who had power over machines or had an entrance to oil. This changes radically. Internet is free for all. Not the power counts, but the added value one is capable to supply. The exchange of information leads to minimal power for internet-providers – if they are comparable with the old factories after all. Not possession decides, but the immaterial contribution to the net end the exchange of information will be.

8.2.1 A New Energy Order?

The energy world functions like an old – hierarchical – factory. The ones that have power over raw materials, transport networks and as large as possible power plants, have power and decide what will happen. If scarcity of resources increases, the energy companies want to become even bigger in order to create a profitable economy of scale and trying to reduce energy prices as much as possible. That this on the long-term never will be successful because resources are finite. If the Internet revolution is applied on the energy world a new energy landscape glimmers. Then it becomes not only possible to consume energy, but supply it to the net as well. Rifkin (2004)describes in his book 'The hydrogen economy' how this new landscape could function. Every household has the power to gain energy. Sustainable options like solar panels or windmills, but more complicated alternatives like the use of geothermal energy can be used at a local level to provide in ones own energy demand. As fossil resources will become increasingly expensive, these sustainable options are already more competitive. But is consumers are allowed to deliver their energy-surpluses to the net, the self-production of energy becomes really profitable. Because the potential production of energy at household level exaggerates the demands of that household, delivery is potentially a chanceful option to get rid of these surpluses. Two developments support the emergence of these free accessible energy networks: the necessity to produce sustainable energy in order to minimise greenhouse gas emissions, but more important, the societal developments, where services represent values more than material issues. This development, mainly caused by the intrinsic cultural changes, seems unavoidable. The meaning of this is that, at a local and regional level energy landscapes need to be developed, which provide the net with energy and take energy whenever necessary.

For Northern Netherlands the spatial possibilities of a sustainable energy system are for the first time explored in the Grounds for Change project (Roggema, et al., 2006). Not every landscape contains identically energy characteristics and therefore not every source of energy can be used everywhere. These characteristics determine the most optimal combination of energy resources. For Northern Netherlands the potentials of wind, hydropower, solar, geothermal and biomass energy production are researched (see also Chapter 6). The specific combination of suitable energy potentials is the base for energy landscapes (Fig. 8.3), which can be layed out based on the available energy types.

For the province of Groningen these potentials are researched in more detail (Dobbelsteen, et al., 2007). The combination of possibilities to produce energy and

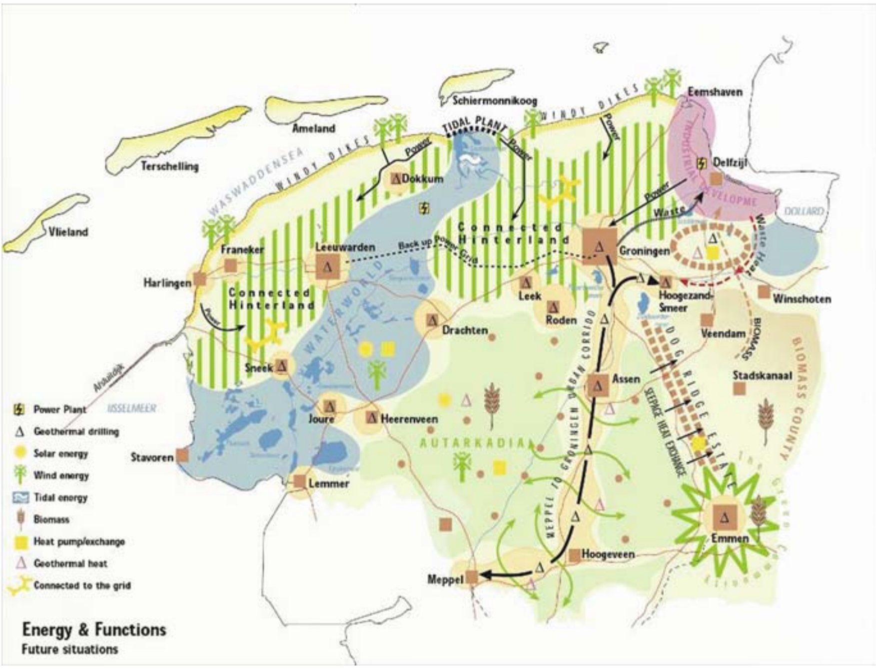

Fig. 8.3 Energy landscapes in Northern Netherlands (Source: Roggema, et al., 2006)

combine local demand for cooling and heating as well as the production of solar, wind, water and earth leads to a spatial intervention map for Groningen, which represents the energy steered measures. By letting this regional energy production steer the spatial lay out two objectives are realised: energy demand is minimised because functions are positioned closer to the energy source and the sub-regional combination of most optimal sustainable energy sources delivers a constant amount of energy to the *energy-net 2.0*. The supply of energy from a certain area is levelled out, which minimises high peaks and lows by exchanging energy between each other at a low scale.

8.2.2 Landscape 2.0

Free traffic of energy is a matter of technique. If it is technically spoken possible, every person is able to produce and deliver energy to the net. The energy needs to be produced at a local level. Landscapes and buildings need to be adjusted to make this production possible. Would a same reasoning be possible for the adjustment of landscapes and building to the effects of climate change?

Then, a platform for exchange of measures, which increase the adaptive capacity of a certain area, needs to be installed. This platform functions as the place where contributions and withdrawals of adaptive capacity can be exchanged. The contributions can be done individually or collectively at a sub-regional level, for instance by a regional arrangement of citizens, companies and governments. Important is that a free exchange takes place and money is not the driving force. If collectively a water storage basin is created in a certain area or other measures are taken to minimise the effects of climate change the adaptive capacity of this area is increased. Others will profit from this and will contribute at their turn to increase the quality of the landscape or provide enough cooling capacity in the city by planting trees or create ponds. The exchange of measures at area level develops, which results in a climate proof region and enforces the development of new landscapes. This is profitable for everyone. The types of measures with the highest value are those measures, which are successful at the place where they are taken, but also are capable of changing an entire region (Roggema, 2008c).

8.3 Challenges of Complexity in Planning

Current planning methods are being challenged by several developments in society. Society itself is changing from an industrial society towards an Internet society (Toffler, 2006). Beside the changes in society, the same society is confronted with more and more turbulent circumstances. Uncertainty about the future is increased by long-term changes that are ahead of us. Climate change and energy supply are two important examples of this. The current planning system creates an end-image of the future in which current problems are solved. But this way of planning no longer satisfies, because the problems we face today are complex and long-term oriented. The question is if current planning systems contribute to the building of resilience into society or that another planning system is needed to do so. Planning has the assignment to react to the uncertain developments of the future and has to contribute to the generation of resilient communities. The theory on complex adaptive systems may help planning to adjust itself to the new questions and to give answers to these new challenges. A new planning paradigm might emerge. This chapter elaborates on the theoretical background of increasing complexity in planning.

8.3.1 A Society in Turbulent Circumstances

Today's society is confronted with an increasing turbulent environment. Emery and Trist (Emery & Trist, 1965) describe turbulent environments as follows: 'the dynamic properties arise not simply from the interaction of the component organisations, but also from the ground itself. The "ground" is in motion'. Translated to the spatial planning field, the spatial elements or components (buildings, infrastructure and people) do not only interact and form a system together, but dynamic properties also arise from the ground itself. Literally: from the soil, the natural system itself. This natural system is currently influenced, and will be in the future, by a mass depletion of fossil energy resources, a relatively rapid climate change and a transformation to an Internet economy. These 'external' factors and 'inclusive' properties of the natural system itself, cause a turbulent environment for the spatial system. The energy supply system, climate change and the Internet-economy have similar characteristics. They:

- Are complex and difficult to overview and understand at once;
- Include lots of uncertainties;
- Are strongly interrelated with other functions and with each other;
- Have impact on the long-term.

The fact that these phenomena are difficult to understand also implies a new environment for spatial planning practice. The unpredictability of interrelated long-term developments leads to a decreasing grip of the planning system on future developments, because traditional planning methods (blueprints, short-time oriented) are no longer useful (Roggema, 2008c).

Thus, the new demands are difficult to integrate in spatial planning practice (Fig. 8.4). The planning system is too stiff and not easy adjustable. To increase the flexibility of the spatial system theory on complex adaptive systems may be used. The objective is that the resilience of the spatial system increases in order to deal with unexpected and unpredictable developments. The resilience of the spatial can be defined using the ecological definition of resilience: *The capacity of a system to absorb disturbance and reorganise while undergoing change so as to still retain essentially the same function structure, identity and feedbacks* (Walker, et al., 2004). The Groningen case (Chapter 2) shows a method and the first results how resilience can be improved.

In this paragraph a short description of the changes in society is presented. The way these changes malfunction in the current planning system and the way today's planning community deals with this increasing gap will be explored. Furthermore, the theoretical background on complex adaptive systems is researched and used to design a new planning paradigm, which is better prepared to deal with turbulent circumstances.

8.3.2 Internet-Economy: The Turbulence Driver

In the Internet-economy, people are no longer only consumers of news, adds or products, but they become also a generator of information and are able to deliver to the Internet in order to share their deliveries with others (Bakas, 2005; 2006; NRC Next, 2007; Eye Magazine, 2007). This free space of exchange, where every consumer is also a producer, could influence the spatial design of regions. Society is transforming from an industrial economy, based on power and position, towards an Internet economy, based on values and knowledge (Toffler, 2006; Greenfield, 2003). The impact individual people or collectives of individuals generate to (trans) form society, just starts to become visible, but will increase in the near future (Roggema, 2008b), when a landscape 2.0 could emerge. The following transformations can be seen already:

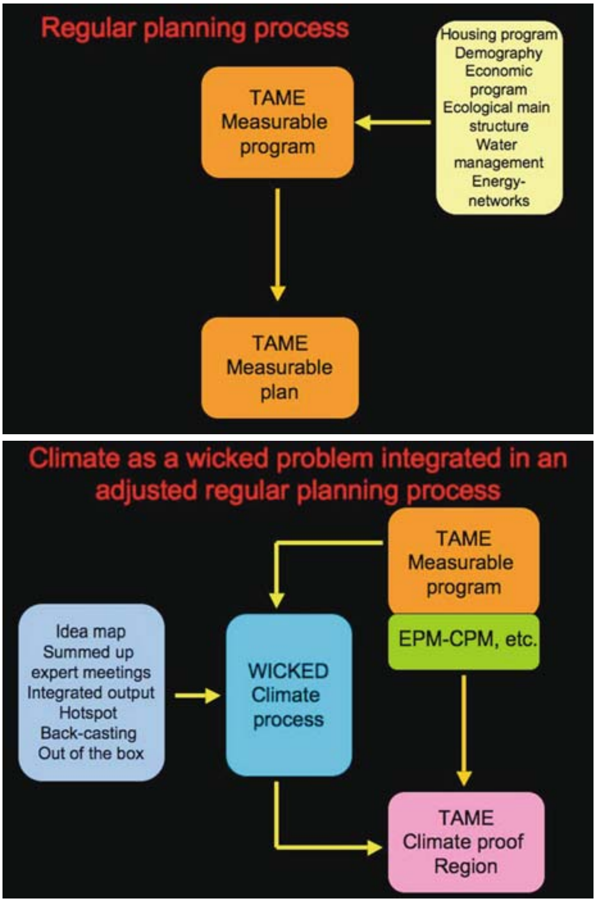

Fig. 8.4 Comparison of a tame planning process and a wicked one, in which is more room for turbulent adjustments (Roggema, 2008d)

- It is no longer useful to create an end-image of a society, constructed by politicians and used to determine how people behave. People need to be seduced to change or show certain behaviour. Society emerges as a result of the interactions and summed up behaviour;
- Climate change is an illustration of how an increasing series of complex interactions lead to problems, which occur and become apparent at a later stage. The exact relations between interactions and effects are impossible to overview by individuals;
- The new economy is a connection of people, ideas and information. In this new economy flexible network organisations take over. In this new world it is more important to be a connector of knowledge than an owner of goods. Possession is not the key factor. The key factors are the immaterial additions to the network and the exchange of information;

- When the transition to an Internet-economy is used to understand future changes caused by climate change and energy supply, new landscapes lie in front of us. It is no longer only possible to consume landscape for living, enjoying or production it can also deliver climate resilience and supply energy to the spatial environment.
- People add individual elements to a bigger world, knowing – partly unconsciously – that they are part of a system, built out of billions of parts and consisting of unpredictable interactions. They realise that it is impossible to single-handedly create one future state of society. They know that individual contributions and interactions form the future. While it seems that people are only concerned about their short-term happiness, look at the way they vote for instance, yet their inside voice tells them that they are constantly shaping the future in a way that is difficult to understand.

These changes in society offer a chance to adapt more easily to climate change, because large groups of people intend to work together, not in a power based way, but based on the contribution of values. This state of mind opens views to a stronger built society than the hierarchical one, because people are no longer just consuming energy or political messages, but they start to produce them their selves and start to contribute. Instead of a one-way society a 'both ends' society is emerging.

8.3.3 The State of Today's Spatial Planning Practice

Climate change is a long-term development. Starting today, the changes will continue for the next century and beyond. Building houses and generating urban patterns are processes with a similar time span: they also last 100 years or more. Thus, in theory, it should be easy to combine and integrate long-term changes and developments with spatial planning. In practice however, spatial planning mostly fixes its horizon on a period of maximal ten years (Fig. 8.1). This short-term focus in a situation, where long-term changes are predicted creates unnecessary difficulties. Although it is relatively easy to incorporate long-term changes into the spatial planning system, the issues of climate change and energy supply are only rarely found in current spatial plans.

The spatial planning system that is used today is not very flexible. Current problems are analysed and formulated in quantitative terms as much as possible: number of houses, acres of land for new industrial areas, needed area for ecological structures etcetera. Once the decision is made the size of developments and the objectives are fixed. This may be called a tame planning method, in which rationality and a normative approach is dominant. Conklin (Conklin, 2001) characterises tame problems as follows:

- Relatively well-defined and stable problem statement;
- Definite stopping point, i.e. we know when the solution is reached;
- Solution can be objectively evaluated as being right or wrong;

- A problem belongs to a class of problems which can be solved in a similar way;
- Solutions, which can be tried and abandoned.

Because the focus is on the first couple of years, it is difficult to include long-term and complex elements into the planning process. This causes a laborious adjustment of turbulence matter in the tame planning methods. To incorporate the turbulent environment into a spatial planning method an adjusted method (Fig. 8.4) must be developed, in which room is created for a wicked (as the opposite of tame) bypass (Roggema, 2008d). If this bypass is included in the process, these turbulent environments are given the surroundings in which they fit: irrational, unsolvable problems are placed into a wicked process.

Rittel and Webber characterise wicked problems by ten characteristics (Rittel and Webber, 1973):

1. There is no definite formulation of a wicked problem;
2. Wicked problems have no stopping rules;
3. Solutions to wicked problems are not true or false, but better or worse;
4. There is no immediate and ultimate test of a solution to a wicked problem;
5. Every solution to a wicked problem is a 'one-shot operation'; because there is no opportunity to learn by trial-and-error, every attempt counts significantly;
6. Wicked problems do not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated in the plan;
7. Every wicked problem is essentially unique;
8. Every wicked problem can be considered to be a symptom of another {wicked} problem;
9. The causes of a wicked problem can be explained in numerous ways. The choice of explanation determines the nature of the problem's resolution;
10. (With wicked problems) the planner has no right to be wrong.

8.3.4 New Environment for Planning: Small Adjustments Made

Recently, the first small adjustments in the current planning system become visible. The planning community becomes more aware that their environment is changing towards an increased turbulence. Therefore, an increasing number of projects are carried out in a more interactive way. In the planning processes more stakeholder involvement is organised and the co-operation is improved. In the Netherlands this kind of planning processes are called development planning or area development. The following characteristics of this planning approach are defined (Zonneveld, 1991; Schön and Rein, 1994; Castells, 1995; Teisman, 1997; Dammers, 2000; *Innovatienetwerk,* 2002; Esselbrugge, 2003; Rooy et al., 2006; Dijk, 2006; Ruimtelijk Planbureau, 2004; Adviescommissie Gebiedsontwikkeling, 2005; IPO, 2001; *VROM,* 2003; VROM-raad, 2004, 2006; WRR, 1998):

- *Include a specific defined intervention.* In planning processes a well-defined impulse, which is capable of starting the engine of the system is included. This intervention needs to be very specific and located, with a strong emphasis on the impact it has or is expected on changes in the system (the system innovation).
- *Choose some kind of fuzzy future direction*. A dynamic planning process takes the future dynamics of society as starting point and needs to offer room for unpredictability by initiating a certain direction, which fits best in the broad band of future dynamics.
- *Enhance a higher level of complexity in the region*. To increase the overall fitness in a region the system has to be brought to a higher level of complexity (Homan, 2005). It is expected that this lead to a higher level of resilience. The overall fitness of a system increases by bringing together a large pool of elements (a lot of participants), which co-evolve and are able to reach a creative jump (Homan, 2005).
- *Create a permanent dynamic process in which participants often change*. Participants involved in the process tend to defend original concepts and to act defensively towards possible changes in these concepts. To prevent this from happening, an atelier might be introduced, in which one group of involved partners defines and executes an intervention after which the lead is given to the next group, which makes its own creative jump.
- *Keep numerous perceptions involved in the entire process*. The amount of perspectives in innovative processes is large. Instead of aiming to converge the perceptions in the final phase of the process it might be better to keep several perceptions, which exist next to each other in different constellations and enrich each other like in internet communities.
- *Prevent cultural patterns from inducing repetitive solutions automatically*. Cultural patterns in organisations lead to repetitive solutions, produced by those organisations, even if the problems and issues are new. If a discussion is started on the applicability of these solutions, these organisations tend to close the ranks and strengthen their believe in the existing solutions (Roggema, 2005). It is estimated that this effect increases if councillors take responsibilities for longer periods (three terms or more).
- *Use projects to start processes, not to finish them*. Projects function as a spatial-functional impulse, which are able to change future pathways in long-term problems like climate change and energy supply. Thus, these projects are not aiming to create an end image for the future, but to start the building of a system of higher complexity, which is supposed to be more resilient.

The question remains if the adjustments the planning and design community carries out in the planning processes are strong enough to deal with real turbulent circumstances. Probably, it does not meet these demands, because the adjustments are done within the existing (tame) planning system. Larger adjustments are necessary. Therefore, the main objective for a new planning paradigm is to increase the capability to build up resilience for turbulent circumstances.

8.3.5 Increase Resilience

Resilience is defined as: ‘the capacity of a system to absorb disturbance and reorganise while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks’ (Walker et al., 2004; Walker and Salt, 2006). Thus, the increase of the resilience of a system means that a system is better capable in absorbing disturbance. When a system is placed into a turbulent environment it is necessary to increase adaptability in order to deal with turbulent ‘attacks’ on the system. Adaptability is defined as the capacity of actors to influence resilience.

The crucial aspects of resilience are the following (Walker et al., 2004; Walker and Salt, 2006):

- Latitude: maximum amount a system can be changed before losing its ability to recover (before crossing a threshold);
- Resistance: ease or difficulty of changing the system;
- Precariousness: how close the current state of the system is to a limit or ‘threshold’;
- Panarchy: the resilience of a system at a particular focal scale depends on the influences from states and dynamics at scales above and below (for instance global climate change).

Actors in the system are capable of managing the resilience of a system and influencing the adaptability of the system. The collective capacity to manage resilience determines whether the actors can successfully avoid crossing into an undesirable system regime or return to a desirable one. Actors may use four ways to influence resilience and increase adaptability:

- Move thresholds
- Make the threshold more difficult to reach
- Move the system away from the threshold
- Avoid loss of resilience by managing cross-scale interactions

If the adaptability can be increased the system has better chances to deal with turbulent circumstances, because it is easier for the system to absorb disturbance and reorganise itself while undergoing change. The level of complexity of a system may very well be a crucial factor in determining this system’s capability to adapt. Is a simple system less adaptive and is it less capable of influencing resilience? And do complex systems contain a higher capacity to do so, which make them more adaptive? If so, this offers spatial planning an opportunity to deal with turbulent circumstances: The regional spatial system is a complex system, which functions according the rules of complexity, adaptability and resilience. Thus, the planning system should be organised according to these rules as well: the first images of a new planning paradigm.

8.3.6 Complex Adaptive Systems

In order to deal with turbulent circumstances, the adaptability of systems can be increased if the collective capacity to manage resilience is improved (Walker et al., 2004). This requires a collective view on the future 'dream', the collective future objective. This collective view can be better developed if the characteristics of self-organisation are taken into account. Self-organising systems are capable of increasing adaptability, or increase their overall fitness (Homan, 2005), and reach their complexity level by organising them-selves. When a new 'view on the world' (i.e. a climate proof region) is shared by thousands of individuals, who start to aim for the same objectives, the system will auto-develop from that point on. Johnson (Johnson, 2001) describes the following guidelines:

1. Put more agents/cells (individual elements: streets, people, buildings) into the system and give them a longer trail, i.e. more impact;
2. Follow those trails, which make agents more sophisticated. The trail needs to be enlarged and interconnected to create a higher level order;
3. A huge pool of individuals and some simple rules;
4. Create the un-average. Social un-average elements are important as the announcers of what is happening in the system. The law of the few states that there is always a small number of un-average exceptions with extraordinary creativity, which may flourish between a 'bunch of average'. These exceptions play a crucial role in bringing the system to a higher level of complexity. If they are able to give a push or an impulse the system starts to evolve;
5. Unexpected solutions cause the adaptation of the system, which makes it more resilient and better prepared to adapt;
6. The regional city landscape is the complex adaptive system (Jacobs, 1961). Find the kind and number of nodes (for example shopping mall areas), the transport system (freeway/internet), interactions and information-flows of our time. What are the new 'neighbours, sidewalks, communities, strangers and cities' (Jacobs, 1961)?
7. Formulate the positive and negative feed back loops in order to reach a resilient regional community

To improve collective management of resilience a collective new view on the world needs to be created and stimulated. Usage of advertisement and the creation of love marks (Roberts, 2006) may be useful here.

The improvement of the adaptability of a self-organising system can be sustained best in complex systems, because the actors in these systems have, if compared to simple – closed/linear – systems, better capacity to do so (Fig. 8.5).

8.3.7 Typology of Complex Systems

Systems in general can be subdivided in 4 categories (Wolfram, 2002): (I) closed system, (II) linear feed back systems, (III) systems randomly open to assimilation

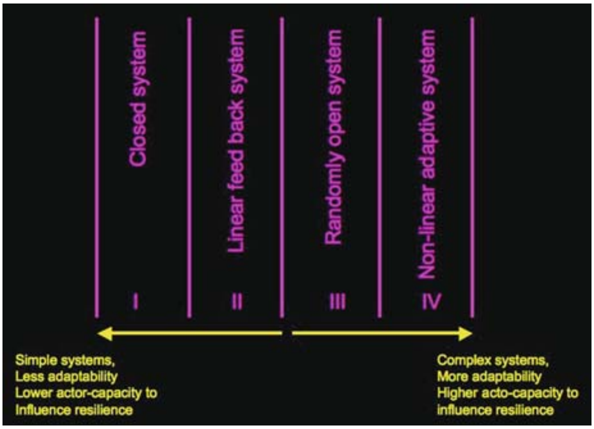

Fig. 8.5 *Simple and complex systems*

and (IV) non-linear adaptive systems. De Roo (2006) describes the characteristics of class IV systems. These systems are able to behave such as to maximise benefits of stability while retaining a capacity to change (Mitchell Waldrop, 1994).

The question is how to interpret design projects in terms of complex systems. The following aspects of design projects are relevant:

- They contain a large number of interactions;
- Simple rules underpin complexity;
- Adaptation, self-organisation and co-evolution are apparent;
- The design transforms and retains the project;
- Design principles are characterized by robustness, emergence and fitness for purpose.

De Roo describes the same characteristics for class IV systems (De Roo, 2006). In addition, experience shows that the subject of design is often sensitive to impulses and tipping points.

The question at this stage is which planning approaches would be most effective if the future consists of Class IV systems, manifest in a large number of interactions. The insights of organisation dynamics can be useful here. The conditions to improve the overall fitness of an organisation are (Homan, 2005):

- Large groups of individual elements lead to emergence of collective patterns under certain conditions (amount of connections, quality of relations and network matter);
- Enough diversity but not too much to start autocatalytic processes;
- Idea-interaction (Homan calls it idea-sex) between different elements may lead to creative jumps where new structures and information is created;

- Co-evolution of local systems leads to emergence of collective patterns, enhancing the overall fitness of the system;
- Complex systems manifest several co-existing patterns (patches), rather than either one overall pattern or a large variety of local systems;
- Local ideas function as nuclei, eventually influencing and patronising large parts of a complex system.

The common characteristic in the conditions described, are large numbers and many interactions. There needs to be a large pool of elements. The chance that things interact increases and new processes cause the increase of the overall fitness of the system.

If systems of higher complexity are better equipped to increase adaptability and deal with turbulent circumstances, regional spatial systems should be brought to a higher level of complexity to be better prepared for turbulent circumstances as initiated by future climate change and energy supply. If the system is not randomly self-organising itself it requires some kind of incentive. New crucial interventions need to initiate a creative jump (Geldof, 2002), which starts a process of increasing adaptability, leading to the change of the entire regional spatial system and to a more resilient system. What is missing so far is a trigger setting these processes in motion, such as a focal point that enforces the pool of elements to interact and starting the process of changing the system. These points, where 'dovecotes flutter', ultimately make things happen. Every element in the system orientates itself to these points, and by doing so the system as a whole changes. The result is an innovation coming out of a bunch of ideas. An impulse needs to be added in order to reach a tipping point.

8.3.8 Tipping Points

The tipping point is that magic moment when an idea, trend or social behaviour crosses a threshold, tips, and spreads like wildfire. The possibility of sudden change is at the centre of the idea of the tipping point. Big changes occur as a result of small events. The situation is similar to the phenomenon of an epidemic. Epidemics follow three rules (Gladwell, 2000):

1. The law of the few, a small part of the whole is doing all the work (80/20);
2. The stickiness factor: the message makes an impact. It is impossible to forget;
3. The power of context: sensitivity to the environment, influence of the surrounding

By applying these rules to planning and design, the question when a design becomes a success, reinforcing the required changes, can be understood. First of all the law of the few tells us that a successful design will originate from a small group of individuals. The design is not what the common people expect. To change things the design will be away-from-the average (Ridderstråle and Nordström, 2004; Florida, 2005; Roggema, 2005).

Secondly, the stickiness factor suggests that a successful design sticks in ones heads. Once having seen the image of the design it is not forgotten. Roberts calls it a visible love mark (Roberts, 2006). A good example of this is the design for Almere Poort, the Wall (Fig. 8.6) (MVRDV et al., 2001).

Fig. 8.6 The Wall in Almere Poort, MVRDV, 1999

Finally, the power of context in relation to design processes tells us that a design with huge impact provides the solution to a commonly felt problem. If a fundamental change is required, such as climate change is asking for, a widely shared context of deep trouble improves the chances of change. A sense of real urgency is required for fundamental change. A crisis will provide the energy to jump to the new situation (Timmermans, 2004). If the existing system dissatisfies, a crisis is required to jump to the next level of complexity required to upgrade the system (Fig. 8.7) (Geldof, 2002). These crises can be seen as the tipping points in design processes.

Geldof describes the relation between complexity, the level of order, the adaptability and the cyclic process of stabilisation and crisis (Geldof, 2002). If there is no order at all or a complete fixed order the complexity is low, but at the optimum point the highest complexity is reached (Fig. 8.8). At the same time this point represents the highest adaptability of the system. A crisis is developing when the order of a system increases and at the same time the adaptability decreases. During a crisis, the system 'flips' from chaos towards the old trail. Two routes can be followed from that point on, depending on the availability of collective actors managing the resilience of the system and realising a creative jump (Fig. 8.7) (Geldof, 2002, Homan, 2005). The system dies or starts all over again. If a creative jump is made, the system is capable of evolving towards higher complexity and reaches a new stable situation with high adaptability (Fig. 8.8).

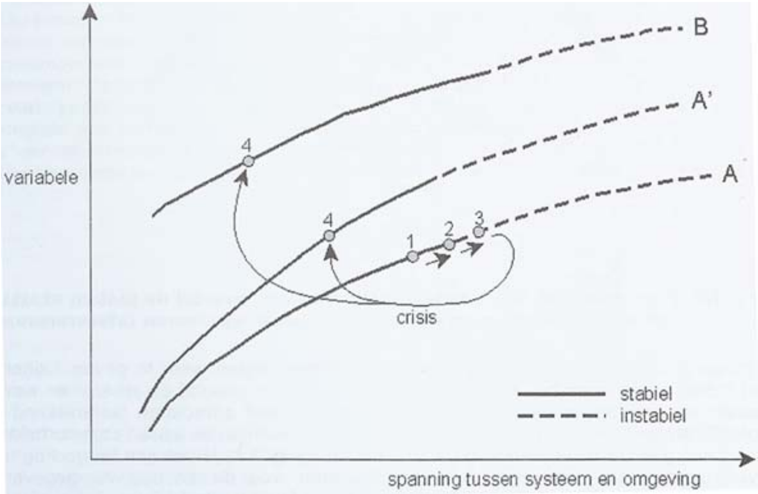

Fig. 8.7 Crisis enforces the jump to a higher level of complexity, Geldof, 2002

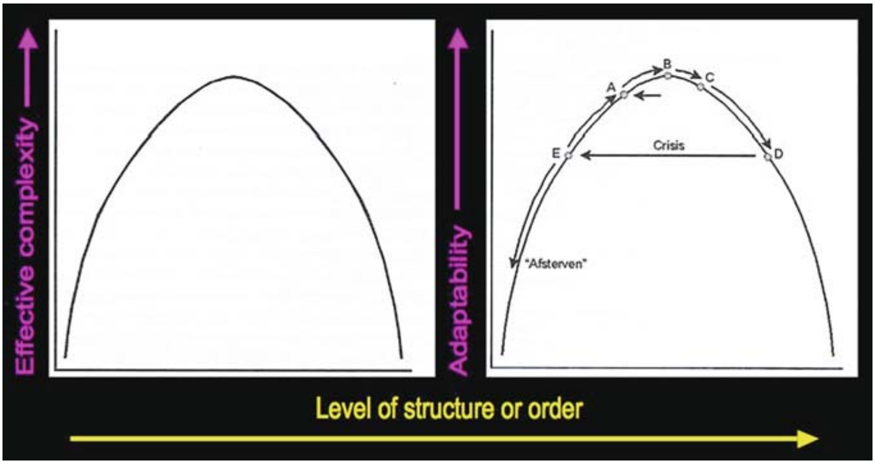

Fig. 8.8 Relation between level of complexity, adaptability and crisis (Geldof, 2002)

8.3.9 A New Design Paradigm, Swarm Planning

Translated to planning design terms, the effective spatial intervention creates a tipping point, directing all spatial, societal, political elements in such a way that the entire region changes. Contemporary planning approaches only show little adjustments, while big ones are required to deal with the turbulence of climate change and energy supply. A new spatial design paradigm, following the rules of increasing adaptability in order to make areas more resilient, will emerge in reaction to new demands and developments. The first signs are there, but a structured approach is presented here. In this paradigm, which can be called swarm planning, (Roggema, 2005), the role of spatial design is to introduce essential impulses to influence the entire system, like a swarm of birds is reshaping itself constantly under external influences, without changing its function. Spatial design will no longer be concerned with the entire image, but will focus on those essential design interventions that enforce the region to reshape itself. No blueprint design, but acupuncture planning (Jacobs and Roggema, 2005).

Thus, for a swarm planning approach (Roggema and Dobbelsteen, 2006) to be successful, two aspects are essential: the (spatial) characteristics of the region and the availability of extraordinary ideas. Complex systems theory suggests that the swarm paradigm will work where the following conditions are met:

- A large group of individual elements (people, buildings);
- Many connections (virtual, roads, rail, water);
- High quality of relations (fast, intense);
- High quality network (flexibility, intensity);
- Enough, but not too much, diversity (neighbourhoods, groups);
- Several co-existing patterns (patches).

If these circumstances pertain idea-mergers between different elements will lead to creative jumps, and new structures and information are created. A small group of extravagant idea creating people will enforce this and transform it into a sticky idea, which influences and shapes large parts of the region. If the sense of urgency is there -climate change for instance- a suitable trigger brings the idea to a tipping point and collective patterns emerge out of co-evolution of local systems, leading to an increased overall fitness of the system, which is able to adapt more easily to climate change, resulting in a resilient area.

This paradigm is not yet common, but the first examples in spatial design are there. The way interventions are planned in the design in the 'Blauwe Stad', in the remote parts of Groningen province (Karelse van der Meer, 2003), the projection of new islands in front of the Northern coast of the Netherlands (Roggema, et al., 2006; Alders, 2006; Boskalis, 2006), but also in projects like the Öresund-bridge and its impact on the accessibility, economic welfare and image of Malmö and Copenhagen or the way Mendini (Mendini, 1994) changed the entire inner city in Groningen through the Groninger Museum project are examples of swarm planning.

8.3.9.1 Swarm 'Avant-La-Lettre': The Groninger Museum

The 'Verbindingskanaal' is a waterway at the edge of the city-centre of Groningen, located between the central station and the inner city. In the past, the easiest way to reach the inner city was to walk around the canal. As a consequence the area at the city side of the Verbindingskanaal became neglected, attracting hooligans and criminals. A representative of the municipality decided on the implementation of a new building in the canal, connecting the station with the inner city. As a result of this the neglected part of the city centre changed into a very lively, attractive area, used by a large number of people. The intervention of building the Groninger Museum exactly at this location transformed the entire city (Figs. 8.9 and 8.10).

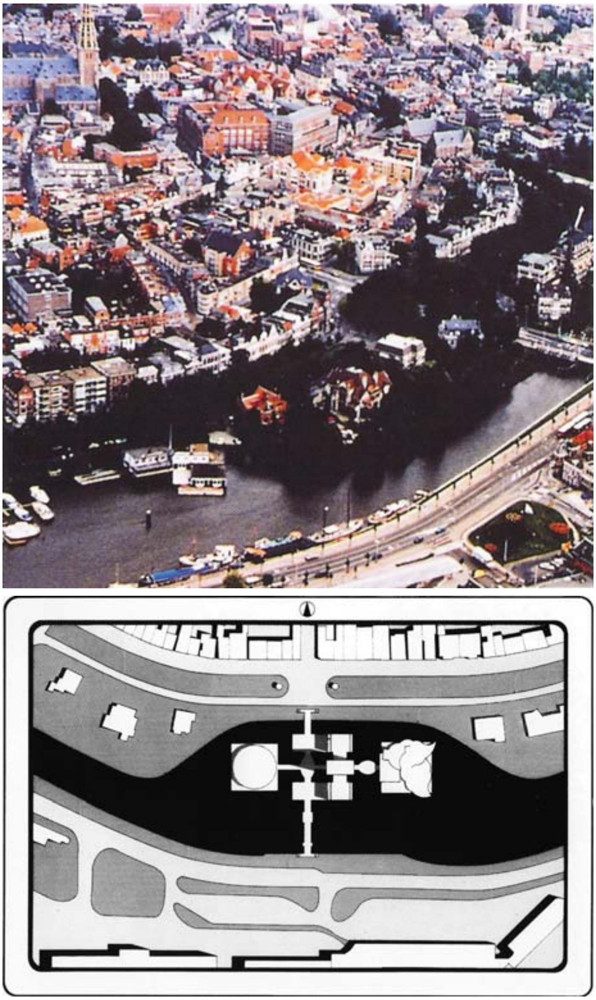

Fig. 8.9 The Groninger Museum positioned in the Verbindingskanaalzone, before (*left*) and after (*right*)

8.4 The Groningen Case

At the start of the development of a new regional plan for the province of Groningen in the summer of 2006, the circumstances were analysed. In the starting document (Huyink, 2006) of the planning process three pillars were defined: economic developments, demographic changes and climate change. By the end of 2006 two events happened, which increased the political sense of urgency. The first event took place

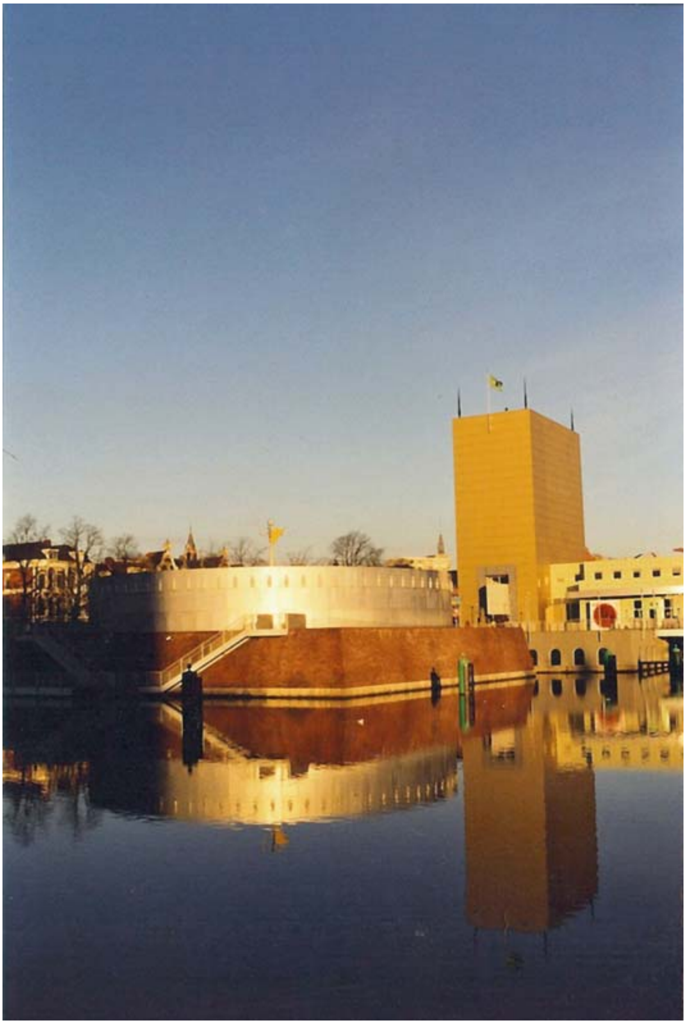

Fig. 8.10 The Groninger Museum

in the night of November 1st 2006: In front of the Groningen the highest sea water level ever was measured. Some (small) urban areas were flooded and at several places dikes were almost breaking through. Despite the fact that there were no casualties and the damage caused was small, the event functioned like a wake up call for regional politicians. The second event was the presentation in autumn 2006 of the movie ‘An inconvenient truth’ by Al Gore. The mass-media attention the movie caused generated public attention for the issue of climate change and increased the awareness among the public, but also among politicians. People became aware of the turbulent environment they live in, the long-term changes that might be happening in the future and the possible risks that are connected with these changes. This resulted in political urgency to increase the resilience of society and the spatial system, using the new regional plan.

The design of the regional plan was carried out in three phases: The analysis, the interaction and the reflection. Every phase was finished with a political document. The role of climate change in the process is shown in Fig. 8.11.

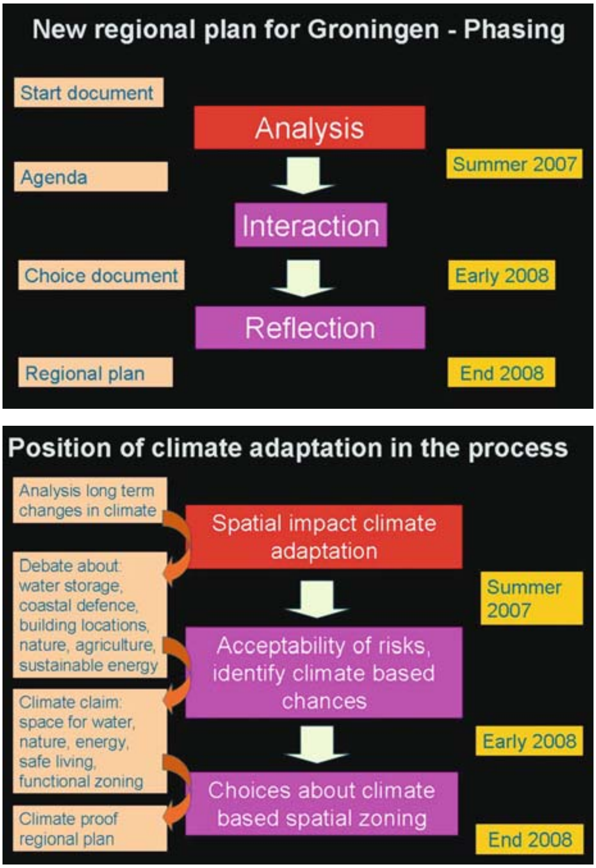

Fig. 8.11 Planning process and role of climate change (Roggema, 2007b)

In the analysis the long-term changes were identified and the potential impact on the provincial area was defined (understanding the system). In the second phase the acceptability of risks was discussed and the spatial claims (quantitative) were defined (measurable input in 'tame' planning system). In the final phase the strategic interventions with the capacity to increase resilience, were described.

8.4.1 Understanding the System: Mapping Climate and Energy Potentials

In order to understand the existing system and explore the way turbulence causing factors like climate change and energy-supply function a method of mapping the potentials was developed (Dobbelsteen et al., 2007). This mapping method was used for energy as well as for climate potentials. The key-factors, which are crucial for spatial planning were defined for climate change as well as for energy and put subsequently on maps. The climate change factors, which are of special importance for the Groningen situation, are the future changes in precipitation and the possible sea level rise scenarios. The energy potentials focus on the potential energy production from renewable resources. Therefore, solar, wind, geothermal, hydro and biomass potentials are mapped.

8.4.2 Improving Resilience: Use of Swarm Planning Paradigm

The next step in the planning process was the transition of the knowledge about the regional climate and energy system into interventions and ideas, which might improve the resilience of the region. Two ways were explored.

The first way aimed at integrating the potential maps into a climate proof map of Groningen: the idea map. This map shows an end-image of a climate proof province. It can be seen as a desired future on the long term and does not give insights in the way this future might be reached. The map functioned as a source for debate and gave direction to the planning process.

The second way focused on the definition of strategic interventions, which should be introduced today in order to start the change of the region towards higher resilience. These strategic interventions imply and stimulate the desired changes on the long term. These interventions can be seen as the first steps towards realisation of a climate proof province.

8.4.3 Strategic Interventions: The Groningen Impulses

The second way to improve the preparation for turbulent environments is to place strategic interventions (Roggema, 2009). These interventions are not meant to define exactly an end state of the area, but they mark the start of processes, which emerge from that point on by themselves and influence a larger area. The impact of the intervention may be predicted and needs to generate more resilience in the area, but the exact future developments in the area are not defined. This approach makes it possible for stakeholders, involved parties and citizens to co-operate and contribute to the development of the area. The objective of this approach is to increase resilience in the entire province. This is realised by loosening the fixed state of the existing situation. In most of the situations this fixed status is the cause of large risks. By introducing the flexibility to deal with future threats or challenges and creating the space for the impact of these threats and developments, society is better prepared and already used to the situation and possible events, which occur in the future. The windows of Groningen (Fig. 8.12) show several of these opportunities, where loosening the tight and normative rules enable the area to react proactively, increase preparedness and are able to return to their original state after a change more easily: improved resilience.

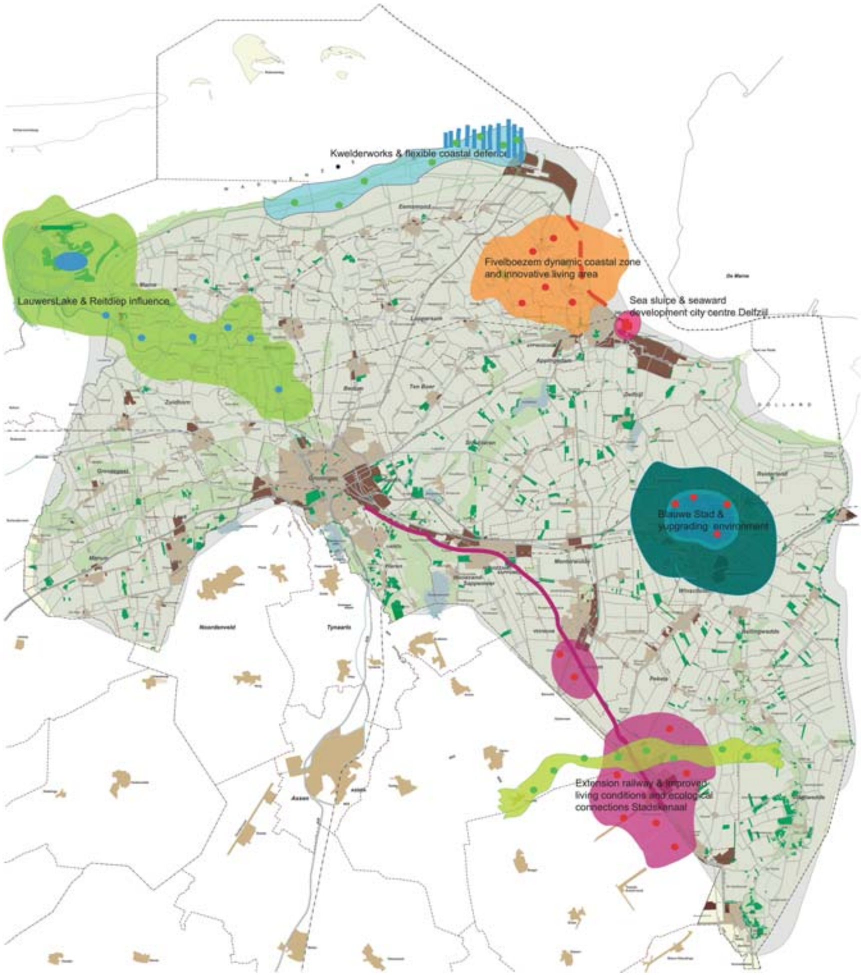

Fig. 8.12 Windows of Groningen, strategic interventions (Source: Roggema, 2009)

These strategic interventions are the impulses, which are added to the area and adjusting the area without changing its function. The impulses make use of the capacity the complex adaptive spatial system has (if enough space can be created to do so) to adjust itself to new circumstances and developments. The interventions function like the simple impulses, which are capable of reshaping a swarm of birds: constantly transforming, but staying the same swarm of birds.

In the Groningen case several of these interventions are proposed. They have in common that a single intervention opens the way to an indirect effect in a larger area.

1. Heightening the closure dam of the Lauwers Lake enables the area to store more rainwater in winter, influencing the entire stream area of the Reitdiep;
2. Creating new kwelderworks near the Eems harbour enables the Wadden Sea to create new arable land, which may be used as wished in the future. For agricultural purposes, as an industrial area or an ecological zone;
3. Perforating the dike between the Eems harbour and Delfzijl opens the opportunity to create a dynamic coastal system, which is able to supply the hinterland with sand, that sedimentates here. The sand lets the soil rise at the same pace as the sea level or faster and an innovative way of living can be introduced;
4. Repositioning the Sea sluice of Delfzijl outside the city makes it possible to create a safer storm surge and offers Delfzijl the chance to develop its waterfront towards the sea;
5. Generation of a luxurious living area in a back-dropped surrounding makes it possible to extend the capacity for water storage and influences the living standards of these surroundings positively;
6. The introduction of a new railroad, which connects the City of Groningen with the Peat Colonies, enables the southern part of the province to develop a robust ecological corridor, which gives space to shifting ecological habitats and makes an interesting living area possible amidst nature.

A couple of these interventions are described in more detail.

8.4.3.1 Fresh Water Storage in Lauwers Lake

The first example of a strategic intervention is dealing with the rising sea level and the upcoming shortage of drinking water (Meliefste et al., 2008). In the design fresh water will be stored in the Lauwers Lake (Fig. 8.13) by heightening the level of the water in the Lake. This higher water level makes it possible to keep up with the risen sea level and the water board is still able to let water flow into the sea without pumping. As a result of the risen water level the entire water system (the swarm) of Groningen is forced to adjust itself. The risen water level in Lauwers Lake also implies the rise of water level in the Reitdiep stream and other small canals and brooks. The capacity to store rainwater is increased by this simple intervention, which helps to deal with heavy rain showers and potential flooding in villages and towns. In other words, by solving the first problem and intervene in the Lauwers Lake, the entire region is challenged to adapt effectively to the effects of climate change.

8.4.3.2 Kwelderworks Eemsdike

The second strategic intervention is to re-introduce old-fashioned kwelderworks in front of the Groningen coast (Fig. 8.14) and especially in front of the weakest and

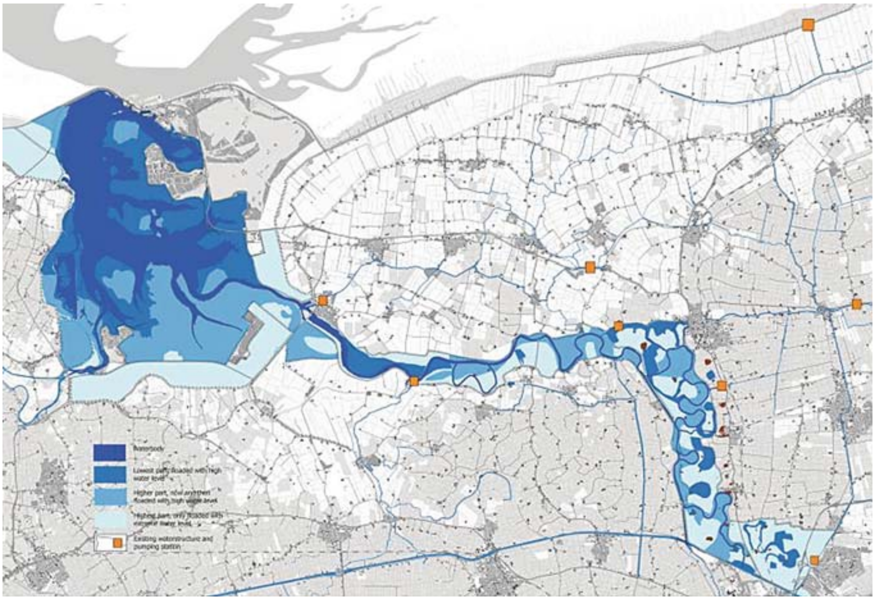

Fig. 8.13 Proposal for fresh water storage in Lauwers Lake (Meliefste et al., 2008)

most vulnerable part near the Eems harbour (Meliefste et al., 2008). The kwelderworks start natural processes, which fixate sand and mud. These processes enable the soil to slowly grow along with the rising sea level until it finally rises above the sea level. Because of this, the kwelderworks are capable of protecting the shore. The offensive way the kwelderworks near the Eems harbour are positioned creates extra space. This newly created land (the swarm) is not meant for a specific purpose. This choice can be made at a later stage. When new arable land is needed it is possible to turn the area into agriculture, but when the economic development of the Eems harbour requires expansion of industrial area it is also possible. And when the ecological quality of the Wadden Sea requires extra space, it may be realised on this location as well. The introduction of the kwelderworks implies a better protection of the coast and makes it possible to postpone the choice what to do with the reclaimed land until it is needed.

8.4.3.3 Blauwe Stad

The eastern part of the Province of Groningen has traditionally been the poorest region in the Netherlands with pervasively high unemployment, low levels of education and poverty. People who could, left the area. Due to heavier rainfall the need to find water storage in the lowest parts of the province is urgent. The Blauwe Stad area is one of the lowest places in the province and this fact, in combination with the back-dropped character of the area, has led to a third strategic intervention: the introduction of a new luxurious village around a lake, the Blauwe Stad (Fig. 8.15). This

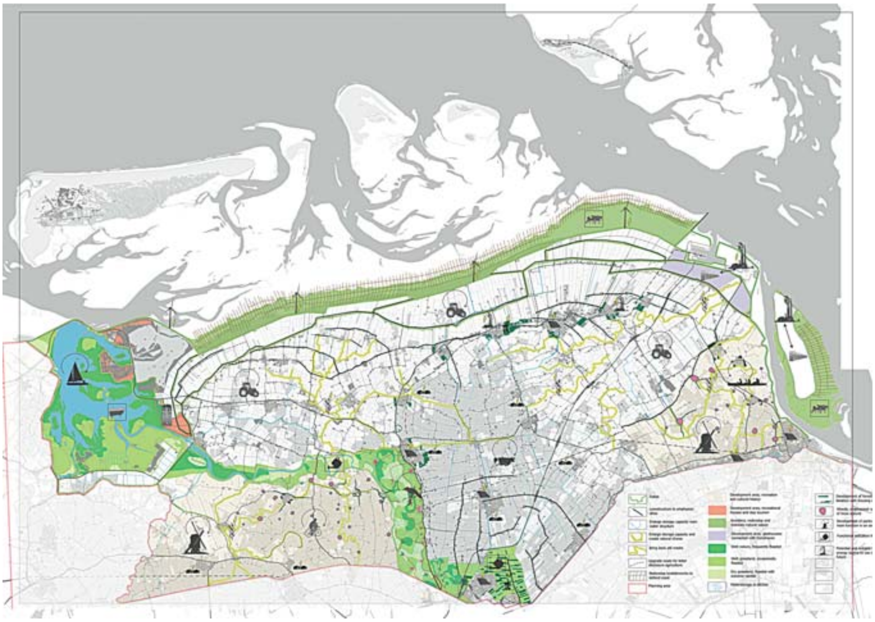

Fig. 8.14 Kwelderworks near Eems harbour (Meliefste et al., 2008)

intervention resulted in the upgrading of the entire area (the swarm) around the village, where economic development improved, the amount and quality of amenities increased, the infrastructure is improved, the possibilities to deal with large amounts of water is increased and unemployment is decreased. The indirect development of the area evolves by itself, after the impulse of the Blauwe Stad has been done.

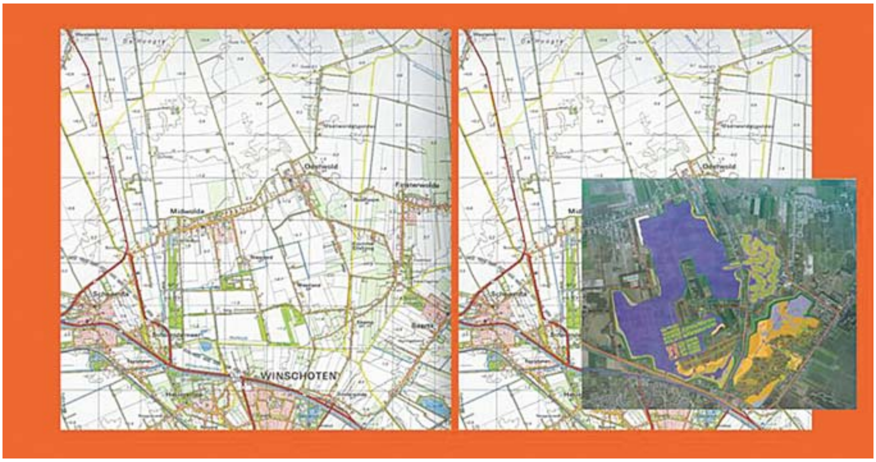

Fig. 8.15 Blauwe Stad implemented in the landscape of eastern Groningen

8.4.3.4 Dynamic Coast Fivelboezem

The coastline between Eems harbour and Delfzijl is the most vulnerable in the province. In the hinterland a second dike supports almost every dike piece in the province. This second dike is absent in this area. A breakthrough here causes a flood that would reach the province capital within 24 h. The economic damage is largest if this breakthrough happens. This strategic intervention consists of the perforation of the existing sea dike and the creation of an extra dike in the hinterland (Fig. 8.16). The area between the old and new dike will be flooded semi-permanent. In this area dynamic circumstances emerge, both from an ecological point of view (brackish, changing water levels) as from a human perspective (living on newly built *wierden* (artificial hills), changes in wet and dry surroundings). Society will have the chance to adapt to future threats, like a flood, because the area is designed for it. After water enters the area, it leaves and the area can turn back into its old position very easily. Moreover, in the future it might be difficult to define what the original state of the area was, covered with water or not?

Fig. 8.16 Dynamic coastal development Fivelboezem (Roggema et al., 2006)

8.4.4 Steer the Swarm

The existing spatial planning system has difficulties creating those effective interventions, which are capable of dealing with increasing turbulent circumstances (like the uncertainty of energy supply and rising energy prices and changes in climate). These aspects are turbulent because they are long-term, uncertain and play a role in the far future. In traditional terms: they cannot be planned, but will occur as surprises.

It is possible to deal with these uncertainties and create resilient areas if areas are given the opportunity and space to change along with sudden changes and at the same time build experience today which is required for future threats and challenges. If the area is given this opportunity the resilience will be improved. The area will be capable of dealing with the effects, threats and challenges these future changes imply. When the area is given the possibility to change with the changes, the spatial order is not fixed in a certain state, but the spatial system is designed in a way that it is capable to change its patterns, its 'being' and the way it looks according to the requirements of that date or the changing, unexpected demands of the future.

In the current 'fixed' spatial planning system almost no spatial flexibility is included. Because of that there is just no space available to create a buffer to adapt to fast changing circumstances more easily and to increase preparedness.

The planning system of the future has to include steering principles, which enable areas to adapt more easily and change its spatial patterns as required by future threats and challenges. These steering principles include, according to the Groningen example two elements: space to change and strategic interventions. These elements differ from place to place, depending on the characteristics of the natural system and spatial identity. Thus, the swarm in the area can be steered in a desired direction of higher resilience.

Depending on the specific qualities of the area the spatial regime can be distinguished. The combination of spatial and natural character of the system in combination with a well-defined intervention creates the resilience regime for that area. In abstract terms, a 'Mondrian' typology can be derived (Fig. 8.17) as in the concept Atlas Groningen is developed (Roggema and Huyink, 2007).

8.4.5 The Groningen Case Discussed

Evaluating the Groningen case several remarks can be made. The development and usage of innovative methods as well as the applicability in practice will be discussed.

8.4.5.1 Mapping

The method to map Climate change and energy potential information gives good results in understanding the spatial potentials the regional system contains. The results of the mapping method can be used in several ways. First of all the size of potentials can be derived from the maps, sometimes measured in covered area or otherwise in potential energy production. The second use of the maps is that they

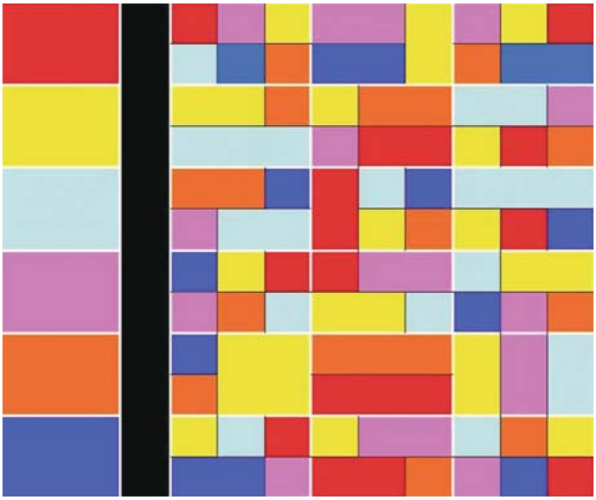

Fig. 8.17 A 'Mondrian' combination of interventions (*left column*) and identities (*right field*) (Roggema and Huyink, 2007)

function as a layer to base policies and designs on. Taken the potential maps as a base design interventions or measures can be found. The final way they can be used is as an inspiration for integration. The maps offer information which was not available in earlier planning processes.

8.4.5.2 Idea Map

The constructed idea-map for an adaptive Groningen functioned as a trigger for debate. However, the question may be posed if the content of the map is too integrated and coherent. It seems that the idea-map is more or less the same as an end image of a future Groningen, but then an adaptive one. The idea-map is an interesting starter for discussion, but it contains the risk of stepping into the same pitfalls as the existing planning practice: a far to fixed image of the future is translated into strict spatial measures, while the future becomes increasingly unpredictable.

8.4.5.3 Interventions

The definition of strategic interventions in combination with the creation of flexible space in the area in order to give space to unpredicted developments can be an approach, which is capable of both dealing with an uncertain and turbulent future as well as creating the spatial flexibility to give stakeholders the power to intervene and steer towards a more resilient future in the area. The main question remains which intervention has the best results i.e. leads to higher resilience of the area.

8.4.5.4 In the Real World

Although these innovations were developed during the planning process of the new regional plan for Groningen, the question is if and how the developed interventions will be realised. Despite the fact that decision makers decided to define four area assignments, where integrated area development should take place, and these areas are the same as the areas where interventions are proposed, it is still uncertain if these interventions will be part of the area development. This might lead to the conclusion that the thinking on improving resilience is not translated into political objectives yet. The existing planning process is still a tame process, where the problem analysis and the derived solutions are the objective instead of aiming to increase the adaptive capacity of spatial systems, enhancing an increased resilience. The question is if the sense of urgency to prepare for future turbulence is high enough among decision makers of today.

8.5 Conclusions

The resilience of areas to deal with a turbulent future may be improved by applying the principles as defined in the theory of complex adaptive systems to spatial planning methods. So far, there are not many examples of spatial planning, which use this theoretical background in planning practices. The Groningen case shows that a region can be made more resilient and better able to deal with turbulence when the principles of complexity and resilience are used. Usage of these principles may change the planning practice towards a more adaptive and flexible form of planning. And because every region will have to deal with more turbulent circumstances in the future it may be concluded that the first experience with this new planning paradigm (swarm planning) can be used in other regions as well.

Societies are better prepared for a turbulent future if strategic interventions are included and in a spatial sense the space and conditions are created to adapt in planning system. If the space is created the capacity of stakeholders and citizens to contribute to the development of the spatial system in the area can be implemented more easily. When strategic interventions are combined with the spatial conditions to adapt to future threats and challenges and when the area is given the time and opportunity to get used to dealing with future threats and challenges, resilience is improved.

When the interventions are well defined they are able to steer the swarm. Swarm planning is capable of starting adaptive processes, which makes it easier to adapt society to emerging turbulent circumstances. If a simple intervention has a wider spatial impact the measure is more powerful and potentially has a higher impact on resilience.

When the possible effects of turbulent environments are included into the design and spatial layout of the area these future threats and challenges are no longer a surprise, but are rehearsed and have become familiar situations: the area has adapted before it is confronted with the changes.

In order to increase resilience of a region the ‘adaptive’ principles of swarm planning must be applied. Therefore swarm planning has to learn from complex adaptive systems theory. The following principles can be defined:

1. The regional spatial system must be seen as a complex adaptive system;
2. Improvement of resilience can be reached by implementing strategic interventions;
3. The definition of the elements of complex adaptive systems for the local situation is essential as well as the way in which they can increase the impact of an intervention;
4. A large pool of genes (measures, inhabitants, functions), some simple rules and enlargement of trails (improving impact) are the start of long-term changes;
5. Potential mapping of climate and energy aspects may be used to discover those genes of the region, the trails and the simple rules, which are able to create a climate-proof region. The spatial translation of these potentials into isolated spatial typologies, which may play a major role in interconnecting in a future society, is not defined yet. In history, the sidewalks in a neighbourhood functioned like the interconnection platform, but current and future interconnections are presumably made in a different way and at different places. The transport system, the sidewalk, the stranger (the ‘away-from-the-average’?) and the ‘city’ of our time are yet to be discovered;
6. Swarm planning (large pool), with a well-defined (simple rule) impulse (which is able to enlarge the trail/impact) may be able to steer a region into the desired direction

In Fig. 8.18 the mutual relations between all facets of the case are visualised. When large impact changes, like climate change, an Internet society or uncertain energy supply are, are about to happen, they imply an increasing turbulence. These developments influence the regional spatial system. In order to understand this regional system better, the principles and characteristics of complex adaptive systems can be of help as well as the regional mapping of climate and energy potentials. Lessons learned from adaptive systems, combined with the regional energy and climate characteristics, offer the opportunity to find the most suitable strategic interventions and localisation of flexible space. These two elements lead to increased resilience of the regional spatial system, if used in the right spatial planning system. The increase of resilience in the regional spatial system implies that the region will be better equipped to deal with the described turbulence.

The described new planning and design paradigm emerges naturally because the experience and attitude to life of current and future generations, which want to supply and use services and products in a value-based way. Using this attitude, problems of climate change and the energy supply may be solved. The fundamental changes in society will be executed anyway. After the industrial, the Internet revolution will happen. The climate and energy world better anticipates on these changes. By doing so, this might bring solutions, because a shift towards sustainable energy

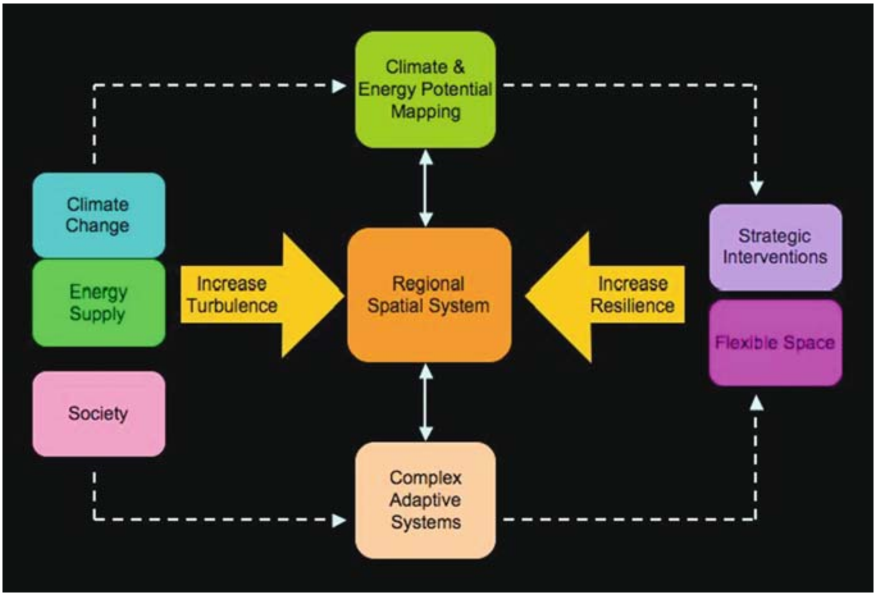

Fig. 8.18 Interrelatedness and mutual influences (Source: Roggema, 2008e)

and the adaptation to climate change is not only necessary, but can only made possible if individuals and groups participate and contribute at a local level.

The first experiences in Groningen show that it is possible to rewind and rethink the future. Local energy potentials and adaptation possibilities can be implemented in spatial developments, starting now. Developments can and will happen fast. Do you remember? Only ten years ago my e-mail exchange was dependant on a little house in a side street in Ushuaia, Patagonia.

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Conclusion

The Role of Spatial Planning and Design

Climate change is influencing our future. A long period of climatic stabilisation lies behind us. The changes are researched and knowledge on the content of these changes is being developed. But in practice this knowledge is not yet implemented very much in spatial planning. The first examples and projects become visible around the world, but the general practice faces a major challenge.

The Chapters Summarised

- Many countries already have formulated an adaptation strategy, as described in Chapter 1. Most of the strategies are generally formulated and contain policy statements and objectives. The role spatial planning and design plays in the strategies, is mostly small.
- The way adaptation to climate change can be integrated in design is described in Chapter 2. The Dutch and Chinese examples illustrate that if the natural system of the site is taken as a base for the design the adaptive capacity of the area can be increased. The future changes in climate need to be combined with the local characteristics of the natural system: ecological, relief, soil and water. Human interference often transforms the natural system into a controlled and artificial system. This results in difficulties to adapt to unforeseen changes. If, however, the natural system functions naturally, with its own dynamics, its flexibility, its normal internal changes and succession, the adaptability of the system increases. This needs to be included in spatial designs.
- In Chapter 3 a gallery of possible solutions for the improvement of the coastal defence is presented. There are many ideas available, but in the end technical solution prevail: the technical standards, budget limitations, sectoral thinking and juridical impossibilities lead to suboptimal results. In order to increase the resilience in the coastal zone multifunctional and flexible solutions are to be preferred instead of fixed and fierce dikes.
- In Chapter 4 some tools and examples are described on the way water management can be organised. The focus in water management lies on risk management

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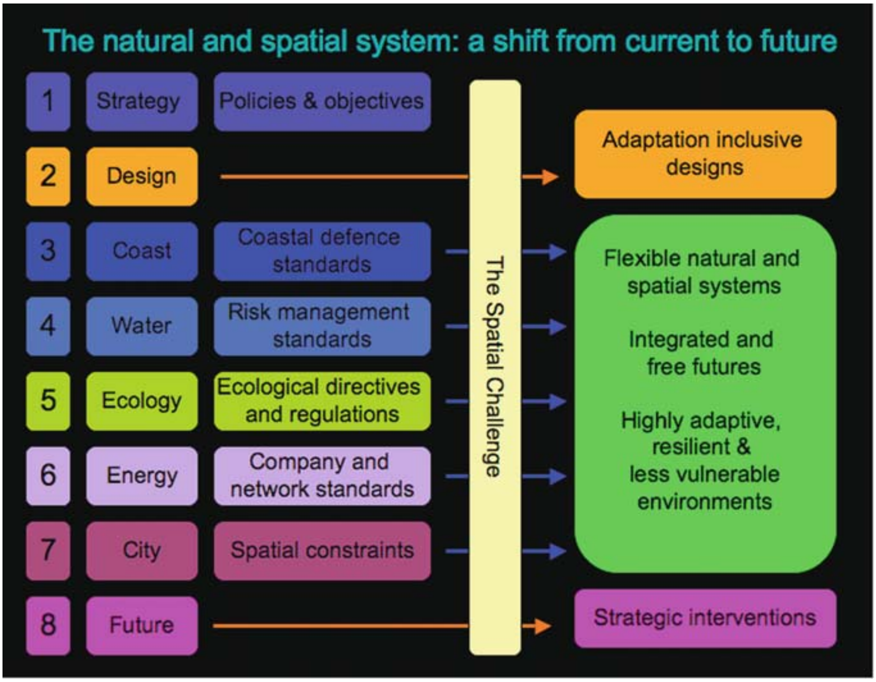
and the protection measures to decrease the chance at a flood. The standards on strengths of dikes and the periodicity of dike breeches are more in the spotlight than the question to design the area behind the dike in a way that a flood can be dealt with and water is a profitable element instead of a threat. The fact that a flexible system is less vulnerable for the effects of a flood is not yet prominently apparent in the debate.

- The same remark can be made for ecology. It seems to be more important that general policies, like directives and the status of ecological areas, are carried out instead of the realisation of a robust and well functioning ecological system, which is capable of adapting climate changes (Chapter 5).
- The market dominance results also in standards in the energy sector. The centrally and hierarchical organised energy sector sets the standards, which are a given for local situations. It seems that the network and regulations cannot be changed, even if circumstances ask for it. This makes it very difficult to create a more flexible energy network, in which deliverance of local produced energy to the grid is easy. In Chapter 6 is described how the local energy potentials can be mapped in order to provide information on the possibilities to provide the grid with local produced and sustainable energy.
- In Chapter 7 the effects of climate change in urban environments are described. Excessive heat stress and water annoyances in dense urban areas cause major problems. The existing spatial boundaries of city patterns in combination with the high square meter prices in the city are a constraint to find space for public green and water, which is necessary to adapt the city to increased temperatures and extreme weather events. The city needs to increase its internal flexibility. Public spaces need to be able to change their function if climate circumstances ask for it and extra space needs to be generated for green in order to moderate climate changes.
- Planning for a climate proof future, as described in Chapter 8, is impossible if current processes and practices are sustained. The long-term changes are to a certain extent unpredictable and trying to define a predictable future through spatial planning leads to mismatches. A fixed and detailed image of the future layout of an area needs to be replaced by a rough image of the future, which can be adjusted anytime if needed. Here, an increased role of spatial planning and design is at stake, because the creation of these rough images needs to be done by creative people, who are capable to think out of the box. Designers are able to stimulate spatial imagination, which provides the required spatial flexibility to constantly adjust the spatial future.

Standards Are the Standard

A general conclusion can be drawn that in existing practice the standards are the standard. An existing conglomerate of standardised thinking withstands an innovative development, which is needed to anticipate on fundamental and long-term changes.



Adaptation to Climate Change: A Spatial Challenge

The spatial challenge or spatial task is to implement and initiate a shift from this sectoral standardised thinking, with higher risks, towards multifunctional and flexible thinking based on the dynamics of the natural system. Spatial planning and design should not only implement the shift, but also needs to play a leading role in the transition. The key characteristics needed in such a transition are creativity and innovative thinking without boundaries. New pathways need to be discovered and the future needs to be visualised. Cross-sectoral thinking and integrated design needs to be enhanced. The required innovative capacity is available in designers' brains. A highly adaptive, resilient and less vulnerable environment can be designed if the pressure to fulfil all kinds of standards is minimised. This will result in a new paradigm: adaptation inclusive planning.

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