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Rural Water Supply in Developing Countries

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# Water

**Supply** in Developing Countries

Proceedings of a workshop on  
training held in Zomba, Malawi,  
5-12 August 1980

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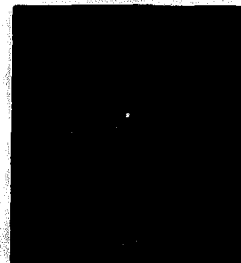
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# **Rural Water Supply in Developing Countries**

**Proceedings of a workshop on training  
held in Zomba, Malawi, 5-12 August 1980**

*Sponsored by:*  
*Government of Malawi*  
*International Development Research Centre*  
*Canadian International Development Agency*

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## Foreword

The 1980-1990 decade has been chosen by the United Nations as a period when a special effort will be made to overcome the lack of adequate water supply and sanitation facilities for large sections of the populations of the less-developed world. The manpower resources to realize these goals are minimal in most countries.

The regions of East and Southern Africa are areas where the scarcity of adequately trained personnel is acute and there is a lack of information on newly developed low-cost technologies.

In August 1980, two workshops were held: one in Malawi on water supply and another in Botswana on sanitation. Full delegations from Ethiopia, Tanzania, Malawi, and Botswana attended. Selected representatives from Kenya, Swaziland, Zambia, Lesotho, and Mozambique were also invited to participate.

The regional workshops were not intended to be an end in themselves but were planned to be followed by small, national training workshops carried out by the participants in their own countries. The aim of the workshops was to further disseminate the information on low-cost technologies and discuss the implementation of curricula changes and training needs recommended at the regional meetings.

These proceedings include papers presented at the first meeting, summaries of the resulting discussions, descriptions of the field visits, resolutions, and action plans. It is hoped that, through wide dissemination, the influence of this training workshop will spread beyond the countries of the attending delegates.

The International Development Research Centre (IDRC) is indebted, in particular, to T.D. Thawale of the National Research Council and to L.L.B. Munthali and P. Marcello of the newly formed Department of Lands, Valuation and Water for ensuring success of the workshop.

Eric Schiller, an IDRC consultant, acted as workshop coordinator. Editing was undertaken by the Communications Division, IDRC. A special word of thanks is due the support staff of the Health Sciences Division.

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# The Development of Self-Help Gravity-Piped Water Projects in Malawi

L.H. Robertson<sup>1</sup>

Malawi covers 95 000 km<sup>2</sup>, including a number of mountains which are the sources of perennial rivers and streams. Of the total population of 5 million, 420 000 live in the rural areas of Mulanje. These people are served by 2700 village taps, which they themselves have installed by laying 2000 km of piping. The total cost has been K2 million (K1 = U.S. \$1.2484), an average of K750 per tap unit and a cost of K5 per head of population.

The majority of people get their domestic water supply from shallow wells or streams. When these dry up during the dry season, water has to be carried long distances.

With the growth of population and the increase in cultivation, rivers and wells dry up earlier in the year. Water supply, therefore, becomes more and more of a problem. As the population becomes more dense, the health hazard from polluted rivers becomes greater.

## Technical Background

The design objective of the project is to pipe pure mountain water, by gravity systems, from mountain streams to villages on the fertile plain.

The design criteria are: (1) 27 litres per person per day; (2) one tap to approximately 160 people; and (3) a design flow of 0.075 litres/s at each tap (when all taps are open).

All taps are public standpoints; water must be carried away (which limits consumption); and the water is free, so it is used by everyone.

Population figures are obtained from census maps. The layout and details of villages are obtained from aerial photographs. Alignment of pipelines is determined from 1:50 000 ordinance survey maps and profiles are plotted for each line.

The overall design capacity, as well as considering the existing population, takes into account the food production capacity of the soil, and is based on the (estimated) maximum population which the land can support.

From these data, required flows and pipe sizes can be calculated and the network designed.

The full range of pipe sizes is used: 12-90 mm PVC, and the larger sizes, 100-250 mm asbestos cement.

Pressures used are up to 10 atmospheres (10.3 kg/cm<sup>2</sup>). A suitable site is chosen to ensure that the header tank is at the proper elevation, the intake being high enough to feed this tank. For large projects, the main pipeline will feed a number of branch line tanks, which will then be header tanks for the branch line systems, as well as providing night storage, thereby enabling the main line to be utilized throughout the night.

Because the streams used for water supplies come from mountain forest reserves, the only purification methods employed are screening and sedimentation. Work is now being carried out to introduce

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slow-sand filtration. This would greatly increase the number of rivers which could then be utilized and would extend the scope of this program.

## **Management and Planning**

### **Development of Project Management**

As a result of the first two pilot projects in 1968 and 1969, four things became apparent:

(1) The villagers and their leaders, having seen the possibilities, wanted more of these projects. They had become convinced that water could flow long distances through pipes (without the use of an engine) and that government was able to assist through the provision of pipes and expertise. Thus, the credibility gap between government and the villagers was bridged.

(2) Although it was essential to start with a small pilot project, until the people were convinced of its merits, it would become necessary to expand the project to cover a larger area in a comprehensive manner. This might involve as many as 100 000 people in one project.

(3) If projects of this size were to be attempted there must be proper technical supervision. Although the digging and backfilling of all the pipelines could be done using self-help labour, the actual laying and jointing must be done to a high standard and there are many aspects of the job which require the supervision of a technical assistant.

(4) The project leadership and organization would have to be such that it could maintain enthusiasm over a prolonged period (2 years), between the start of a project and the completion, when taps are turned on in the villages.

### **Project Leadership and Committees**

The key to the success of these projects is the involvement of the whole community, and the setting up of an organization that can handle the large amount of work that has to be done and ensure that everyone does his share.

The first step is to hold a public meeting to announce the project. At this meeting all leaders are present: member of parliament, chiefs, and party leaders. The chief will ask his people if they want the project and are willing to work for it. In this way, the self-help commitment is established from the start. The meeting then appoints a project committee to organize the work.

The project committee has the support of the chiefs and all the leaders and people. It is, therefore, able to control the work that has to be done and to overcome any problems which may arise. It is important that these committees are not appointed by the government, but that they derive support from the people, chiefs, and party leaders.

For a large project, there will be a number of section committees within the main committee, which will be responsible for the different sections of the pipeline system.

Finally, there will be a village committee in each village to oversee the construction of the tap site and apron with soakaway pit, etc. This committee will be responsible for the cleanliness of the tap surroundings and for the maintenance of the tap (replacement of washers, etc.).

With this type of organizational structure, it will be clear to the people that the government's role is to assist the people with the installation of their project. This is very different from the government putting in a project for the people. It is now widely recognized that participation by the people is essential for the success of rural projects and that when a committee is given responsibility, it responds to the trust given to it.

It is, however, necessary for the project management to spell out the specific tasks that have to be done: digging of the pipeline, excavation of the tank site, collection of building stone, or digging of river sand. It is also essential that lines are marked out before digging starts. The technical assistant is the vital link between the project and the people.

### **Technical Assistant**

The technical assistants are carefully selected for their practical experience and suitability for working with people in the field. They are trained in all the necessary skills, mainly through in-service training. They become very proficient at their work and are respected by the people. They are also personally involved in the success of their section of the project and become highly motivated.

Weekly staff meetings and annual refresher courses help to maintain high standards and build a strong team spirit. These also provide an opportunity for discussions and exchange of ideas on the problems of management in the field.

### **The Role of the Engineer**

The necessary support for the field staff is provided by the project engineer, who has previously designed accurate and easily interpreted plans for the project. He is responsible for the coordination of the work, for setting out standard procedures, for programming the work to fit in with the seasons, for supplying pipes and other materials, and for solving all the technical and other problems which may arise in the field. In this way, he ensures that the whole project goes ahead with a momentum that can maintain the local enthusiasm.

In addition to being competent, the engineer should have a high degree of motivation, with qualities of leadership and

sound judgement, which will enable him to evolve appropriate management techniques suitable for the rural project situation.

### **Conclusions**

The basic principles which have contributed to the success of these projects can be summarized as follows:

(1) The system has evolved as a response to a real need.

(2) The community has been involved in the project at all levels and through the whole cycle of planning, implementation, and maintenance.

(3) As a result of this involvement and because of its basic importance to the success of the program, a sense of pride and ownership in the project is generated within the local community.

(4) Rural communities have always been conservative and cautious of innovations until the innovations have been shown to be appropriate to rural conditions. It has been possible to gain the confidence of the rural communities, through successful demonstration, and to involve them in a technical program of development, which then generated confidence for further projects.

The success of this project did not, of course, happen overnight, but has taken 10 years of patient understanding and persistent hard work from dedicated field staff.

## Mulanje Tour

A field trip, which was an integral part of the workshop, gave the participants the opportunity to observe the Mulanje gravity-fed rural water supply system. This tour included visits to view all of the main components that make up the system: village tap outlets, storage tanks, the laying of pipes, and the intake system located high on the slopes of Mulanje Mountain. The tour involved not only visits to the sites, but at each location village committees and workers were present to explain and to show how they had built and continue to maintain their system. The tour was climaxed by a visit to a working site where village men and women were busy laying PVC pipes in the ground.

One feature that became clear was that in constructing this extensive rural water supply system, the water authorities worked with the existing tribal infrastructure, i.e., rather than trying to bypass traditional values they sought to work within them. The role of chiefs was not reduced, but was considered important in assisting with the organization of the people and the planning of work schedules.

In designing the water system, the physical constraints imposed by the environment were carefully considered. It was estimated that even with the most efficient agricultural practices, the land could not support more than 300 people/km<sup>2</sup>. This, therefore, became the design density for the water standpipes. The amount of water allotted was 6 gallons (27 litres) per person per day. In view of the limited amount of water available on the mountain there were no plans to increase this limit. Also, any increase in water consumption would tend to go to a privileged few and develop inequalities among the villagers.

Originally, this water scheme used much self-help labour. Where the task was large and complex, however, as in building concrete storage tanks, it was eventually found to be more efficient to contract this work out to competent local masons. In addition, as development proceeded it was considered that self-help labour would become more difficult to obtain, so that with time more professional, paid skilled labour would be used. The use of local personnel and committees, however, would probably continue to be more efficient for constructing small-scale local tanks, keeping the standpipe area clean, and repairing taps and washers.

Education of the users was stressed. The villagers had to be convinced of the superiority of the piped water system in order to (1) operate and maintain it carefully and (2) continue to use it in preference to less hygienic sites (e.g., pools, temporary rivers) that become available during the rainy season.

# Rainwater Catchment in Botswana

Gilbert J. Maikano<sup>1</sup> and Lars Nyberg<sup>2</sup>

The Republic of Botswana, with an area of 561 800 km<sup>2</sup>, lies at the centre of the Southern African Plateau, at a mean altitude of 1000 m above sea level. The climate is continental and semi-arid, with an average annual rainfall of 450 mm. The rainfall is erratic and unevenly distributed, ranging from 300 mm in the southwest to 700 mm in the northwest. Over 90 percent of the rain falls in the summer months between November and April, although some light rains occur as early as September. The country lacks perennial surface water, except in the northwest and a few springs, dams, and pools in the east. Mean maximum and minimum temperatures vary according to region, but the former seldom rises above 30°C and the latter seldom falls below 5°C.

About 84 percent of the land surface is covered with Kalahari sand, which supports low savanna-type vegetation. Rainfall is normally held in the top few metres and is largely lost through evaporation. Only 5 percent of Botswana has the combination of adequate rainfall and suitable soils necessary to provide for arable agriculture.

The population is estimated at 857 000, about 80 percent of whom live on the eastern side of the country, where there are suitable soils and sufficient rainfall to permit arable agriculture. About 15 percent of the population lives in towns and the remaining 85 percent lives in large villages, rangelands,

and cattle posts. A peculiarity of life-style in Botswana is that most people have more than one home, i.e., the main village or town, where people reside from July to September; the rangeland area, where people reside from October to July; and in some cases, the cattle-posts area, where people stay for various lengths of time. This pattern of living makes it difficult to provide potable water to all the communities all the time.

One of the main constraints to productive arable agriculture is the lack of water, both for human consumption and animal watering, during the time prior to the main part of the rainy season. This causes plowing to begin late, which results in poor crop yield.

## Rainwater Catchment Concept

Lack of water at the beginning of the rainy season has brought about the introduction of the rainwater catchment. It was felt that if water from the first light rains could be collected and stored, it could then be used for human consumption and draft-animal watering prior to the heavy rains; thus, plowing could begin earlier, resulting in a better crop yield.

## Feasibility Studies

With cheaper alternative sources of water supply not available, the construction of rainwater cisterns becomes justified. This is particularly true at the beginning of the plowing season, when there are no other sources of water in many parts of Botswana.

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At Pelotshetlha, in the Southern District of Botswana, an integrated farming pilot project has engaged farmers in a new and alternative rainwater harvesting scheme. Advantage is taken of a traditional grain-threshing floor, which is used as a rainwater-collecting surface. The floor is surrounded by a low mud wall and is plastered with a mixture of clay and cow dung that provides a smooth, relatively hard surface. Plastering is done annually at the beginning of the crop-harvesting season.

These floors, which are common all over the country, slope gently toward one corner, where a small hole is usually made to allow the waste out. Under this pilot project, a shallow basin connected to a rainwater cistern by a short length of PVC pipe has been provided. This basin acts as both a collecting and sedimentation device.

The cistern is entirely underground, but has a brick curb to exclude surface runoff and to provide a bearing surface for a cover. In the initial cisterns, the cover was constructed of lengths of tree trunk. Because it is not easy to find long lengths of tree trunk, the width of these initial cisterns was restricted to 2 m. Also, because the surfaces of tree trunks are uneven, gaps occurred in the cover and permitted dust to enter the cisterns. This type of cover has, however, been found effective enough to provide shade against the sun and, thus, prevent algal growth in the water.

The cistern itself was waterproofed by a thin layer of cement plaster applied on a chicken-wire mesh that was pegged along the sides during plastering. The finishing plaster was smoothed over to render the surface waterproof. To date, no evidence of seepage loss has been noted.

### **Design and Construction Options**

These initial rectangular cisterns have been criticized because the rectangular shape is structurally less strong due to differential stresses that will, in time, cause the plaster to crack at the corners and on the long sides, which are 8 m in the larger of the current cisterns. Also, the surface area to

be plastered is about 25 times greater in a rectangular cistern than in a circular one of the same capacity. Thus, plastering costs are higher.

It is now recommended that circular tanks be used and that the rectangular ones be monitored to determine if they crack. If they do, they can be replastered and checked before the next rainy season. If the rectangular tanks fail, either they will be backfilled and circular tanks will be dug nearby, or an attempt will be made to convert them to an elliptical shape.

The roofing of circular tanks can take the form of precast concrete slabs incorporating a hole for drawing water in the same manner as for hand-dug protected wells. The slab can be cast in portions to facilitate handling, which can be eased through the use of pulleys. As tank size increases, the covering slab thickness will also increase. It can vary from 2 cm at the edge to 7.5 cm at the centre. The slab can be reinforced by five strands of barbed wire in the thick slabs and two strands in thinner ones.

Another alternative being tested is a domed cover, which is cast on a mound of earth that is carefully shaped and whose size is calculated to be larger than the outside diameter of the tank. The height of the centre of the dome varies with diameter (i.e., about 40 cm for a 10 m<sup>3</sup> tank and increasing to 1.5 m for a 25 m<sup>3</sup> tank). A well-shaped chicken-wire mesh is then pegged to the mound and plastered with cement mortar, which is then allowed to set for 5 days. In the case of domed covers, the hole for the dipping bucket should be toward the side so that people do not have to climb the dome to draw water. When the dome is set, it can be carefully lifted on poles and mounted on the tank.

### **Selection of Size**

Table 1 gives the dimensions and estimated costs of four tanks ranging from 10–25 m<sup>3</sup> in capacity.

### **Operation and Maintenance**

As mentioned earlier, the plastering of the traditional threshing floor is done annually

Table 1. Estimated costs (pula) of underground rainwater tanks of four different capacities (m<sup>3</sup>).  
In all cases tank depth is 2 m.

	10 m <sup>3</sup>		15 m <sup>3</sup>		20 m <sup>3</sup>		25 m <sup>3</sup>	
	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
Diameter (m)	2.52		3.09		3.57		3.99	
Floor area (m <sup>2</sup> )	5		7.5		10.0		12.5	
Total plastered area (m <sup>2</sup> )	20.8		26.9		32.4		37.5	
Man-days 1.27 m <sup>2</sup> /day at P4.00/day	16	64	21	84	25	100	30	120
Supervised man-days (P12.5/day)	4	50	5	63	6	75	7	88
Cement bags (P2.84/bag)	7	20	9	26	11	31	13	37
Wire mesh (P1.44/m <sup>2</sup> )	21	30	27	39	32	46	38	55
PVC inlet pipe		10		10		10		10
Contingencies, at 10% for transport		22		27		31		36
Transport of materials		50		50		50		50
Farm improve- ment grant		20		20		20		20
Total estimated cost		266		319		363		416
Cost per m <sup>3</sup> stored		26.6		21.3		18.2		16.6

Note: P1=U.S.\$1.29.

at the beginning of the harvesting season. This is the only extensive maintenance required for the floor other than sweeping it time and again so that the first rain can find it clean and free from loose dust. The fact that the threshing floor will be used for collecting water means that all possible pollutants must be kept away from the floor.

Some silt will, obviously, be carried in the water and this may necessitate the provision of a simple slow-sand filter, which will require renewing of the filtering material once a year. By introducing a slow-sand filter the bacteriological content of the water will also be reduced.

The cistern will require cleaning before the beginning of the next rains. Plastering of the tank and cover may have to be done as cracks are noticed.

The entire unit must be fenced to prevent damage by livestock, particularly after the people return to their villages. The fencing itself is not a new innovation, nor is it expensive. It is common to have homesteads fenced with tree branches and gates blocked using newly cut branches at the end of the harvesting season.

Water must be drawn by bucket through the manhole and a trough should be available for watering livestock.



## Water Quality

It has been feared that because the catchment area is plastered with a mixture of clay and cow dung, that nitrate and bacteriological pollution would be a serious problem. A sample taken from one of the existing tanks at Pelotshetlha showed a nitrate concentration of 1 ppm. The parameters tested were: nitrate 1 mg/litre; pH 7.2; conductivity 211 mmho; total dissolved solids 190 mg/litre; and chloride 8 mg/litre.

Further chemical and bacteriological tests of the water will be conducted, particularly because pathogens may also be found as a result of the use of cow dung. Such monitoring will be done while water from the previous rains is still in the tanks and also after the tanks have filled from the next rains.

## Rainfall Analysis

Rainfall data for Pelotshetlha over the last 10 years were used to calculate the amount of water it should be possible to obtain with a catchment area of 150 m<sup>2</sup>. Consumption figures of 20 litres per person per day for a community of 7 persons and 60 litres per ox per day for 6 oxen were used and the calculated water demand was 0.5 m<sup>3</sup> per day.

As mentioned earlier, the aim is to encourage early plowing by providing people and cattle with a safe water supply.

Today, people rely on water from pools. The oxen are often in poor health and as a result, when the first heavy rains come in November, plowing takes a long time.

Table 2 gives the amount of water that can be collected using water catchments and the earlier dates on which land preparation can begin as a result.

Table 2 indicates that an average of 17 days can be gained for land preparation before the start of plowing. (Normally, plowing begins with the first rainfall of >25 mm.) The following rainwater catchment data indicate the amount of rainfall it was possible to obtain in three different areas: Kanye: average, 8.0 m<sup>3</sup>; 0-5 m<sup>3</sup>, 4 years out of 19; 5-10 m<sup>3</sup>, 10 years out of 19; >10 m<sup>3</sup>, 5 years out of 19. Mahalapye: average, 6.2 m<sup>3</sup>; 0-5 m<sup>3</sup>, 11 years out of 20; 5-10 m<sup>3</sup>, 3 years out of 20; >10 m<sup>3</sup>, 6 years out of 20. Ghanzi: average, 3.4 m<sup>3</sup>; 0-5 m<sup>3</sup>, 15 years out of 20; 5-10 m<sup>3</sup>, 4 years out of 20; >10 m<sup>3</sup>, 1 year out of 20.

## User Education

The experiments on rainwater catchment have been publicized in *AgriNews*, a bulletin

Table 2. Normal starting date for plowing vs. possible starting date of land preparation through the use of water catchments.

Normal starting date for plowing	Amount of water collected before plowing begins (m <sup>3</sup> )	Possible starting date of land preparation with water catchment tank	Time gained (days)	Year
13 November	10.9	22 October	22	1971
7 November	5.6	7 November	0	1972
30 November	23.0	19 October	42	1973
18 November	9.0	5 November	13	1974
12 November	8.1	6 November	6	1975
7 November	19.9	14 October	24	1976
23 November	11.4	6 November	17	1977
29 November	13.7	6 November	23	1978
1 November	21.5	20 October	12	1979

of the Ministry of Agriculture. Agricultural demonstrators continuously take farmers in their areas of operation to Pelotshetlha to show them the rainwater catchment project run by the integrated farming pilot project. It is hoped that these measures, as well as others in the future, will prepare the farming community to accept and maintain these devices.

Today, the pilot project has about 10 underground tanks built and more are under construction. In all, it is hoped to have 80 completed by the end of 1980.

### **Conclusions**

From rainfall statistics it is possible to state that in areas around Kanye and Mahalapye there is no need to construct tanks larger than 12-15 m<sup>3</sup>. In the dry Ghanzi area, the tank volume can be reduced to 8 m<sup>3</sup>. Before the heavy rains start in

November, the average amount of rainwater it is possible to catch on a 150 m<sup>2</sup> threshing floor in these three areas is: Kanye, 8 m<sup>3</sup>; Mahalapye, 6.2 m<sup>3</sup>; and Ghanzi, 3.4 m<sup>3</sup>.

Usually, the farmer is expecting enough rain for plowing in November and after the rain he takes his oxen out to the land. With the introduction of rainwater catchment tanks he can move with his family and oxen to the land 2-3 weeks earlier and be able to prepare for plowing so that he can start as soon as the rain comes.

In this way, the possibility exists that the farmer will be supplied with water during his entire stay at the land and when he comes back to the land for harvesting, his tank, in most cases, will again be filled with rainwater, which will last for a long time.

The quality of the water, although still not satisfactorily investigated, is a definite improvement over the water collected in pools, which is often contaminated by excreta from animals.

## Shallow Wells and Hand Pumps

ged Mammo<sup>1</sup>

At present, there is a general lack of potable water in rural parts of Ethiopia. There are a number of ways of supplying such water: engine-driven pumps, from boreholes, shallow wells, springs, rivers, lakes, etc.

Of the many alternatives, springs are widely regarded as the cheapest source of clean water, if they are available. Rivers and lakes are few, and streams last only during or just after the rainy season, after which time they are too turbid to be used as a source of potable water.

Another source of potable water is hand-dug wells. In rural Ethiopia, one of the local craftsmen is always the well digger. At present, however, most hand-dug wells are improperly constructed and use primitive water-lifting devices such as buckets and inner tubes that are unhealthy and time consuming. The use of hand pumps would facilitate the withdrawal of water from these wells.

In a country like Ethiopia, where there is a tremendous demand for hand pumps and a shortage of funds for importing foreign goods, a plausible hand pump has to be inexpensive and reliable to be imported.

This report, apart from a short section on wells, is essentially a comparison of some hand pumps that are in use in Ethiopia, both imported and locally designed and manufactured.

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The project is financially and technically supported by the International Development Research Centre (IDRC) and the United Nations Development Programme/United Nations Industrial Development Organization (UNDP/UNIDO), and implemented through the Ethiopian Water Resources Authority (EWRA).

The designing and manufacturing were carried out in the Mechanical Engineering Department, Faculty of Technology, Addis Ababa University. This research is essentially a continuation of research on hand pumps and windmills that took place at Addis Ababa University during the "Development through Cooperation Campaign," which spanned the years 1974-1976.

### Wells

#### Selection of Well Sites

According to the EWRA Central Region, and presumably in general, almost all water points are established at the request of the local population. When the request arrives, a team is sent to determine what type of water-point design will satisfy the local demand, as well as be most economical to implement.

The team first considers the possibility of springs in the vicinity. If none are available, it must then consider shallow or deep hand-dug wells or perhaps boreholes with engine-driven pumps. Wind-powered water points are not, as yet, available.

## Construction

When the most economical water-point design is a hand-dug well, a work crew is sent to camp near the site. Presently, a major problem exists with the supplying of construction and other support equipment to the work crews. As much as 50 percent of the crew's productive time can be lost trying to purchase and ship materials and handling per diem requisitions.

Technical difficulties are less of a problem. For example, if the soil is too loose, it will cave in before the casing is lowered. A temporary wooden frame, therefore, must be made as digging proceeds. Another problem with loose soil is that it keeps falling into the water, making frequent cleaning of the well necessary. In one location in Awara Melka, 200 km southeast of Addis Ababa, the aquifer material contained a lot of pumice which is much less dense than water. These rock particles were suspended in the water and were sucked into the hand pump that had been installed. After a month of operation the piston and foot valve were both stuck.

There is now a standard well design developed by the Central Region for use by the EWRA. The United Nations Children's Fund (UNICEF) and the Evangelical Church Mekane Yesus (ECMY) are two of the well "suppliers" to this project with their own standard designs. These designs are affected by the pump type to be used, the terrain, and the degree of cleanliness required of the water (e.g., UNICEF well covers have no manhole).

This particular project doesn't deal with well digging or construction directly, but requests wells to: (1) have studs cast in the concrete to match the holes in the pump stands being used and (2) be easily accessible from the main road and within a 200 km radius of Addis Ababa. In areas beyond this boundary, maintenance and follow-up are carried out by local residents. Eventually, all manufacturing (except for pistons and foot valves), installation, and maintenance of pumps will be carried out by the regions themselves. Currently, there are no hand pumps installed in boreholes in the Central Region and very few elsewhere.

## Hand Pumps

In the EWRA Central Region (where more than two-thirds of the pumps are installed to date) there are three categories of hand pumps being used. The following list gives the category and the types of pumps used within each: (1) imported: (a) Consallen, (b) mono (myno); (2) semi-local: (a) Boswell; and (3) local (EWRA/IDRC): (a) BP, (b) BPL, (c) type C, (d) type D. This list doesn't include all hand pumps that are in use in the Central Region, but is a collection of those hand pumps which are closely connected to the EWRA and, hence, this project.

### Consallen

These hand pumps were installed when the United Kingdom was giving aid to the EWRA Central Region. They are installed mainly in the Maki area about 130 km south of Addis Ababa, and have a 2, 2.5, or 3 in. (5.1, 6.4, or 7.6 cm) piston and cylinder (depending upon the depth of the well); a 1.25 in. (3.2 cm) riser PVC pipe; steel pump rod; and steel pump stand with lever. The piston has rings and is running in a stainless steel cylinder. The foot valve consists of a rubber sealer against a slotted or perforated steel body. Unless foreign particles are introduced, the sealer is quite effective. The riser pipe is connected with a PVC flange to the pump stand.

When operated, because of the tight fit between the piston and cylinder, the pump feels heavy, even at low pumping heads. Also, the riser pipe snakes, particularly at faster pumping speeds. Consequently, the PVC flange at the pump stand breaks and repeated failures of the 1.25 in. (3.2 cm) riser pipe at the threaded connection were experienced. Foot valve leakage was not acceptable in many cases, after some time of operation. Except for the flange connection in the stand, the part of the pump above ground stands up to a lot of mishandling.

### Mono

This is a rotary positive-displacement pump. The piston is a solid steel helix

running in a matching rubber cylinder. There may or may not be a foot valve because the fit of the piston and cylinder is very tight. The transmission shaft is steel and is guided by rubber bearings in the riser pipe. Pumping is accomplished by rotating the arms that are on opposite sides of the pump stand. A bevel-gear pair transmits the torque to the pump rod (transmission shaft), which has the piston attached to its other end.

This pump is normally regarded as the best type as far as reliability and ease of pumping are concerned. The only maintenance problem is oil loss at the seal of the gearbox bearings. The United Nations Children's Fund, which is importing and installing this type of pump, leaves a quantity of oil with a person living nearby to fill up the gearbox once a month or as required. The newer version of the mono pump, the myno pump, will have double O-rings at these points in the gearbox to reduce oil leakage. If, however, there is a considerable loss in the height of the static water level (drought), parts which rely on water for lubrication, such as the starter in the mono pump, could suffer heavy wear and tear. The greatest problem with this type of pump is its cost, which is presently about U.S.\$1200.

### **Boswell**

In the past, this pump was imported in its entirety. Now, the only imported parts are the pump rod, piston, and cylinder. The Boswell pump is basically a piston pump with a distinctive, above-ground structure. The piston and foot valve both possess leather cup seals to minimize leakage. The cylinder is brass-lined, galvanized steel pipe. The foot valve can be withdrawn without taking up the 2 in. (5 cm) galvanized steel riser pipe by screwing the lower end of the piston into the foot valve. The pump rod is galvanized steel.

There are many varieties of this pump, but generally the pump stand is always offset from the riser pipe. The lower arm is very long (about 2 m, with a relatively small mechanical advantage of 3.3) and the pump stand is relatively high.

Installation of this pump is difficult because the stand and riser pipe are offset. As a result, alignment of the pump rod end of the lever with the "stuffing box" (the above-ground portion of the riser pipe) is never perfect. The pump rod upper end normally scrapes the wall of the riser pipe. The stops which limit the up and down strokes of the handle are frequently worn away. The piston cup seals expand when immersed in water and pumping is very heavy, even at low heads, just after installation. By the time pumping is no longer heavy, the cup seals have worn down and are almost ready for replacement. Unscrewing of the piston from the pump rod has been experienced.

The pump stand, piston, and cylinder are the major problem areas of this pump. In agreement with UNICEF and EWRA staff, it was decided that an attempt be made to modify the Boswell pump in this project. The tentative plan was to (1) have the stand screwed directly onto the riser main by using the type BPL pump stand designed by this project for this purpose (with a mechanical advantage of 4 and a maximum stroke of 20 cm); (2) redesign the leather cup seal to reduce piston-cylinder friction, but keep volumetric efficiency reasonably high; and (3) have pins drilled through parts of the piston to prevent it from working itself loose.

The pump stand is being manufactured at the Society of International Missionaries (SIM) workshops at the rate of 120 per year. It is planned to manufacture 160 per year by extending the SIM and/or the Oxfam workshop at the EWRA.

The pump rod, piston, cylinder, and foot valve are still being imported at a cost of U.S.\$100 per pump. The pump stand is being made locally for Br370 (U.S.\$178) and the 2 in. (5 cm) galvanized steel riser pipe is locally purchased.

### **Local EWRA/IDRC Pumps**

This project is working on three types of hand pumps: types B, C, and D. Type B pumps are further subdivided into types BP and BPL. They consist of a piston, cylinder, and foot valve submersed in water. Type BP

(Fig. 1) uses plastic (PVC) riser pipe and a direct-acting handle operating in a bicycle-pump fashion. It is designed for shallow-well pumping (up to 20 m depth). Type BPL (Fig. 2) is the same as type BP below the well apron, but employs above-ground leverage and is designed for use in deeper hand-dug wells (depths up to 35–40 m). Type C (Fig. 3) is an inertia pump in which the water column and riser pipe are suspended on a spring and oscillate at the natural frequency of vibration of the system. Type D is also an inertia pump in which only the water column is oscillating.

**Type C (Fig. 3)**

These pumps have pipes that are suspended on a spring on the well apron. The foot valve is at the other end and pumping is accomplished by oscillating both pipe and water in the pump. The pump is self-priming, has very few parts, and has

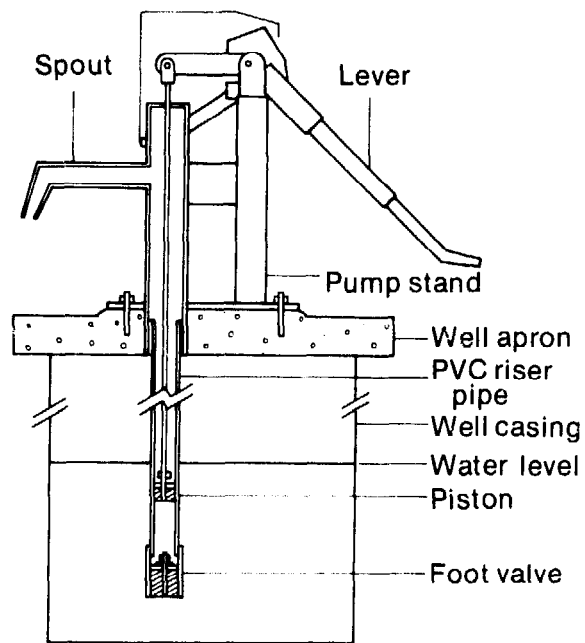


Fig. 2. Type BPL pump assembly.

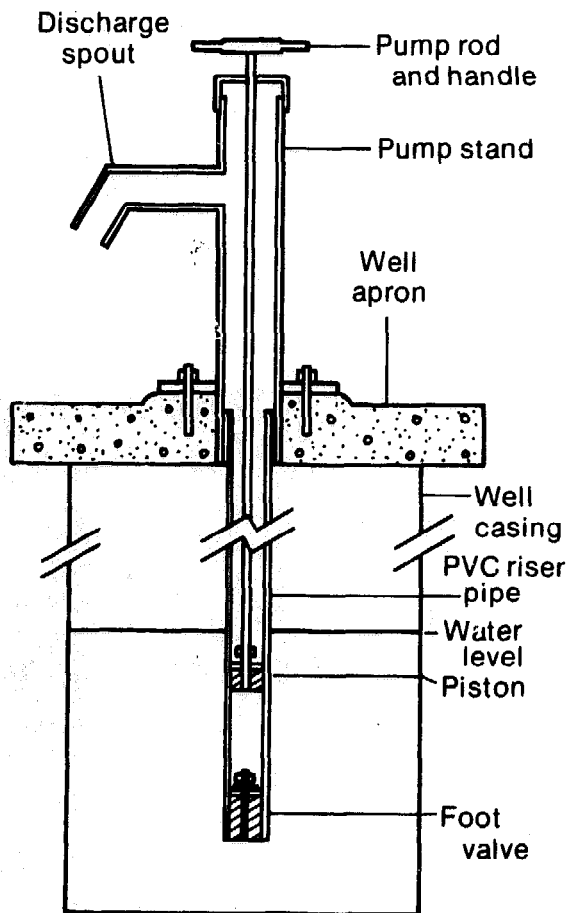


Fig. 1. Type BP pump assembly.

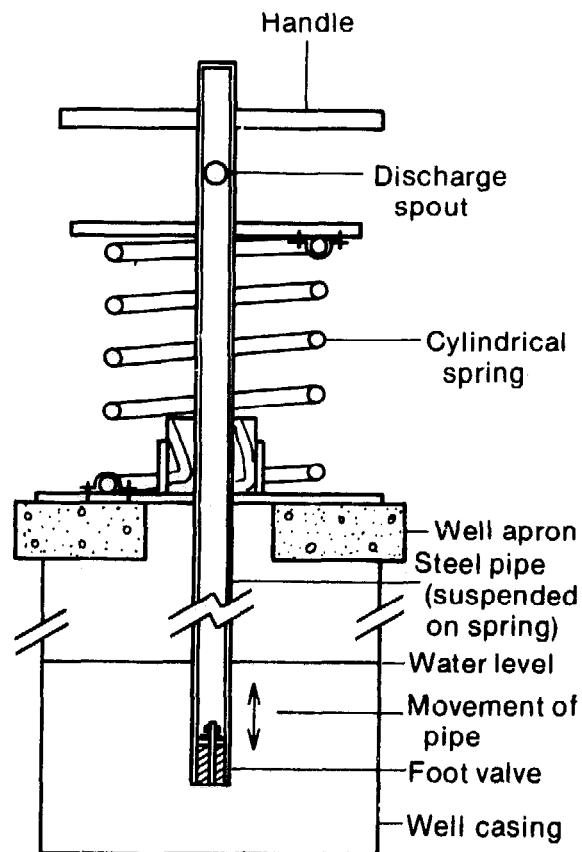


Fig. 3. Type C pump assembly.

high efficiency. It can, theoretically, be used with very high heads, and is relatively easy to pump. Collection of water is accomplished via a flexible hose attached to the discharge spout. Development of this pump has been slow due to the emphasis placed on other pump types. The main problem with this pump is that the required spring characteristics are demanding. The operating speed, i.e., the natural frequency of vibration of the system, must be 1.5–2 Hz. On wells with heads of up to 14 m, induced stress in the spring wires is 3000–5000 kg/cm<sup>2</sup>. Because the springs are not readily available locally, facilities for the manufacturing of the springs will be necessary if the pump is to be used. Another problem which must be solved involves obtaining the steel needed to make the springs, because it is not available locally. It will be necessary to overcome these difficulties if the type C pump is to be successful.

#### **Type D**

This pump has a stationary pipe in which the water oscillates at its natural frequency. Excitation is accomplished by a piston and cylinder arrangement on the top. At the other end of the pipe is a foot valve.

Because the pipe is stationary, induced stresses are relatively low. The fact that the pump head (cylinder and actuating piston) could be arranged offset from the well makes this pump attractive as a sludge pump (dewatering pump). This pump is not self-priming, however.

Experiments on this pump were temporarily stopped due to a foot valve problem (it would not tolerate muddy water). When the foot valve problem was finally solved, priority was then given to type C pump development and later, based on a consulting report from the University of Waterloo, toward the type BP pump. The BP pump has since been used as a sludge pump as well, which led to further delay in the development of the type D pump. More information on the type D pump will become available in the future when efforts will be geared away from the type BP pump, which is now in a relatively advanced stage of development.

#### **Type B**

This pump consists of a pipe at the end of which is a foot valve. The lower end of the pipe serves as a cylinder. The piston is submerged in the water at the end of a pump rod. The piston has a valve incorporated in it. A type A pump, which was the same as the type B pump, except that it had no valve in the piston, was discarded early in the project in favour of the type B pump.

Experiments on the type B pump were first started using galvanized steel pipe for the riser pipe and cylinder. It was found, however, that the surface of these pipes was too rough, resulting in an inefficient system and considerable wear on the piston. It was then decided to line the bottom metre of pipe (the cylinder) with thin PVC pipe.

The type BP pump (Fig. 1) as it stands now, has a pump stand made of galvanized steel pipes that are welded and painted. The riser pipe is PVC (1.5 or 2 in. (3.8 or 5.1 cm)) and screws directly onto the stand. The joints between the pipes are made using steel couplings and at the end is a foot valve. The pump rod consists of pipes cement welded by bell ends, and at the lower end is the piston. This type of pump is designed for pumping from depths up to 10 m with the 2 in. (5.1 cm) (BP50; Fig. 4) riser pipe and from depths up to 20 m with the 1.5 in. (3.8 cm) (BP40) riser pipe. Lower heads (1–4 m) could be handled with 3 in. (7.6 cm) or 2.5 in. (6.4 cm) pipe, but these sizes are not produced locally. The handle is made of wood and is clamped onto the 0.5 in. (1.3 cm) PVC pipe/pump rod. There is no mechanical advantage on the BP50 and BP40 versions, which decreases pump stresses and cost while making pumping more difficult.

Installation of both the BP and BPL pumps is not time consuming; 3 h are sufficient for two technicians and a helper to completely install a BP40 or BP50 pump. In one instance, installation was completed in 1.5 h. The BPL pump would take about 5 h to install because the pump rod has to be measured exactly, and the steel rod and 0.75 in. (1.9 cm) PVC pipe/pump rod joined on-site. The following are some the problems experienced with this pump that have now been solved.



*Fig. 4. BP50 pump supplying 20–25 m<sup>3</sup>/day from a depth of 3 m to the town of Assossa (pump installed in August 1979).*

**Pump stand.** The most frequent problem with the pump stand involved the pump-rod guide, which was also serving as a crude stuffing box. The wood which was used had to be boiled in oil to make it a more durable bearing surface. When fastened with screws and/or when it was in contact with the handle during pumping, the guide would break and the pieces would go down into the riser pipe. To avoid the screws that initiated most of the cracks, the “cap” idea was started. The impact of the handle was still breaking the wood, however, so it has now been replaced with polyethylene, which has to be imported.

Another problem involved children putting material in the spout opening, which caused heavy piston and cylinder wear and eventual sticking. To eliminate the problem the spout, which was straight originally, was designed to face downward to make it more

difficult for children to put material into the opening.

In one instance, the base plate cracked and the pump stand and riser fell down. To remedy this problem, ribs were welded onto the base plate to reinforce it.

**Pump rod.** Within 1 week of the installation of the first pump, the pump rod was broken about 30 cm below the handle. Although thin-walled steel tubing was added to reinforce the pump rod, this too was breaking, just below the lower bolt that attaches the pump rod to the handle. As a result, present pumps have at least 1 m of pump rod reinforced with a solid steel bar. To avoid drilling holes in the pump rod it is now clamped to the handle by friction only. A better solution to this problem, however, would be to use a solid nylon bar which is strong enough, but is lighter and can be welded to the PVC pipe. Nylon of this nature will be manufactured locally some time in the future. The pump rod stop (which prevents the rod from being pulled out all the way) was frequently becoming detached. Now, a bell-end joint on the pump rod about 50 cm below the handle also serves as a stop.

**Riser pipe/cylinder.** This is the major problem at present. Because the 2 in. and 1.5 in. (5.1 cm and 3.8 cm) pipes received from the local factory were not consistent in their dimensions, had wavy internal surfaces, a high out of roundness rate, and an uneven wall thickness, longitudinal cracks in the pipe developed after a few weeks of operation. After being approached on the matter, the management of the factory that had been providing the pipes pledged to supply pipes of better quality.

In a couple of instances, the riser pipe failed at the root of the thread coupling it to the pump stand. Currently, a design change is under way that avoids threaded connections (stress concentration). Because plastic couplings are not locally available, standard steel pipe couplings are used for the other connection.

Because the largest high pressure pipe produced by the factory is 2 in. (5.1 cm) in diameter, it is used in the lower head pumps



(1-4 m) (2.5 or 3 in. (6.4 or 7.6 cm) pipes would give higher discharges).

**Cylinder.** The last metre or so of riser pipe also serves as the cylinder. Field tests have shown that loss of volumetric efficiency has been mainly due to wear on the PVC cylinder rather than on the polyethylene piston. Thus, it is now envisaged to have the last metre of the riser pipe consist of a detachable unit, which can be replaced when it wears down (every 6-12 months, depending on the amount of usage and type of pump). It is more critical on the BPL type pump with its short (20 cm) stroke.

**Piston.** The piston also becomes a serious problem on the BPL type pump. Longer pistons (two coupled together) were unsuccessful in decreasing the rapid loss of volumetric efficiency. A design change to a piston with rings, after the preliminary IDRC (University of Waterloo) design, and which can easily be installed and withdrawn in the riser/cylinder, is under way. No changes in design are immediately planned on the pistons of the BP50 and BP40 pumps. However, there may be slight changes when the units go into mass production.

**Foot valves.** The centrally-pinned type design was abandoned early in the project in favour of the present design, in which the sealing rubber flapper is free to move up and down on a central stem (brass bushing).

Because the steel washers adjacent to the brass have shown a tendency to corrode, the bushing is made of steel. The 1.5 in. (3.8 cm) foot valve was troublesome because it had little sealing area. Now, all foot valves are of the 2 in. (5.1 cm) type, with an adaptor/coupling for use on 1.5 in. (3.8 cm) pipes. This foot valve is now very effective in sealing and highly tolerant to foreign particles. There have been no further foot valve problems since the last modification, except once, when excessive amounts of floating pumice were sucked into the pump.

### Cost Comparisons

Prices quoted in Table 1 are from the people who import the pumps. In the case of the local pump (type BP), the figures are taken from Aseged and Jensen (1979).

### Conclusions

With respect to costs, spare parts, and backup, the best pump is the type BP pump for heads of up to about 20 m. However, the robust pump-stand design of the Consallen and overall reliability of the mono pump are desirable. In these respects, the type BPL

Table 1. Price breakdown of various pump types.

Pump type	Price (Br) (1 Br = U.S.\$0.48)	Approximate amount of foreign currency in price (%)	Remarks
Consallen	900 <sup>1</sup>	100	
Mono (myno)	2480 <sup>1</sup>	100	Myno with double oil seal will be slightly more expensive than mono
Boswell	860 <sup>2</sup>	40	25 m head
BP50	185 <sup>3</sup>	20	8 m head
BP40	220	20	16 m head
BPL	450	20	25 m head, with similar piston as in BP50

<sup>1</sup>Consallen and mono pump prices are for the pump stand, piston/cylinder assembly, and pump rod only.

<sup>2</sup>Stand, BR370; riser (5.1 cm x 25 m), Br300; piston, foot valve, and pump rod, Br207.

<sup>3</sup>Labour cost for type BP pumps assumed at Br5/h.

pump requires further development.

It has also been shown from field tests, however, that no hand pump is maintenance free. Routine inspection and maintenance cannot be done by the EWRA because it does not have the manpower, organization, or sufficient funds.

Therefore, in order for any hand-pump program to be successful, the participation of the community is imperative! Maintenance should be carried out at the

village level, with only marginal involvement from a central government body.

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Aseged, M. and Jensen, K. 1979. Research and development in water pumping technology in rural areas. Interim Technical Report, Polyethylene/PVC Hand Pump. Addis Ababa, Ethiopian Water Resources Authority.

# Shallow Wells Project, Shinyanga Region

Y.N. Kashoro<sup>1</sup>

Shinyanga Region is one of the 20 regions in Tanzania south of Lake Victoria. It has an area of about 50 000 km<sup>2</sup> and is divided into four districts (Shinyanga, Maswa, Bariadi, Kahama) and one subdistrict (Meatu). It has a population of 1 325 000, who are settled in 684 villages.

The region has a semi-arid tropical climate, with an average annual rainfall of 700–1000 mm. The rains start in mid-October and end in early May. The elevation in the region varies between 1500 m above sea level (asl) in the Bariadi District and 1100 m asl in some parts of the Kahama District. The majority of the region has an undulating landscape. The temperature is fairly constant throughout the region, with highs ranging from 28°C in March to June to 32°C in October and lows varying from 15°C in June and July to 19°C in October to December.

## Shinyanga Shallow Wells Project

The Shinyanga shallow wells project started in October 1974 in response to recommendations of the Shinyanga water master plan survey, which was carried out in 1973. In the survey report it was recommended that 2000 shallow wells be constructed in the Shinyanga Region as a quick and inexpensive method of serving most of the population in the region. This was followed by a bilateral agreement

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between the United Republic of Tanzania and the Kingdom of the Netherlands, whereby it was agreed to set up a construction unit to construct 700 shallow wells and in the course of construction to train Tanzanians to man the project. This task was accomplished in June 1978 and the project was turned over to the Tanzanians. Table 1 shows the present distribution of shallow wells throughout the region.

## Selection of Well Sites

Requests and applications for well construction come from the villages to the districts and, finally, to the region. At the district level, the applications are compiled in order of priority, the most needy villages being first. These lists of villages are then sent to the regional development committee with a copy going to the regional water engineer. The regional development committee decides which district or part of the region should be started first, bearing in mind that concentration in one particular area could be cheaper and construction could progress more rapidly.

Table 1. Shallow-well distribution throughout the Shinyanga Region.

District	No. of wells	No. of villages	Population served
Shinyanga	365	115	109500
Maswa/Meatu	262	80	78600
Bariadi	222	52	66600
Kahama	145	50	43800

Knowing the villages and their priorities, a hydrogeologist studies aerial photos, maps, and all available data to locate possible seepage areas, riverbeds, old riverbeds, possible valleys, vegetation, etc. This is followed by a visit to the village, at which time he contacts the village chairman and others from whom he can seek information such as where the village is currently obtaining its water supply during the dry season and where, within the area, water might be found. A reconnaissance survey is then made of the village to locate potential sites for shallow wells based on accessibility, soil suitability, and population within the village. A study of the geology of the area is important for locating recharge areas and possible aquifer locations. Rainfall and evaporation data are also useful for determining potential water supplies in an area. Based on all of this information a survey plan is then made.

#### **Surveying of Well Sites**

After a thorough investigation, potential well sites are marked and a survey is carried out to determine if water is present and, if so, its quality and quantity. Two methods of drilling are used in the surveys depending on the material being penetrated: hand drilling methods are used in soft material and in hard material a mechanical drill is employed. Hand drilling can easily go down to a depth of 10 m in sand, loam, and other loose materials, whereas mechanical drilling is capable of penetrating hard weathered and cemented materials and normally continues until the water table is reached. If, during drilling, the soil tends to cave in or collapse, a casing is used. When the aquifer is reached, its thickness is measured and a pump test is carried out to determine the yield of the well. Water samples are also taken at this time to determine water quality. In the Shinyanga Region, high fluoride and salt contents are the main hazards to the potability of groundwater, particularly in East and Central Shinyanga District and Maswa. These factors influence the health of consumers. Efforts are made during site selection, however, to avoid such pollution problems.

#### **Well Construction**

In Shinyanga there are three methods used for constructing wells: hand-dug wells, hand-drilled wells, and mechanically-drilled or dug wells.

##### **Hand-Dug Wells**

This type of well is constructed using traditional methods of digging a hole with a hoe or pickaxe. After reaching the aquifer, the hole is lined with concrete rings and covered with a concrete cover. Hand-dug wells become very expensive if the depth goes beyond 10 m. This is mainly a result of the need to use dewatering pumps during their construction and the cost of lifting soil from the well, which is time consuming and very laborious if hard layers are encountered. Using this method, one well sinker with four self-help labourers can dig two 7 m deep wells per month. This method of producing wells is appropriate in cases where it is felt that it is important to leave some knowledge of construction techniques at the village level.

##### **Hand-Drilled Wells**

Hand-drilled wells are drilled by using a 25 cm auger turned by two self-help labourers. When the hole has reached the required depth, it is lined with slotted 15 cm diameter PVC pipe casing and gravel-filter packing is applied around the outside of the pipe. This method is the cheapest method for drilling wells for hand pumps, but is only applicable in sand and soft materials where it is not difficult to drill with such an auger. One foreman and eight self-help labourers can drill two wells per week using this method.

##### **Mechanically Drilled Wells**

Where the aquifer is deeper or the material is harder and cannot be penetrated by hand drills, a percussion rig is used. The borehole is cased with slotted 15 cm diameter PVC pipe with gravel-filter packing around the outside of the pipe. This method, with some modification, could be used as a quick method of constructing inexpensive shallow wells. One foreman, four rig-crew members, and three labourers can produce one well per week. This method is the only

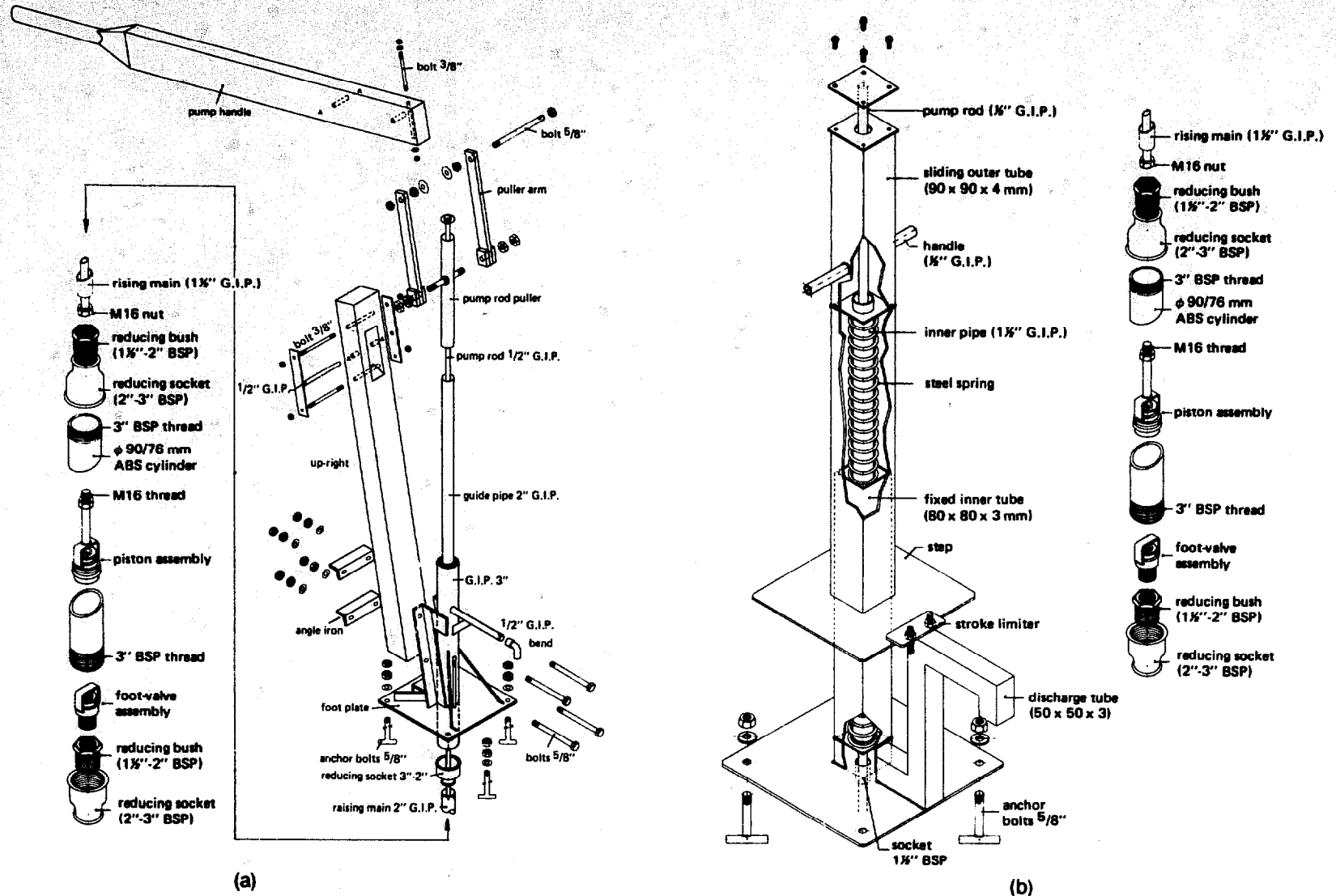


Fig. 1. (a) Shinyanga pump; (b) Kangaroo pump (reproduced from *Shallow Wells*, 2nd ed., 1979, pp.126, 130, DHV Consulting Engineers, P.O. Box 85, Amersfoort, The Netherlands).

Table 2. Well-inspection report, June 1979–May 1980.

District	No. of wells	Total inspected	No. of repairs	Low recharge wells	Dry wells, November 1979	Wells polluted/disinfected
Shinyanga	365	400	120	80	15	30
Bariadi	212	300	50	10	3	4
Maswa	152	200	30	5	10	7
Meatu	110	95	20	3	5	5
Kahama	145	310	46	6	3	24
Total	984	1305	266	104	36	70

one practical in cases where many wells must be produced in a short period of time. Its main disadvantage, however, is that it does not involve the community nor leave any drilling expertise in the community.

### The Shinyanga Pump

The Shinyanga pump (Fig. 1a), which is an improvement of the United Nations Children's Fund (UNICEF) and Uganda pumps consists of four main parts: pump stand, wooden upright and handle, rising main and pump rod, and pump cylinder and piston. After taking the necessary measurements, the pump is installed and the rising main and pump rods are cut, threaded, and screwed together with the pump cylinder. The pump is then lowered into the well and the wooden uprights and handle are bolted together on the pump stand.

With the exception of the cylinder and piston, the rest of the pump is fabricated in a Shinyanga workshop. The workshop has the capacity to manufacture 35 pumps per month. Since June 1978 about 200 pumps have been sold to other regions in Tanzania.

### The Kangaroo Pump

This pump (Fig. 1b) was designed to try to minimize maintenance by avoiding the use of hinge points requiring periodic lubrication. The head of the pump incorporates a spring which is compressed by pushing on a foot plate. As the spring recoils it produces the energy for the pumping stroke. Water can be pumped from a depth of 6 m with a 4 in. (10.2 cm) cylinder,

10 m with a 3 in. (7.6 cm) cylinder, and 20 m with a 2 in. (5.1 cm) cylinder. Because there are no hinges and wear on the pipes is minimal, a maintenance-free period of 10 years has been estimated for this design.

### Maintenance of Shinyanga Shallow Wells

When construction is completed, the well is turned over to the village chairman, together with a certificate of well ownership. Two people are then selected and trained to maintain the well. If repairs to the well are required, a form is filled out and sent to the district maintenance officer, who is housed in the office of the district water engineer. Most of the villages now understand this system. However, due to a lack of transportation and an increasing number of breakdowns, the district maintenance officer cannot always cope with all of the requests for repairs which are received. By employing a maintenance officer at the divisional level, as the number of well repairs increases, this problem may be reduced. Apart from this, regular inspections are carried out at wells to determine their condition. Water level checks are also carried out. Pollution and chemical fluctuations are monitored as well (Table 2). In Shinyanga, unless improperly installed, the Shinyanga pump normally has a 2 year maintenance-free period. Women and children, being the most common users, look after their pumps well, because they know that a breakdown means walking a long distance to obtain unclean water. As a result, nobody tampers with the pump.

## Shallow Wells Program in Malawi

**T.H.B. Nkana<sup>1</sup>**

The aim of the shallow wells program in Malawi is to assist villages in obtaining their own protected wells, which can provide a plentiful supply of disease-free water.

The program operates within the Groundwater Section of the Department of Lands, Valuation and Water (DLVW). Office personnel include engineers and administrators, field personnel include project supervisors and assistants, and labour is provided by the rural people on a self-help basis. Tools, cement, slabs, pumps, and technical expertise are provided by the DLVW. Funding for the program comes primarily from the Christian Service Committee of the Churches of Malawi (CSC) and the United Nations Children's Fund (UNICEF).

Areas suitable for water supply from wells are those with perennially high water tables. This condition is met in the plateau areas and particularly in the dambo areas of the Central Region. Fortunately, areas suitable for wells rarely overlap with those suitable for gravity-fed water schemes, so that much of Malawi can be serviced with one of these two water-supply systems.

In 1975, a pilot project was started in the District of Lilongwe, where 30 wells were constructed and pumps were installed. Due to the success of the project, the program was expanded into the neighbouring districts of Dowa, Ntchisi, Kasungu, and Dedza, all of which are in the Central Region. Five hundred wells had been

constructed by the end of 1979 and the program continues to grow.

Until recently, the wells constructed were relatively shallow, averaging 6 m in depth; were installed with a PVC pump; and had a correspondingly low head. Currently, an experimental project is under way to test and develop both construction and pump design for wells ranging in depth from 10-15 m.

### Implementation

Well construction is implemented through village action groups or development committees, organized in a manner similar to those village committees responsible for gravity-fed piped-water schemes. To achieve the high level of motivation and strong unified leadership required of the village authorities, the project assistants may take these leaders on a tour of completed wells and wells under construction. These tours are particularly effective because the village leaders have the opportunity to discuss with their fellow village leaders, who are already in the program, the relative merits and costs of the project. At this point, the prospective village leaders for the project are able to decide to what extent they wish to participate in the program. Meetings involving the whole village are then arranged, at which time the project assistant can explain the program to the entire community, obtain popular support for it, and elect a working committee responsible for the tools and materials such as cement, slabs, and pump

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<sup>1</sup>Wells Programme Officer, Department of Lands, Valuation and Water, Dowa, Malawi.

fittings required for both construction and maintenance.

Where strong program leadership exists within the rural community, it is possible to set up a program subcentre through which a complete system of protected wells can be constructed for the surrounding area. The advantages of working through a subcentre are great, both from the point of view of stable organizational structure and the abundance of wells to set the precedent as the program spreads from one village to the next. Currently, there are six fully functioning subcentres.

### **Execution**

The preliminary tasks of well construction are carried out by the community under the leadership of the village committee. These tasks include: (1) provision of 1000 bricks for lining the well; (2) collection of sand and gravel for mixing cement; (3) digging a 1 m diameter hole to a depth of 6 m; and (4) transportation of cement and slabs to the site (not always necessary).

In the past, lining of the well was done by a project assistant, but now local builders do this on a contract basis. Generally, "dambo" clays are self-supporting, so only the top 1 or 2 m of the well are lined to prevent the entry of surface waters. The slab is positioned by the builder, with the assistance of the community. The builder then plasters the apron and drainage channel. Finally, the

project assistant delivers the pump and assists the village committee with its installation.

### **Maintenance**

Each village committee is responsible for the maintenance of its own well. Routine duties and repair capabilities include: (1) removal of the pump and cleaning of pipe cylinders and foot valve; (2) detection of pipe cylinder, foot valve, and plunger wear and replacement of foot valve and plunger, where possible, in Mark II and III pumps; (3) tightening of the nuts securing the pump to the slab; (4) replastering of the apron and drainage channel with fresh cement; (5) removal of sediment and debris from the apron and drainage channel; and (6) prevention of slab misuse, such as the washing of dishes and clothing. Any replacement of parts or repairs that cannot be handled by the village committee are referred to the local project assistant.

### **Training**

Project assistants are recruited at the 8th year level of education and given a 2 week course in the skills and techniques used in well construction and community motivation. Local builders employed for well construction are trained in well siting; soil types; building techniques; and Mark I, II, and III pump assemblies and maintenance.



## Mark Series Well Pumps

K. Jellema<sup>1</sup>

The hand pump is probably the most important contribution made by the government to the community in support of the wells program. Often, it is the pump that makes people enthusiastic about the program and, consequently, willing to dig a well on a self-help basis. When the people see how a pump on an existing well facilitates the drawing of water and improves water quality, it speaks for itself, encouraging the spreading of the program.

### Mark Series Pumps

Pump design in its early stages was governed mainly by criteria such as investment costs, ease of installation, and local availability of parts. Later, the emphasis shifted toward factors related to maintenance and pollution control. It is now felt that the skills and resources required to make repairs, as well as the cost of worn-out parts, are of more importance than the initial investment costs.

There is another factor which influenced pump design. Being a program oriented toward assisting village communities, the response of the rural people was often so encouraging that pump production could not keep up with demand. Shortage of imported materials sometimes prompted the designer to follow solutions which might not be the best but would, at least, allow pump production to continue.

<sup>1</sup>Wells Engineer, Department of Lands, Valuation and Water, Lilongwe, Malawi.

### Design Modifications

The pump used in shallow wells was developed completely as a result of field research; no laboratory testing was carried out at all. This resulted in a considerable number of modifications, both to the pump-stand assembly and the "in-well" parts. Four pump stands have been in use since 1975, all of which operate on the "bicycle pump" principle (Fig. 1). Because pumping heads are usually less than 5 m, there is no need for lever-type pump stands and the accompanying "hinge" problems. A bicycle-type pump has the additional advantage of high plungers without seals (cup leathers or piston rings). Badly worn plungers still function satisfactorily when operated at high pumping rates. The advantages of a PVC pump pipe were realized soon after the first Mark I pumps were installed. No corrosion, lower investment costs, and a smoother surface are the obvious benefits of a PVC pump pipe.

Design modifications to the plunger and foot valve (in-well pumping mechanism) were more extensive than those to the pump-stand assembly (Tables 2, 3). Further modifications were introduced as a result of an International Development Research Centre (IDRC) sponsored international pump-research project. For example, the plunger was changed from a perspex disc to a PVC disc with a polyethylene sleeve because there is little friction between PVC and polyethylene. Thus, nearly all of the resulting wear occurs on the polyethylene part, which is cheap and easily replaced.

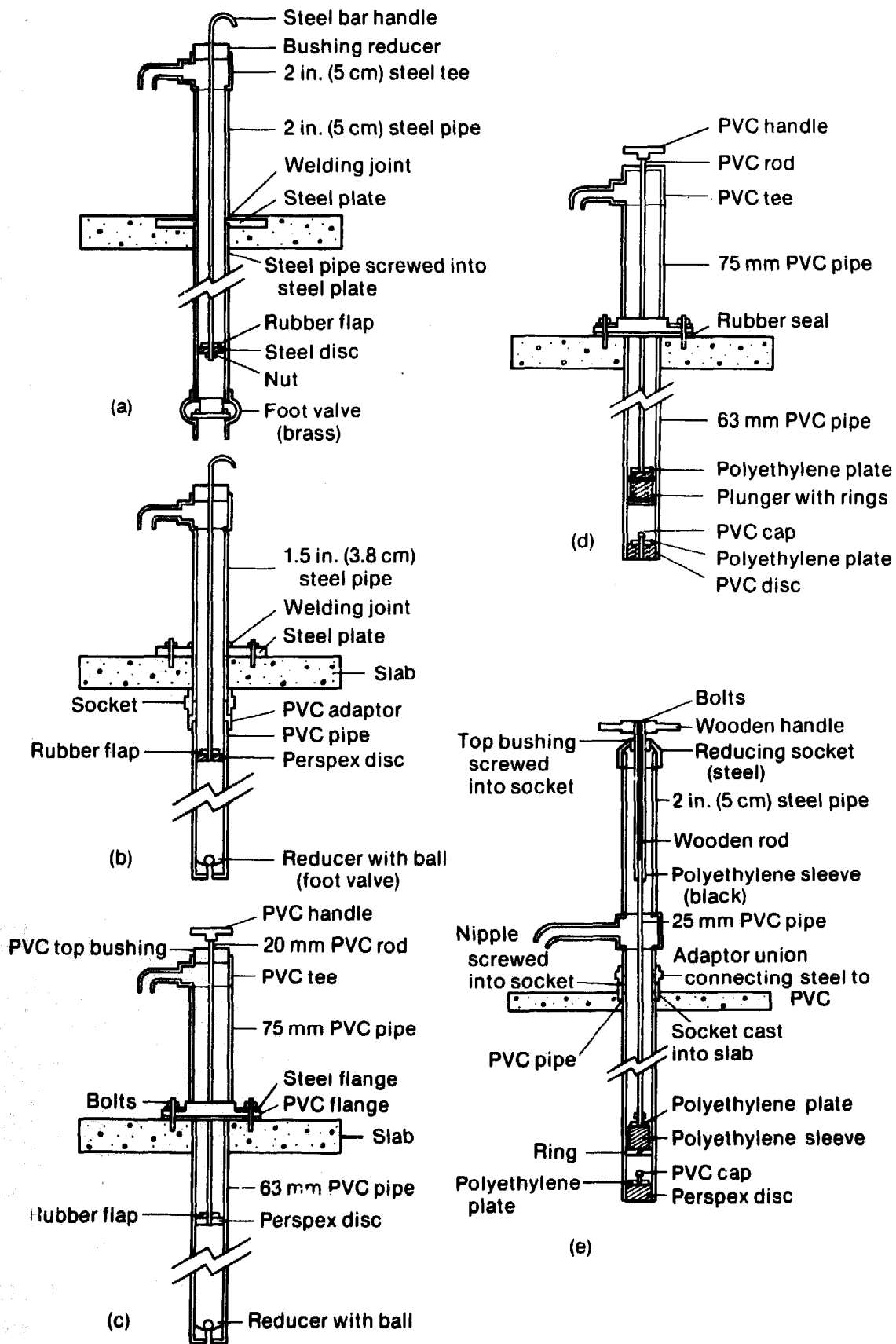


Fig. 1. Mark series well pumps: (a) Mark I; (b) Mark II; (c) Mark III; (d) Mark IV; and (e) Mark V.

Table 1. Modifications incorporated into the Mark V pump.

Pump type	Problem	Solution used in Mark V pump
Mark I-IV	<p>Splashing water at the top bushing</p> <p>The pump had to be removed for measuring water levels in the well or when adding chlorine</p> <p>Wastewater and dirt enter the well through small gaps between the flange and slab</p>	<p>Lowering the outlet tee and extending the outlet pipe away from the well head creates storage above the outlet, resulting in decreased leakage</p> <p>A small socket (1 in. (2.5 cm)) is cast in the slab and closed with a plug that can be unscrewed for inspection</p> <p>The pump stand is screwed into a 3 in. (7.6 cm) socket that is cast into the slab. The resulting seal stops dirty water from entering</p>
Mark II	<p>The steel pipe of the pump stand is connected to the PVC pump pipe by means of a PVC adaptor with internal threads. Rust and frequent dismantling spoil the PVC threads</p> <p>Plunger inspection and checking for foot-valve leakage requires lifting of the entire pump</p>	<p>A special fitting, called an adaptor union, connects the pump pipe to the stand. This union has no PVC threads, only a PVC collar that holds the pump pipe</p> <p>The PVC pump stand features a retractable plunger. In the case of the Mark V pump, the plunger can be withdrawn after the pump stand is unscrewed from the adaptor union</p>
Mark II-III	<p>Bouching as a result of foot valve closure</p>	<p>The plate-valve stroke of the foot valve should be as small as possible. At present, a valve stroke of 5 mm is used. A further decrease, however, might be feasible</p>
Mark III-IV	<p>The top part of the 20 mm PVC rod wears out in 1-2 years. When replacing the rod, a new handle is also required</p> <p>Replacing the top bushing results in the cutting of the PVC pump rod</p> <p>The PVC flange on this PVC pump head cracked due to excessive forces and/or aging of the PVC as a result of exposure to ultraviolet light. Repairs included a complete new pump-stand assembly</p>	<p>The stronger 25 mm class 16 PVC pipe is protected against wear by a 1 in. (2.5 cm) polyethylene pipe that can be replaced by taking the bolts out of the handle</p> <p>After removing the wooden handle, the top bushing can be screwed into the socket</p> <p>A pump stand made of galvanized pipe and fittings is very strong and all parts can be replaced if necessary</p>

Table 2. Pump-stand assembly.

Mark series	Standpipe	Handle	Rod	Fixture	Top bushing
I	2 in. (5.1 cm) steel	Steel bar		Loosely to slab	Reducer
II	1.5 in. (3.8 cm) steel	Steel bar		Flange and bolts	Reducer
III/IV	75 mm PVC	PVC tee	20 mm PVC	Flange and bolts	PVC plate
V	2 in. (5.1 cm) steel	Hardwood	25 mm PVC	Screwed into 3 in. (7.6 cm) socket	Polypropylene

Table 3. In-well pumping mechanism.

Mark series	Pump pipe	Plunger body	Plunger valve	Foot valve
I	2 in. (5.1 cm) steel	Steel disc	Rubber flap	Brass
II	63 mm PVC	Perspex disc	Rubber flap	Reducer with ball
III	63 mm PVC	Perspex disc	Rubber flap	Reducer with ball
IV	63 mm PVC	PVC disc with polyethylene rings	Polyethylene plate	PVC disc
V	63 mm PVC	PVC disc with polyethylene sleeve	Polyethylene plate	PVC disc

Table 1 lists the problems experienced and the resulting solutions that were incorporated into the Mark V pump. Field testing of the Mark V pump only started in June 1980, so it is too early for an evaluation of its field performance. However, the following problems are anticipated: (1) The 25 mm PVC rod is reinforced with a hardwood rod 1 m long. Consequently, the rod is less flexible than that of the Mark III/IV pump. As the rod becomes bent, due to extensive pumping, it will touch the inside of the steel pump stand. The resulting wear of the 1 in. (2.5 cm) polyethylene pipe might be unacceptable. (2) Installation of

the pump requires a 24 in. (61 cm) pipe wrench. Wrenches of this size are difficult for field assistants to carry on a bicycle. Fortunately, once the nut of the adaptor, which is welded to a 3 in. (7.6 cm) pipe end, is screwed into the socket, there is no need to unscrew it because the pump pipe can be lifted through the nut. (3) Replacing the polyethylene sleeve on the plunger requires the use of solvent cement. This means it can only be done by a field assistant, not by the pump attendant. Further experimentation will be carried out to overcome this problem.

# The Ndowa Pump

J. Kanyenda<sup>1</sup>

Concurrent with the development of the Mark V pump, a hand pump suitable for use with heads of up to 10 m was being developed by the Christian Service Committee of the Churches of Malawi (CSC). It is called the "ndowa" pump, which means paid pump. The cost of materials for a 6 m long ndowa pump is approximately U.S.\$60. This price is significantly lower than the least expensive imported pump, which costs U.S.\$300 in Malawi. Overhead and labour costs for the ndowa pump are lower because production techniques do not require diverse or elaborate machinery. Furthermore, the pump has been designed so that the parts most susceptible to wear are inexpensive and easily replaced.

## Pump Stand

The ndowa pump, like the Mark pump series, is based on a bicycle pump type action, which requires no lever. The pump stand is made of 2 in. (5.1 cm) galvanized pipe and fittings, and the pump pipe is a 50 mm class 10 PVC pipe. The plunger can be retracted through the standpipe after the reducing socket, which holds the bushing, is unscrewed. The outlet tee, which is situated just above the slab, is welded to a 2.5 in. (6.4 cm) pipe end. A 2.5 in. (6.4 cm) socket is cast into the slab and the pump stand is screwed into this socket. This system of anchoring the pump stand to the slab provides better

protection against the entry of contaminated surface water into the well than the conventional system of using bolts and a flange. A long outlet pipe is usually screwed into the outlet tee and this pipe is supported at the end by a pillar, thereby keeping wastewater away from the well head and reducing the chances of contamination.

## In-Well Mechanism

A 50 mm pump pipe is screwed into the galvanized tee of the pump stand by means of a reducing adaptor bushing. Because the plunger is retractable, the bushing, with male PVC thread, does not need to be unscrewed for maintenance inspection. The advantage of the 50 mm pump pipe, compared with a 36 mm pipe, is that the former is more flexible, facilitating installation and removal for maintenance in deeper wells. However, smaller plunger area allows water to be pumped from deeper wells without exceeding the maximum permissible force on the handle, which is approximately 15 kg.

Another feature of the ndowa pump is the large 32 mm pump rod with an internal air chamber. Water enters the pump rod through the plunger on the downstroke, compressing the air in the rod. During this stroke, part of the water is forced through the outlet due to the displacement of the air within the large rod. Expansion of the air in the pump rod takes place during the upstroke and forces additional water up into the pump pipe. These two phenomena create

<sup>1</sup>Assistant Research Officer, Christian Service Committee, Blantyre, Malawi.

a steady outflow of water and, at the same time, reduce the required lifting force on the pump rod and, therefore, the effort required from the user.

In the ndowa pump, both the plunger and foot valve are of unusual design. The main plunger body has a polypropylene adaptor, which slides around the 32 mm pump rod. Its movement controls the opening of the holes in the pump rod. The stroke is limited to 6 mm by an end cap and a socket, which are solvent cemented onto the pump rod. The adaptor used is a standard adaptor filed down to fit inside the pump pipe.

In the foot valve, a 1 in. (2.5 cm) polypropylene adaptor is screwed into a 50 mm to 1 in. (2.5 cm) PVC reducing bushing and solvent cemented into the end of the pump pipe. The moving part of the foot valve consists of a short piece of 25 mm PVC pipe. The pipe has holes in it and a cap at each end. The end cap on the lower end is perforated with small holes. The valve stroke is about 6 mm.

### **Pump Design Recommendations**

Hand pumps will always require maintenance, which can be expensive. The expense can be reduced, however, if pump

design is based on the following criteria:

(1) Parts which wear out quickly should be inexpensive and replaceable by the village pump attendant. Worn-out parts should be easily detected and should only cause less satisfactory operation, not total pump breakdown. Replacement parts should be available from stores nearby.

(2) Field assistants should be familiar with simple methods of checking the condition of plungers and foot valves. If the state of operation of these parts is not up to a minimum standard, they should be replaced by the field assistant (preventive maintenance).

(3) Major pump problems should be reported to authorities through established channels. Where feasible, the faulty pump or part should be taken to the nearest workshop for repair.

(4) Field assistants should have easy access to replacement parts, a small workshop, and technical advice.

(5) Wells that cannot supply sufficient water at all times are hard on the pump. Because users are required to use greater force on the pump, the resulting wear is considerably increased. Attempts should be made to increase the yield of such wells or to decrease demand by providing more wells in the area.

## Water Pumping by Wind Energy in Kenya

M.N. Opondo<sup>1</sup>

A survey was carried out from 15–30 May 1980 in Kenya to collect information on the present use of wind energy for pumping water. The findings from the survey indicate that wind energy has been used for over 100 years in Kenya to power well-designed and durable windmills manufactured by Southern Cross, Australia; Aeromotor and Dempster, U.S.A.; and Climax, England. Today, only a few of these windmills remain (Fig. 1), having been replaced by diesel engines. With the demand for oil and other fossil fuels continuing to increase, however, it has become necessary to look for alternative sources of energy. Thus, wind-energy technology has been revived.

Since 1973, industrialized countries have concentrated on the development of windmills with rotors of up to 100 m in diameter for generating electricity in the megawatt range, which can be fed into national electricity supply grids. In developing countries, on the other hand, windmill technology was new to many scientists, research facilities were inadequate, and manpower was limited. Because this is still the case, the feasible application of this technology is confined to the use of windmills for pumping water and generating electricity in the 1–10 kW range.

The main objective in these countries is to reduce the need to purchase foreign materials to supply energy by developing methods of producing energy that utilize local resources. Thus, windmills would be

<sup>1</sup>Panel Leader, Wind Energy Technical Panel, University of Nairobi, Nairobi, Kenya.

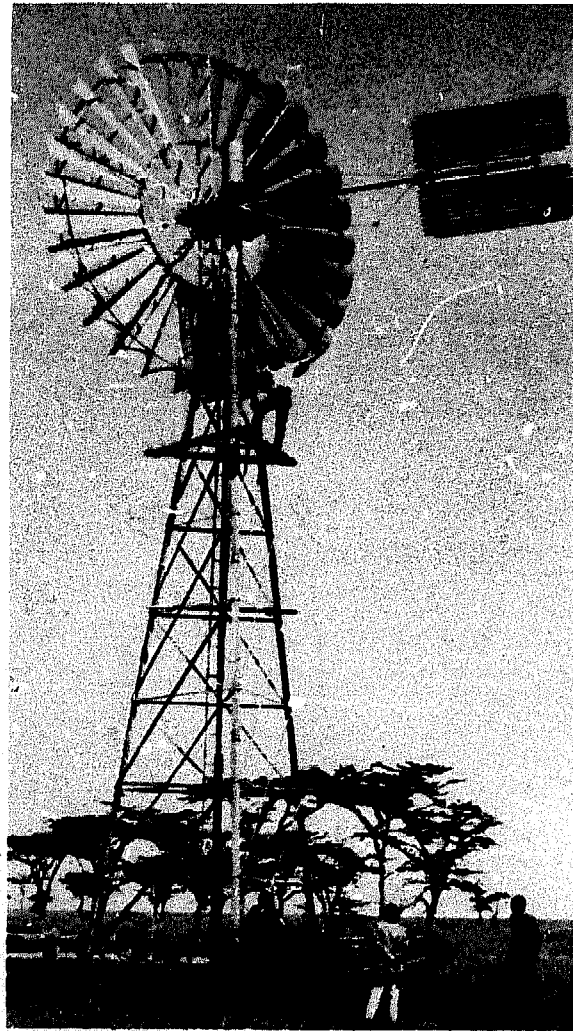


Fig. 1. Southern Cross windmill with a rotor diameter of 21 ft (6.4 m), installed more than 30 years ago.

produced from locally available materials. This led to the construction of several types of windmill rotors, e.g., in Kenya, a

windmill was produced in 1976 with bamboo arms and sheet-metal blades (Fig. 2); another, the Cretan sail windmill, had a cloth sail and bamboo arms (Fig. 3). The VITA windmill was produced by the volunteer in technology assistance program based in Maryland, U.S.A., for use in developing countries. These windmills, however, were generally less efficient than the imported models.

As a result, a second stage of windmill development followed, leading to improved machines, e.g., the Kijito windmill, manufactured by Bobs Harris Engineering Ltd. (Fig. 4); the Mbita windmill (Fig. 5), an improved version of the Cretan sail windmill; the KIE (Kenya Industrial Estate) windmill, manufactured by Plough and

Allied Products in Kisumu; and Carl Jensen's design, installed in Kisumu through the KIE (Fig. 6). There is, therefore, a wide variety of windmills, and it is difficult to accommodate them all in large-scale installations. Because all of these products are at the research and development stage, careful technical scrutiny is required before any one of them can qualify for large-scale use.



Fig. 2. A rotor with sheet-metal blades and bamboo poles made in 1976.



Fig. 3. A Cretan sail windmill with bamboo poles made in 1976-1977.

## Wind-Power Devices

The criteria for identifying a good windmill are: (1) it should have at least 30 percent conversion efficiency; (2) it should be durable, with a lifetime of at least 20 years; (3) it should be affordable by low-income communities; and (4) it should be effective in conserving foreign exchange.

A windmill can only convert a portion of the kinetic energy available in the wind blowing through the area swept by its rotor into mechanical or electrical energy. Kinetic energy ( $E$ ) is given by the formula

$$E = 0.5 \rho A V^3$$

where  $\rho$  = density of air;  $A$  = area swept by the rotor; and  $V$  = mean wind velocity.





Fig. 4. The Kijito windmill.

Theoretically, a windmill of ideal aerodynamic efficiency can convert approximately 59 percent of the kinetic energy into useable energy. It is difficult to design a windmill approaching 50 percent efficiency. The best windmills presently known can only reach 30-40 percent efficiency. The efficiency of conversion is known as the coefficient of performance ( $C_p$ ). The power available from a windmill, therefore, is given by the formula

$$P = 0.5 \rho C_p A V^3$$

### Kijito Windmills

The Kijito windmill has evolved from the Intermediate Technology Development Group (ITDG), London, prototype design. Its  $C_p$  can reach 30 percent. The Kijito windmill has a swivel-head rotor that always turns into the wind, thereby preventing damage from high-speed winds, and its blades are moulded from fiberglass, which gives them a good aerodynamic profile and

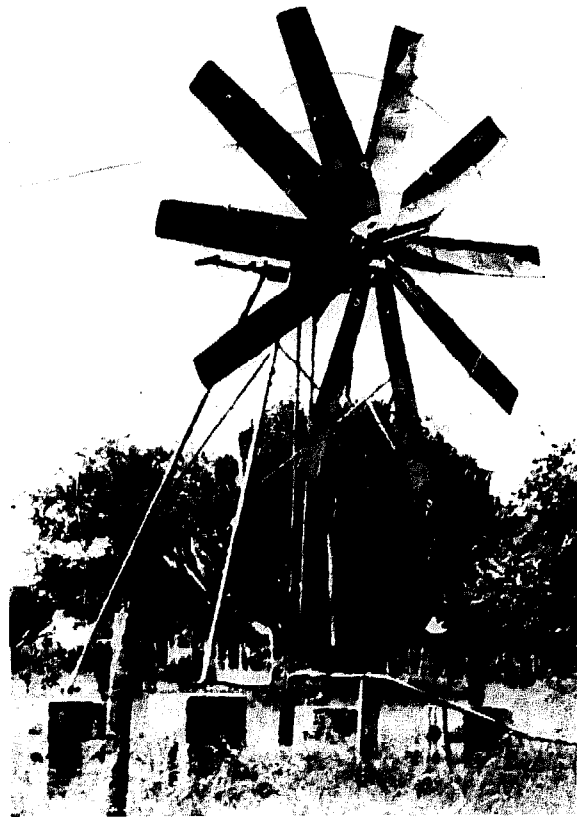


Fig. 5. Front view of a Mbita windmill with twisted blades.

makes them efficient.

The maintenance requirements of these windmills are minimal. They require only monthly lubrication inspections. The manufacturer, therefore, feels that there is no need to train servicemen to look after them, because the chances of failure are minimal. It is recommended that in case of major problems, repairs are best carried out by experts from the production unit. The largest rotor available with the Kijito windmill is 7.3 m in diameter. It has 24 blades and its rated pumping capacity is 220 m<sup>3</sup>/day from a depth of 250 m in a wind with an average speed of 5 m/s.

Despite their good performance, Kenyan wind-energy technical experts feel that Kijito windmills have not yet satisfied the standards required of windmills destined for widespread use in the rural sector of a developing country, i.e., the price of these windmills is higher than the price of some of the alternative windmill designs; a large

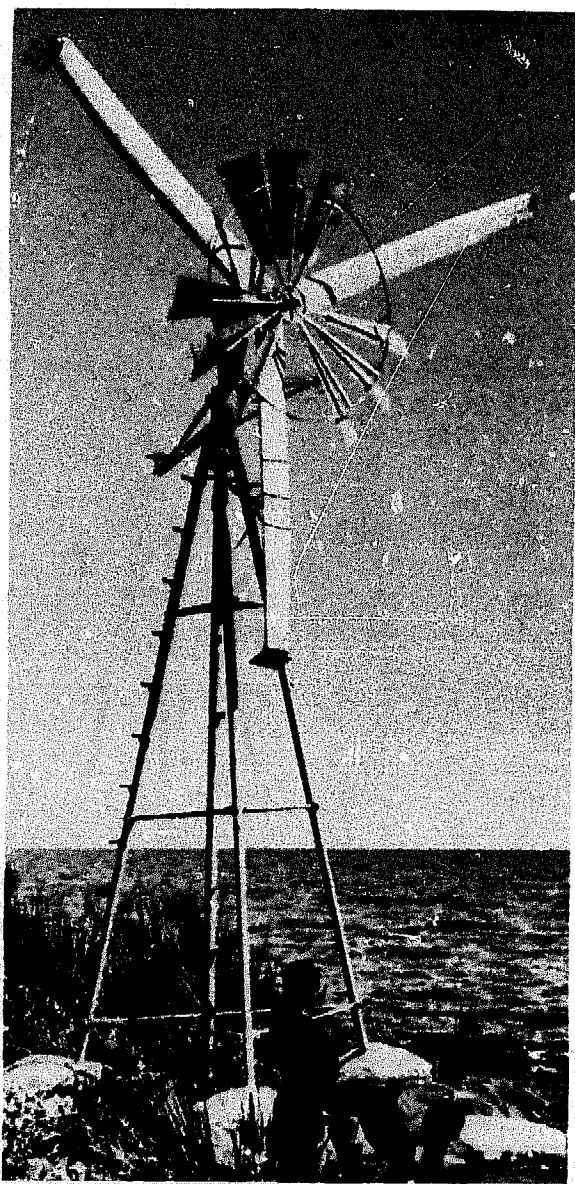


Fig. 6. *The Carl Jensen design.*

proportion of the materials used to construct the windmill is imported; and the design itself has not been successful in all cases (e.g., the fiberglass blades have been known to break off after only 4 years of use, due to the effects of weathering). Because the Kijito windmill is still a new product, there is room, through continued research and development, to modify the design to meet the standards of windmills used in developing countries.

### **Mbita Windmills**

The windmills at Mbita, on the shores of

Lake Victoria in South Nyanza, are of excellent design, produced by a Dutch engineer (Herman M. Carlsen, Mbita Catholic Mission). The blades are made of galvanized sheet metal and have good aerodynamic efficiency. Very little material is imported for making these windmills. A 6 m diameter rotor, used for deep-well pumping, would cost U.S.\$2300. In the production unit, where the windmills are made, trainees are engaged in all aspects of the fabrication and construction of the machines. Training in the use of these machines is readily available to all interested persons.

These windmills have operated successfully under the stormy conditions of the lake region for about 2 years, and further improvements are being made in their design as more ideas develop from field tests. A subsidy program is being considered to encourage and enable prospective users to install them. The Mbita windmills have, therefore, made remarkable advances towards realizing success in rural water supply.

### **The CITC Cretan Sail Windmill**

The production of the CITC Cretan sail rotor has been abandoned because of its poor aerodynamic properties. The only achievement has been the construction of a tower which costs U.S.\$370. It is envisaged that a Mbita wind rotor and a CITC windmill tower could be assembled together to achieve a very cheap water-pumping device, and collaborative work between the respective organizations is highly encouraged.

### **The KIE (Kisumu) Windmill**

Plough and Allied Products have produced a machine comparable to the Mbita windmill costing approximately U.S. \$2300. The organization is also willing to participate in training prospective users. In collaboration with academic institutions, Plough and Allied Products is attempting to develop methods to reduce the cost of producing its product. It is also anxious to have the government, particularly the

Ministry of Energy, participate in their wind-energy development work.

## Water Pumps

Water pumps have followed the same trend as windmills. For many years metal pumps were produced cheaply in commercial sectors. Today, commercial pumps are quite expensive, and scientists have produced a wide variety of alternative designs. The choice of a hand pump is often not critical, because even an inefficient pump can deliver adequate water for consumers' demands. The power requirement for a water pump is given by

$$P = \xi \delta QH$$

where  $\xi$  = the efficiency of the pump

$\delta$  = specific weight of water

$Q$  = flow discharge rate

$H$  = height to which the water is raised

The difficult task usually arises when a windmill is to be properly matched to a pump.

## Windmill Size

When deciding on the most appropriate size of windmill for a particular use, it is necessary to carefully match the windmill to the water pump and to ensure that the wind-power potential matches groundwater potential.

To match the windmill to the pump, such factors as average wind speed, rotor diameter, performance efficiency, water demand (pump capacity), and well depth must be considered. These factors can be accounted for by using mathematical equations to calculate the best pump and windmill combination to meet the needs of the consumer.

Consumer needs and windmill size, however, must also match the groundwater potential of the area. The collection and analysis of meteorological data on wind regimes are used to calculate the amount of power that can be harnessed and, therefore, the size of windmill and pump needed to

meet the water demand. If this demand is found to be higher than the groundwater potential calculated from geological data, then supplementary sources, such as rainwater storage, must also be considered.

## Operating Characteristics and Design Details

The requirements and design parameters of a good windmill have been highlighted in the foregoing discussion. Scientists, however, are not yet satisfied with the performance of even the best windmills currently available. Many attempts are in progress aimed at increasing performance but the problem that arises is that as performance is increased so is the level of sophistication. An example is shown in Fig. 6, where the windmill has a starter rotor containing shorter blades and a larger drive rotor consisting of three blades with flaps on the tips to prevent the blades from rotating too quickly. In developing countries, although the achievement of high efficiency is also of paramount importance, greater priority is given to the designing of machines which are durable and not dependent on imported materials for their construction.

## Construction, Production, and Installation

Because research and development work is time consuming, it will be necessary to continue using the windmills that are currently available until improved designs can be developed. Collaborative work among organizations involved in manufacturing wind-powered devices is, therefore, desirable and should continue. In Kenya, prototypes of new designs can be constructed at the KIE (Kisumu) and CITC, Nairobi. Manpower training takes place at Mbita, KIE, and CITC. Trainees are instructed in the construction of windmills and how to repair them in the field.

## **Financing**

The production and installation of commercial windmills is self-financing because there are organizations that finance enterprising industries. The financing of users, on the other hand, is a major limitation to large-scale windmill use, because very few people can afford windmills individually. On a communal basis, convincing all of the people in a community to purchase a windmill jointly is not easily accomplished. Although the use of windmills in rural areas should be promoted, the problem of a shortage of financing must first be solved. Training of farm technicians to install and maintain these machines will also require substantial funding, carefully planned to produce fruitful results. It should be noted that research and development are an essential part of these programs and that funding of well-planned research programs should be encouraged.

## **Conclusions**

The use of wind energy for pumping water

has reached the stage where it can be exploited on a large scale in Kenya, and the four manufacturing organizations mentioned earlier, which have brought this technology to a useable stage, are appreciated. Methods of assisting the manufacturers in the installation of windmills on a large scale should be outlined and put into practice. Because all of the present manufacturers need to modify their products to suit local requirements, they should receive research and development support. Prospective manufacturers should also be given technical and advisory support to enable them to enter the industry. In order to make the water supply program successful, manpower training in the construction and maintenance of windmills will be necessary.

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The survey team is grateful to the Ministry of Energy for sponsoring the survey trips and making the early stages of wind-energy research in Kenya a success. It is hoped that this support will continue, thereby enabling the team to achieve its ultimate goal. Gratitude is also extended to Miss Elizabeth Efiketi for preparing the text for reproduction and presentation.

# **An Assessment of Water-Pumping Technologies Using Locally Available Energy Resources, Botswana**

**R. Carothers<sup>1</sup>**

## **Problems with Respect to Water Supply**

Botswana is a dry, semi-arid country with little or no surface water throughout most of the year. Rainfall is erratic and although a number of rainwater catchment dams have been constructed, about 75 percent of the people and livestock depend on groundwater as a source of water supply. In some areas water is close enough to the surface to allow for the construction of shallow wells, but in most cases the drilling of boreholes is required. In the eastern part of the country it is possible to find water at depths of 25 m or less, but the national average is 100 m and increasing as new boreholes are drilled. Because of the depths of the boreholes and the demands placed on them, power sources superior to hand pumps often become necessary for withdrawing water from wells.

The original pumping systems installed throughout Botswana used reciprocating pumps driven by diesel engines. In the days before high fuel costs these could supply water reasonably cheaply, but they suffered from maintenance problems. The saline nature and high grit content of the water in many boreholes caused excessive wearing of pump seals. Because of a shortage of trained

maintenance crews, repairs could take up to several months. Also, the diesel power plants have been the source of a variety of faults in the past. Recently, government and many private borehole operators began using mono pumps. These can supply water from deep boreholes with less pump-related maintenance problems. As a result, the government prefers to continue using mono pumps.

The rising price of petroleum-based fuels has added a new economic element to the problems facing water supply systems. During 1979 the price of diesel fuel in Botswana doubled and further increases are expected during 1980. A directive from the president's office has recently involved government ministries in the search for suitable wind pumps that could be used both for government and private borehole operations.

During a survey carried out in 53 neighbouring villages, the Rural Industries Innovation Centre (RIIC), which is located at Kanye in the southern part of Botswana, found that problems related to water supply were by far the main concern of village dwellers. The search for suitable water-pumping technologies led the RIIC to investigate the possibility of using local energy resources including biogas, solar radiation, and wind energy. Because of previous pump-related maintenance problems, it was proposed that new systems be designed to operate using the mono pump.

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Windmills for pumping water were a possibility, but it was not known how suitable these would be under Botswana's windy climatic conditions. A limitation of commercial windmills was that they would be unable to operate the mono pumps. Perhaps other options would offer greater benefits. Cow dung, in plentiful supply in the cattle fields, could be fermented in biogas plants to produce a substitute for diesel fuel. Advances were being made in technologies for harnessing solar radiation and it could be that these would work well under Botswana's clear, sunny skies. To compare these different methods, the RIIC decided to undertake a program of testing wind, biogas, and solar pumping techniques. The intention was to study each alternative to determine what difficulties, including maintenance problems, might arise and to determine, in economic terms, which option could provide water at the lowest cost. To carry out the economic comparisons it was necessary to refer all costs to a unit pumping capacity that was the same for each pumping technique. In this report all costs have been referred to a unit pumping capacity of 1 kW-h/day. In terms of the amount of water pumped per day, 1 kW-h/day is equivalent to pumping 36 m<sup>3</sup> from a depth of 10 m; 18 m<sup>3</sup> from 20 m depth; 7.2 m<sup>3</sup> from 50 m depth; and 3.6 m<sup>3</sup> from a depth of 100 m.

### **An Assessment of Alternative Pumping Techniques**

As a means for comparison, an attempt was made to determine the present-day value of all costs for a standard diesel engine on a per unit pumping capacity basis. It is worth noting that the analyses for the diesel engine and other options are specific to costs occurring in Botswana at the present time.

#### **The Diesel Engine**

A study carried out on behalf of the Government of Botswana (Department of Water Affairs 1975) produced a cost breakdown for the installation and

operation of a diesel engine over a 20 year period. An updated summary of this study is given in Table 1. These results are, if anything, overly optimistic in favour of the diesel engine, particularly in the assumption of a 20 year operating life.

#### **Biogas/Diesel Pumping**

Although the maintenance problems associated with diesel engines would still remain, it is possible to develop an alternative energy source, using locally available resources, to fuel existing diesel engines. At the RIIC, biogas digesters have been constructed in which a mixture of 60 percent methane and 40 percent carbon dioxide (biogas) is produced through the anaerobic fermentation of cow dung and water. This biogas can be fed into a diesel engine after only minor modifications to the engine and will replace 85 percent of the diesel fuel. There are, however, technical problems associated with supplying sufficient biogas for the engine throughout the year. The rate of gas production decreases during the colder winter months. To supply sufficient biogas to replace 85 percent of the diesel fuel during this period, the biogas digesters must be made considerably larger than those supplying gas during the warmer months of the year. This requires higher investment costs. It is this "worst case" that has been used in the economic analysis shown in Table 2. The economic outlook improves, however, if the biogas plant provides 85 percent of the fuel for 8 months and 42.5 percent of the fuel for 4 months. Although fuel costs increase, they are offset by reduced investment and as a result the costs per kilowatt hour per day pumping capacity decrease.

There are other economic factors that favour the use of a biogas/diesel pumping system. The 85 percent saving in fuel equates to a similar saving in foreign expenditures, whereas the cost of establishing the biogas digesters involves mainly labour and, therefore, contributes positively to the national economy. Another advantage of the biogas/diesel pumping option is that it can be designed to supply

Table 1. Operating costs for a diesel engine (based on 1980 rates).

<b>Technical data</b>	
Engine	ST 1 (4.5 kW (6 hp))
Borehole depth	115 m
Demand	600 head of cattle
Annual hours of operation	3036
Years of operation	20
Fuel consumption (litres/year)	3656
<b>Cost data</b>	
Engine	P1460 (P1.00 = U.S.\$1.27)
Fuel	P0.42/litre (middle rate for stationary engine, January 1980)
Energy delivered per day	21.6 kW-h (assuming 8 h of operating time per day and pump/transmission efficiency of 60%)
<b>Operating costs</b>	
Engine	P1460
Fuel	P13418
Repair and maintenance scheme (Department of Water Affairs 1975)	P6582
Spare parts	P616
Overhaul	P877
Total	P22953
<b>Cost per kW-h/day pumping capacity</b>	
Based on 1980 diesel prices	P1063
Allowing for 5% per year inflation in the price of diesel fuel	P1522

fuel for larger diesel engines which are required when pumping water from very deep boreholes.

### Solar Pumping

In considering the use of solar radiation as an energy source for pumping water, it is necessary to determine the amount of solar energy available and to evaluate the technologies that could be used to capture this energy.

Botswana is fortunate in having abundant solar radiation, being situated within one of the world's few areas that receives more than 3200 h of sunshine annually. In addition, the intensity of the radiation is high, ranging from 0.7 kW/m<sup>2</sup> in winter to 1.2 kW/m<sup>2</sup> in summer (the mean level of solar radiation throughout the year is approximately 5.4 kW-h/m<sup>2</sup>/day). It is interesting to note that at this rate the solar energy falling on 4 m<sup>2</sup> would be equivalent to that delivered (during 8 h of operation) by the 4.5 kW (6 hp) diesel engine discussed earlier.

Unfortunately, the technologies for capturing this energy are expensive and are generally felt to be uneconomic at present for pumping water. Nevertheless, research aimed at developing solar pumping equipment is continuing. A photovoltaic panel that converts solar radiation into electrical energy which is then used to power an electric motor and pump is one type of pump being considered. Another possibility involves the vaporization of a heavy organic liquid which causes the transfer of a liquid mass in a rocking-beam arrangement. Both of these pumps, however, require further development to reduce their cost of operation.

### Wind Pumps

As in the case of solar pumping, consideration of wind pumps as a means of providing water requires a knowledge of both the energy available and the performance characteristics of the wind pumps being considered. In practice, there

Table 2. Operating costs of a biogas/diesel pumping station (based on 1980 rates).

<b>Technical data (for engine, borehole, and other data see Table 1)</b>	
<b>Biogas plant (summarized from McGarry 1980)</b>	
Gas yield/kg dung	0.050 m <sup>3</sup> /kg
Gas production rate (winter, 17°C)	10% of digester volume per day
Gas production rate (summer, 27°C)	30% of digester volume per day
Consumption rate of biogas by engine	0.9 m <sup>3</sup> /kW-h
Diesel equivalence of biogas	1 m <sup>3</sup> of biogas = 0.25 litres of diesel fuel
<b>Operating costs</b>	
<b>Case 1. Biogas plant providing 85% of fuel throughout the year</b>	
Engine	P1460
Fuel	P2013
Repair and maintenance (Department of Water Affairs 1975)	P6582
Spare parts	P616
Overhaul	P877
Total	P11548
Cost per kW-h/day pumping capacity	P535
Cost for biogas plant per kW-h/day of delivered energy	P650
Total operating costs per kW-h/day pumping capacity	P1185
<b>Case 2. Biogas plant providing 85% of fuel for 8 months and 42.5% of fuel for 4 months. (The engine and maintenance data are the same as case 1, except fuel prices increased to P3891.)</b>	
Total	P13426
Cost per kW-h/day pumping capacity	P622
Cost for biogas plant per kW-h/day of delivered energy	P430
Total operating costs per kW-h/day pumping capacity	P1052
<b>Cost per kW-h/day pumping capacity</b>	
<b>Assuming 85% of fuel replaced by biogas throughout the year</b>	
Based on 1980 diesel prices	P1174
Allowing for 5% inflation in real terms for diesel fuel	P1242
<b>Assuming 85% of fuel replaced by biogas through 8 months and 42.5% replaced through 4 months</b>	
Based on 1980 diesel prices	P1040
Allowing for 5% inflation in real terms for diesel fuel	P1171

are complexities in evaluating both of these parameters.

#### Wind Monitoring

The energy available from the wind depends on the cube of the wind speed, i.e.,

doubling the wind speed means that the available energy increases by a factor of eight (2<sup>3</sup>). As a result, equipment capable of measuring only average wind speed over a given time interval, when used to predict



available wind energy, can introduce large errors. In response to this, equipment has been developed to measure and record instantaneous wind speed, thus providing a frequency distribution of the wind speed and allowing a more accurate prediction of the energy available to be made.

### **The Filippini Rotor and Mono Pump System**

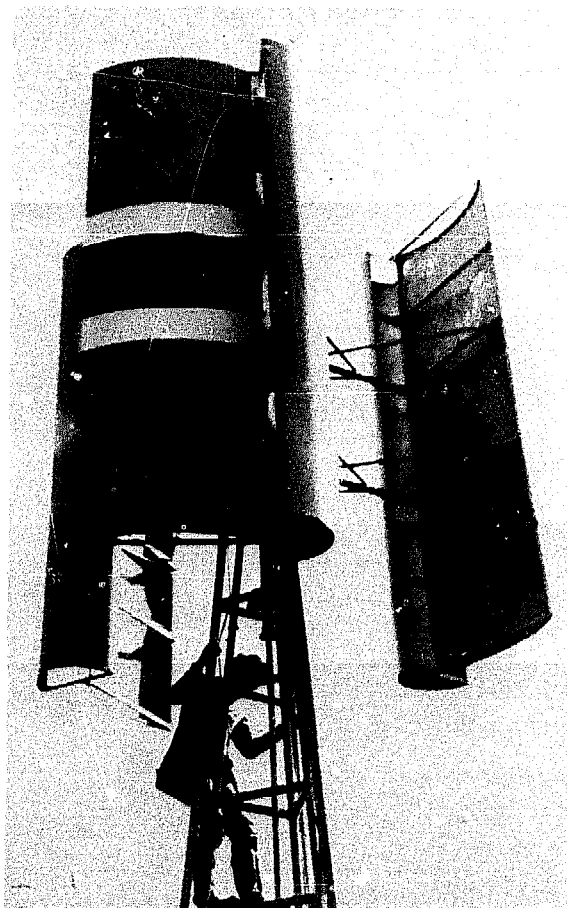
The mono pump presents some serious technical difficulties when operated by wind. Its high starting torque and high operating speed (revolutions per minute) require that the transmission of the wind pump be specially designed to overcome these problems.

A three-stage transmission was used to achieve the high pump speed required and a clutch mechanism was designed to overcome the starting problems. This system also allowed for easy hand operation of the pump if there were prolonged periods with no wind or if the wind rotor required repairs.

The choice of the Filippini rotor (Fig. 1) as a means of driving the mono pump also solved one additional problem. The mono pump requires a rotary drive, whereas most conventional (horizontal-axis) wind rotors operate reciprocating pumps. The vertical-axis feature of the Filippini rotor allowed for the coupling of the rotor and pump with a straightforward V-belt drive system.

It can be shown that the efficiency of a wind-pump system decreases for wind speeds above the minimum level required for the wind pump to operate. By selecting a pumping rate per rotor revolution that corresponds with wind speeds that provide maximum energy, maximum efficiency of the system will be achieved. This is illustrated in Table 3.

The optimization of the Filippini wind pump has been made easier because the clutch mechanism allows the unit to start at the minimum operating wind speed. Wind pumps that do not have a clutch will usually require a wind speed higher than the minimum operating wind speed before they will actually start. If these speeds are significantly different, then allowances for



*Fig. 1. Filippini rotor at the Ramonedi site.*

this need to be made in predicting the amount of water that will be delivered in a particular wind regime.

Although the Filippini rotor has been successfully matched with a mono pump, it must still be classified as an experimental wind pump. Further work to develop a high-wind protection system for the rotor and to refine the clutch mechanism will be necessary before production can begin.

### **The Experimental Horizontal-Axis Rotor**

The horizontal-axis wind pump that was originally designed by the Intermediate Technology Development Group (ITDG) of the United Kingdom is currently being field tested in several countries. Figure 2 shows one version of the unit that is already in commercial production in Kenya. The ITDG design used in Kenya is well made but expensive when compared with other locally manufactured wind pumps and imported

Table 3. Operating costs of Filippini rotor/mono pump system.

<b>Technical data</b>	
Filippini/mono pump system optimum efficiency	11%
Energy delivered per day (winter, starting/min. running wind speed = 15 km/h)	1.6 kW-h/day
Energy delivered per day (winter, starting/min. running wind speed = 20 km/h)	2.5 kW-h/day
Available energy per m <sup>2</sup> of sweep area	3.59 kW-h/m <sup>2</sup> /day
Sweep area	11.7 m <sup>2</sup>
<b>Cost data</b>	
Rotor and tower (cost estimate based on prototype)	P1500
<b>Operating costs</b>	
Wind rotor and tower	P1500
Spare parts	P252
Total	P1752
<b>Cost per kW-h/day pumping capacity</b>	
With starting/min. running wind speed = 15 km/h	P1095
With starting/min. running wind speed = 20 km/h	P701



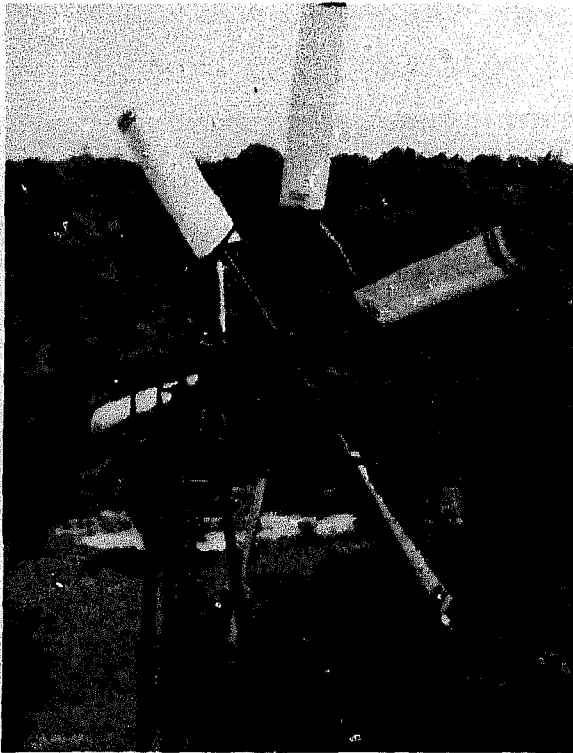
Fig. 2. Intermediate Technology Development Group rotor as produced in Kenya.

commercial models. Part of the high costs is attributable to moulded fiberglass blades, which are specific to the Kenyan rotor.

The ITDG design, as built in Botswana, incorporates all-metal blades, as in the original concept. However, because the transmission was intended to drive reciprocating pumps, major modifications are required to run the rotary-drive mono pump. Efforts are under way to obtain a suitable right-angle drive gearbox that will be able to handle the torque loads.

As with the Filippini rotor, a clutch will be necessary in the transmission to overcome starting problems. The inclusion of a clutch will have additional advantages in reducing construction costs. With a clutch, the rotor will be able to start without a load and as a result will require only six blades. The 24 blades of the normal rotor are needed only in starting. A rotor with fewer blades will run faster, thereby requiring less step-up in the transmission to meet the high pump speed (revolutions per minute) requirement,

and will normally operate with a greater overall efficiency. The rotor in its present stage is shown in Fig. 3.



*Fig. 3. Intermediate Technology Development Group rotor as produced in Botswana.*

Because the ITDG rotor in Botswana has not yet been connected to a pump, data on the performance and costs per kilowatt hour per day pumping capacity are not available.

#### **Commercial Windmills**

The manufacturers of commercial windmills do not specify the performance of their windmills over a range of operating wind speeds. It is not possible, therefore, to accurately predict the energy delivered under actual wind conditions. It is, however, possible to predict the output under idealized conditions, where all of the available energy occurs at the minimum operating (maximum efficiency) wind speed for the windmill. On this basis, the costs per kilowatt hour per day pumping capacity have been estimated for a Climax and Southern Cross wind pump (Table 4). Thus, under idealized wind conditions it is poss-

ible to compare one windmill against another, but it is not realistic to compare the windmills against other pumping options. Better data will become available as the Government of Botswana monitoring program continues to develop.

#### **Summary**

In comparing power sources (in economic terms) that make use of locally available energy resources, with the existing diesel engine, it appears that both the biogas and wind-pumping options are practical alternatives. The use of biogas as a supplementary fuel becomes particularly attractive due to the probability of further increases in the price of diesel fuel. The use of wind as a power source for pumping water seems to be the best economic choice even now, provided that the wind pumps are properly matched with local wind regimes. Solar pumps would be impractical at the present time, but would become the least expensive option in the future if the price of photovoltaic equipment continues to drop as predicted.

There are other economic factors to consider. The biogas and wind systems will involve local costs (if the wind pumps are produced locally), which will contribute to the domestic economy. The use of biogas or wind for pumping, on the other hand, requires a higher initial investment than that required to use the diesel engine. Where capital funds are in short supply, therefore, the diesel engine as a power source could be the most economic short-term choice.

When comparing the alternatives, the diesel engine and the biogas option are the most similar. Both can be operated at any time by the user and neither require large storage facilities nor backup systems. They can also meet large pumping demands when these occur. Both of these systems, however, have the maintenance problems associated with the use of the diesel engine. The biogas system, although providing considerable fuel savings, also introduces the need to operate the biogas digester and requires the collection of dung.

Table 4. Operating costs of commercial windmills under idealized wind conditions.

<b>Southern Cross - Seneschal, 7.5 m diameter</b>	
<b>Technical data</b>	
Southern Cross windmill	
overall efficiency	15 31% ?
(inaccuracies arise because testing procedures are not specified in manufacturers published data)	
Energy delivery per day	24.6 - 49.1 kW-h/day
Available energy per m <sup>2</sup> of sweep area	3.59 kW-h/m <sup>2</sup> /day
Sweep area	45.6 m <sup>2</sup>
<b>Cost data</b>	
Windmill rotor and tower	P5700
<b>Operating costs</b>	
Windmill rotor and tower	P5700
Repair/maintenance scheme	P2870
(Department of Water Affairs 1975)	
Total	P8570
Cost per kW-h/day pumping capacity under idealized wind conditions	P175 - P348
<b>Climax No. 12, 3.7 m diameter</b>	
<b>Technical data</b>	
Climax windmill overall efficiency	8 - 17% ?
(inaccuracies arise because testing procedures are not specified in manufacturers published data)	
Energy delivery per day	3.2 - 6.4 kW-h/day
Available energy per m <sup>2</sup> of sweep area	3.59 kW-h/m <sup>2</sup> /day
Sweep area	10.5 m <sup>2</sup>
<b>Cost data</b>	
Windmill rotor and tower	P1640
<b>Operating costs</b>	
Windmill rotor and tower	P1640
Repair/maintenance scheme (estimated)	P700
Total	P2340
Cost per kW-h/day pumping capacity under idealized wind conditions	P366 - P731
<b>Cost per kW-h/day pumping capacity under idealized wind conditions</b>	
Southern Cross - Seneschal	P175 - P348
Climax No. 12	P366 - P731
Filippini rotor	P380

Note: The values in this table should be taken as approximate.

Wind pumps can deliver in the range of 1-20 kW-h/day of useful energy, which would be equivalent to pumping 3.6-72 m<sup>3</sup> of water from a depth of 100 m each day. This would make them useful to supply small to medium water demands. In general, they require less frequent and less sophisticated maintenance. Wind pumps, however, require larger storage facilities or backup systems (manual operation in the case of the Filippini wind pump) to allow for extended calm periods. Locally produced wind pumps can be matched more effectively to domestic wind regimes and preferred pumps. Also, the decision to produce wind pumps locally boosts the level of expertise within the country that can be applied to future maintenance needs and in training others in the selection and use of wind-pumping systems.

### **Implications for Training**

As imported energy costs continue to rise, it seems inevitable that Botswana will turn more toward locally available energy resources for the pumping of water. It will be necessary to maintain an up-to-date assessment of the available energy resources and the technologies that may be used to apply these to pumping water. There will also be a need for field personnel to carry out basic energy assessments for individuals or

groups, and to recommend the most appropriate pumping systems. Additional skilled and semi-skilled manpower will be required to design, manufacture, and maintain biogas or wind-powered pumping systems.

In Botswana, progress toward meeting some training needs has been made, as new windmills are being manufactured at Kanye and Gabane, with work also starting in Serowe. Biogas pumping systems have also been developed and tested at the RIIC site in Kanye. The Government of Botswana evaluation program of commercial windmills will be a means whereby the skills necessary to assess the wind energy resources available could be developed. This program, along with the tests of experimental wind pumps and biogas systems, could be used to develop future training materials and programs. These could then be used to equip extension staff with the knowledge and support materials necessary to play an essential role in advising local groups or individuals as to the most suitable pumping system for their needs.

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# Simple Water Treatment Methods

J. Gecaga<sup>1</sup>

Water quality must satisfy two requirements: it must be safe to consume and it should be attractive to use. A study among the Masai of Kenya showed that they preferred using a rain pond rather than piped water, which is exceptionally good, coming underground from Kilimanjaro's rain forest. Making water potable may be realized by judicious selection of the source or by purification after recovery. For good health, the quantity available must be adequate.

The agency responsible for controlling water quality should oppose vigorously the use of treatment processes which the community concerned cannot afford to procure, operate, and maintain with its meagre financial resources. Modern equipment designed to minimize maintenance problems is expensive and requires skill in its operation. On the other hand, equipment which is less costly needs constant maintenance and repair. Sufficient attention must be given to the cost effectiveness of the designs and materials selected. Too often, cheap materials used to minimize initial costs lead to early failure in service and a loss of supply for protracted periods while replacements are obtained and installed. These failures are not confined to the more complex systems with motorized pumps. Throughout the developing world thousands of hand pumps are unserviceable and research is being carried out to discover the reasons and improve designs. Field

investigations in Kenya showed that out of more than 20 slow filters constructed, none of them were functioning properly. This explains, in part, why a careful study, based on engineering and economic analyses, may have to be made to compare, in doubtful situations, the relative merits of long pipelines bringing in untreated water from distant springs, artesian wells, or infiltration galleries. When such studies cannot be made, experience shows that, whenever possible, it is wise to make a larger investment in order to eliminate operational and maintenance problems.

Among the factors to be considered are the following: (1) amount of funds available; (2) cost of construction of different designs for the same projects; (3) cost of operation (gas, oil, chemicals, personnel); and (4) useful operating life for each proposed design.

When considering treatment systems, it should be realized that one treatment may be able to perform various functions. For example, slow-sand filtration contributes to clarification and removal of iron and pathogenic organisms. Conversely, the same result can be attained by different treatments, as in the case of the removal of suspended matter, which may be accomplished by sedimentation as well as by filtration.

## Plain Sedimentation

Plain sedimentation in natural or impounded reservoirs is useful for the removal of gross turbidity and for a

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reduction in bacteria, particularly pathogenic bacteria. It can be effective either alone or in combination with slow-sand filtration or chlorination.

Generally, plain sedimentation will have the following effects:

(1) Reduction in turbidity. The efficiency of sedimentation in the reduction of turbidity is dependent upon the nature of the suspended material and the settling time allowed. Before a decision is reached regarding the use of this treatment process, it is necessary to study the nature and characteristics of the suspended matter in the untreated water. The quantity of suspended matter varies a great deal in most tropical surface waters. For example, suspended solids in the Tana River can range from 10.3–2792.8 mg/litre and at the Kamburu dam from 15.9–284.2 mg/litre.

(2) Reduction in bacteria. Simply holding water in a reservoir will reduce the total number of bacteria. This is particularly true of pathogens, which do not usually find water a suitable environment for growth. The more adverse the conditions for bacterial growth, the less growth will occur, e.g., as in water with low pH.

(3) Storage. Any reservoir or tank constructed primarily for accomplishing sedimentation also provides space for storage. Ample storage helps to guarantee a continuous supply of water, which is a fundamental objective.

Basins for plain sedimentation can be constructed as simple dug basins with an overflow rate of 1–10 m/day.

### **Aeration**

Aeration is sometimes necessary to accomplish the following:

(1) To control tastes and odours. When tastes and odours are caused by dissolved gases, such as hydrogen sulfide, aeration is necessary. It can also be effective, perhaps to a lesser degree, when odours and tastes are caused by decomposing organic matter, chemical wastes, or secretions from microorganisms.

(2) To precipitate iron and manganese. Iron is more common in natural waters than

manganese. A chemical examination of the untreated water will reveal the nature of iron compounds in the water. Usually, the iron is in the form of ferrous bicarbonate or ferrous sulfate. Upon contact with free oxygen (0.14 ppm O<sub>2</sub> for each part per million of iron oxidized), ferric oxide will be formed. The reaction takes place at a pH of 7.0 or more. This compound is insoluble and will settle out.

(3) To expel carbon dioxide. Excessive amounts of CO<sub>2</sub> make water aggressive and cause it to dissolve the exposed iron in the water pipes of the system. Aeration can be useful for the removal of CO<sub>2</sub>, which escapes into the air.

Methods of aeration may be classified into three broad groups: waterfall aerators, bubble aerators, and mechanical aerators. Under rural conditions it would normally be uneconomical to provide pumping solely for the purpose of aeration. It might be possible, however, to combine the aeration process with pumping from the source to a storage area. In a gravity system, ample head may be available to provide for aeration.

Waterfall aerators may be constructed as spray aerators with upward or downward water outflow, as multiple tray aerators, or cascade aerators, the latter having the advantage that the loss of carbon dioxide can be kept to a minimum. Spray aeration requires an elaborate pipe distribution system to deliver the water to the various nozzles, making its construction rather expensive. Multiple tray aerators offer the cheapest and simplest construction, requiring little space and performing an excellent job both with regard to oxygen absorption and removal of undesirable gases. Cascade aerators require more space and are more expensive to construct, but should be used when the water recovered is in carbon dioxide–bicarbonate equilibrium, meaning that the loss of carbon dioxide would result in the precipitation of calcium carbonate.

In every case, however, preliminary studies with a small pilot experimental plant are recommended. In this way, a definite idea can be obtained regarding the efficiency of the aeration process under a given set of

circumstances before any large expenditure on construction of aeration structures is made. Figure 1 shows a typical aerator.

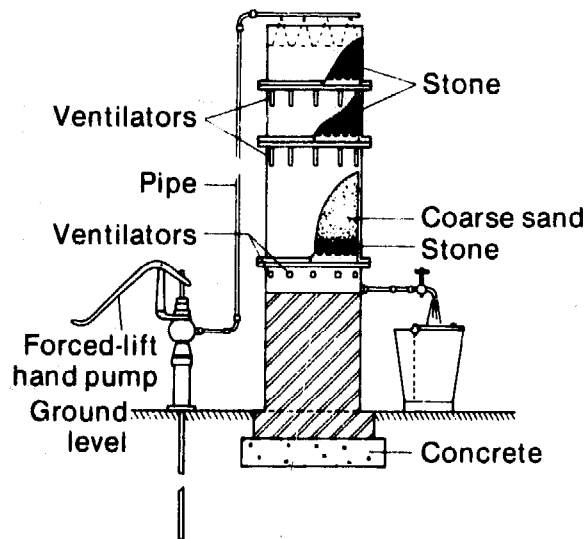


Fig. 1. National Environmental Engineering Research Institute (NEERI), Nagpur, India, iron removal unit.

### Slow-Sand Filtration

Huisman and Wood (1974) claim that "no other single process can effect such an improvement in the physical, chemical and bacteriological quality of normal surface waters." Slow-sand filters have a high degree of efficiency in the removal of turbidity, tastes, and odours. Furthermore, no chemicals are used. Some additional advantages of this method for developing countries are: (1) the cost of construction is low, particularly when manual labour is used; (2) simplicity of design and operation means that filters can be built and used with limited technical supervision; (3) importing of material and equipment can be negligible, and no chemicals are needed; (4) power is not required if a waterfall is available on site, because there are no moving parts nor requirements for compressed air or high-pressure water; (5) variations in rainwater quality and temperature can be accommodated provided turbidity does not become excessive; and overloading for short periods is not harmful; (6) water is saved (an important matter in many areas) because

large quantities of washwater are not required; and (7) sludge, which is often a major problem with water treatment by more sophisticated methods, is less troublesome.

### Application

Slow-sand filters are most practical in the treatment of water with turbidity below 50 mg/litre (expressed as  $\text{SiO}_2$ ), as this permits a longer filter run, although untreated water turbidities of 100-200 mg/litre can be tolerated for 2-3 days. The best purification by slow-sand filtration occurs when the average turbidity is 10 mg/litre or less. When higher turbidities are expected, slow-sand filtration should be preceded by some type of pretreatment, such as plain sedimentation, storage with microstraining for algae removal, rapid "roughing" filtration, and sedimentation preceded by chemical coagulation and followed by rapid filtration.

### Design of Slow-Sand Filters

Untreated water. Turbidity should be less than 50 ppm for the water applied to the filter; higher turbidities can be accommodated for short periods.

Filter loading. The rate of filtration should be 0.1-0.2 m/h. The lower the rate of filtration, the more effective will be the treatment.

Filter sand. It should be uniform, with a uniformity coefficient of about 2.00 and not greater than 5.0, and free of organic matter. The effective size should be 0.15-0.35 mm. The finer the filter sand, the more efficient will be its filtering action, but the quicker it will clog, thus increasing operating costs. For proper functioning of the purification process, a minimum filter thickness of 0.6 m should be provided. Because the top layer (10-20 mm) of the filter bed will have to be removed regularly during operation, a new filter should be provided with a filter bed 1 m thick (range 1-1.4 m) so that the bed will not have to be refilled more than once every few years.

Filter gravel. It should be graded so as to prevent the penetration of sand and yet provide for the free flow of water toward the underdrains. The following minimum depth



of graded gravel is acceptable: a 15 cm layer passing an 80 mm screen but held on a 10 mm screen; a 5 cm layer passing a 25 mm screen but held on a 10 mm screen; a 5 cm layer passing a 10 mm screen but held on a 5 mm screen.

**Underdrainage system.** This is required for three purposes: support for the filter media, collection of the filtered water, and uniform distribution of the filtration rate. The simplest form of underdrainage system consists of lateral drains spaced less than 4 m apart, and a main drain. Filter bottoms are sometimes gently sloped downward from the midpoints between the laterals. The laterals usually consist of porous or perforated unglazed tiles, glazed pipes laid with open joints, or perforated pipes of asbestos cement or polyvinyl chloride, covered with layers of gravel. The main drain may be constructed of pipes or made from concrete.

**Filter control.** Generally, filter control is accomplished by means of a system of hand-operated valves to regulate the filtration rate and the depth of water over the filter. A simple filter control system is shown in Fig. 2.

**Continuous operation.** It is important that maximum precautions be taken to ensure continuous operation and to maintain the water level above the sand. This is necessary to protect the layer of silt that builds up on the surface of the sand and the slime film that coats the sand grains near

the top of the filter. These deposits help considerably to increase the efficiency of filtration.

**Filter cleaning.** Cleaning is accomplished by very carefully scraping (5-8 cm) sand from the top of the filter. This done, the filter is put back into operation. The dirty sand is placed in a washing box for cleaning and reuse. This process can be repeated until about 40 percent of the sand is removed. At this time the cleaned sand is returned to the filter to the original level.

**Sand-washing.** In rural areas this job is normally done by hand. The sand is agitated in a box with water running through it at a low velocity in order to wash out the fine particles. As the process goes on, the washing water becomes clearer as the sand is cleaned. The sand can then be stored and is ready for replacement on the filter.

### Rapid-Sand Filtration

The term rapid-sand filtration implies a water treatment process which includes coagulation sedimentation, filtration, and disinfection. The design of the basic units of a conventional water treatment facility is well documented and, therefore, will not be discussed here.

### Chlorination and Disinfection

The disinfection of potable water is almost universally accomplished by use of gaseous chlorine compounds. Chlorine and

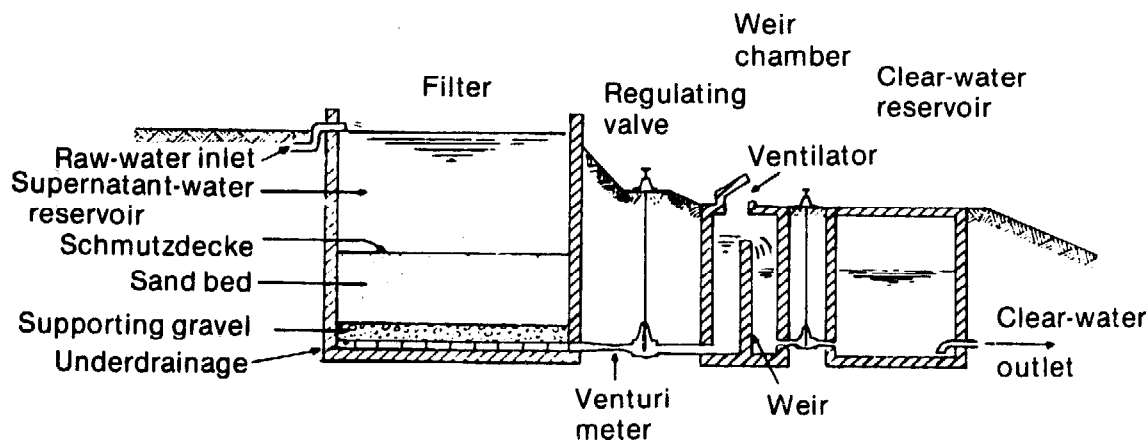


Fig. 2. Slow-sand filter (after Huisman and Wood 1974).

chlorine compounds, such as chloride of lime or calcium hypochlorite, are relatively cheap, readily available, and provide a disinfectant that has prolonged action.

The object of chlorination of potable waters is the destruction of bacteria through the germicidal effects of chlorine. There are several important secondary uses for chlorination, such as oxidation of iron, manganese, and hydrogen sulfide; destruction of some taste- and odour-producing compounds; control of algae and slime organisms in treatment plants; and as an aid to coagulation.

The requirements for effective chlorination are met when the chlorine dosage is sufficient to react with the organic matter, ammonia, iron, manganese, and other reduced substances and at the same time leave sufficient excess or residual chlorine for disinfecting purposes. Also, the concentration of residual chlorine should compensate for the deleterious influence of any prevailing high alkalinity, low water temperature, or short period of contact.

For urban water supplies, chlorine is often applied as a gas, but for rural schemes a solution made from bleaching powder is more convenient. Figure 3 is a simple but

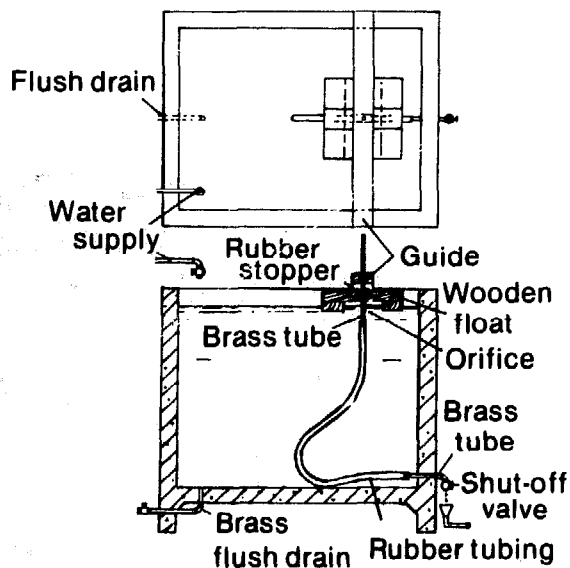


Fig. 3. Plan and cross-sectional views of equipment used for discharging a batch-mixed chlorine solution into a tank or open conduit (modified from Wagner and Lanoix 1959, p. 182). Note: Brass material may be replaced by plastic.

reliable device for discharging a batch-mixed chlorine solution into a tank or open conduit. Figure 4 is an example of simple chlorination pots which can be used for wells and storage tanks.

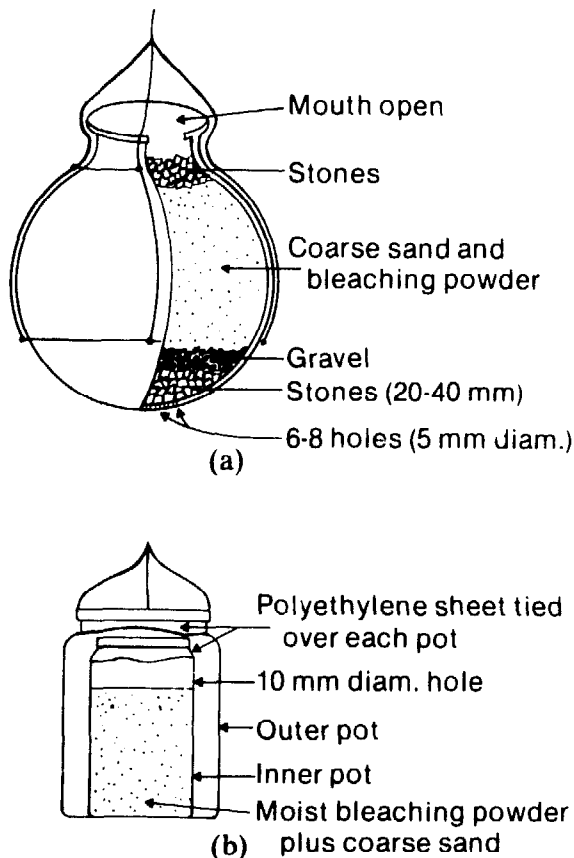


Fig. 4. Chlorination pots used for wells and storage tanks: (a) single-pot system; (b) double-pot system.

## Fluoridation

Minute concentrations of fluoride in water consumed by children during the period of tooth formation have been found to reduce dental cavities by as much as 60-65 percent. The concentration of fluoride that accomplishes this varies with the rate of water consumption (the range is 0.6-1.7 mg/litre). Fluoride compounds used for controlled artificial fluoridation are sodium silicofluoride, sodium fluoride, fluosilicic acid, and calcium fluoride. Fluosilicic acid is always used as a solution and is convenient for use by communities without treatment plants. Calcium fluoride, as naturally mined fluorspar, can be dissolved in an alum

solution and added to water with alum to effect simultaneous coagulation and fluoridation.

### **Defluoridation of Water**

When water supplies contain excessive fluorides, the teeth of people using the water become mottled with a permanent black or grey discoloration of the enamel.

At present, three defluoridation methods have proved possible. The first two methods employ insoluble granular media, such as activated alumina or bone char, which remove the fluorides as the water percolates through them. The media are periodically regenerated by chemical treatment when they become saturated. In the third method, the fluorides are removed along with magnesium through the use of settling basins and then discarded. Research is currently under way in Kenya to find cheaper and simpler methods of defluoridation.

### **Conclusions**

In an article discussing long-range planning for water service in the U.S.A., Dr Abel Wolman of Johns Hopkins University, Baltimore, has said "Adequate water service, at a reasonable price, is an attainable objective. If it has not yet been

attained, it is only because the skilled workers in this field have not seen fit to define the objective, to delineate the principles which control its implementation, to devise the structure for administration and management, and to establish the fiscal principles which might safely and wisely provide the sinews for the project." The author of this paper believes that this objective can also be met in developing countries provided that the principles outlined above are adhered to. In the field of water treatment, I believe that it is a bit naive to imagine that only simple treatment facilities like slow-sand filters will have a significant impact on all of the varied water supply programs in developing countries. Water engineers working in these countries need to keep abreast of current water supply technology to be able to make rational decisions in this very important field of national development.

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Huisman, L. and Wood, W.E. 1974. Slow sand filtration. Geneva, Switzerland, World Health Organization (WHO).

Wagner, E.G. and Lanoix, J.N. 1959. Water supply for rural areas and small communities. Geneva, Switzerland, World Health Organization.

White, G.F., Bradley, D.J., and White, A.U. 1972. Drawers of water, domestic water use in East Africa. Chicago, Illinois, University of Chicago Press.

## **Technology: Discussion**

The discussions of the papers in the technology section were characterized by debate on the different options available.

The discussion was often detailed and technical. It was clear that some of the low-cost renewable technologies were not simple but could be quite sophisticated. The discussion on wind-power pumping was a case in point. Wind-power potential, blade design, tower design, drive mechanisms, matching the windmill to the water pump, and groundwater characteristics were some of the many features considered. It was clear that in the case of wind-power pumping devices research and development was still actively going on, even while units were being installed.

There was a constant debate about the choice between high-cost, capital-intensive devices that require minimum maintenance and low-cost, locally made technologies that often require careful, extensive maintenance. The imported steel pumps used in Tanzania were compared with the locally made plastic models used in Malawi and Ethiopia. This issue also was raised when imported windmills were compared with locally made models.

The discussions were also characterized by debate on the various options that are now available in the renewable energy technologies. A great variety of hand pumps are being developed. Various simple methods of slow-sand filters, honeycombed concrete filters, and other simple treatment methods were discussed. It became clear to trainers that a variety of options had to be included in any training curriculum to allow technical personnel to be familiar with the wide range of technical choices available. It was making known this increase in the number of options available for rural water supply that was one of the goals of the workshop.

Kenya presented a brief description of the rooftop rainwater catchments that are being constructed there. The roofs are usually made of corrugated iron and the cisterns are locally-made using concrete. At present, this is one of the most successful technologies at the local level of development.

# **Role of Operation and Maintenance in Training (with Emphasis on Hand Pumps)**

**Aseged Mammo<sup>1</sup>**

The Ethiopian Water Resources Authority (EWRA), like its equivalent organization in most developing countries, has the immense task of supplying clean water to the country's rural population. To do that, however, it must overcome many shortcomings: organizational, financial, and human to name but a few.

Training at the EWRA is geared toward alleviating the shortage of skilled manpower, its most pressing need at present. To achieve that goal, the EWRA's training programs cover all relevant positions from pump attendant to postgraduate courses outside of Ethiopia.

This report will look at the training of field personnel who are involved with the maintenance of engine-driven rural water points. Comparative analyses of the operation and maintenance of hand pumps installed in various regions of the country will be discussed in detail. Thus, it is suggested that the reader be acquainted with the designs of some hand pumps currently used in Ethiopia as described by the author in a report presented earlier in these proceedings.

## **Engine-Driven Pumps**

Of the numerous water points made by the EWRA in rural Ethiopia, the most

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scattered, costly, and relatively "fragile" are the diesel-powered deep well and submersible pumps used in boreholes. Training at the EWRA concentrates on providing skilled and semi-skilled labour for borehole drilling and the maintenance and operation of pumps installed within these boreholes.

There are four levels of training for rural water supply operation and maintenance. The relatively short course for pump attendants covers diesel engine operation, daily maintenance of the engine and pump units, and writing reports on their performance. The course for plumbers and welders deals with the installation, maintenance, and repair of equipment for water supply and piping networks in rural areas. Field mechanics are trained as "maintenance mechanics," and they make up a mobile unit responsible for routine inspections and subsequent preventive maintenance on units in the field. The course covers diesel and gasoline power plants, deep well "mono" and submersible pumps, hand pumps, and cutting and welding. The fourth course, designed to train mechanics to overhaul the equipment at regional levels in the field, is yet to be started.

## **Status of Hand-Pump Maintenance**

Compared with motor-driven pumps, hand pumps are cheaper, simpler, more numerous, and serve a much smaller community per pump. They are widely

scattered and in many cases access to them is difficult, even by four-wheel drive vehicles. If they fail, the people using them just open the manhole cover and use the inefficient and unsanitary, but reliable, bucket at the end of a rope. Therefore, efforts by the EWRA to train mechanics to perform routine inspections and maintenance on all hand-pump installations becomes unrealistic.

The following is a short description of the status of some hand pumps with respect to training at the EWRA. The pumping elements of the mono pump are basically the same as those of an engine-driven pump, thus making the hand pump version very expensive but reliable. This pump is, therefore, included in the syllabi of the maintenance and overhaul mechanics' courses. The other unit is a hand piston pump. A demonstration model (Boswell pump) can be found at the training centre. This design is rather inefficient but is included in the syllabus as an introduction to all hand piston pumps and as a possible "heir" to the imported versions (although part of it is still imported) because some of the stands are being manufactured at the EWRA's premises.

### **Comparative Analysis of Pumps and Users**

#### **Maki**

In this area, 130 km south of Addis Ababa, are found the mono, Consallen, Boswell, and EWRA/International Development Research Centre (IDRC) type pumps. These hand pumps have been in use here for some years now. Installation and maintenance on the mono and Boswell pumps are carried out by the United Nations Children's Fund (UNICEF), on the EWRA/IDRC pumps by this project, and on the Consallen pump, at one time, by the Central Region. Since the United Kingdom government stopped providing direct aid, however, the Consallen pumps have been neglected. The problem is aggravated by the fact that the level of water in the wells drops during periods of drought, in some cases

completely drying up the well. This is a result of inadequate information on water depth when the well was originally developed. Abuse of pumps by the local population is relatively minor.

#### **Awara Melka**

The only pumps found in this area are of the EWRA/IDRC type, the first of which was installed in May 1979. Since that time, 10 pumps have been put into operation within 25 km of the town. The people of this area are largely nomadic herdsmen and training them is of little value. Abuse of the pumps is exceptionally high. In one instance, about 6 mm of steel were worn away from the handle of a type BPL hand pump in less than 3 months of operation!

The need for water in this semi-arid region, 200 km southeast of Addis Ababa, is immense. Engine-driven water points are not necessary because the area is scarcely populated. The only time pumps in this area are kept in proper working order is when a village chief is willing to take care of them. A fence is constructed around the water point to keep cattle away and the key to the door lock remains in the nearby chief's hut overnight. Attempts to fix the pumps by the user have so far resulted in worsening the situation.

Maintenance is carried out by research crews only, because the well digging crews do not have the tools required to deal with the pumps. It is difficult for the research crews to work in this area, however, because it is normally very hot and dusty, and access is often limited to four-wheel drive vehicles. At two sites, the temperature of the water in the dug wells was 50-70°C. Without a proper well-draining pump the digging could not continue. Furthermore, it is not possible to install any type of hand pump under these conditions.

A short-term solution may be to train the well digging crews in the installation and maintenance of these pumps, and station them permanently in the area. However, a lasting solution will come only when the nomadic Afar people are settled. Until then, wells employing buckets as water-lifting

devices are the only realistic option. Designs to keep wells more sanitary during operation should also be developed.

### **Assossa and Hosanna**

In these two areas, which are located 800 km west and 250 km southwest of Addis Ababa, respectively, wells for EWRA/IDRC pumps were prepared by the Evangelical Church Mekane Yesus (ECMY). The wells are relatively shallow, 1-6 m, in most places. In the Assossa area, the traditional lift pumps with piston and cylinder above the well, and mono pumps have been installed, in some cases more than 10 years ago. The immediate surroundings of most of the pumps in both areas are heavily populated. However, there is little pump abuse.

In Assossa and Hosanna, as well as any other area where the ECMY produces wells, it is now agreed that they (ECMY) will provide the installation and maintenance with their own development crews. Initially, installation was carried out by the research crew. The ECMY technicians have received no formal training, but some relatively novel aspects (e.g., cementing of bell-end joints) were demonstrated and/or explained to their field personnel in letters. Feedback to and from the research crew is in 2 or 3 months. In two cases, pump stands that were sent for installation in Assossa would not fit into the well covers. These pumps are now being used for well draining during the digging of new wells. The ECMY has so far solved all of its field problems without the help of the EWRA.

### **Goba (Robé)**

This new settlement area, 250 km south of

Addis Ababa, is a prospective candidate for hand-pump installation. The United Nations Children's Fund has dug about 20 wells and installation will be carried out, in part, by the research crew. All subsequent installation and maintenance will be the responsibility of the settlement's craftsmen.

At present, this arrangement seems to be the most suitable for a hand-pump program. The "villages" concerned will be virtually self-sufficient to the extent of producing spare parts from local materials. Manufacturing of the pumps by the research crew and preparation of the wells by UNICEF are well under way.

## **Conclusions**

This report has attempted to point out that all hand pumps, unlike engine-driven pumps, cannot be installed and maintained by a central government unit. These numerous pumps can only be successfully handled at the small community level.

Based on the experience of the hand pumps installed by the EWRA/IDRC research project, it was found that the more successful programs were located in those areas where maintenance was carried out from within the community itself. Continued research, until an economical and robust local pump is produced, should be encouraged.

In view of all this, Ethiopia now has a considerable advantage over many other developing countries because most of its rural population comes under well-organized peasants' associations. Taking care of pumps installed to supply cleaner water to a community should be a relatively straightforward procedure.

# Operational Maintenance in Malawi

L.W.C. Munthali<sup>1</sup> and G.A. Kamwanja<sup>2</sup>

If the government's efforts to upgrade the standard of living in rural communities by supplying them with potable sources of water are to be realized, then operational maintenance of these systems is of vital importance. The success of these efforts depends upon the operational maintenance organization. Unfortunately, this branch of rural water supply is the weakest link between the organizers/planners and the users. This is due to several factors: (1) unrealistic assumptions made by the organizers when setting up the operational maintenance network; (2) difficulty in identifying which sector of society will shoulder the operating and maintenance costs; and (3) manpower-training difficulties due to funding, organizational, and planning problems.

This paper will attempt to outline the present state of operational maintenance in Malawi and focus attention on possible solutions. The three major rural water supply systems in Malawi to be discussed are: the gravity-fed scheme; the shallow wells program; and the borehole program.

## Gravity-Fed Scheme

Responsibility for the maintenance of a piped-water project is divided between the

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main project committee and their subcommittees and the village committees, all of which are established prior to the installation of the project. The project committees are responsible for reporting failures in the pipeline and intake, whereas the village committees report on the taps. A few people within the project area are trained by the field assistant in methods used to mend and join PVC piping, to repair breaks in the line, and how to clean each of the screening, sediment, and storage tanks.

There are two problems with this maintenance system: (1) the people trained to maintain the system are not employees and as a result they may leave the area without notifying the main committee or training a replacement; and (2) the people who monitor breakdowns in the system have to travel long distances to report any problems and to collect materials at the project subcentre to repair the system.

## Shallow Wells Program

One of the major problems with this program is that the PVC pump is still being modified by the research branch of the program. As a result, no fully field-tested pump is available. The first pump was a Mark I pump, which has undergone modifications through the Mark II, III, and IV series. It is being modified further into a Mark V model. The result of such diversity in this experimental pump is that it requires a large and varied stock of spare parts.

In this program, maintenance is carried out by an action committee in the village



that owns the well. Because the pump is simple in design, it can be easily maintained using spanners and requires little expertise. The committee is also aided by a project assistant.

The main faults of the PVC pump are the wearing out of the PVC plunger, washers, and the cylinder. The PVC pump has an advantage over the borehole pump, however, because it needs no lubrication. Also, because it serves a small community it is not as overused as the borehole pump.

One of the problems of maintaining the pump is that it is assumed that the self-help spirit in the rural communities, generated during the project, can be perpetuated indefinitely. The other problem is that no funds or funding agencies are identified for operational maintenance and as a result the program tends to deteriorate as spare parts dwindle and are not restocked.

### **Borehole Program**

Of the 300 boreholes drilled annually, 250 are fitted with hand pumps to supply water to rural communities. There are several types of hand pumps being used as the government tries to find one which is durable and inexpensive. Unfortunately, this has been difficult to achieve because the most durable pump is also the most expensive. The pumps used are: Climax, Goodwin, Bush pumps, Limani mono pumps, and National pumps. The first two pumps are supplied from Britain and the last two pumps from South Africa. Only the Bush pump is locally made. The diversity of pump types has further aggravated the problem because it requires that parts for all pump types be stocked. Of all of these pumps, only the Climax pump is durable enough to withstand prolonged usage; but again, it is the most expensive pump. Conversely, the cheapest pump, the Bush pump, is also the weakest pump, requiring maintenance more often. The other pumps are relatively durable but require more attention than the Climax pump.

The most common causes of borehole-pump breakdown are: (1) The number of

people using the borehole as their only source of water is much too large; sometimes as many as 500 persons. The result of this heavy usage is premature breakdown. (2) Poor workmanship by maintenance crews due to inadequate training. This is primarily the fault of planners. (3) Use of low-cost pumps. This results in increased maintenance and frequent breakdowns, which makes the use of cheaper pumps a poor choice economically. (4) Waters aggressive to mild steel, resulting in frequent replacement of parts. (5) User mishandling because of a lack of knowledge on how to operate the pump. (6) The failure of the community to develop a feeling of ownership of the pump and to realize the importance of clean water results in neglect of the pump, followed by breakdown. (7) The borehole maintenance units are too few to maintain all of the boreholes. This results in long periods without servicing. Because they are few, the units can only respond to breakdown calls. This also results in inefficiency. (8) Incorrect gravel packing, resulting in silting and leakage in the cylinder due to the abrasive nature of the sand.

### **Maintenance Organization**

There are 20 units strategically located throughout the country to service and maintain 4000 pumps. Each maintenance unit operates a 5 ton truck that has a winch and mast mounted at the back for lifting the pump head. A borehole pump is serviced after it is reported broken down. A member of the community reports the breakdown to the district council which, in turn, reports to the maintenance unit of the Department of Lands, Valuation and Water in that particular district.

The maintenance section is headed by a senior wells maintenance officer who is both the administrative and technical head of that section. His deputy is a technical officer. These two people supervise three regional foremen who are the field officers controlling the 20 units. Each unit is divided into four subunits. The wells maintenance

assistant heading each unit organizes trips to each subunit. He leaves his base and establishes a temporary working base in the subunit with the highest number of broken-down pumps. This reduces the amount of travelling that would otherwise be required. As he works in one subunit, pump breakdowns accumulate in the other subunits. He then moves to the next subunit with the highest number of broken-down pumps. The regional foreman makes sure that the units meet all operational requirements and supervises the overall program.

### **Recommendations**

During the organizational stage, operational maintenance of the project must be considered and, if possible, included in the early phases of the project with the

intention of improving its organization with time.

Training should be considered in terms of the following questions: (1) What part of the system can successfully be maintained by the rural communities, taking into account their literacy? (2) Could the rural communities themselves organize and fund that maintenance, and/or if it must be handled by the government, what is the best approach to achieving this end to include community involvement? (3) Who is best suited to training the rural communities? Could the field staff who installed the system together with the rural community provide the training?

It is, therefore, envisaged that any training program for operational maintenance must involve mainly the field assistant and the users. Thus, the program must be geared toward these two groups.

## **Role of Operation and Maintenance in Training**

**S.K. Ichung'wa<sup>1</sup>**

It is the policy of the Kenyan government to provide piped water to every household by the year 2000. The government is trying to achieve this goal in two ways: through the construction of national water projects for domestic use and livestock development and through the construction of small water supplies through implementation of the national motto "harambee" (self-help).

The Ministry of Water Development (MWD) has decentralized services and every provincial headquarters has full maintenance facilities. The system goes down to the district level. The district headquarters also has full maintenance facilities. This is where operational work is generally carried out.

At the moment, Kenyan engineers, in collaboration with Canadian engineers, are undertaking the training of operational staff in western Kenya. Most of the training is on-the-job in nature. This is a quick method of transferring technology from one country to another. The main purpose, however, is to strengthen operational and maintenance capabilities.

### **Training of Operation and Maintenance Staff, Ministry of Water Development**

The current practice for the selection of candidates for training as inspectors

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requires that the individual should have passed the East African Certificate of Education (EACE) examination ("O" level) division III or above. The candidate should also have indicated an interest in working with the MWD. Applicants meeting the minimum requirements are invited for interview by the Public Service Commission.

Having passed the interview, they are selected to undergo a training program at the MWD training school, Nairobi. The candidate is enrolled in the preselection course that commences in July of each year. This course provides exposure to many facets of the MWD operation curriculum and syllabus, which comprises the following subjects: administration, accounting, purchasing, stores, hydraulics, hydrology, drilling, water law, water treatment, construction, sewerage, mechanical work, drawing, and pipe work.

On the basis of the student's performance in these subjects, as well as in the individual's course assignments to various sections of the MWD, a person is selected for further training.

During field training, the trainee inspector gains experience in all areas of the work of the provincial MWD organization, but is permitted or encouraged to specialize in one discipline, either construction or operation and maintenance.

### **Training Programs**

#### **Water Supply Inspectors**

After the 6 month preselection course at

the training school, those chosen for training as water supply inspector trainees undergo a 2 year training period in the field. This is on-the-job training consisting of different activities such as supervision of construction, administration, and water treatment in different districts within the province to which the person is posted. During this period, the trainee's capability is assessed and confidential forms are completed by his direct supervisor and sent to the principal of the training school.

After this period in the field, the trainees return to the training school in Nairobi for a final 3 month revision course and thereafter take their final examinations. Success in these examinations leads to a final posting as inspectors of water supply in the provinces as well as in the districts.

#### **Engineering Assistants**

Candidates wishing to train as engineering assistants are also selected after the 6 month preselection course at the MWD training school. They must have done well in the preselection examination held after the 6 month training period. While the inspector trainees are being sent out to receive on-the-job training in various districts, the selected engineering assistant trainees are sponsored for further training at the Kenya Polytechnic for eight terms of 3 months each.

Before commencing the course at the Kenya Polytechnic, the chosen candidates are first posted to various sections within the province, for 4 months, to familiarize themselves with the many facets of the MWD organization. During this period, the trainee is under the direct supervision of a qualified person who has been in the field for many years.

At the end of 4 months of on-the-job training in the field, the trainees then start their first term at the Kenya Polytechnic. The first stage consists of three consecutive terms of classroom instruction, which comprises the theoretical and practical aspects of mathematics, surveying, elementary quantities, civil engineering construction, hydrology, hydraulics, soil mechanics, and services. The students then

take an intermediate examination and thereafter they are again posted for 4 months of on-the-job field training at various locations within the provinces. Upon completion of the on-the-job training, the successful candidates return to Kenya Polytechnic for three consecutive terms, after which they take the final ordinary diploma examinations and are then posted to provinces and various sections at the ministry's headquarters as water engineering assistants. The entire course lasts for 2.5 years, six terms at the college and two terms of on-the-job training.

Candidates who have served for a number of years and done well at the ordinary diploma level can apply to attend a further 3 year course at the Kenya Polytechnic to obtain a higher diploma. This in-service course also consists of eight terms in a sequence similar to that of the ordinary diploma course.

#### **Skilled Tradesmen**

Fundamental to the needs of the MWD is a mixture of skilled tradesmen in a number of different disciplines. The skills involved may be directly related to the function of the ministry, i.e., pipe fitters, plumbers, plant mechanics, carpenters, masons, or welders.

The scheme currently being implemented by the MWD to meet its requirements for skilled personnel is the appointment of subordinate staff personnel as "apprentices."

The apprentice is assigned to and works under the supervision of a certified tradesman. The effectiveness of adequate on-the-job training is only as good as the qualified tradesman makes it, and is totally dependent on the particular jobs that the tradesman and his apprentice are called upon to deal with.

Opportunities for formal technical training are offered via apprenticeship and learning programs for persons entering the employment market with differing academic qualifications. For technical apprenticeship the student requires an EACE, form II is required for craft apprenticeship, and the Certificate of Primary Education (CPE) is required for the learning program. The

foregoing training opportunities fall under the jurisdiction of the Ministry of Labour through the Directorate of Industrial Training.

Skill-development courses are also offered both to upgrade skills and provide short-term relief for skilled-staff shortages. At the present time, the MWD makes use of these training opportunities, but only on a limited scale, even though these opportunities represent a long-term solution to the countrywide shortage of technical personnel. A thorough analysis is required to determine the future technical manpower requirements of the ministry. These requirements could require constant annual revision in the light of current development.

### **Operators**

The candidates are usually recruited directly from school and should hold an EACE division IV or above. These people are appointed as operator trainees grade II. Those persons holding the CPE and having completed the Kenya junior school examination (KJSE) can be appointed as operator trainees grade III.

The operator trainee is assigned to and works under the close supervision of a qualified water supply operator. During this on-the-job training, the operator trainee should be able to learn the overall operation and maintenance of pumps and engines used for supplying water. He should also be able to learn simple water treatment methods. In the office, the trainee is taught general office organization, meter reading, repair of broken pipe work, and connection and disconnection of water meters.

After some time, the trainee can be recommended for the 2 month water operator course at the MWD training school in Nairobi. At school, the operator learns about the operation and maintenance of pumps, engines, and motors used in water supply systems, and details about pipe fitting, administration, and the principles of water treatment. Following this course, the operator trainee may be assigned the duties of full operator or he may be appointed to assist another operator. Periodically, the operators are invited to attend refresher courses at the MWD training school.

### **Apprenticeship Training**

One option in training technical personnel which the MWD has not sufficiently utilized is the apprenticeship training program offered by the Ministry of Labour at the industrial training centres in Kisumu, Nairobi, and Mombasa.

(1) Technical apprenticeship: The candidates are usually recruited directly from school or from agencies such as "Employment Exchange" and the "Directorate of Industrial Training." The minimum educational qualification for entry is the EACE, with credits in English, mathematics, and appropriate science subjects. The training of these apprentices is usually carried out at a postsecondary institution such as Kenya Polytechnic and includes practical fieldwork.

(2) Craft apprenticeship: The minimum educational qualification for entry is form II secondary vocational/technical school or equivalent. Suitably qualified holders of the national trade test grade II may be considered for entry in a craft apprenticeship program at an advanced level. The director of industrial training is responsible for the operation of the scheme and the first 6 months of the training are considered to be a probationary period. The craft apprenticeship program is organized into five stages and is spread over a 1 year period. It consists of a combination of theory and practice plus on-the-job training, supervised by personnel from the training institution.

Upon completion of each craft course, the training institution submits to the employer progress reports on the performance of the apprentice. Upon successful completion of the apprenticeship course, the institution issues a nationally recognized certificate of apprenticeship.

### **Conclusion**

These training programs are part of a well-planned master water plan developed by the Kenyan government for the entire country. As a result of these programs Kenya has a considerable operation and maintenance staff.

# A Sociological Approach to Water Development

J.A.K. Kandawire<sup>1</sup>

This paper attempts to stimulate some thought regarding two questions: (1) What must someone involved in training people in the development of rural communities understand about the communities themselves? (2) What methods of persuasion should be used to obtain the cooperation of rural communities when introducing new techniques for the development of rural water supplies? These are not new questions and they are raised here not to give new answers but to highlight sociocultural problems.

Three important aspects of the problem of rural development are leadership, organizational framework, and cultural conservatism. How these three aspects can be connected will be shown when describing, in general terms, what is happening in Malawi in the field of rural water development. In this regard a brief outline of the general organizational framework in Malawi will be given. It will include an explanation of the way Malawi uses the approach of self-help in the development of rural water supplies; the problem of traditional health practices, with special reference to traditional culture in Malawi; and an attempt will be made to suggest a sociopedagogical approach to rural water development. This approach involves "group discussion" and "community self-survey" as aids in training for technological innovation in the development of rural water supplies.

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## Leadership and Organizational Framework in Malawi

The government of Malawi realizes that the success of the rural water supply program depends upon an ideal combination of the central and local government systems, in which rural communities can have an adequate measure of representation and participation in determining the character, extent, and direction of development (SDSECA 1971). For this reason, it formed an integrated department through which to plan and execute the program of rural water supply. The department in question brings together three different water supply programs: gravity-piped water, shallow wells, and boreholes. These were brought together under the newly created Department of Lands, Valuation and Water (DLVW) within the office of the president and cabinet (OPC) in July 1979. The spirit of "self-help" governs the formation of the department as will be shown by the way it relates to rural communities, thus forming an ideal organizational framework. Prior to the formation of the DLVW, water-related functions were scattered throughout 14 departmental or subdepartmental units distributed throughout six ministries.

The creation of the DLVW means that water is now regarded by the government of Malawi as a high priority and that lines of communication between rural communities and those responsible for the provision of technical knowledge related to water supply are simplified. These lines pass through the

district development committee (DDC), which is very important in district administration because it provides a direct link between the central government and rural communities, or through the management of agricultural development projects. Requests for assistance originate in villages and are sent to the DDC through councillors. Each DDC discusses a number of project proposals of different kinds, all of which are related to rural development, and submits to the OPC a request for funding (CSC 1974). After funding has been established, the DLVW is directed by the OPC to begin work on the project.

The DDC is made up of the district commissioner, who is also its chairman; the district chairman of the Malawi Congress Party, League of Malawi Women, and League of Malawi Youth; the district council chairman; members of parliament from the district; the district medical officer, ADMARC official; and technical officers of other departments such as Community Development, the DLVW, and the Ministry of Agriculture and Natural Resources. Traditional leaders are not members of the DDC although literate ones may be co-opted. These leaders play their role in area action groups (AAG). Party leaders operating below the district level sit on this committee together with their chiefs. The AAG is responsible for forming work committees, establishing work responsibilities, and undertaking the actual labour. However, the practice is to form a special project committee for a major project such as a piped-water project. This project committee is divided into branch committees which are further divided into village committees.

Technical staff of different ranks sit on committees appropriate to their rank. For instance, water development assistants sit on village committees, project supervisors sit on branch committees, and project managers sit on the main project committee. In this way, the central government is represented at the grass-roots level just as rural communities are represented in the DDC, which would otherwise be dominated by officials. This organizational framework

is ideal for a rural development approach that stresses the involvement of potential beneficiaries in the rural development program. Using the community development principles, rural communities can participate in the entire program cycle of planning, construction, and maintenance. The organizational framework also makes a clear distinction between the role of community organization and that of the DLVW headquarters, as well as its field staff. The DLVW provides technical support to rural committees, whereas community organization provides all the labour and organization required to successfully complete a safe water project.

This relationship enables the beneficiaries to take the first step toward the development of rural water supplies. They identify the need and then ask for assistance from the government through the appropriate channels already described, i.e., requests from villages are routed either through the DDC or through the Ministry of Agriculture and Natural Resources.

The involvement of the whole community in the development program presupposes that people in the community are aware of their problems and that they will make an effort to solve the problems through self-help methods. Yet, in reality, not all such people may be aware of, and willing to solve, their problems because of some cultural barriers. The organizational framework outlined here can be used as a channel through which rural communities can be taught to understand sociocultural problems of development. In Malawi, such sociocultural problems, insofar as they may affect the development of rural water supplies, can be discerned from the works of Marwick (1965), Mitchell (1966), and Wilson (1963).

### **Cultural Barriers in Malawi**

This section will provide an outline of the contrast between the scientific explanation for problems such as disease and the traditional explanation based upon the systems of belief held by the Chewa, Yao,

and Nyakyusa peoples. For example, with regard to drinking water, health experts say that water is the carrier of germs which cause diseases such as typhoid and cholera. It follows that the outbreak of these water-borne diseases can be prevented at the source by providing clean water to people. In contrast, the explanation for such diseases in much of traditional Africa is based on beliefs in the power of witchcraft and sorcery, ancestral spirits, and sex taboos.

To take Chewa beliefs in sorcery as an example, it is said that sorcerers in that society cause different types of misfortune among people and that these sorcerers usually attack their matrilineal relatives (Marwick 1965) with whom they have quarreled. This is also true of the Yao people, who believe that sorcery operates between people who are linked by kinship ties and this means that sorcerers kill matrilineal relatives by magic (Mitchell 1966). The point to be emphasized here is that it is only quarreling matrilineal relatives who believe that one is practicing sorcery and magic against the other, and that such conflicts usually lead to group segmentation (Mitchell 1966).

Patrilineal Nyakyusa also believe that illness among them is caused by "witches," "murmuring," and "the breath of men." They further believe that witches are certain people among them who have pythons in their bellies, and these pythons are believed to give power to witches to harm others as well as cattle (Wilson 1963). What motivates witches to harm others, it is said, is their greed and lust for human flesh and the milk from cows. To obtain these valued foodstuffs, witches are believed to go to their victims in dreams during the night. "The breath of men," on the other hand, is believed to be used by villagers to punish wrong-doers in society (Wilson 1963). For example, a son who insults his father in the presence of his father's neighbours thereby insults the entire age-group of his father who murmur in response to the insult. Similarly, a daughter-in-law who looks at her father-in-law shocks the age-group of her father-in-law who then murmur against her. These

murmurs are what Wilson calls "the breath of men," which are believed by the Nyakyusa people to bring onto wrong-doers, or their children or cattle, some prolonged illness.

Sorcery among the Chewa and Yao people can be prevented by the immediate settlement of differences between quarreling matrilineal relatives (Marwick 1965; Mitchell 1966). Nyakyusa people, on the other hand, are protected against witchcraft by their village headmen (Wilson 1963). A Nyakyusa village headman is given this power at "the coming out ceremony" when the country of an old chief and his village headmen is formally handed over to his two eldest sons and their respective headmen to administer (Wilson 1963). During this ceremonial occasion, all new village headmen are treated with medicines to give them the power to see and fight witches through the medium of dreams at night.

Beliefs in the power of ancestral spirits over living members of their lineages also exist. Among the Chewa people, the belief is that lineage spirits manifest themselves in the form of illness in a living member. This occurs when the living members do not make regular offerings to the spirit, when the rituals performed following the death of the spirit are performed incorrectly, or when the spirit's name has not been passed on to a successor (Marwick 1965). A similar belief is also held by the Yao (Mitchell 1966) and Nyakyusa (Wilson 1963) peoples.

An example of the beliefs in taboos is that which forbids a man to commit adultery when his wife is expecting a baby. It is believed that failure to observe this taboo causes harm to the wife. The Chewa people refer to this as *mdulo* (Marwick 1965) and the Yao people call it *ndaka* (Mitchell 1966). Similar taboos are imposed on close relatives or mourners who have lost a kinsman, and on relatives of boys and girls who are being initiated into adulthood.

These systems of belief and others constitute cultural barriers which may limit the extent to which rural communities participate in developmental projects, such as water supply projects, designed to benefit the rural community. People in rural



communities need to appreciate the scientific relationship between water and disease. This could be accomplished through some form of informal adult education program. It is only when the people understand why they are participating in a water project that they will appreciate the value of clean water in the prevention of disease.

### **Sociopedagogical Approach**

It has been suggested earlier that the organizational framework outlined thus far can serve as a channel through which people can be made aware of cultural problems. This point is made here based on the assumption that people's awareness of their own problems, and their attempts to solve these problems through self-help methods, will modify their attitudes toward new technical innovations. The proposal here is that this change should be brought about through the development of mature and able local leadership (SDSECA 1971). A committee structure is ideal for this purpose. This section considers how the committee structure can be used to achieve this educational goal. It advocates the use of organized group discussions aimed at developing constructive mental attitudes and healthy social relations among members of the group (UNESCO 1958). An organized group discussion has rules which enable one to focus the discussion on a specific goal. Six such rules will be mentioned here: group composition, the need for a democratic and peaceful atmosphere, material arrangements when preparing for the discussion, launching and developing the subject, choice and preparation of the subject, and the need for flexibility (UNESCO 1958).

In order for a group to be compatible it must satisfy two requirements: it must be composed of people of differing origin and social status, so as to have a variety of opinions (UNESCO 1958); and it must not be too large or too small, 7-20 people being a workable size (UNESCO 1958).

Ensuring orderly guidance of the

discussion and a democratic atmosphere within the group is the responsibility of the organizer of the group. As such, the organizer is supposed to ensure that the group discussion leads to the sharing of ideas among participants and not to the imposition of the organizer's own decisions on the group (UNESCO 1958). The need for a peaceful atmosphere is closely related to the need for a democratic atmosphere in that a properly conducted meeting is one that discourages polemics and reconciles opposing views, thereby ensuring peace and maximizing the benefits of having different opinions expressed by members of the discussion group.

The arrangements to be made when preparing for the discussion should ensure that a spirit of equality among members of the group prevails. A classroom situation that puts one person in an authoritarian position is not recommended for adults, but rather a relaxed atmosphere such as a circular or oval arrangement that ensures that all participants exchange ideas freely.

With respect to launching and developing the discussion, a democratic atmosphere reassures participants that the person who is launching the discussion is their equal. Likewise, the latter feels the same about his colleagues and in this way he is not likely to use an authoritarian tone, which usually frustrates discussions. In such a situation the group leader can easily bring a runaway discussion to order, but to be able to do this he should be quick to step into the discussion whenever he sees that it is not developing well.

The choice and presentation of subjects to be discussed by the group should reflect the personal interests of group members. Furthermore, only one subject should be discussed at a time (UNESCO 1958). Relating the subject matter to people's interests has the advantage of ensuring that all members of the group may contribute to the discussion.

All of these rules are presented here to serve only as guides. Their application to specific situations should be governed by the principle of flexibility. What is important is the achievement of the adult education goal

at which the group discussion is aimed. Another method which can be used to achieve this goal is the community self-survey.

The community self-survey has been defined as "some kind of specific research method whose own character is derived from its socio-pedagogic aim" (van de Lest 1962). As a sociopedagogical method, the community self-survey has to be conducted by the people facing the problem they wish to solve. The procedure adopted in community self-surveys must be simple enough to enable someone with an elementary form of education to follow it.

The scientific procedure which social scientists follow begins with a general problem and proceeds to the reformulation of the problem. This is followed by enquiries, data collection through interviews, and then data analysis leading to interpretation.

Experts in methods of social research advise that the first step in reformulating a research problem is to make the problem concrete and explicit (Selltiz et al. 1965). This step requires that a set of questions related to a central problem be formulated (Goode and Hatt 1952), and that "the content of questions should particularly be suited to obtaining information about what the respondents know, believe or expect, feel or want, intend to do or have done, and about their explanations or reasons for any of the preceding" (Selltiz et al. 1965). It is advised that a preliminary list of questions should be submitted to experts, both in the field of the problem and in related fields, for their comments (Goode and Hatt 1952). In assessing these data, the reliability and validity of the information collected from respondents must be considered.

After deciding on the type and form of questions to be asked, the next problem is deciding who should be interviewed. The solution to this problem depends upon whether questions are aimed at obtaining objective factual information or subjective information based on people's beliefs and feelings. The selection of people to collect the information may also pose a problem depending upon the level of their literacy

and the complexity of the interview schedule.

Once data have been collected, the next step is to process them in order to find out whether the responses can be used to answer the research questions. If the data collected actually relate to the problem being studied, interpretation should not present too great a problem in spite of the fact that the people interpreting the data have a low level of literacy and may not have been exposed to a social science study of this nature in the past.

## Conclusions

This paper has attempted to explain what a person involved in training people in the development of rural communities should understand about such communities and what methods should be used to obtain the cooperation of the people in the community. It has been suggested that in addition to understanding those cultural aspects that tend toward conservatism, people involved in the training should also understand the sources of group divisions within the society, because problems of community organization usually arise from group divisions which may or may not be based on cultural differences. It has also been suggested that by trying to understand the cultural aspects of a community, attention should be drawn to the way the social structure is defined, because it is through the structural principles that groups of people, as well as their leaders, can be identified.

Leadership in this paper has been treated together with the organizational framework based on an example from Malawi. When explaining the Malawi organizational framework no attempt was made to expose its possible weaknesses. The following are a few such weaknesses which come to mind.

(1) There is the separation between the DDC and the management of special agricultural development projects. This conceals differences in the operation of the principle of self-help. Special agricultural development projects receive heavy monetary input, whereas projects which fall under the DDC umbrella receive

comparatively little aid. As such, the latter type of project is more dependent upon local participation than on outside help. Nevertheless, in both cases agricultural extension workers who have been exposed to self-help principles, community development workers who claim to be experts in promoting self-help activities in rural areas, and health assistants are all used to influence participation from the rural communities.

(2) There is a difference in the nature of the water programs for special agricultural development areas and those for other areas. Boreholes and shallow wells are used in special agricultural areas, by individuals who hire government services at their own expense to drill a borehole, and by communities that submit a request to have a borehole drilled. On the other hand, a piped-water program involves a very large group of people and is never an individual's concern. Hence, the nature of the water program can influence the extent to which community participation in it can be achieved.

(3) The sociopedagogical approach as a method of persuading people to cooperate with water development assistants can be complemented by a community self-survey. It has been suggested here that people in the local communities should choose the subject, formulate the problem, collect data, arrange, and interpret it. In the same way as they are assisted by officers who are trained in technology, they should also be assisted in all stages of carrying out such research by a well-trained social scientist.

(4) This last problem involves extension services in rural areas. If agricultural extension workers, public health workers, community development workers, and

water development assistants do not adopt a common approach to rural development, there is bound to be confusion in the field. This confusion can be minimized if the DDC takes great interest in bringing about some collaboration among these groups. The DDC can discharge this duty reasonably well if an interministerial committee in Lilongwe, in which all of the ministries represented in the field participate, gives the DDC its strong support.

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# **The Role of Operation and Maintenance in Community Rural Water Supply Training**

**A. Mzee<sup>1</sup>**

Mankind cannot live without water. To survive, the equivalent of at least three pints of water per day must be taken into the body in the form of foods or liquids. This is only a small portion of our water needs, however, because water is needed for cooking, cleaning, and washing; water is also essential for agriculture and livestock; for practically all industrial processes; for use in hospitals; as a source of power; for cooling and for numerous other uses.

It is for this reason that nations are concerned with the exploitation and utilization of their water resources. It is for the same reasons that colossal amounts of money are being spent to implement water projects and programs in developing countries to meet the needs of the rural populace. Unfortunately, in a number of cases the expected returns from these projects are not fully realized. Most of the water projects that are commissioned become partially or fully inoperative. Where do things go wrong, or, more precisely, what is the reason for such a state of affairs? Could it be due to finances, equipment, systems, or the people themselves? Whatever other reasons are advanced, the operation and maintenance personnel seem to be the main cause of the problem. It is their inability, due to a lack of proper training, to carry out their various responsibilities effectively that is the root of

the problem. There is, therefore, a strong relationship between the performance of water projects and training in the field of operation and maintenance. In the water sector, one cannot talk of training without including operation and maintenance needs. In this paper, an attempt is made to discuss training requirements for proper operation and maintenance of community water supply projects run by public institutions.

## **Operational and Maintenance Management Requirements**

In the management of community rural water supplies, it is generally accepted that operation and maintenance functions are better managed if they are decentralized. However, in doing so the chain of technical communication in terms of information flow, instructions, data and records must be streamlined, coordinated, and maintained from top to bottom. For instance, it should be possible for the village mechanic or operator to pass on information regarding an abnormal breakdown to his local district or regional (provincial) branch and finally to the headquarters of his institution, which in turn should either seek further technical advice elsewhere or provide appropriate assistance in the shortest possible time. Because maintenance problems are highly technical and unpredictable, no one isolated functional unit can solve all the problems. For a water project to continue to give the

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expected performance, timely maintenance is essential.

The success of a rural water supply program or project is hinged on how effective the program is operated and maintained. Operation and maintenance is a permanent feature of the program and its continuity depends on the existence of systematic and comprehensive working principles built on past history and experiences. Normally, such principles are developed when maintenance service is based on specified sequences of operation that can be chosen to suit a particular condition and circumstance. In general terms, the sequences consist of the standard activities given in Fig. 1.

To develop such a program, sound knowledge of the duties and responsibilities of the operation and maintenance unit is required. However, such a system should be supported by the availability of balanced resources in terms of finances, manpower, materials, facilities, and transportation on

the one hand, and on the other, be under the proper supervision of maintenance and cost conscious technically disciplined personnel capable of working in accordance with professional ethics and with a sense of commitment to public service. To keep the morale of such personnel high there must be attractive service schemes and fair methods of providing rewards and incentives. Finally, because the efficiency of operation and maintenance is based on fast decision making and quick action, an operation and maintenance setup must at all costs avoid cumbersome formalities and unnecessary administrative bureaucracy.

### How Training Should be Carried Out

Every water project that is completed requires competent personnel for its continued operation and maintenance. A shortage of such people suggests the need for

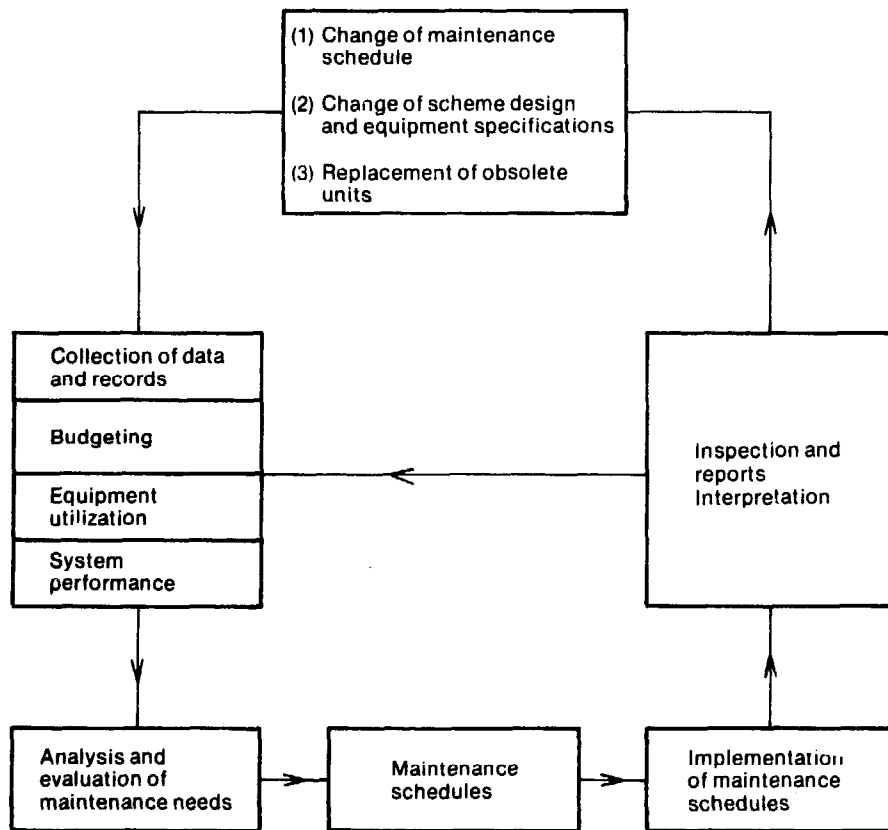


Fig. 1. Maintenance service for water supply programs.

training at all levels and in all fields of water supply maintenance. The training of additional personnel must be commensurate with the number and type of water projects under consideration. In preparing training programs for operation and maintenance personnel it is important to know and define the objective of the training, be it at the village, craftsman, technician, or engineering level. Is it for meeting additional needs, improving the quality of the personnel, upgrading already competent personnel, or introducing new techniques? It should aim at training people who can do the work and provide the required services. It should by no means be intended to create knowledgeable people who cannot be put to use as soon as it is practically possible. For this reason, training programs for operation and maintenance are more meaningful if classified in terms of formal, in-service, and informal training.

Formal training equips the candidate with the basic academic qualifications necessary for working in a given discipline. This is acquired as general education, mass education, or workers' education. It does not possess special requirements as far as operation and maintenance are concerned. The individual abilities of the trainees, however, determine the speed at which they can translate theory into practice. Experience shows that it is better to start by assuming that all trainees are of equal ability when preparing for the in-service training.

In-service training is perhaps the most important part of training insofar as operation and maintenance are concerned. It is during this stage that maintenance consciousness is instilled. After in-service training, one is able to assess the potential of the would-be operation and maintenance personnel. Apart from the trainees themselves, the prerequisites for good in-service training include availability of work, facilities, experienced personnel to work with (preferably with equivalent academic qualifications as the trainee), and a comprehensive training schedule. Insofar as operation and maintenance are concerned, it does not mean much to assign a trainee to a counterpart. The nature of in-service

training in operation and maintenance is such that one has to actually do the work in order to learn. Furthermore, there are no tailored solutions to operation and maintenance problems.

The in-service training should start with a short orientation course, during which time the trainees should be introduced to the various functions of the organization, the duties of the position, rules and regulations, current practices, communication and information systems, etc. It is useful at this time for the trainees to discuss the in-service training schedule that they will follow. This schedule will include topics such as general maintenance; design, installation, and performance of water supply systems; safety; records management; and materials and manpower management.

At the end of in-service training, the trainees should undergo practical objective testing. For instance, the training could lead to the professional registration of an engineer or an upgrading trade test in the case of a craftsman. In-service training without a time limit, goal, and benefit is likely to be frustrating, vague, and lax. As mentioned earlier, in-service training is the responsibility of the Operation and Maintenance Department. However, to ensure that a homogeneous level of training is maintained it must be checked, inspected, and coordinated by formally trained instructors. Such instructors should be capable of evaluating the operation and maintenance needs relevant to the formal training in the academic institutions. The schedule should be prepared by operation and maintenance personnel who should also be responsible for its execution on a rotational basis. The schedule covers those areas of operation and maintenance relevant to the trainees that have immediate application or are already in use. At the end of the in-service training, efforts should be made to measure its success. An important indicator is the ability of the trainee to apply the theory in a practical work situation. In reality, the productivity of operation and maintenance personnel begins with the end of in-service training. It is at this time that reliable independent work can be expected.

The novice operation and maintenance worker has much to learn before becoming competent in the work. During this time, and after, the operation and maintenance worker must constantly update his knowledge by attending informal training sessions at a water supply demonstration training centre. The demonstration centre, if properly utilized, is of particular assistance for the administration of upgrading tests and the introduction of new work methods to the craftsmen and operation and maintenance personnel. Here trainees can easily comprehend the working principles of water schemes and see how a water supply project should ideally be run. The centre should be designed to meet engineering standards and be supervised by experienced field officers.

### **Choosing the Correct Level of Technology**

As mentioned earlier, effective maintenance service is based on specific sequences of operation selected to suit particular conditions and circumstances. It is worth mentioning here that such a selection, as a rule, is governed by the level of technology available and the type of technology mix used in the development of the water supply. Because it is not always feasible to use a particular level of technology, and because the level of technology available is of fundamental importance in facilitating operation and maintenance activities, the selection of various water supply technologies to be used must take these facts into consideration. It is clear, however, that the presence or absence of other resources and the desire to meet demands completely overshadow the need to use appropriate technology to facilitate operation and maintenance. Any attempt to satisfy all of these conditions is likely to complicate matters and cause undue delays. The logical compromise is systematic training. Those who advocate intensive use of hand pumps, windmills, and the like as appropriate technology to facilitate operation and maintenance have yet to

provide workable alternatives where such technologies are not feasible. Without political bias or inner motives the people should be required to adapt to the technology used in the development of water resources and not vice versa. With technology developing, cultural and traditional bonds must be broken to accommodate the newly developed innovations. This is where training instructors face the challenge of technological development of the country as a whole.

Understandably, community rural water supplies are better managed if the beneficiaries are involved in the supervision of the project. Their participation can either be in kind or monetarily. Villagers can be expected to protect, operate, and even supervise the projects. Such involvement can have detrimental effects if not considered in the technology, design, and equipment selection. Simpler and less sophisticated projects and equipment should be used at the expense of obvious advantages, and appropriate training should be given to the beneficiaries. In practice, however, the technology used is normally of such a level that operation and maintenance requires a formally qualified and trained employee who expects to be inspected, supervised, advised, and rewarded. The training programs for beneficiaries must, therefore, be selective and distinct.

### **Conclusions**

When preparing a training program for operation and maintenance of a community water supply, consideration must be given to the prerequisites of a good operation and maintenance system. The training objectives should be clear and practical. The training should be carried out under conditions which permit monitoring and control of the end results and it should take into consideration the technologies in use and type of people being trained. Lastly, the training should be recognized, appreciated, and rewarded.

## **The Role of the Ministry of Education in the Training of Future Users of Rural Water Supply Systems**

**J. Kuthemba Mwale<sup>1</sup>**

This paper will attempt to show how the Ministry of Education educates future users of rural water supply systems, what problems the schools face in this process of education, and what measures have been taken in order to remedy these problems.

Some suggestions have been made regarding the role that rural water supply personnel could play to consolidate the knowledge that rural water supply users have gained in school. This has been envisaged in the form of extension work and adult education, which have to form a necessary instrument for educating the rural community.

It is essential that the user of rural water supply systems should be educated in the maintenance and care of the water supply because even a system that is well maintained by technical staff can be nullified by negligent, poorly educated users.

It is logical and appropriate to utilize the existing infrastructure for educating the people, i.e., the Ministry of Education through its school system. The primary school system is particularly useful for this purpose due to the large distribution of schools within the country (e.g., the average distance between primary schools is approximately 3 miles (4.8 km)).

The primary school system educates

future users in two major ways: directly in schools and indirectly through the integration of school and community. In the schools, future users of rural water supplies are taught the protection and care of water supply systems, i.e., methods of purifying water and an elementary introduction to germ theory.

Both theory and practice are taught at the primary level. For example, teachers may teach purification and care of water by actually bringing a pot of water into the school, boiling it over a wood fire, and then sieving it. Through this practical demonstration, teachers emphasize that this is what the pupil should do to prepare water for drinking at home.

The thinking behind the indirect method of educating the population, through the integration of school and community, is that those who have received formal school education and have gained a knowledge of hygiene will influence and persuade their neighbours in the community through daily encounters, visits, and discussions to learn about hygiene.

In most cases, this integration of school and community begins very early. School children participate in adult projects such as digging wells and constructing covers or shelters for these wells. There is also the latrine-construction project that schools embark on, which spreads into the community through the participation of schoolchildren in village projects.

It should not be assumed from the system

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described here that the whole process is smooth and easy. There are four major problems that the schools face when educating the future users of rural water supply systems. There are problems arising from the discrepancy between traditional society and educated groups about germ theory; some teachers lack competency in teaching health education; there is a scarcity of educated people in rural areas; and there is a lack of knowledge in handling rural people by the few educated individuals living in the rural community.

It is not easy for the rural community to understand and accept that the diseases they suffer from are caused by microorganisms such as bacteria and viruses. It requires some degree of education to enable them to understand and accept the germ theory as we understand it ourselves.

Even in the schools, not all of the teachers are competent enough to handle all of the health education topics. This results in confusion and/or misunderstanding on the part of the pupils. In rural areas there is very little to attract the educated children to live there. A large number leave the rural community in search of paid employment elsewhere. This reverts the community to urban and semiurban centres.

Even if these individuals stayed in the rural areas, their impact would not be felt much because they have no skills in handling and persuading adults toward better health. Also, by the nature of the society, children may not teach adults for it is looked upon as impudence or rudeness for a youth "pretending" to teach his elders.

The problem of a lack of competence of some teachers in handling health education subjects has been approached practically through a cooperative system in which the schoolteachers invite health officers to the schools to lecture on health education topics.

This has helped, although in some cases it was observed that these health officers gave too much and too advanced content to the schoolchildren. This results in the teachers having to simplify the content to suit the level of the children.

Rural settlement schemes have helped to bring back into the rural community some of the educated people to help educate their neighbours. These schemes have aided in the spread of hygiene knowledge in the rural areas. Some rural individuals have learned simple methods of purifying and caring for water and the use of pit latrines. However, there is still a need to educate the rural community about the causes, prevention, and cure of diseases and the skills of dealing with elders.

This is one area where rural water supply personnel could take over the role of educating the rural community in the maintenance and care of water supplies and health education. This could be done through the existing structure of village committees, district committees, and area development committees, with the extension worker as the teacher.

The rural water supply personnel should, apart from knowing the construction, maintenance, and care of rural water supply systems, also know the structure, organization, and social dynamics of rural communities. Such knowledge should enable them to be comfortable in the rural community and competent at their work.

They should be able to understand the cultural systems of beliefs and traditions of the people they are to work with. This might enable them to influence the people and persuade them to change their attitudes toward clean water supplies, causes of diseases, and the use of pit latrines.

In conclusion, it should be emphasized that there is a great need to educate the future user of rural water supply systems if he is going to benefit from them. This education should not end after primary school but should continue in the form of adult education and extension work by government extension workers and literacy teachers. It is important that the rural water supply personnel should take over the role of educating the rural water supply user from the point where the Ministry of Education stopped, to guarantee continuity and relevance of the knowledge to their health.

## Health Education in Rural Areas

Y.M.Z. Nyasulu<sup>1</sup>

A community that has traditionally relied upon dambo wells and streams for its water supply may not readily accept a different water supply without resistance. A new water system implies changing the attitudes of the people and may mean changing their values as well. This paper will try to focus attention on the health aspects of rural water supplies and the training of health personnel in rural areas.

The introduction of clean water supplies should be accompanied by simultaneous sanitation and health education. It has been shown and clearly demonstrated that provision of clean water supplies does not automatically result in a decrease in the incidence of water-related diseases and that little impact on health status can be anticipated unless the introduction of new water systems is accompanied by programs in proper excreta disposal and health education.

### Common Diseases

Health problems and disease patterns found in Malawi are similar to those of many other developing countries. Using hospital statistics as a rough indicator, it appears that diseases such as measles, malaria, and gastroenteritis are the main causes of death, with the largest mortality falling within the under-five age-group. The crude birth rate is 50.5, with most women

bearing 7.7 children during their reproductive years. The crude death rate is 28.2, and the estimated infant mortality is 142 per 1000 live births. The 1977 census indicates an annual growth of 2.92 percent.

Diarrheal diseases are listed as the third major overall cause of death, but they are the foremost cause of death among the water-related diseases. Diarrheal diseases also play a role in the cycle of malnutrition and infection, which weakens and often kills young children in Malawi. Unlike schistosomiasis and malaria, the diarrheal diseases have several transmission routes, and the primary transmission routes of some viral diarrheal diseases have not yet been conclusively established. Most of these illnesses, however, are water- or food-borne or transmitted by contaminated hands or flies. These diarrheal diseases are classified as (1) fecal-oral, (2) waterborne, or (3) water-washed illnesses.

One such diarrheal disease, which has received considerable attention in Malawi since late 1973, is cholera. The Ministry of Health (MOH) has been successful in controlling outbreaks and minimizing deaths. The 1973 epidemic had the positive side effect of drawing attention to the need for expanded sanitation and health education efforts and to the importance of clean water supplies. In the Mulanje Mountain area, which is served by rural piped-water systems, no more than one cholera case per village was reported in 1974, as opposed to the average of 20 cases in villages without water systems.

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Among the more common water-related illnesses are typhoid, paratyphoid, skin and eye diseases (such as scabies and trachoma respectively), and onchocerciasis, a water-related insect vector disease that can cause blindness. It is important to note that experience with water-related diseases in many countries has demonstrated the importance of a multiple-intervention approach. The best results are achieved by combining the provision of clean water with safe excreta disposal and hygiene and sanitation education. The reasons for this are clear: (1) many water-related diseases have more than one route of transmission; and (2) improper excreta disposal can contaminate what might have started as a clean water supply.

### **Relationship Between Pollution and Gravity-Fed Water Supplies**

In Malawi, the gravity-flow water systems have not yet been affected by much, if any, fecal pollution because the water is piped from areas that have no human habitation or cultivation. This lack of pollution was demonstrated during the cholera epidemic referred to earlier, in which villagers using the water systems were well protected. Unfortunately, it is not safe to assume that these rural piped-water schemes will protect the population from other water-related diseases nor that the water schemes will stay unpolluted indefinitely unless proper sanitation measures are introduced. Health education efforts must be aimed not only at protecting new or existing water schemes, but also personal hygiene, avoidance of lakes or streams harbouring schistosome-infected snails, and proper waste-water disposal to avoid anopheles mosquito breeding areas.

### **Health Education**

Through the Ministry of Health (MOH) there is a national sanitation program involving several cadres of health personnel. The director of this health inspectorate

program is the health superintendent at MOH headquarters in Lilongwe. The health superintendent reports to the secretary of health on the need for public health regulations. These health programs in each of the three regions (North, Central, and South) are coordinated by regional health inspectors who supervise the district staff and liaise between the ministry and the district staff. There are 52 health inspectors assigned to the 24 districts throughout the country, with the larger districts being subdivided into areas and managed by several health assistants who are normally assigned to health subcentres. The district health inspectors supervise and work with the health assistants. They submit a report to the regional health inspector on all field activities. There is a total of 134 health assistants scattered throughout the districts, with the actual distribution determined by the location of health subcentres and adequate housing.

Health inspectors are trained for 3 years after "O" levels (equivalent of 10th grade) at the Malawi Polytechnic; a constituent college of the University of Malawi in Blantyre. The training program began in 1966, but was discontinued in 1969 due to saturation of the job market. Plans are now under way to reopen the program because vacancies have developed in the MOH. Health assistants are given 2 years of training after junior certificate (JC) level at the School of Hygiene in Zomba. Both health inspectors and health assistants are expected to focus their attention primarily on water-supply protection, disease surveillance, promotion of pit latrines, environmental cleanliness, and hygiene education. Health assistants work directly with the people in the community and help them to identify their health problems. They are responsible for urging villagers to construct pit latrines and for providing the relevant technical guidance. They work together with the surveillance assistants and report to the district health inspector. There is no government subsidy program for pit-latrines construction; rather health assistants concentrate on using affordable materials. Ministry of Health officials estimate that

approximately 40-50 percent of households in Malawi have latrines.

To assist with health education and disease surveillance at the village level, the MOH employs approximately 220 "surveillance assistants" on a daily-wage basis. The workers were originally hired to work in the cholera-control program, but now they are given 3 months of in-service training by health inspectors in order to function as general health promoters. The number assigned to each district ranges from 6-14 depending upon the areas which were most seriously affected by the cholera outbreak. The surveillance assistants reside in the village with the people where their duties include pit-latrines construction, water protection, disease control, water chlorination, and immunization programs. They report to the health assistant on a weekly basis.

The health inspectors have encouraged the formation of village health committees to help hasten the sanitation and disease-control programs. These committees consist of the village headmen and others selected by the people. The members of the committee are taken to training centres to attend a course that emphasizes the methods by which diseases are transmitted. The diseases discussed are the common communicable diseases such as cholera, bilharzia, malaria, measles, tuberculosis, diarrhea, dysentery, and others. For example, the committee members learn how bilharzia is transmitted. When a person who is infected with bilharzia urinates in stagnant water containing small water snails, the schistosome eggs will hatch and enter the snail (Kacilombo) where they will grow and reproduce. Small fish-shaped organisms (Kakolidoli) then leave the snails in search of a person or warm-blooded animal. This training allows the village health committee members to understand the life cycle of the bilharzia disease in order that it can be explained to other village inhabitants. Although such organisms have been observed in the past, their association with disease has not been understood.

Once the association between water and

disease is understood, then steps can be taken to prevent disease. For example, committee members have learned that bilharzia can be prevented by (1) never washing or bathing in infected waters; (2) never urinating in water; (3) constructing and using pit latrines; and (4) ensuring that persons with the disease receive proper medical treatment.

Thus, the training received by the village health committee enables its members to understand the methods of disease transmission and how to prevent it. When the training course is completed, in 3-4 weeks, the committee members return to their village where they can teach other members of the community what they have learned.

In addition to the group of health workers described above, who are the main cadres for water and sanitation education, the MOH maintains a small health education unit (HEU) at its headquarters. The HEU is headed by a health education specialist, who supervises visual aids and graphic arts assistants, a newsletter editor, and a Peace Corps health educator. The HEU staff produce a variety of educational posters, daily radio programs, and a newsletter called "Moyo." In addition, the health education specialist conducts in-service health education seminars for a variety of MOH personnel because the ministry believes that all health workers must participate in educating the public.

With respect to special water-related disease-control programs, the MOH has a small bilharzia (schistosomiasis) unit that is working on control programs on several irrigated estates in the three regions of the country. Limited use of molluscicides, treatment, and health education is carried out; however, the program is seriously constrained by a lack of adequate funds. The malaria-control program consists of prophylactic drugs routinely given to preschool children and antenatal patients at maternal and child health (MCH) clinics. Some spraying is carried out in urban areas as well.

## **Problems**

There is a general realization by both MOH officials and Department of Lands, Valuation and Water (DLVW) rural water supply officials of the need for greater coordination between the groups introducing new water schemes and the personnel responsible for health and sanitation education. At the local level, some coordination is achieved informally; health inspectors are invited to give health education talks at tap-dedication ceremonies. However, there is lack of coordination over time between pit-latrline construction, community sanitation surveillance, and new water schemes.

In addition to the problem of coordination, another reported problem within the MOH sanitation program has been the difficulty of providing adequate transportation for district health inspectors and health assistants. The MOH cannot afford to provide, or to absorb, the cost of vehicles for all its personnel. Health inspectors have been encouraged to purchase their own motorcycles and to use them officially on a mileage reimbursement basis. The amount reimbursed, however, is low and apparently very difficult to change, which serves as a deterrent to personal ownership.

A final constraint is one of insufficient knowledge about the sociocultural aspects of health-, water-, and sanitation-related behaviour of rural people. Because health education is really an exercise in changing or reinforcing certain kinds of behaviour, it is important to know what people do and how they can be positively influenced. Even when planners do know the characteristic and behavioural patterns of rural people, they may not understand how to motivate and influence them. Health education campaigns can become more effective and more persuasive if they incorporate the social and cultural values of the people.

## **Recommendations**

The MOH has the organizational structure and experience for handling health and sanitation programs regarding water supply. Personnel of the DLVW may utilize the existing structure through coordination, cooperation, and consultation. However, in the training of rural water supply personnel, health and sanitation should be taught at all levels with varying emphasis to prepare them for their future partnership with the MOH.

## **The Role of Women in Rural Water Development in Kenya**

**W. Getechah<sup>1</sup>**

It is the Kenyan government's policy to provide piped water to every household by the year 2000. The government is trying to achieve this goal in two major ways: (1) through its efforts to construct what are known as national water projects to provide water for domestic use and for use in other economic activities such as raising animals and spraying coffee; and (2) under the national spirit of "harambee" (pulling together), the government encourages the people to contribute as much as they can toward community water projects, so as to induce further contributions by either the government or foreign aid donors. It is this latter case that is of interest because the contribution of women is an integral part of the community effort to bring running water closer to the home.

In terms of national water development, the self-help element is very small, but it has, nevertheless, made an impact in rural areas in particular and these efforts have brought clean water to thousands of households. This paper is an attempt to assess and portray the very important role of the rural woman in Kenya in community water development.

### **Why Should Women be Involved?**

In traditional African societies, fetching water from the river was one of the many

tasks relegated to women. The trend toward modernization has not relieved rural women of this task. Indeed, at a time when more men are drawn into urban areas in search of more lucrative employment, the woman's energies are spread over an increasing variety of tasks, some of which were formerly performed by men, such as animal husbandry and even house building.

The burden of fetching enough water for the household cannot be exaggerated. According to studies carried out by the United Nations Economic Commission for Africa, the carrying of water is the most strenuous physical burden of all the tasks performed by African women. It is estimated that one-sixth of all the energy expended by women in rural areas is used for carrying water. In some cases, a single water fetching trip lasts 4 h or even a day!

Assuming that an average woman carries 4 gallons (18.2 litres) of water per trip, she would definitely not be able to fetch enough water for domestic consumption as well as other household requirements such as feeding the animals and spraying coffee. It is, therefore, not surprising that women have spearheaded much of the efforts to bring water closer to the home. Not only would plenty of clean water at home enhance the rural socioeconomic activities but also the woman's energy would be channelled to many other neglected areas.

Because women are the main beneficiaries of water projects, they have been a major instrument in creating an awareness and in

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translating this awareness into programs. They have assisted in mobilizing support for the projects, raising the initial capital, and in most cases contributed most of the labour.

### **Women's Contribution**

The role of women in rural water development can only be discussed in the context of self-help input into community water projects, and to a lesser extent into government-assisted water projects. According to the Ministry of Water Development, many water projects, even current government-assisted ones, started on a self-help basis. This means that women have had to assist in the initial phase of nearly every project.

The involvement of women in rural water projects is characteristic of the impact which women's groups have made in an effort to upgrade living conditions in rural Kenya and also to alleviate their water-carrying burden, as indicated earlier. Furthermore, this involvement in rural transformation is a result of the current sociopolitical conditions that prevail in most rural areas of Kenya. The following are a few of these conditions:

(1) As mentioned earlier, the prospect of a regular, well-paying, and "prestigious" form of employment has increasingly drawn more men into urban areas, often leaving women as the sole head of the household. Self-help efforts that called for household contributions subsequently found women involved in all sorts of social and economic activities.

(2) In the absence of water projects, the task of fetching water falls exclusively on the woman; hence, her enthusiasm to have water pumps erected and maintained in a serviceable condition.

(3) In rural areas, women seem to have a higher sense of organization than men. It is easier to enlist their labour than that of men and their loyalty to and enthusiasm for the project seem to last longer.

(4) Due to the traditional African attitude towards work and the colonial experience of forced communal labour,

many men consider it degrading for them to engage in communal work and this attitude has reduced the men's contribution towards self-help labour to the minimum. Men feel more appropriately employed when they are engaged in money-earning occupations.

The major factors involved in the successful erection and maintenance of a water supply project are capital, labour, materials, and management and maintenance skills. In view of the prevailing conditions of poverty, ignorance, and lack of technical know-how among rural women, the women tend to leave the more technical tasks, such as management and maintenance of machinery, to the men, whereas they (the women) tackle the bulk of the nontechnical work such as digging trenches and carrying building materials. After the idea of a project has been conceived and accepted by the community, the women's groups are often the driving force that keep up the momentum.

Raising the initial capital is the first step in a new project. Quite often this sum has to be paid by the woman if she is the head of the household. The 1969 Kenyan census indicated that one-third of rural households is headed by women (ECA/ATRCW 1975), and other studies have indicated an even higher proportion.

The ability to make cost estimates, keep books and records, and negotiate for outside financial assistance is rare among rural women. Although many aid organizations have insisted that project committees must include a female secretary or treasurer, these offices are almost exclusively held by men.

Maintaining the pumps and piping systems is a second area where the men's contribution is vital. Training in this area is given mainly to men. It is strongly felt, however, that training in the maintenance of water systems should also be extended to women.

### **Case Studies**

The following two case studies will illustrate the role of women in community water projects. The focus is on the self-help input of the project.

### **Karweti Water Project**

The Karweti water project is located near Githunguri in Kiambu District in the Central Province of Kenya. The local community, particularly the women, had for a long time felt the need to have piped water near their homes. Karweti is a very hilly area and the women used to spend hours fetching water for domestic needs, for cattle to drink, and for use in spraying coffee. The inability of the women to carry enough water up the steep hills often imposed a limit on the number of cows a household could keep or how much coffee they could grow.

The driving force behind the launching of this project was a local woman who was a community development worker. Although she had no problem mobilizing the overenthusiastic women, she recognized the women's financial and management inadequacy to handle such a project unaided by their menfolk. Her next task, therefore, was to sell the idea to the men. She was able to get about 200 households to enrol as members of the project. Initially, every member, usually the head of a household, contributed KSh 300, and the community, mainly the women, dug the trenches and moved the construction materials. Every member now pays KSh 10 each month to buy diesel fuel for the pump and to pay the pump attendant whom the project committee has employed. The project is managed by a committee of nine members of which four are women. The chairman and secretary of the committee are men and the treasurer is a woman.

### **Kihara Water Project**

The Kihara water project is located near Gatundu in Kiambu District in the Central Province of Kenya. The idea of a water project in this locality developed out of an attempt by a women's group called Mabati Women to instal water tanks in every member's home to store the water caught on the roofs of houses.

The group approached a government minister for financial assistance and he suggested that a water pump would be more appropriate because it would provide water

to more people and on a more reliable and regular basis. The 32 members of the Mabati Women's group then acted as the nucleus around which the local community channeled their efforts. Money was raised on a household basis and the digging of trenches and laying down of pipes were mainly carried out by the women of the area. The women have remained the operational and management core of this project. Although five of the nine members of the project committee are men, the chairman, secretary, and treasurer are women.

The benefits that the above two communities derive from having piped water in their homes are many. The most important benefit is that the woman no longer has to spend hours transporting water. It is possible now to have a cleaner home as well as keep more cows and grow more coffee. Also, a successful project fills the community with pride and provides the impetus to embark on other projects.

### **Conclusions**

The above are but the highlights of how Kenyan women are assisting in rural water development. Although the women are making a substantial contribution, their potential has not been fully exhausted and they could do a lot more if their educational level was upgraded.

Teaching the women to be literate and training them in skills such as bookkeeping, project management, and project evaluation would go a long way toward intensifying their contribution toward rural projects. Equipping them with the above skills would also make them more self-reliant. In Kenya, the adult education and extramural departments are two examples of government attempts to eliminate illiteracy nationally.

Since 1976, the Ministry of Water Development has recruited an average of five women each year to attend its training school (total enrollment approximately 150 students). The proportion of women to men is very small largely because girls graduating from high schools lack the necessary



background in science subjects, and also many girls are not inclined to become water technologists. However, with the gradual correction of the imbalance in educational opportunities offered to girls and boys, and the change in attitude, more and more girls will present themselves to be trained as water technicians in the future. Of the handful of the women who have completed the course successfully, most opt to become

water laboratory technicians or water bailiffs. The principal of the water school is hopeful that with the change in attitudes all fields of water technology will be infiltrated by women.

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Economic Commission for Africa/African Training and Research Centre for Women (ECA/ATRCW) 1975. Women and national development in African countries. The African Studies Review, XVIII (3), 65.

# Community Participation in Rural Water Supply Development

Tsehaye Haile<sup>1</sup>

Public (community) participation, an indispensable social component of rural water supply programs, has sparked considerable discussion in many rural development forums. There are few ideas that have been more popularized and idealized than that which is usually referred to as community participation.

The success of rural water supply programs depends on the extent to which society is considered during the planning stages. Genuine and unflinching involvement of the intended beneficiaries right from the initial stages ensures the success of village water supply systems. Enthusiastic community participation can play a significant role in developing and increasing community awareness, a sense of responsibility, and pride of ownership toward the village water supply system, resulting in success and a high level of performance of the system.

In general terms, community participation implies development to be achieved with and by the people, not just for the people (EEC/APC 1979). Participatory rural development has received a great deal of attention in recent years in development literature, national plans, political platforms, and in the lending programs of most donors. Since the 1960s, interest in promoting participation of the lowest

income groups through rural development programs has gained wide acceptance.

Rural development is generally understood as a means of improving the living standards of the low-income population residing in rural areas. As stated by Lele (1975) "improving the living standards of the subsistence population involves mobilization and allocation of resources so as to reach a desirable balance over time between the welfare and productive services available to the subsistence rural sector."

## Mass Participation in Rural Development in Ethiopia

In an effort to materialize the objectives of the ongoing national revolutionary development campaign, the rural masses of Ethiopia are undertaking multidimensional rural development activities. The rural development undertakings, which are enthusiastically being carried out jointly or separately by the peasants' and urban dwellers' associations, will with all certainty lay the groundwork for the task of socialist construction which revolutionary Ethiopia has launched.

Although crude mutual cooperation in the sense of working together has existed in Ethiopia for years, the rural mass of the country had no chance to organize themselves during the prerevolutionary era. With perhaps a few exceptions, the

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past landlord-dominated Ethiopian leadership had been apathetic toward, if not at odds with, the concept of mass participation in rural development.

Today in Ethiopia, the revolutionary government unreservedly encourages and supports the rural masses to take part in developing the rural economy. Since the enactment of the fundamental rural land proclamation in March 1975, several thousand peasants' associations, based on socialist principles, have been established at village, subdistrict, regional, and national levels under the All Ethiopian Peasants' Association (AEPA). One of the major functions of the peasants' association, in addition to safeguarding the gains of the revolution, is to work collectively and to speed up socioeconomic development by improving the quality of the instruments and level of productivity.

Each of these associations serves an area of 800 ha. Although these organizations are new (only 5 years old), they are a potential focal point of rural development and are of national as well as local significance. They are familiar with the problems and needs of their areas and are able to express local demands for a wide range of services based on the actual needs of the rural population. In towns and larger villages, urban dwellers' associations play a similar role.

### **Community Participation in Rural Water Supply Development in Ethiopia**

As mentioned earlier, sporadic community participation in rural water supply development has been witnessed in several rural parts of Ethiopia during the prerevolutionary era. Since the 1974 revolution, however, community-initiated self-help water supply schemes have become more common.

At the national level, the Ethiopian Water Resources Authority (EWRA), the principal government institution vested with general water resources and rural supply development responsibilities, has recently prepared a community participation

promotion document pertaining to rural water supply works. The objectives of the EWRA community participation projects are: (1) to utilize effectively the resources of the consumer by encouraging the community to invest either cash or labour in the construction, operation, and maintenance of water supply projects, thereby indicating that further government funding should be used to increase water supply facilities in other areas or for additional work in the same area; (2) to ensure the success of village water supply systems and reduce the chances of systems failing as a result of misuse, vandalism, or a lack of maintenance; (3) to ensure that rural water supply is given due social consideration and is appropriate to the needs and desires of the villagers and to increase the usage or consumption rate of improved water by the community; (4) to eliminate the paternalistic approach to development and encourage communities to depend upon and pool together their potential manpower and financial resources in order to be self-reliant instead of becoming passive government aid handout recipients; (5) to develop and increase community awareness, a sense of responsibility, and pride of ownership on the part of the villagers toward the water system; (6) to promote and encourage community run and initiated self-help water supply schemes to enable the country to fully or partially meet the United Nations Water Supply and Sanitation Decade objectives; and (7) to help promote water use and health education programs (EWRA 1980).

### **Areas and Scope of Community Participation**

It is fundamental to any successful water supply scheme that the people concerned be involved in as many stages as possible in the entire process. If due consideration is not paid to social aspects when planning, the risk is high that the water supply system will either not be used or it will be misused. It is essential, therefore, that a high degree of

community participation in rural water supply works is applied. In principle, communities should participate in the planning, construction, operation, maintenance, and evaluation phases of rural water supply projects.

### **Planning Phase**

Until recently, social factors were almost completely ignored in rural development planning. Planning emphasis was mainly on the physical aspects, whereas the social aspects, i.e., how the project was related to the lives of the people, were left out in many cases. The input from the community at the planning stage should deal mainly with the identification of community needs and priority setting, the choice of suitable technology, and the siting of the supply points in a way that is acceptable to the community.

The social aspect of rural water supply development calls for a thorough investigation and adequate knowledge of local conditions. Information on problems felt by community, community resources, experience, and preference are prerequisites for joint planning of rural water supply programs.

It is essential that social considerations regarding the siting of the water supply are taken into account together with technical considerations. There must be communication between technicians and the community on the most appropriate site of communal facilities. This calls for considerable background information and knowledge about the community's needs and attitude toward the new system.

### **Construction Phase**

After participating in the choice of system and technology, the community is also expected to contribute in the actual installation of the facilities. During the construction phase, the degree of community participation is greatly influenced by the type of technology being used. In cases where sophisticated technology is applied, community participation is generally low. To promote

community involvement in rural water supply development the EWRA is intending to adopt simple technology such as spring protection and shallow hand-dug wells. However, even in areas where the exploitation of groundwater resources requires sophisticated drilling equipment and deep borehole schemes, village participation in the form of free labour contribution for digging pipeline trenches, the construction of earthworks associated with pump platforms, or installation of public stand posts, etc., can be significant.

### **Operation and Maintenance Phase**

Operation and maintenance of the rural water supply is a crucial part of the program. Generally, the community is willing to contribute and associate with the system if the service is satisfactory. The community should have a clear understanding of the contributions expected from it after the completion of the system and of the increased public health benefits from the improved system. Upon completion of a water supply system, an explicit and formal agreement specifying the community's and agency's responsibilities with respect to operation and maintenance tasks must be established. According to the EWRA community participation promotion document mentioned earlier, the routine day-to-day operation and simple maintenance, pump attendants salaries, lubricants and fuel would be the community's responsibility (EWRA 1980). Pump attendants would be appointed from and by the community and trained in maintenance techniques free of charge by the EWRA. After training, pump attendants go back to their respective communities to operate and maintain village water supplies.

### **Evaluation Phase**

It is essential to any development activity that continuous follow-up is carried out in order to avoid repeating mistakes and to adjust the approach where possible. The people who know the most about how the project is functioning are the community

people themselves. They can play a vital role in providing feedback and in pinpointing the difficulties and the successes of the water supply system for both technical and social aspects.

### **Promotion of Community Participation**

Nowadays, community participation in rural development projects is gaining wide acceptance. During the last two decades, it has become more and more widely accepted that it is futile to implement rural development programs without the participation of the intended beneficiaries, the rural poor (EEC/APC 1979).

There are no universal techniques for involving community people in rural development. Each country has its own set of parameters and problems requiring a solution of their own. If the initiative for the water supply comes from the people themselves, the process of involving them may be easier. Local organizations and cooperative societies are favoured as the most appropriate forms of group action on the part of the people. In rural Ethiopia, all necessary base organizational frameworks are laid down. The peasants' associations, women's associations, and youth organizations are playing instrumental roles in mobilizing mass participation in rural development.

To gain meaningful community participation in rural water supply development, preparation is under way to establish "village water committees" as subcommittees to the rural development committee or as an independent and integral committee within the framework of the local peasants' associations. Village water committees will be made up of five persons, of which at least two will be women. One of the prime objectives of these committees will be to promote community participation at the planning, construction, operation and maintenance, and evaluation phases of a rural water supply scheme.

Trained community participation promoters will be deployed to the rural areas

to carry out motivational and community organization activities. The promoters will monitor all community participation and provide feedback for planning and evaluation purposes.

### **The Role of Women in Rural Development in Ethiopia**

It is generally agreed that rural women should be actively involved in shaping the future of their societies for the betterment of all concerned. However, the diversity and importance of the economic and social roles played by women in rural life in most developing countries has often not been appreciated in the past by development planners. Measures to involve women in all phases of rural development cannot be isolated from the overall development strategy. Development programs which do not involve women fail to realize their full potential (UNICEF 1977).

In Ethiopia, the voices of rural women are now being heard by the revolutionary government. Before the revolution in Ethiopia women were underrepresented in government institutions. Today, the opportunity exists for women to use rural services that can make their lives easier as well as provide more skills and knowledge and promote development of an effective infrastructure through which women can express their needs and increase their self-reliance. Women are organizing their association from the local level to the regional level. Efforts are also under way to establish a national women's association that would give them more influence when participating in economic, social, and political struggles. Such organizations would increase their political consciousness and confidence and enhance their pride in whatever role they play.

There is a noticeable trend in Ethiopia that is providing a greater opportunity for women to participate in rural development. Today, in addition to their household duties, rural women in many parts of Ethiopia are working side by side with their male counterparts on environmental

sanitation, road cutting, reforestation programs, cooperative farms, and other rural development projects including rural water supply development.

### **Water Consumption (Usage) Pattern**

No scientific investigation on household water consumption and the social use of water has been conducted in Ethiopia. However, from scanty enquiries and studies it appears that household use of water varies tremendously. Several factors affect the amount of water withdrawn by individual households. Some of these factors are the size of the family, distance from the water source, income level, education, cultural heritage, character of the water supply, cost of obtaining water as measured by energy or cash expenditure, climate, and terrain.

The EWRA design standard for rural consumption indicates 20 litres per day per capita. The actual daily consumption in most areas, however, barely exceeds 10 litres per day per capita. In some localities the consumption is as low as 5 litres per day per capita. Table 1 gives the results of a water consumption rate survey of 70 households comprising 391 people in the Hararghe administrative region of eastern Ethiopia.

#### **Choice of Water Source**

The manner in which people choose between alternative water sources and the criteria they use to do so are largely determined by distance and price factors. Quantity and reliability are of lesser importance.

In most parts of rural Ethiopia, people use whichever source they consider to be the best at the time. They turn to their second choice when the first one is not available. In some places, distance seems to be more of a determining factor than price. People will not usually walk further to an EWRA water supply if there is an alternative source nearer their home, even though that alternative source is dirty. Despite the fact that the EWRA water is free in most parts of the

country, consumers usually use it only after nearer sources have dried up. In some places people use poor quality water from ponds and unimproved shallow wells even though an extra 10 min walk could take them to an improved water source.

Seasonal variation of water consumption is a major factor affecting water use from EWRA supplies. This is mainly due to people using alternative sources during the wet season rather than variations in individual consumption.

#### **Water Use in the Household**

In Ethiopia, only 4 percent of the total rural population, the rural population making up about 90 percent of the country's total population of 30 million people, have access to improved water supplies. There are no scientific studies illustrating the social use of water. However, water is generally used for consumption, hygiene, and to a lesser extent for amenities. In the household, water is also used for cooking, washing utensils and clothes, bathing children, and for watering animals. During the dry season, most rural people, particularly the poor, wash themselves and their clothes infrequently, if at all. However, during the wet season, people use considerable quantities of water at the source, predominantly for washing clothes and for personal hygiene.

#### **Perception of Water**

People in rural areas have a different perception about water. Their general outlook is different from their urban counterparts who are usually more concerned with quality as well as quantity. In many rural communities in Ethiopia, people pay little attention to the quality of water. They are prepared to drink unclean water. For most rural people, any water is safe to drink. The health impact of an unimproved water supply is not noticed. In most localities, the same source of water, be it ponds, dug wells, or springs, is used for human consumption, washing, bathing, and for watering livestock. This problem is also compounded by poor storage of water when it reaches the home. Water may be

Table 1. Consumption rate survey of 70 families in Hararghe.

Site	No. of households	No. of persons	Total daily consumption (litres)	Average daily per capita consumption (litres)	Average distance (km)	Water source
Jara	3	27	147	5.4	20	Stream, dry season
Tuluguled	3	20	168	8.4	Nil	Use their own cisterns
Kocher	3	12	98	8.2	1.5	Improved spring
Lugo	3	14	160	11.4	0.7	Improved spring
Chinahassen	4	25	149	6.0	0.7	Improved spring
Babile	6	25	165	6.6	1.1	River and shallow well
Barjok	4	17	95	5.6	3	Spring
Erer area	3	15	162	10.8	1	River and riverbed
Harar area	3	13	139	10.7	1.7	Stream
Midegalola	7	40	256	6.4	1.8	EWRA well
Byoweraba	3	13	126	9.7	0.67	EWRA well
Deder area	4	13	165	12.7	0.6	Unimproved source
Jijiga town	5	38	515	13.6	0.44	Municipal public fountain
Hameresa	3	18	210	11.7	0.2	Public fountain
Mieso	2	12	150	12.5	0.7	Municipal public fountain
Mechara	2	13	210	16.2	0.4	Stream from a spring
Jijiga area	4	28	310	11.1	15.5	Nomadic centre carries in large containers on camels
Tuluanot	1	5	40	8.0	2	EWRA well
Gebi Gebu	1	3	14	4.7	4	River and riverbed
Kuni	1	5	45	9.0	0.8	Spring
A. Teferi	1	5	36	7.2	0.9	Spring
Awaday	1	10	105	10.5	0.2	From an individual with a house connection
Kobo (town)	1	6	80	13.3	—	Water vendor
Kobo (area)	2	14	90	6.4	1	Spring

reasonably acceptable and potable at the source, but due to poor and unclean storage it usually becomes contaminated. This poor perception of water has greatly contributed to the deteriorating state of health in the rural areas of the country. Over 70 percent of the prevalent diseases in rural Ethiopia are caused by poor water supply and sanitation.

It is recognized that the only possible way to change the attitude, as well as the consumption pattern in the rural community, is by intensification of water education. In order to avoid the main cause of surface water contamination, i.e., from waste disposal, methods of handling excreta and solid waste must be part of water education. At present, there is a water education project being carried out at the primary school level. The emphasis of the project is on the education of children and women. Such water education programs could result in bringing about changes in attitudes toward the use of water within the household.

The impact of health and water education in transforming family behaviour and attitude toward water use largely depends upon the degree of cooperation between the community, schools, and home. To impart and transfer the desired knowledge, the health education curriculum must be community oriented and less academic in content.

In countries like Ethiopia, where the rural majority has little or no access to rural social services such as schools and health stations, water education programs using the medium of schools suffer from limitations. Well-organized, broader

approaches in the form of national water and sanitation campaigns are required for transferring meaningful knowledge and lasting changes regarding the water perception of the rural masses. A concerted effort to persuade people to adopt the use of improved water supplies would undoubtedly result in a great impact and change of attitudes.

One useful and suitable method of reaching the rural masses, particularly women, would be the effective use of mass media such as radio programs. In Ethiopia, there is a weekly health program transmitted through the radio voice of revolutionary Ethiopia. The content of the program is general environmental sanitation, of which the proper use of water both in the household and at the source is one aspect. In addition to radio programs, the use of local and traditional media such as the street announcer, locally produced printed matter, lectures, exhibitions, drama performances, puppet shows, etc., may provide easier accessibility (WHO 1979).

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## **Operation and Maintenance: Discussion**

There were lengthy and diverse discussions on training for operation and maintenance of rural water supply projects. Everyone agreed upon the importance of this topic. The following points were made:

Firstly, it is necessary to have a clear, well-defined operation and maintenance program. One can then outline a training schedule to meet the needs of the program.

The need to decentralize maintenance procedures and training was emphasized. This requires in-service training by experienced persons in the field. It is also useful to have orientation courses in workshops before sending technician students into the field for in-service training.

Operation and maintenance training are very important when dealing with the smaller-sized plastic hand pumps. This maintenance can often best be carried out by the local village people. It is important, however, that they have a sense of "owning" their pump and being truly responsible for it.

It is crucial to involve women in the training process for operation and maintenance at the village level, but there are obstacles in the way of this development. Some cultures are not yet ready to accept women as maintenance technicians. Unfortunately, women are often too busy with other chores to engage in this new task. If the pump breaks down, however, the task of obtaining water will usually fall to the women. Sometimes there are communication problems between male technicians and the women in the village whom they would teach. These can be problems of language or of social custom. Technicians are often too busy with their technical tasks to set aside time for the training of village women. In spite of all these difficulties, women have often done a very commendable job of keeping the pump site clean and there is considerable pressure for them to be able to participate in higher levels of pump maintenance. The change will begin when women enter more of the training programs related to rural water supply.

There was a fairly extensive debate concerning whether or not rural water should be provided free of charge. Malawi and Tanzania provide water free to rural communities and cited the following reasons: A charge for the water may cause people to use nearby polluted water sources during the wet season because they are "free." Also, the rural peasantry cannot afford to pay large tariffs so the cost of collecting the money may be more than the money actually received. Because the villagers, in most cases, contribute much of the labour for the construction and maintenance of the system, they are, in fact, providing a form of payment.

Kenya, on the other hand, instituted a multi-level payment system depending upon the ability of the community to pay. It was hoped that this method would cut down on the wastage of water and help reimburse some of the operational costs of the system. This was considered necessary because although donors often contribute funds for capital assistance, rarely are operation and maintenance costs funded externally.

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Ethiopia found that it was not effective to charge the rural population individually but communities could be charged and then the community would decide upon the method of payment by its members.

Finally, some specific suggestions for operation and maintenance training were:

(1) Maintenance centres, including training centres, are best established in a decentralized manner, in the regions.

(2) Leaflets should be written in the local language to explain the parts, construction, and maintenance procedures for the new, simple plastic pumps being manufactured.

(3) Water operators at the village level need broad training to cope with the diversity of problems they are likely to encounter.

(4) The need for operation and maintenance training is very much a function of the durability of the equipment, e.g., countries that opt for the lower-priced plastic hand pumps will need a well-run network of decentralized and diversified maintenance depots.

(5) Development of rural water supplies brings about the need for more careful coordination in maintenance, operation, and training. With the creation of the Department of Lands, Valuation and Water, maintenance crews may soon be trained to deal with groundwater, gravity, and shallow well hand pump systems. These previously came under the authority of different departments. Thus, in Malawi, the future may require a more versatile, more broadly educated maintenance person in rural areas.

## Manpower Surveys in Ethiopia

K. Achamyeleh<sup>1</sup>

Rural water supply development is a field requiring the combined technologies of most disciplines of engineering. Professional personnel such as hydrogeologists, civil engineers, sanitary engineers, mechanical engineers, and electrical engineers are indispensable. At the subprofessional level surveyors, geology assistants, engineering assistants, draftsmen, construction foremen, drillers, mechanics, welders, and electricians are needed.

In economic and social development, the key factors that govern the pace of progress are natural resources, capital, and skilled manpower. In developing countries, where priorities for the allocation of scarce financial resources are based mainly on economic projects that are considered directly and immediately productive, rural water supply development suffers from the chronic problem of lack of financing. As a result, it is difficult for this sector to compete with other sectors to obtain the technical manpower required. Thus, in many cases the sector is forced to develop its own skilled manpower at all levels through training, mostly with external assistance. Training for water supply development, therefore, becomes essential for most countries.

In the case of Ethiopia, two factors may be cited as the major obstacles hindering the natural development of manpower in the water supply sector.

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(1) General shortage of skilled manpower: The prevailing general shortage of skilled technical manpower in the country makes it difficult to acquire new staff because stiff competition among employers is created. The usual result is that water agencies cannot offer as attractive employment conditions as other similar organizations. This state of affairs is detrimental to the intentions of a water agency to expand its manpower to meet an accelerated program such as the International Drinking Water Supply and Sanitation Decade. To improve this situation, government has started allocating graduates from institutions of higher education to various organizations on the basis of priorities.

(2) Less attractive system of employment: The water sector in Ethiopia has less attractive salary scales than most other competing organizations. Furthermore, there is no rational system of promotion as yet. Thus, the water sector has not attracted an adequate number of qualified staff. These factors coupled with others make special training necessary in order to obtain additional manpower.

Prior to deciding on training, a thorough assessment of existing and available manpower should be carried out. The extent of manpower deficiency at all levels and for all categories should be defined. This assessment or survey should aim toward providing knowledge on: (1) type, number, and qualifications of all key personnel at all levels employed in the water development agency; (2) the type and qualifications of skilled manpower available for employ-

ment; (3) the manpower available within the country for further training; and (4) technical training institutions within the country and their capacity.

All information pertaining to the availability of manpower outside the agency is normally established during the search for prospective employees. Where rural water supply and all water-related development are centrally coordinated, which is the case in Ethiopia, information can be obtained easily through the central institution (e.g., in Ethiopia from the Commission for Higher Education and the Ministry of Labour). Upon completion of the manpower survey, deficiencies at the various levels can be determined and planning and organization of training programs to eliminate the deficiencies can begin.

### **Scope of Survey**

The survey should provide adequate information on the number and type of manpower engaged in water-development activities. In assessing available manpower, one should carefully determine the type of staff at all levels, standard of education and training, and current performance. Information on prevailing systems of employment should also be gathered.

Given that a detailed development plan has been prepared and that this plan contains comprehensive information on all the inputs required for its realization, one would then assume that a forecast of skilled manpower requirements at all levels has also been made. A manpower survey would provide information on the availability of manpower from regular sources. The survey would also establish whether or not there is a deficiency of manpower and if so, would supply indications of where these deficiencies lie.

It is not so simple to make an accurate forecast of manpower requirements. At best these forecasts are only guides. Nevertheless, on the basis of acquired experience, and where such experience is lacking on the basis of normal engineering assumptions, standards for manpower requirements must

be established. From such standards, and in relation to the targets set in the development plan, the number and categories of personnel required for rural water supply development activities are derived.

The types of activities would vary depending upon the system of water supply selected. The most common systems for rural water supply in Ethiopia are boreholes, hand-dug wells, spring improvements, ponds, and cisterns. The individual components of activities that are carried out at various stages are: siting, surveying, designing, drilling, test pumping, pump installation, construction and distribution of reservoirs, and construction of wells and spring improvements. Also, maintenance and repairs of water supply installations are activities which come at a later stage but for which an estimate of manpower must be made. Projections of manpower requirements are made on the basis of assumed standards for each of these activities.

### **Future Projections and Training Plans**

In Ethiopia, rural water supply, urban water supply, and hydrometeorology are under one authority. Programs of manpower development are centrally carried out for all three subsectors.

Having made projections of manpower requirements to fulfill planned targets for all categories, one must now identify the source from which all the manpower in excess of what can be obtained from known sources should be obtained. An assessment of the capacity of existing national institutions and a forecast of the likely number of new graduates that may be attracted to the water development sector, based on past experiences or extrapolation of experiences, should also be made. The balance of manpower required to implement the plan will have to be obtained through training.

Training may take the form of upgrading the skills of existing staff or training new recruits. For lower level technicians, the type of training needed to upgrade

employees may be different from that required to train new recruits. One can set the minimum academic standard for new recruits but this may not be possible for existing personnel who compensate for their lack of formal education with job-related experience. Generally, upgrading courses for existing personnel may require more of the theoretical aspects, whereas the recruit courses may emphasize practical application. Evidently, priority needs to be given to the more specialized categories such as drillers, pump operators, and hydrometeorology technicians. The requirements of training, duration, and curriculum will change depending upon the type of personnel available within the country for training. The survey should, therefore, attempt to provide as much accurate information as possible on all aspects of available manpower.

## **Recommendations**

Prior to the planning of training programs, a comprehensive survey of manpower in the field of water supply is essential. The manpower survey should provide complete information on all aspects of manpower including: (1) availability of manpower in all categories and at all levels; (2) standards of training and education; (3) conditions of employment and performance; and (4) existing institutions for training within the country. If a water-development plan has been prepared with a manpower-requirement forecast, manpower requirements should be determined by comparing the forecast with available manpower. If there is no long-term development plan, the survey may establish the needs of manpower on the basis of current activities and annual plans.

# Manpower Surveys in Tanzania

R.M.A. Swere<sup>1</sup>

It is common, in many organizations, to make plans for the future without first assessing the present situation. This often leads to doing things that are not necessary or useful. What should be done before making any plans is to determine what resources are available. It is then possible to determine whether or not the presently available resources are sufficient for a particular purpose. Having obtained information on the present situation, one can accurately plan the action to be taken to reach a required target.

Similarly, with respect to manpower, taking stock of the people available in a given area or organization is essential if any manpower planning is required. Such an exercise, commonly known as a manpower survey, consists of taking stock of the people available in terms of quantity and quality.

There are several methods of conducting a manpower survey. The method employed varies with the type and organization of the institution being dealt with. Surveys in Tanzania are commonly conducted by a team of interviewers, departmentally, or through correspondence.

## Survey Conducted by a Team of Interviewers

This method of conducting a manpower survey is used extensively in Tanzania. It is

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also, in the opinion of the author, the method which provides the most accurate results in comparison with the other methods. It involves a group of people selected and trained to carry out the survey. Generally, the survey consists of a questionnaire, which contains all the questions to be asked and provides spaces for answers to the questions.

The training normally takes 2-4 weeks depending upon the complexity of the survey. Techniques of approaching people, the psychology of getting answers from people, and a knowledge of the information required are very important and must be taught thoroughly if accurate results are to be obtained. Upon completion of the training, the surveyors are sent into the field, each one to their respective area, to carry out the survey. The disadvantage of this type of survey is that it is the most expensive method.

## Survey Conducted Departmentally

A departmental survey is the cheapest type of survey and can be carried out conveniently within the office where the people who are to be interviewed are employed. Questionnaires are sent to the officer in charge of an organization along with a request for those people from whom information is required to respond to the questionnaire. In this type of survey the officer in charge is required to verify, in each case, that the information supplied is correct. The officer in charge may also be

required to comment or supply certain information about each person who has completed the questionnaire. The accuracy of the data supplied and the time taken to conduct the survey depend upon the importance the officer in charge attributes to the survey.

### **Survey Conducted Through Correspondence**

When the survey involves selected people who are scattered over a large area, it becomes convenient and cheaper to write to the people involved and ask them to provide the information required. This is normally done only when representative information is required. In this case, it is not necessary to interview each person in the particular group. The questionnaire is sent either to the specific (named) person or to anonymous people. If the questionnaire is being sent to a specific person, then it is addressed to that person's mailing address. In cases where the questionnaires are sent to unspecified people, they are distributed randomly through post office box numbers, house numbers, or through other means of communication. The disadvantages of this method are that the information received may not be very accurate or a reply may not be received at all.

### **Information Collected and its Significance**

There may be many alternate methods of collecting manpower information in use in other countries, particularly in developed countries. In Tanzania, however, the most commonly used methods are those described here, with departmental surveys being utilized most within the water sector. Currently, another survey is being organized with the assistance of the World Health Organization and the International Reference Centre for Community Water Supply. This survey will employ the use of interviewers.

Although every manpower survey may have its own purpose and the specific information required may vary from one survey to another, there is a certain amount of general information required when carrying out any manpower survey. This information consists of name, age (birth), sex, marital status, basic education, training, profession, date of first employment and designation, various employment to date, date and nature of present employment, reasons for changing employment (i.e., previous employment), membership in professional bodies (institutions), present duties, persons you report to in the organization, the number of people reporting to you, and your future plans. In addition to the information supplied by the person being interviewed, the supervising officer is required to comment on the person responding to the questionnaire.

The above information is supplied by the employee. There is also information that must be supplied by the organization. The information generally required from the organization includes the name of the organization, type of business, date of establishment, organizational structure, total number of employees by grades, total number of vacant posts, number of employees undergoing training (and fields) within the organization and outside, posts designated for those persons receiving training, number of people leaving the organization during a specified time period, number of people joining the organization during a specified time period, reasons for leaving (retirement, expulsion, resignation, transfer), and staff development programs (training programs, promotions, insurance schemes, pension schemes, and other incentives) available.

To complete a manpower survey, information about the nature and extent of activities carried out by an organization is required. An analysis of the tasks carried out by each cadre of people is essential. From this information it is possible to determine what skills are involved in performing certain tasks and the manpower required to complete the tasks within a specified time



period. It is then possible to determine the total manpower required, in terms of skills and qualifications, within the organization. In addition to information about current activities, an organization's future activities should also be surveyed.

All of this data can then be analyzed to provide the following information about a given organization: the total number of people employed; the number of people at various categories (levels) of education; the number of trained (in different skills) employees; the number of people leaving the organization per specified time period; the number of people currently required by the organization; the number of people with various skills (training) currently required by the organization; the future manpower requirements (in terms of number and quality); and the present surplus or deficit of manpower within the organization.

Having obtained this information, it is then possible to begin filling any gaps in present or future manpower requirements. In cases where employees' skills are below those required for the tasks they are performing, additional training will be necessary. Similarly, if there is a shortage of personnel within an organization, it would be necessary to recruit people from the market and train them. In such cases, the organization is said to have a "training need." Where people can be employed from the market, a training need does not exist. In cases where a training need exists and the training is likely to take a long time, temporary recruitment measures from abroad are taken to enable the organization to function.

In 1976, a manpower survey was carried out for technicians working in the water sector throughout the country. This survey was carried out through departmental heads. Questionnaires were prepared and dispatched to the regional water engineers'

offices with a request that the questionnaires be completed and returned to the ministry's headquarters within a month from the date of issue. Several points of interest were observed from this particular survey: not all questionnaires were completed and returned within the specified time period; some questionnaires were completed incorrectly; some questionnaires were not completed and, therefore, not returned at all; and the questionnaires which were completed incorrectly and those which were not completed at all were completed after a second request to do so was made. These observations revealed some of the disadvantages of the departmental method of conducting a manpower survey. The survey revealed that (1) the head of the office must be interested enough in the surveys so as to persuade those people being surveyed to complete the questionnaire correctly and on time; (2) the people being surveyed must understand the purpose and the importance of the survey; otherwise, they may get the impression that the survey may result in dismissals; and (3) the questionnaires should be simple enough to enable those persons completing them to do so with ease and without making errors.

## Conclusions

It is important to remember that regardless of the method used to conduct a survey, the people involved in it should be made aware of its purpose so that accurate results are obtained. It is also recommended that where training is being organized and/or where recruiting of additional staff is being planned, surveys of available manpower should first be carried out to determine exactly what training is needed and what type and number of additional personnel are required.

# Planning and Organizing Training in Ethiopia

Michael Musie<sup>1</sup>

This paper will attempt to explain how planning and organizing of training are carried out within the Ethiopian Water Resources Authority (EWRA).

## Structure

The EWRA has a general manager under whom there are offices that have advisory functions. Some of these are the Planning and Programming Department, Training Department, and the Legal Department. As well, there are four operational agencies: Urban Water and Sewerage Agency, Land and Water Studies Agency, Water Well Drilling Agency, and Rural Water Supply Agency. Other than noting their existence, these agencies will not be discussed further in this paper.

## Functions

The main tasks of the Planning and Programming Department are to prepare a short- and long-term investment plan, follow up its implementation, and evaluate and report accordingly. One other important task entrusted to this department is the preparation of a manpower study in the short term and a projection of the future manpower needs to meet the targets set in the physical plans of projects.

The main function of the Training Department is to follow up and implement

the training requirements indicated by the manpower survey, both in the short and long terms.

In short, study of manpower needs is carried out in the planning office and implementation of training programs is carried out within the Training Department.

## Matching Training Needs with Manpower Surveys

As far as the EWRA is concerned, training is carried out at three levels. At the professional level, most training is carried out in foreign countries and applies to fields such as hydrogeology and civil, mechanical, sanitary, and hydraulic engineering. Training at the subprofessional level deals mainly with engineering aids (technicians) and takes place at the local university. The third level concerns the training of maintenance mechanics, overhaul mechanics, plumbers, welders, drillers, electricians, hydrometeorological technicians, and pump attendants. This training is carried out in the EWRA headquarters temporary workshop. At all levels, the actual training is carried out after the manpower survey has been completed and a plan of operation has been clearly established.

## Organizing for Training

### Selection

Postgraduate students are selected by the

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EWRA Training Department and committee appointed by the general manager. The criteria used are qualifications, job performance, and general attitude toward future service. Selections for civil and mechanical engineering candidates, who will study in India, are made by the Ethiopian Higher Commission for Education in collaboration with the Training Department. Selections of engineering aids and other technicians are made by the EWRA. Pump attendants are selected by peasants' associations.

### **Accommodation**

Professionals studying abroad are accommodated in boarding colleges. Engineering aides are paid a monthly allowance of about U.S. \$75. This is to cover their out-of-pocket expenses and accommodation costs. Technicians are paid about U.S.\$120 per month to cover their living costs.

### **Location**

Training is carried out in four locations: postgraduates are currently trained in The Netherlands; civil and mechanical engineers are trained in the Indian universities of Roorkee and Calicut; engineering aides are trained in the Technology Faculty of Addis Ababa University; and technicians are trained in the temporary workshop at the EWRA headquarters. The curricula are determined by the respective heads of the departments.

### **Management**

The overall management and organization are carried out by the Training Department, which is staffed and equipped to meet training needs.

## **Using Local and Outside Training Resources**

Professionals are trained in foreign universities. For postgraduate studies in The Netherlands, the European Economic

Community (EEC) has granted a sum of about U.S.\$140/month. Civil and mechanical engineers are trained through the assistance of the Swedish International Development Authority (SIDA) and the Canadian International Development Agency (CIDA). Currently, there are 76 such students, at a cost of about U.S.\$3000 per student per year. Another 80 students will begin studies in October 1980.

Engineering aides (technicians) are trained in collaboration with the local university. The curricula are designed to suit the needs of the EWRA. Financing for this program is made possible through the assistance of the United Nations Children's Fund (UNICEF). Technicians are trained locally in the EWRA workshop through financial assistance from the United Nations Development Programme (UNDP) and by the International Labour Organisation (ILO). Recurrent expenses are met by the Ethiopian government and UNICEF. Trainees allowances are paid by UNICEF.

A new training centre is to be constructed in Awassa. The construction costs are expected to be of the order of U.S. \$800 000. The construction is to be financed by West Germany and the EEC. After completion of the building, West Germany will provide instructors, the Ethiopian government will provide local instructors and pay recurrent expenses, and UNICEF will continue to pay for board and lodging of the trainees for the next 3 years.

## **Evaluation of Training**

Training is normally evaluated through reports from departmental and section heads where the trainee is assigned to work or through field visits by the training staff. The evaluation is normally followed by adjustments in the curricula or additional training.

## **Future Plans**

Beginning in September 1980, 20 additional engineering aides will commence

a 2.5 year training period at Addis Ababa University. Another 80 students (25 mechanical engineers, 55 civil engineers) will begin classes before October 1980. The engineering students will receive 4 years of training at Indian universities, leading to a Bachelor of Science (B.Sc.) in their respective fields.

The training centre for water works personnel, being constructed in Awassa, is

expected to be completed by February 1981. Initially, the centre will be staffed by expatriates. In preparation for eventually taking over the training program, however, six Ethiopians will begin 15-24 months of study in technical fields in December 1980. Upon completion of the studies, these people will take over the training duties at the centre that were formerly held by the expatriates.

## Planning and Organizing Training in Tanzania

R.M.A. Swere<sup>1</sup>

Training is an area that should receive high priority in every independent African country today due to the lack of training during colonial times. If there was any training at all during that time period, its sole purpose was to maintain colonial rule.

When African countries gained their independence, most of them found that they had few properly trained people. For the most part, those few people who had training were trained in clerical duties, interpretation, and junior administration. Training in technical fields had been very much neglected. As a result, when independent African governments came into power they had to mount massive training programs for their people. In some countries the training was carried out without proper planning, resulting in a surplus of trained personnel in certain fields and a deficit in others.

It has now become apparent that proper planning is necessary before any training program can be implemented. A training program should be worked out in response to a "training need" that has evolved from a properly designed manpower planning program. Without proper planning, training may not serve its intended purpose.

A training program can be national in nature or specific to the needs of an organization, ministry, or any other

institution. Regardless of the organization, however, the program must be based on a known requirement.

A manpower survey leading to manpower planning is the key to a successful training program. Upon completion of the manpower survey, an organization is able to compare its requirements with its present staff. If the comparison indicates that more trained people are required, then a training need is said to exist.

Having established a training need, it is then possible to organize and implement a training program to fulfill that need. In countries like Tanzania, where the resources needed for carrying out a training program are limited, extensive planning is required before any training can begin. The conditions of sufficient training facilities, adequate funding, and suitable trainees must all be satisfied before training commences.

Because training facilities are limited, facilities for training in a specific field may not be readily available within a country. The first step toward organizing a training program, therefore, is to assess the availability of the training facilities within the country. Where facilities are inadequate, the possibility of improving existing facilities should be considered before considering construction of a new facility. The alternative to this is to assess the availability of the required training facilities in neighbouring countries.

In preparing training facilities within a

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local institution or department, the availability of training space, training apparatus, and instructors must be considered. It may also be necessary to prepare a curriculum if one has not been prepared.

Depending upon the nature of the training, the training space does not have to be elaborate; protection from the weather and cleanliness are the main criteria. Training of mechanics, plumbers, and pump operators can conveniently be carried out under these conditions.

Training apparatus should include all of the materials required to conduct a given course. For example, a mechanic's course would require spanners, screwdrivers, overalls, used pumps, and motor vehicles. If the situation allowed, audiovisual aids, model pumps, and motor vehicles prepared for training purposes could be obtained. Similarly, training apparatus for other areas of study should be listed and obtained before training begins.

The availability of instructors is an important factor to be considered before training starts. If instructors are not readily available, people from relevant fields could be selected to act as instructors on a full-time or part-time basis. It would be beneficial for these people to attend a short course on teaching methods before they begin teaching. A number of countries offer short courses on training instructors. If they are not offered within a country, a request to attend such a course in a neighbouring country should be made.

At the Dar es Salaam Water Resources Institute a program to train instructors is being prepared with the assistance of the International Labour Organisation (ILO). The instructors trained here will be dispatched to the regions to conduct the training of craftsmen under the regional water engineers. When the program is completed and in full operation it will be open to trainees from neighbouring countries.

Preparation of a curriculum is another important task in establishing a training program. In this regard, the manpower survey, which indicated a need for training,

can also be used to establish the subject matter to be covered in the program. Training programs that have already been established may not necessarily meet the specific training required. In such a case a special curriculum must be worked out.

In developing a curriculum for a specific purpose, the duties to be performed and the skills required must be analyzed and discussed with the supervisors of the work to be done and the people currently doing the job. This is essential to ensure that the syllabus being developed meets the required purpose.

Having secured training facilities, or even while efforts to locate training facilities are being carried out, the funds required for carrying out the training program should be sought. This is normally done after a cost estimate is worked out. In governments where funds are allocated on an annual basis, as in Tanzania, the funds required for a specific year of implementation should be included in the annual estimate.

At times, the costs of training become large, particularly higher education training within or outside the country. In such a case it may be difficult to obtain the necessary funds within the annual government allocation. If this happens, training is likely to be jeopardized and possibly delayed to a later date. A problem such as this may be solved by asking for financial assistance from another country or financing agency. Often there are donor countries and other international agencies that are ready to help finance a worthwhile training program.

Currently in Tanzania, a number of training programs are being financed by various international agencies. In particular, two training programs that should be noted are (1) a 4 year program involving 159 students financed by the Swedish International Development Authority and leading to a degree in civil engineering and (2) a program designed to train technicians that is being financed by the Swedish International Development Authority and the World Bank.

Sometimes it is not enough to have adequate training facilities and funding. It is also essential to have the right trainees for

the program. The candidates selected for training must possess the necessary qualifications for a particular course.

Once training facilities and funding are made available and the trainees have been selected, the training program can begin. If possible training courses should be offered within the country requiring the trained personnel. This will ensure that the program will focus on problems and solutions as they relate to that country. Only where there is no alternative should a course be attended in a foreign country.

Upon completion of the training program, graduates should be placed in relevant positions. Often, in countries where manpower shortages are still significant, such as in Tanzania, graduates are placed in positions that are not relevant to their fields of training. As a result, it is not possible to get the maximum benefit from the training received by the graduate because it is not being applied. Another disadvantage of improper job placement is that it is not possible to evaluate the training program because the training is not being applied.

Graduates who are placed correctly, on the other hand, should be evaluated so as to determine the success of the training program. The feedback should be conveyed to the training institution concerned for adjustments, if necessary, in the course being conducted. The evaluation is also essential to determine whether or not the graduates have obtained sufficient training for the jobs they are performing.

The exercise of designing, executing, and evaluating training programs and determining training needs should be carried out on a continuous basis by the

training officer in an organization. In Tanzania, for example, more than 60 different types of on-the-job training are being conducted departmentally. Before training begins, the syllabus is determined and the necessary equipment and instructors are acquired. The training for a particular field is broken down into three grades corresponding to the grades of employment of the junior technicians, i.e., water technician grades III, II, and I.

The organization of this training is such that the instruction and daily management of the training are carried out at each of the regional water engineers' offices. Quality inspection is carried out by the training section of the ministry in conjunction with the Water Resources Institute. Examination and testing are done by the Water Resources Institute.

The evaluation of current training programs has revealed a need for improved instruction and examination of the subject matter and improved supervision of the programs. The syllabi have also proved insufficient, leaving out a significant amount of important material.

Plans are presently under way, with the assistance of various donors (United Kingdom, ILO, International Reference Center for Water Supply, World Bank), to improve the programs by providing expertise, funding, and equipment. Plans are also being made to improve training for instructors, update the present system of testing trainees, and to establish a special wing at the Water Resources Institute that will be responsible solely for the supervision and monitoring of the training programs.

# **The Planning and Organization of Training for Water Development in Kenya**

**R.C. Shikwe<sup>1</sup>**

## **Historical Development**

### **Institutional Framework**

Water is scarce, yet vital to life and development. Its management, therefore, attracts many agencies and organizations. At different points in time, the responsibility for the management and development of Kenya's national water resources has been shared between various organizations, government ministries, local authorities, and parastatals. Each organization has concerned itself with one aspect of water use or another. Such uses include water supply for human and livestock consumption, irrigated agriculture, and hydropower generation. Prior to 1964, public water supplies were the responsibility of the Ministry of Works and the African Land Development Organization (ALDEV) in urban and rural areas respectively.

In 1964, the Ministry of Works and the ALDEV were combined to form the Water Development Department of the Ministry of Natural Resources. In 1968, the department was transferred to the Ministry of Agriculture and made a division. In 1972, its departmental status was restored. Finally, in November 1974, it became the Ministry of Water Development. The ministry has the overall statutory responsibility for the conservation, control,

and apportionment of national water resources under the Water Act (Cap 372), Laws of Kenya. It is also responsible for water development and supplies, control of water catchments, and water quality and pollution control.

### **The Development of the Rural Water Sector**

Concurrent with the changes in the institutional framework for the management of national water resources, the development of the rural water sector was also receiving attention. The experience of the first decade of independence and the performance of the first two 5 year national development plans had proved that the achievement of development-plan targets in other sectors, such as education, health, power, agriculture, and industry, depended upon the availability of adequate water supplies. The frequent shifting of responsibility for water management between ministries was, in effect, a reflection of the government's attempt to develop the water sector.

Toward the end of the first national development plan period in 1970, a national goal of providing water to the entire population by the year 2000 was set. This was an ambitious 30 year plan to be implemented through multiphased programs and projects. The most important of these was the rural water supply program. The objective of the program, currently in its fourth phase, is the improvement of water supplies available to people living in rural

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areas, who account for 90 percent of the national population. It is anticipated that the fifth phase of the program will commence during the current development plan period (1979-1983); to be followed by others in the series until the entire population is served by the year 2000.

### **Training Objectives and Policies**

The formulation of national training objectives and policies has been conditioned by the need for relevance to prevailing circumstances. During the 1960s, after independence had been gained, there was a need to find human resources to replace departing expatriates. Therefore, the training emphasis was quantitative. The 1970s were a decade of training for development. The challenge then was to equip practicing managers and administrators with the appropriate concepts, skills, attitudes, and techniques required to enable them to play an effective role in national development. The emphasis, accordingly, shifted to qualitative training. The 1980s are destined to be a decade of "fine tuning" to achieve excellence, commitment, dedication, devotion, and loyalty in "service to the nation."

Despite the changes in the emphasis, objectives, policies, and strategies, certain deep-rooted traditional attitudes and concepts toward training still persist. According to these attitudes and concepts, training is synonymous with employment. Selection and admission to preservice training is interpreted as direct employment or reduction in unemployment because it absorbs potential job seekers from the streets into training institutions. Furthermore, successful completion of a training course is viewed as a passport to an automatic promotion. Thus, there is a definite need to uproot such attitudes by developing a new philosophy.

### **Planning for Training**

Training within any organization aims at developing the competence and capability necessary for the effective performance of

the activities entrusted to the organization. This involves inculcating and imparting relevant skills to the individuals comprising the work force of the organization. In planning training programs for rural water supplies, it is, therefore, logical to start with the identification of the nature and magnitude of the activities involved, followed by determination of the relevant skills required for their effective execution. Certain parameters within the Kenyan rural water sector situation are relevant in computing this information. These include the time factor, hydrology, hydrogeology, geography, and demography. For example, there are 20 years remaining in which to supply potable water to the entire population by the year 2000. The population, currently at 15 million, is increasing at 3.5 percent annually. The land area to be covered is approximately 570 000 km<sup>2</sup>, two-thirds of which is arid or semi-arid land (ASAL) with a sparse human population of pastoral communities but large livestock and game populations. The other one-third of the land area, endowed with abundant rainfall and surface water, is densely populated.

From the foregoing, the following conclusions may be drawn: firstly, that the use of both surface water and groundwater resources is imperative; secondly, that the development of the water sector must involve the investigation of the availability and location of the water resources, particularly in the ASAL areas; the assessment of water quantity and quality; the planning and design of water projects; the construction of water schemes; and the operation and maintenance of completed water supplies. These are multidisciplinary activities calling for a wide range of technical and scientific skills. The key technical skills involved are civil, electrical, mechanical, environmental, and sanitary engineering. Scientific skills are required in chemistry, biology, hydrology, and geology. The support of administrative services in accounting, personnel, and supplies and the skills of economists, sociologists, demographers, and systems analysts are also required. All of these skills are required at all

levels of specialization, i.e., professional, subprofessional, technician, and craftsman.

### **Manpower Projections**

Long-term planning for training requires manpower projections over appropriate time horizons. These may be over 1, 2, or 3 years but more appropriately in relation to the 5 year national development plan. The Ministry of Water Development (MWD) is currently preparing the national master water plan, which has prepared manpower projections for the water sector over 10, 20, and 30 year time horizons. The first decade (1978-1988) is also covered by a management study project on the MWD. The two studies make the manpower projections for the first decade fairly reliable for purposes of planning training programs for rural water supply.

The projections are based on MWD programs and the activity levels required to achieve the national goal as set for the year 2000. The MWD's capability to absorb financial expenditures was assessed on the basis of its performance during the first decade of the rural water supply program (1969-1978). This has been used to establish an engineer/expenditure ratio and an engineer/technician ratio. The projections for engineers were made on the basis of anticipated investment. The numbers in other categories of manpower were computed as ratios of the higher categories, e.g., four technicians for every engineer.

### **Manpower Surveys**

The objective of a manpower survey is to determine the actual manpower available in terms of quantity and quality. It is the next step after manpower projections in planning training programs. The difference between manpower requirements and manpower availability indicates a training need if the difference cannot be eliminated through direct recruitment. An in-depth survey, conducted in February 1978, of existing MWD manpower in all grades showed a total staff of 5500. This number is expected to increase to 12700 by 1983. Although some positions will be filled through

redistribution of existing staff or direct recruitment, a training need has been established for engineers at the professional level, engineering assistants at the subprofessional level, water inspectors at the technician level, and water operators/pump attendants at the craftsman level. Training needs for other disciplines vary, but overall, the need for major training within the MWD has been established.

### **Organization for Training**

As mentioned earlier, the development of the rural water sector did not begin until the 1970s. Training for the sector is, therefore, a recent undertaking. The various phases described in the historical development of training objectives and policies are not relevant to rural water supply. When the MWD was created in 1974, there was a training gap of a decade between the MWD and the rest of the service or other sectors. This gap had to be bridged within a few years if the sector was to catch up with other industries and make its contribution to the national economy. Crash training programs appeared to be the obvious solution.

Training, however, is an expensive undertaking. It was imperative to minimize costs by avoiding the creation of new training programs in new training institutions. The objective was to realize savings on infrastructure, which could then be used for the actual training. The MWD, in line with the rest of the government, pursued the policy of making maximum use of existing facilities by avoiding duplication, gaps, and idle periods within the national training system. The MWD, therefore, continues to plan and organize its training programs within the existing national network, utilizing existing facilities at other institutions. Through improvements, improvisations, modifications, additions and extensions to buildings, and training programs within existing training institutions, the MWD has been able to provide both qualitative and quantitative training without having to construct new

facilities. The emphasis placed on on-the-job training and the planned introduction of mobile training units will further ensure decreasing expenses for the infrastructure.

The following are summaries of training programs given within each of the institutions utilized by the MWD for the training of its staff. In addition to the common skills taught at these institutions, the MWD has had specific courses, peculiar to water development, given at the University of Nairobi, the Polytechnic, and the Harambee Institutes of Technology.

### **The University of Nairobi**

This is the highest institution of learning within the republic. It combines both formal education and training and caters to the whole economy. The various courses offered in the Faculties of Engineering and Science are relevant to the water sector's manpower requirements and are regarded as professional training. Courses in civil, electrical, environmental public health, and mechanical engineering as well as chemistry, geology, hydrology, and surveying are offered.

The university is required to produce manpower with motivation and the necessary skills to enhance national development. Certain courses, however, may not be available at the university due to high costs or insufficient demand for them. To overcome this, overseas fellowships and scholarships have been utilized. To meet the requirements of the MWD, for courses in water and sanitary engineering given at the University of Nairobi, the policy of using existing facilities was invoked. This led to the introduction of a special 1 year postgraduate diploma course in water and wastewater engineering. It was made possible through a tripartite collaboration between the University of Nairobi, the MWD, and the Norwegian government through the Norwegian Agency for International Development (NORAD). The undergraduate program of study for the degree of Bachelor of Science (B.Sc.) in civil engineering was examined with a view toward determining its suitability and

relevance to the peculiar needs of water development. It was concluded that the program was too general in nature for the purposes of water development engineering. In its place, a supplementary course in water related subjects, stressing practical application, was recommended. To begin with, a 1 year postgraduate diploma was considered appropriate, with an allowance for future modifications.

This approach can be extrapolated to other disciplines. For example, the need for a similar postgraduate course in hydrology, within the Faculty of Science, was revealed as a result of a review of the undergraduate B.Sc. program offered by the Department of Geography.

### **The Kenya Polytechnic**

This is an institution of further education that caters to people leaving form 4. Before being admitted, trainees must first be employed in industry and commerce in order to obtain employer sponsorship to undertake training programs relevant to their employment. The objective is to acquire relevant skills, thus making the trainees more competent in the performance of their duties. The training programs lead to both professional and subprofessional qualifications.

The MWD utilizes the facilities at the Polytechnic for training its technical subprofessional personnel in selected disciplines. The MWD's trainees attending the Polytechnic must first undergo a 6 month preselection course at the MWD staff training school. Individual preference and performance in the preselection course determine selection and admission to the Polytechnic. Since 1971, the MWD has sponsored students for the following courses: ordinary diploma in water engineering (the first 6 months of this course are given at the MWD staff training school; the remainder at the Polytechnic); building (draftsmanship); science laboratory technician; land surveying; mechanical engineering; motor vehicle technician; and higher diploma in construction (structural engineering).

### **The Staff Training School**

This is the MWD's own and only training institution. It was started in 1965 on a small scale but served the entire public water sector as it was then under the Ministry of Works. It has steadily expanded over the years to its present size and status, with an annual enrollment of 185 into 3 year training programs. The main course programs begin in July of each year, with a common 6 month preselection course.

The school has the responsibility of training subprofessional and technical staff for the MWD. The former, to some extent, is accomplished on an agency basis by the Kenya Polytechnic. The school has trained students from Swaziland, Sudan, and a number of local authorities. Between January and June, in-service, refresher, and upgrading courses are offered. Because the present site has been fully developed and the school still remains overcrowded, plans for the construction of a Water Resources Training Institute on a new site are being developed.

### **The Industrial Training Centres**

These centres implement the national industrial training scheme established under the Industrial Training Act (Cap 237), which regulates the training of apprentices. Its aim is to promote, develop, and regulate systematic and standardized training for apprentices and other indentured learners. It operates on the premise that skills are not inherent but have to be learned. Lack of formal training denies workers the opportunity of acquiring skills to enable them to progress.

Apprenticeship training is designed to provide specialized skills and knowledge geared to the specific needs of the country's industries. It benefits the employer by developing skilled workers; the apprentice by providing the opportunity to acquire the skills necessary for advancement in the trade of their choice; and the country by accelerating its development. The skills acquired under the scheme are relevant and common to many industries. The MWD has utilized these centres without the necessity

of having to request that special courses be arranged.

### **The Harambee Institutes of Technology**

Kenya has a self-help activity called the Harambee movement. It is responsible for a large part of the development within the rural areas. The rural water sector has received double benefits from the movement. Firstly, directly through the construction of self-help water schemes and, secondly, through the movement's latest expression in education in the form of the establishment of a number of institutes and colleges of science and technology, collectively called the Harambee Institutes of Technology. There are 15 such institutes in Kenya.

These offer technical training at the technician and craftsman levels. It has been possible, by the construction of additional facilities through donor assistance, to convert three of these institutes into suitable training institutions for purposes of rural water development. The additional facilities provided by the MWD include hostels, workshops, accommodations for instructors, tools, and equipment. Among the leading donors in this new area of training are the Danish International Development Agency (DANIDA), the Canadian International Development Agency (CIDA), and the Swedish International Development Authority (SIDA). The three institutes will turn out 360 trained water operators per year.

### **The Kenya Water Resources Training Institute**

The manpower projections and surveys already carried out have established beyond doubt that the greatest quantitative training needs are within the subprofessional and technician cadres. The two main institutes for training these cadres are the Polytechnic and the staff training school. They cannot cope with the requirements for operation and maintenance as more complex and larger schemes are completed. To meet this demand and because the MWD's staff train-

ing school cannot be expanded any further, it is planned, through World Bank assistance, to establish the Kenya Water Resources Training Institute on a new site.

### **The Kenya Technical Teachers College**

The need for the training of instructors is obvious. The present staff training school, the proposed Water Resources Training Institute, the on-the-job training, and the proposed mobile training units all need personnel trained in the art of imparting their skills to others. These will be deployed as technical teachers or instructors. The Kenya Technical Teachers College at Gigiri in Nairobi is the appropriate institution for this purpose.

### **The Kenya Institute of Administration and Government Training Institutes**

The above summary has only outlined training programs for technical personnel at all levels. The MWD also needs nontechnical manpower with administrative skills in accounting, personnel, supplies, clerical, and secretarial duties. Even technical officers who occupy supervisory and managerial positions need training in administrative skills.

The Kenya Institute of Administration at Kabete is the main government institution responsible for the training of top executives and middle cadre administrative staff. Two government training institutes at Maseno and Mombasa and a secretarial college at Nairobi cater to the other cadres.

### **Overseas Fellowships**

It is Kenyan government policy to train locally within the Kenyan environment in order to give training a practical orientation and relevance. As stated earlier, however, certain courses may not be offered locally. This necessitates overseas training. Sanitary engineering is a case in point where the MWD has to seek overseas fellowships. However, unless donor sponsorship is forthcoming, this type of training, because of the expense involved, must be reduced to

the very minimum and cater to qualitative training only.

## **Towards a New Philosophy on Training**

### **Manpower and Water as National Resources**

Human beings and water are both taken for granted, yet they are also the two most valuable resources in any nation. Total absence of either can bring to an abrupt end the processes of development, civilization and life itself.

The achievement of national development is not conditioned by the endowment of natural resources and capital only. The availability of manpower with appropriate skills and attitudes to exploit and convert these resources effectively for the national benefit is an imperative condition. Training, therefore, concerns itself with this very important process of imparting and developing the appropriate skills in individuals to enable them to perform tasks related to national development. With regard to national development, training should be viewed as the development of the most important national resource, the human resource. The developed manpower becomes a tool or agent for other development efforts. Manpower training should, therefore, take on a new meaning and a new rating value. For the individual, training is the method and means by which one's potential can be developed to the fullest extent.

Water, on the other hand, is the forerunner of development. Human activities, in a given setting, presuppose the availability of sufficient and reliable supplies of water of good quality. Training for water development should be given a high priority rating in the allocation of national resources for development. This will ensure its availability both as a catalyst and as a factor of development in other fields of human endeavour.

## **Training Programs and Organizational Climate**

There is a growing awareness and acceptance of the need for comprehensive and enhanced training programs. Such programs must be multifaceted and multiphased, covering all levels of specialization from craftsmanship to professionalism. It is important that skill levels be advanced on all fronts so that progress in one sphere is not negated by the inability of other spheres to adapt their activities to changed conditions. The needs of organizations change; technologies change also. In this process, training must be a continuous activity lasting an entire career. It will normally start with induction; continue with on-the-job instruction; and should, from time to time, include specifically designed courses to meet increased responsibilities or adaptation to new technologies. It is at this juncture that training for rural water supply differs from urban water supply in the need for orientation towards, and emphasis on, simpler and cheaper technologies contrasting with the sophistication of urban water supplies.

It should be policy to employ people in meaningful work that provides motivation, challenge, and an opportunity to develop by offering well-defined opportunities for advancement. This requires hiring and promoting individuals on the basis of talent and competence. It also requires providing relevant training opportunities at the appropriate time so that advancement becomes reality, and when one still has much of their working life ahead of them. It contrasts sharply with a situation where training is merely part of employment. Thus, organizations must be flexible, up-to-date, and capable of planning for change. The chronic shortage of particular skills in a given organization may be attributed to the inadequacy of the organization itself. Although the fact of a nationwide shortage of skilled manpower is recognized and accepted, it is the duty of each organization

to strive to make itself competitive in attracting and recruiting whatever scarce manpower is available. It should be noted, however, that it is one thing to recruit, but quite a different thing to retain the recruited manpower. Here, the organizational climate and conditions of service are critical. The challenge facing training for rural water supply is whether or not trained manpower can be retained in a rural working environment when the urban environment can offer more attractive working conditions, e.g., better salaries, housing, education, and health facilities.

## **Conclusions**

The purpose of this paper was to advocate "low cost" as a major objective of planning and organizing training for rural water supply. The Kenyan method is an example of one way the objective can be achieved. It makes maximum use of existing facilities within the national training network, thereby reducing expenses by avoiding creation of new training facilities within the infrastructure. Implied in this is the sharing of common facilities among sectors, which can be extended to an entire region. Infrastructure in this context means and includes physical facilities and training aids or materials. Training programs, course structures, and contents are conditioned by the anticipated working environment. These include the equipment and technologies used. Thus, the author's advocacy for low cost or reduced expenses on training infrastructure applies equally to low-cost technologies for rural water supply.

The low-cost objective, by saving on expensive infrastructure, allows scarce financial resources to be used on the training itself. Lastly, a resource that is often overlooked, but is used effectively in this approach, is that of time. Through the use of existing facilities and instructors, the delay in implementing a training program, while facilities are being constructed and instructors are being trained, is avoided.

## Proposed Curriculum for Rural Water Supply Personnel

J. Kuthemba Mwale<sup>1</sup>

This paper will discuss the need to train rural water supply personnel, the content of the training program, methods of teaching and evaluating the training, and the resources required for carrying out the training program.

The countries participating in this workshop have identified the need to provide trained and competent personnel to cope with the problems associated with rural water supply. Manpower surveys have been used to establish whether or not a training need exists and, if so, the nature of training required, i.e., training additional personnel or upgrading the skills of existing personnel.

Contact and routine consultation with other countries and organizations helps individual countries to realize the training needs of their rural water supply personnel. The type and level of training required by water supply personnel can constitute a problem for developing countries. Three types of training have been identified: basic, in-service, and advanced.

Basic training is that training tailored specifically for new recruits in the profession. It should include orientation to the trade, basic knowledge of rural water supply systems, their maintenance and care, and an elementary knowledge of the structure and organization of the rural communities within one's country.

After individuals have gained some confidence in their job, in-service training should begin. Such training should teach the individual how to resolve problems encountered in the field and how to operate efficiently.

Advanced courses should be designed for those people who have proved themselves efficient at their job and show promising abilities that could be developed through an advanced training course.

The three existing levels of rural water supply personnel are field assistants, field officers, and engineers. The basic training discussed above should be given to all of these groups but at different levels of difficulty.

The field assistant is the front-line worker who transfers the technological information from the engineers to the users in the rural community. For this reason, field assistants should have some knowledge of the structure and organization of the community in which they work, in addition to their technical skills.

A field officer supervises field assistants in the process of transferring technological information and, therefore, must be able to construct and operate the rural water supply systems. The field officer is the middleman between the engineer who designs the water supply systems and the field assistant who brings technological information to the users.

The engineer is a professional officer and decision-maker, who is at the top of the

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hierarchy of water supply personnel. The engineer should be competent in designing water supply systems and supervising their implementation through the technical officers. Knowledge about the rural community would help the engineer to understand why some projects or schemes are resisted and others are accepted.

The Department/Ministry of Water Affairs should be directly responsible for all training of rural water supply personnel, whether the training is provided within or outside the country. Training centres should pool all available information on shallow wells, boreholes, pumps, and all other aspects of rural water supply. This would provide trainees with a broad knowledge of water supply systems, thereby enabling them to utilize their country's resources to the fullest extent. An awareness of successes or failures in other countries may also be of benefit when organizing water supply programs.

The content of the training courses and how they should be taught are areas of great concern. Rural water supply personnel should be taught design, construction, and maintenance of water supply systems. Because water supply is a very technical area, such subjects as natural sciences, mathematics, geography, earth sciences, meteorology, and biology could be relevant.

Organization, management, and some personnel training and supervision should accompany the technical training. Organizational training includes the art of administering staff and equipment and a knowledge of the individual's place and role within the organization. Management and personnel training provides information on handling, understanding, and placing junior personnel in suitable and appropriate positions and recommending them for promotion or dismissal when the occasion arises.

It is felt that some knowledge of rural community structure and organization should be included in the curriculum. Such knowledge will help the rural water supply personnel to feel comfortable among the rural people with whom they will work. The rationale behind this is that one can

positively influence others more easily if they are able to identify with them.

The question of how the curriculum should be taught, however, remains unanswered. One method would be to teach theory in the classroom and practical application in the field and in workshops. The exact proportions of time devoted to theory and to practice would depend upon the level of the personnel and the type of training. For example, more time would be devoted to the theory required for basic engineering training than that required for a field assistant.

Workshops, seminars, and relevant discussion meetings should be encouraged as a productive method of teaching. Students have often indicated, for example, that they pick up more information during such sessions than from classroom lectures.

Staff motivation should be a built-in mechanism that should not only keep people on the job but also encourage them to be efficient, competent, and productive. Some motivation techniques that have been suggested include accrediting all courses of training that an individual undergoes, monetary incentives, improved status, and increased responsibility. It should be possible, for example, for individuals to move from the technical assistant level to a higher level when all that is required is for them to prove that they are capable of being trained to fill the higher position.

Training programs can be realized only when there are adequate resources. These resources include qualified instructors; suitable equipment and materials, such as buildings and machinery; and enough funds to finance the training program. It has been pointed out earlier that the responsibility for training should fall in the hands of a national body that deals with water affairs. This does not mean, necessarily, that such a body will meet all of the needs or assemble all of the resources required for the training.

In such a case, outside organizations may be of assistance to training programs. Through interregional cooperation such organizations guarantee exchange of personnel, experience, and other resources.



Finally, methods of evaluating training programs, beyond examinations based on course content, must be considered. Evaluation of a training program should also involve the graduate's needs and level of development. This will reveal whether or not adjustments or changes are necessary in the training program.

There should also be an evaluation of the community's response to the products and how, in their view, the training course should be run. This should be followed up

because it may provide feedback that may reveal some of the weaknesses and strengths of the curriculum and the teaching methods.

In conclusion, this paper has attempted to provoke some thought on the question of a curriculum for a rural water supply training program. The curriculum and methods of implementation proposed herein, and the questions raised and suggestions offered are intended as guidelines to encourage the development and implementation of better curricula.

## **Training of Workers for Piped-Water Schemes in Malawi**

**H.R. Khoviwa<sup>1</sup>**

Malawi is blessed with abundant water resources. The average rainfall is 1145 mm, ranging from a minimum of 635 mm, to a maximum of 2896 mm. Runoff averages 17 percent, and gross water availability, based on a population of 6.0 million, is estimated at 9000 litres per capita per day. Water supply during the dry season (May–November) is eased by natural storage provided by lakes, swamps, and dambo areas. Several major rivers and numerous mountain streams flow year-round. Malawi is, therefore, in a favourable position, in terms of available water resources, to respond positively to the challenge of providing clean water and adequate sanitation.

Malawi has made remarkable progress during the past several years in providing safe water supplies to the rural population. The sources of supply are piped-water (gravity) systems, protected shallow wells, and boreholes. Piped-water systems offer the most convenient service because water is provided through multiple communal taps.

### **Organization**

The rural piped-water program is administered and technically supported by the Rural Water Supply Section (RWS) of the Department of Lands, Valuation and Water (DLVW). It is implemented by extension workers and self-help labour. The

extension workers consist of 60 water foremen and water operators who are, in turn, supervised by the regionally-based project engineers. The levels of supervision are office staff, headed by the principal water engineer of the RWS; and field staff, consisting of the project engineer, water supervisor, water assistant, water foreman, water operator, and village-level self-help labour.

The actual number of water assistants, foremen, and operators assigned to a region at any one time depends upon the number of rural piped-water subprojects being implemented in that region. The field staff, consequently, is transferred from region to region as required.

Ten trainees are recruited annually, and employed at the lowest level of water operator (ungraded). After an initial interview, trainees are given a combined selection/training course for 2 weeks. Once selected and employed, water operators can be promoted to increasingly higher ranks (up to the rank of water foreman) by completing 1–3 years of on-the-job training and attending upgrading courses offered at the Ministry of Works and Supplies (MWS) training centre at each level. The best and the brightest of water foremen, in turn, can then be promoted to the highest ranks of field and head office staff.

The self-help labour concept advocates that the communities served should be involved at every stage in the development process. The members of the community should regard the project and the resulting

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supply as their own and should be motivated to build and maintain it accordingly.

This is achieved through Malawi Congress Party and government leaders meetings with the prospective users to determine their collective wishes and commitments. Thus, from the time of identification of a suitable project, with respect to the supply areas, the local people participate to the fullest extent of their capabilities until the completion of the project.

## **Training**

Training in the gravity scheme is carried out at three levels: the technician, field assistant, and user levels.

### **Technician Level**

Students graduating at the diploma level of engineering from the Polytechnic, one of the colleges of the University of Malawi, have been trained for 3 years in civil, mechanical, and electrical engineering. Graduates taken into piped-water schemes to fill the position of water supervisor are those who have specialized in civil engineering.

The new graduate undergoes a 2 week induction course and then is sent to supervise an on-going project. Here, the graduate will work closely with the project engineer who designed the project to implement the design. This involves supervising the construction of the intake weirs and the sedimentation and storage tanks, and the laying of the pipeline to the distribution tanks and villages. This requires working closely with the field assistant who translates instructions into a properly constructed design. After 6 months of on-the-job training, the trainee is given a project to design and execute.

### **Field Assistant Level**

The field assistant is taken from the junior certificate level of secondary education, after 10 years of education. His position in the scheme is that of a water operator. Ini-

tially, the field assistant is assigned to an experienced field assistant and only when the trainee proves competent is he given a project to work on independently. If, after independent project work, the trainee continues to exhibit competence, he may be promoted to the position of water foreman or water assistant.

Because the success of the project depends upon community input as well as proper engineering design, the field assistant's role of linking the people to the engineers is one of the most important in the project. The field assistant is trained for 2 weeks in aerial photograph interpretation, map reading, community organization, and leadership in preparation for both the technical and social aspects of the job. In the field, the field assistant is expected to convene meetings for the community, organize the community into action committees, mark out the network of pipelines on the ground, mobilize the community through the action committees to dig trenches for the pipeline, and at the same time supervise the digging itself. Here, the field assistant's job training includes use of various types of tools and how to work with different types of pipes.

### **User Level**

When a project is planned for an area, the local leaders are approached to assess and encourage their willingness to participate in the project to improve their water supply. The leaders approached are the chief and the chairman of the local Malawi Congress Party branch, who are the key people in any village. These leaders work closely with the field assistant who starts teaching them community organization. The leaders are asked to call meetings at which the field assistant can acquaint the community with the aim, scope, and logistics of the project. At this stage, the community must be convinced enough of the ease of water collection and health benefits that the project will bring, that they will be motivated to join in the project work. Village committees and committee leaders are then selected. They decide within the limits imposed by technical needs, the water-

point sites and, hence, the pipe routes, and they provide the unskilled labour, such as pipe trenching and sand collection for the installations.

For the overall project, there is an elected committee which organizes the labour and within this there are area or village groups with their own specific tasks and programs. The work is supervised by trained government officers and assistants.

Upon completion of the project, the committees are instructed in the simple requirements of maintenance and are then expected to carry out their own maintenance, except for occasional visits by the department's area supervisor or when emergency assistance is required (e.g., damaged intake).

### **Problems and Recommendations**

The basic problem with training at all levels, except the users' level, is that too

much must be learned on the job, which reduces both learning and job effectiveness. Formal training by the organizers of the project is quite intensive, but it still does not provide enough time to prepare for the varied roles to be played while in the field. In particular, the field assistant's formal training is inadequate for the technical work given to him by the technician. The field assistant must be able to explain and demonstrate the work to people with absolutely no technical training.

It is recommended that the RWS produce a training manual to expand and standardize training at all levels, as well as to underline the responsibilities of each position.

A group of employees needs to be incorporated into the organization to monitor and assess the effectiveness of the completed scheme on a continuing basis. This would provide more reliable maintenance, repairs, and information for the improvement of future schemes.

## **Views About Water Supply and Training at the Department of Water Affairs, Botswana**

**Gilbert J. Maikano<sup>1</sup> and Lars Nyberg<sup>2</sup>**

Botswana is a country where no perennial lakes exist. In the eastern part of the country, all of the rivers are ephemeral in nature and flow only after heavy rains. Flooding is erratic and during some years there are no floods at all. The seasonal flow of these rivers, however, provides a good source of recharge to the sand deposits of the riverbeds and to the dams, which are utilized as a source of water for urban centres in this part of the country.

In the northwestern part of Botswana, the Okavango delta surface water is readily available. In the largest part of the country, the Kalahari Desert, there is virtually no runoff and there are no rivers or lakes, apart from pans containing water temporarily. Any rainfall in this area would either be absorbed by the Kalahari sand or it would evaporate. It has been estimated that plant roots can reach most of the water retained in the sand (due to high capillarity) and groundwater would, therefore, not be replenished, except locally and infrequently.

There is a long-standing tradition of keeping cattle by the Tswana people. The environment in Botswana is well suited to raising cattle and there are few diseases which restrict or limit production. With a small human population of approximately 850 000 inhabitants and a proportionally large cattle population of over 3 million, the

export of beef is very important (approximately 25 percent of national exports).

Essentially, most families have three places of residence: the home village, the lands area, and the cattle post. The lands area, usually situated several hours walk from the village, is where the farmer grows his crops. The cattle post may be situated several days walk from the village and is often far into the Kalahari Desert. As the name implies, the cattle post is an area where the cattle are kept and is located near a borehole.

### **Water Supply**

There are about 5000 registered boreholes and perhaps another 2000 unregistered boreholes. The average depth of a borehole is about 100 m and often boreholes are 150–200 m deep. It has been estimated that 75 percent of human population and livestock are dependent upon groundwater. In rural areas, all water supplies are dependent upon groundwater.

Initially, drilling of boreholes was carried out by the Drilling Branch of the Department of Geological Surveys in Lobatse. This branch was drilling for both government and private organizations. Because it could not keep up with the number of boreholes required, some private farmers decided to employ private drillers, mainly from South Africa. In most cases it was found that these farmers were cheated

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by the drillers, who did not file their "completion certificate" and did not send samples of the aquifer material to the geological survey for analysis. They inconvenienced the government by not forwarding information of the geological formations of the areas they were drilling in and cheated the farmers by giving them false results of the well yield. In many cases the boreholes went dry. This was all due to a lack of facilities in the government sector to meet drilling demands. As facilities were improved, however, private drilling was discouraged. At present, there are still some private drillers but they are well monitored by the Drilling Branch, which is now part of the Department of Water Affairs.

Today, drilling is carried out by the Drilling Branch mainly for rural water supplies. It follows the design and construction methods developed by the Department of Water Affairs. All of the rural areas are under the supervision of district councils, except for major villages. The projects are classified into three divisions, i.e., WB17, major villages, run by the Department of Water Affairs after completion; WB26, rural water supply for populations of between 500 and 5000; and WB30, small villages with populations of less than 500. The WB26 and WB30 projects are run by the district councils after completion. The district councils also provide private connections at a fee of P110 (U.S.\$150) and a meter charge of about 50 thebe (U.S.\$0.70) per cubic metre; checked at monthly intervals.

## Training

Within the Department of Water Affairs there is a Borehole Repair Service Division (BRS). This division is a service organization for both district councils and owners of private boreholes. The repairs and overhauls of diesel engines are extremely centralized. Steps are now being taken to begin decentralization. Considering that there are 29 different kinds of diesel engines in operation and also a variety of pumps, highly qualified borehole mechanics (field

assistants) are needed. Unfortunately, there has been no training of borehole mechanics since 1975, except for a short course carried out recently. There is also a need to train pumpers. With 7000 boreholes, there are perhaps 7000 pumpers in Botswana; most of them illiterate. The original intention was that borehole mechanics would train pumpers, but this has failed to materialize.

Since 1975, almost all training within the Department of Water Affairs has been at the technician level. One course for civil engineering technicians (3 years duration) and one course for hydrologists (2 years duration) have been carried out. Two courses for drilling foremen (5 years duration) are currently in full progress and another course for civil engineering technicians is planned to start in 1980.

The civil engineering technician course given between 1975 and 1978 was the first technical course of its type given in Botswana. The course was divided into four parts: preselection period (theory) (1 year); on-the-job training (1 year); revision course (0.5 year); and specialization course (0.5 year) and was conducted to meet the needs of the Department of Water Affairs. Upon completion of the course, the 11 candidates were posted in the Design Section, Water Pollution Section, Water Supply Division, and Water Law Section of the Department of Water Affairs. At present, four of the graduates, who were awarded scholarships, are studying abroad to obtain a Bachelor of Science in civil engineering.

Since 1979, there has been a Polytechnic in Botswana. The Polytechnic is conducting City and Guild's courses. There are now 17 trainees attending from the Department of Water Affairs, all of them studying mechanics. There is still no civil engineering course available. Botswana has no university of technology.

It seems to be difficult to apply low-cost appropriate technology in Botswana with regard to water supply. However, the Department of Water Affairs has recently bought 8 windmills and 20 handpumps (gasoline pumps). There is no doubt that problems with repairs to diesel engines are considerable. Today, two-thirds of all diesel

engines are sent to the Republic of South Africa for overhaul and repair. Hopefully, appropriate technology together with more training are the tools required to eliminate this situation.

### **Conclusions**

With regard to water supply, it should be noted that Botswana is a large country with a small population, a large number of cattle, and limited water supplies. It has a tripartite system of rural life that has been forced to

use advanced technology for water supply. In spite of a high potential for industrial development, based on an abundance of mineral resources, there is a considerable lack of technicians and engineers. This has resulted in an economic and technical dependence upon the Republic of South Africa. In an effort to become more self-reliant, Botswana would be interested in sending trainees to other countries such as Ethiopia, Kenya, Tanzania, Malawi, and Swaziland to develop the technical skills they require.

# Training of Water Technicians in Tanzania

M.M. Kivugo<sup>1</sup>

Training of water technicians in Tanzania started a long time ago in the form of on-the-job training. In 1957, a small group of in-service trainees was selected to undergo short courses related to water resources development. Subjects taught included mathematics, building construction, technical drawing, surveying, river gauging, irrigation, and water supply.

In 1971, the Government of the United Republic of Tanzania decided to embark on a 20 year program of rural water supply; envisaging supplies of clean and potable water within easy access to every Tanzanian household by 1991. (Tanzania was, thus, a decade ahead of the United Nations Water Decade.) The execution of this massive program of water-supply schemes demands a vast force of technical manpower, the bulk of which is made up of middle-level technicians. In order to create this category of technical manpower in a relatively short time, the Water Resources Institute was set up in 1974, under the Ministry of Water, Energy and Minerals.

## Development of the Water Resources Institute

With the completion of the first few buildings in 1974, the institute commenced with an initial enrollment of 32 students in that year. As further construction of classrooms and hostel facilities continued,

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the yearly enrollment increased to 62 in 1975, 82 in 1976, and has continued at the equilibrium level of 120 since 1977.

Although the institute has been serving, essentially, national needs, the interests of neighbouring countries are not forgotten; as evidenced by the fact that 12 students from countries outside Tanzania have, so far, been admitted to the institute (one from Botswana in 1975, two from Sudan in 1976, and nine from Burundi in 1979).

The present objectives and functions of the institute can be summarized as follows: (1) to conduct training programs leading to the full technician certificate in water resources engineering, with particular emphasis in hydrology, hydrogeology, and water supply; (2) to arrange and provide opportunities for ministerial in-service and upgrading courses; (3) to act as ministerial examining body for various courses conducted by the regional water engineers in the country; (4) to arrange and provide facilities for seminars and conferences on matters related to water development; and (5) to provide consultancy services to the different technical departments of the ministry and other interested national institutions as required.

## The Full Technician Certificate Training Program (FTC)

The institute offers a 3 year, full-time, residential course leading to the full technician certificate in water resources engineering. To qualify to join the institute



directly from school, a candidate must pass the national form IV examination or equivalent and have credits in mathematics, physics, and chemistry and/or engineering subjects. Special entrance arrangements do exist for employees of the Ministry of Water, Energy and Minerals.

The course combines theoretical instruction, laboratory, and practical work as well as on-the-job training (field training). Each academic year consists of three terms: the first term runs from mid-May to the end of July, the second term from the beginning of September to the end of November, and the third term starts at the beginning of January and continues to the end of March. The first 2 years of the present FTC program deal with basic subjects in civil engineering, with the third year providing more specialized training in subjects dealing with water resources engineering, centring primarily on hydrology, hydrogeology, and water supply. In the second term a period of 17 weeks, beginning in August and continuing until the end of November, is spent on intensive practical on-the-job training in the field, under the direct supervision of the regional water engineers. The field training is an integral part of the curriculum of any engineering course and, therefore, cannot be overemphasized. A system of close liaison between the institute and field staff of the ministry has been developed for the purpose of this program through field visits by institute staff. In the third year, a period of 4 weeks at the beginning of the third term is allotted for students to work on practical project assignments, either individually or in small groups.

Upon graduating from the institute, the graduates are absorbed essentially as senior water technicians into the water sector of the Ministry of Water, Energy and Minerals. Graduates who have taken the works option (water supply) are deployed to work on investigations, design, construction, and operation and maintenance of water supply schemes; those with the hydrology option work on hydrological problems as well as meteorological data observation, collection, compilation, and analysis; and those who

have taken the hydrogeology option work on exploration for groundwater and drilling and construction of wells.

In 1977, the institute took another step forward by introducing a 3 year laboratory water technician course, with an annual maximum enrollment of 15 candidates. Entry requirements are the same as for the FTC course. Upon completion of the course, the graduates are posted as senior water technicians in charge of water quality testing at major water supply plants within the country. They will also man proposed zone water laboratories.

### **In-Service and Upgrading Courses**

The institute also runs short-term in-service courses for craftsmen. Such courses include draftsmanship, surveying, motor and pump mechanics, building construction, and drilling and well construction. The institute will be able to handle at least 60 candidates in this program at any given time. Course duration varies from 1-6 months. More in-service and upgrading courses are conducted during the period when the FTC students are away, undergoing fieldwork or during vacations.

### **Review and Verification of Regional Training**

To facilitate the in-service training programs of the ministry, regional on-the-job training is encouraged. An on-the-job training syllabus for water technicians has been worked out. The institute coordinates the program for training craftsmen in different trades such as carpentry, masonry, plumbing, and pump mechanics and carries out periodical evaluation of the courses.

### **The Curricula**

As mentioned earlier, the teaching program consists of a common core of basic science and civil engineering subjects during the first 2 years, followed by branching out

into the three options in the third year, i.e., civil engineering works (as applied mainly in water-supply schemes), surface-water hydrology, and hydrogeology (groundwater hydrology).

The present curriculum, worked out in 1974, is an adaptation of the courses required for the full technician certificate at the Dar es Salaam Technical College, which itself was patterned after the curricula of the City and Guilds Institute, London.

The relative proportion of students allowed to choose the works, hydrology, and hydrogeology options is maintained at 50, 25, and 25 percent respectively; roughly based on the demand for technicians in these disciplines under the ministry.

The institute is presently busy trying to review the current training program. It is felt that some courses, particularly the course for the hydrogeology option, are unbalanced, with as much as 70 percent of the total time devoted to the study of civil engineering subjects, whereas hydrogeology and related subjects make up only a small part of the overall program. Tentative proposals for a revised curriculum have already been worked out. Under the new proposals, the hydrogeology option is separated from the other options in the first year, whereas the branching out of the other two options takes place at the end of the second year of study as at present. The subjects, their relative emphasis, and the sequence in which they are taught are all sought to be modified so as to make the whole program more intensive and effective.

## Program Features

The Water Resources Institute in Dar es Salaam is the only institute in Tanzania providing facilities for training technicians in water resources. It is directly administered by the Ministry of Water, Energy and Minerals and functions as a centre for producing middle-level technical manpower for the ministry. Candidates, once admitted into the FTC course, are, effectively, employees of the ministry, with the exception of students from outside Tanzania. At the same time, the FTC course of the institute is recognized by the Ministry of National Education and the final examination for the award of the certificate is conducted and evaluated by the National Examination Council.

As the preservice training centre of the Ministry of Water, Energy and Minerals, it is the duty of the institute to offer a program which imparts enough theoretical knowledge to the students while preparing them fully for the practical skills that will be demanded of them when they enter service as technicians of the ministry. On the other hand, as an instrument of national technical education, the institute has not only the responsibility of producing technical manpower suited to national needs, but also of promoting technical education per se; in other words, of making the training program a link between secondary school and university levels of technical education, so as not to deny opportunities of advanced education to students.

# **Training Program for Technical Officers in Malawi**

**G.A. Kamwanja<sup>1</sup>**

The aim of this paper is to try to identify the specific training programs or curricula necessary to train the intermediate engineer, of the technical officer grade, in the rural water supply program in Malawi. It cannot be emphasized enough that developing nations must take great interest in the development of the rural population in order to ensure an even distribution of development throughout the country.

## **Sources for the Recruitment of Intermediate Water Engineers**

If any training program is to be successful, it is essential that an appraisal be made within the country concerned of possible sources of manpower supply, i.e., schools and colleges from which interested agencies can recruit trainees for their courses.

After completion of secondary education in Malawi, students attend the University of Malawi to study subjects such as technology and business at the Polytechnic; agriculture in Lilongwe; and education, arts, and science in Zomba. It would seem inevitable, therefore, that any organization wishing to recruit and train water engineers should look upon the Polytechnic as its primary source of recruits. The students attending this college pursue a general diploma course

in engineering, with emphasis on electrical, mechanical, and civil engineering. Courses leading to a degree in engineering were started at the Polytechnic in October 1980.

The proposed training program is based on the understanding that the hierarchy of the engineering structure is such that at the top is the water engineer, of professional level; followed by the assistant water engineer, of technical officer grade; technical assistants; and the users. The training envisaged here is, therefore, that of the technical officer who once trained will supervise and work with technical assistants in the execution of designated projects, and at the same time will assist and train the users in maintaining the water supply installations after the completion of the work.

To ensure that a minimum of wastage is experienced during and after training, the prospective candidates should be recruited on a trial basis before starting the actual training. Those students showing potential for further studies after training should be encouraged and opportunities should be made available for further training to the professional level.

## **Training Objectives and Staff Development**

The training objectives should reflect the basic established policy, i.e., to provide the rural population with potable water. Such

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training should be geared toward learning the principles that will enhance the desired goals. The training of engineers should satisfy the following broad objectives: (1) At the end of the course, the students should be able to apply the principles related to water supply with the appropriate technology to suit a particular environment. (2) They should be able to plan, manage, and liaise with staff at the junior level and with the users in the care and maintenance of the water supply.

Depending upon the extent of the training program envisaged under the rural development program, it would seem economical in the long term to establish a National School of Water Engineering, under which the nation would pool together all of its water resources personnel and expertise to develop and train students for involvement in the program.

It would be difficult for the Polytechnic to incorporate water-supply courses under the present diploma scheme without jeopardizing the character of the present course, which is general in nature. Furthermore, this would set a precedent for other departments to seek such special treatment. Certainly, the expertise available within the Polytechnic should be utilized, perhaps through the presentation of special courses at seminars, specifically arranged to cater to specialist groups.

Due to a shortage of trained personnel, local residents with previous knowledge in water supply should be recruited as field instructors; the advantage being easy communication, particularly when dealing with the users.

### **Criteria for Choosing Appropriate Technology**

Today, one finds arguments throughout developed and developing countries about what is good for the developing nations insofar as technology is concerned. Some people still argue that teaching in developing countries should be geared toward those subject areas that are relevant to the country in question. Although this is true to some

extent, one still finds that there comes a time when the rudimentary technology becomes inadequate, perhaps due to the fact that it cannot meet the demands put upon it, and as a result an advanced technology must take over. Because of this, it is important that the intermediate engineer be knowledgeable in modern technology on the one hand, and the local technology on the other.

The concept of applying principles learned in one subject area to new situations implies that the subjects taught to technical officers should be broad in nature.

The following guidelines could be used when discussing appropriate technology for the rural water supply program: (1) the choice of technology should be one that would facilitate a significant improvement in the quantity of water; (2) the technology should be as low as possible in cost without jeopardizing the effectiveness of the improvements sought; (3) the technology should facilitate operation and maintenance by users without demanding a high level of technical skill; (4) the technology should make as much use as possible of locally available materials, thereby decreasing reliance upon imported materials; (5) where possible, the technology should encourage the growth of local manufacturing of necessary equipment and parts; (6) the technology should be compatible with local users' values, attitudes, and preferences; and (7) the technology should encourage and facilitate community involvement and participation.

### **Maintenance Centres and Users' Guide**

It is generally found that many self-help projects fail in developing countries after they have been completed, mainly because of a lack of commitment on the part of the users to report any problems that arise. As a result, completed projects deteriorate and fail, making the whole exercise a waste of time and resources. It is, therefore, suggested that the Department of Lands, Valuation and Water should consider the idea of dividing each district into centres and

at the same time seek to employ someone from the user groups. Such a person would be indentified from the action groups as reliable and would have worked together with the technical officers and assistants, as well as other local personnel on the self-help basis, throughout the entire project. This person would be left with a small workshop facility and maintenance tools, such as spanners and pipes, and would be responsible for dealing with any problems reported by the users within a given area. Depending upon the gravity of the problem reported by the users, this person would be responsible for referring the problem to the district water department office.

### **Syllabus**

The following syllabus is suggested for a 1 year course in rural water supply engineering. The course is divided into three modules of 4 months duration, with the first module being conducted in the classroom, the second module in the field, and the third module in the classroom again.

The full-time period in the field is incorporated into the course in order to give the student first hand on-site experience and at the same time give the student an opportunity to learn and to try to identify problem areas within the existing system in hopes of improving the system for the future.

#### **Module One**

The topics covered in module one include: the importance of water to humanity; sources of rural water supply (sources of water supplies in Malawi include gravity-fed systems, boreholes, and shallow wells); feasibility studies; information analysis and recommendations; water installation systems for natural gravity systems and pressure systems; and types and principles of operation of pumps

#### **Module Two**

For the duration of the second module the student is assigned to a work project in order to gain practical on-the-job experience.

#### **Module Three**

The topics covered in module three include: water treatment methods, i.e., removal of minerals and odours and the addition of water softeners; sedimentation techniques; sand filtration; care and maintenance of water systems; public health as related to water supply; project planning and management; resource selection and allocation; and public relations and government procedures, including government regulations and conditions of service; project reporting and communication; education for users; and organizing rural projects and the importance of local party leaders in community development.

# The International Water Technician's Course, Swaziland College of Technology

**M.R.Z. Ntshangase<sup>1</sup>**

## Origin and Development

The international water technician's course was first established in 1976 at the instigation of the general director of the Water and Sewage Board in Mbabane, with the objective of providing staff with a basic all-around knowledge of public health, with specific emphasis on water- and sewage works. Since then, the course has become an integral part of the program offered by the Swaziland College of Technology in Mbabane, thus allowing full advantage to be taken of the facilities offered by other departments and sections on the campus. Moreover, strong support has been received from the World Health Organization and some development agencies since the establishment of the course.

Initially, it was thought that the course (of 4 years duration) would consist of 2 years of theoretical training separated by a period of 2 years of practical work in the water branch. Although only the first year of theoretical training (part I), has been given to this point in time, it has been decided to reduce the interval for practical training to 1 year, so as to provide sufficient time for the practical training without adversely affecting the continuity of the theoretical content of the course. At the beginning of the 1981 academic year, the second year of theoretical training (part II) is expected to

start for the first time.

Since its beginning, the course has been attended by students from Botswana, Lesotho, and Swaziland. The designation of 1981-1990 as the "International Drinking Water Supply and Sanitation Decade" by the United Nations will certainly promote the success of this course.

Table 1. International water technician's course curriculum.

Subject	Part I	Part II
Mathematics	•	•
Hydraulics	•	•
Chemistry	•	
Biology	•	
Water and sewage technology	•	•
Distribution and collection	•	
Drawing	•	
Design		•
Laboratory practice	•	•
Mechanical operation and maintenance	•	•
Electrical operation and maintenance	•	•
Building practice	•	
Plumbing	•	
Surveying (land)		•
Management and administration	•	•
Measurement and specification		•
Hygienics and first aid	•	

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## **Objectives of the Course**

The original objective of the course, as mentioned above, has not changed. The course is expected to prepare staff for progression to middle-level posts in the water industry, i.e., assistant waterworks operators; waterworks and sewage-works operators in charge of plants with conventionally designed treatment; supervisors; inspectors of works; and clerks of works. Table I indicates the courses given to prepare the students for these positions.

## **Admission Requirements**

The minimum requirements for admission to the course are a Cambridge overseas school certificate (COSC) or equivalent, which includes courses in chemistry, biology, and mathematics; a City and Guilds of London Institute (CGLI) certificate in general construction; or a

special recommendation by the sponsoring organization.

## **Examinations, Promotion, and Award of Diploma**

Students' progress and levels of achievement are assessed on the basis of individual assignments and written examinations throughout the course. In addition, reports are requested from the employers to which students are assigned during the practical period. These reports are taken into account in the overall assessment of the students' progress.

Promotion to part II of the course is subject to the satisfactory completion of both part I of the course and the practical period.

To qualify for the award of the diploma, students are required to complete the entire course, including the practical period, to the satisfaction of the authorities of the Swaziland College of Technology.

# Training of Civil Engineers in Kenya

J. Gecaga<sup>1</sup>

The Department of Civil Engineering is one of the oldest departments within the University of Nairobi, with records dating back to 1956, when it was then part of the Royal Technical College of Nairobi. The 3 year Bachelor of Science (B.Sc.) program that is offered forms part of the professional engineer's education (which consists of a university course plus 3 years or more of apprenticeship and training). A B.Sc. is the basic acceptable academic qualification required for registering as a graduate engineer with the Kenya Engineers Registration Board. The industrial training of graduate engineers is carried out by industry. The primary employers of civil engineering graduates include the Ministry of Works; the Ministry of Water Development; municipalities; and consulting and contracting firms. Since the establishment of the degree course, the department has produced over 600 graduates up to 1979; over half of them Kenyans. The current average annual output is between 50 and 60 graduates.

Due to an acute shortage of specialists in the fields of water supply and sewage disposal, the department has embarked upon the following postgraduate programs: a Master of Science (M.Sc.) program in environmental health engineering and a postgraduate diploma program in water and wastewater engineering. Postgraduate work in other areas has been carried out mainly through research and the writing of a thesis.

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Several postgraduate programs involving coursework, examinations, and preparation of a thesis are planned for the future in other disciplines.

This paper will examine some of the design criteria and constraints in the development of civil engineering training programs in developing countries, with particular reference to Kenya. Emphasis will be placed on the training of professionals in the fields of water supply and sewage disposal.

## Undergraduate Curriculum

The design of undergraduate engineering curricula has received considerable attention within Europe but there appear to be few criteria for the design of curricula within developing countries. If curricula are designed on purely educational criteria, then little attention need be paid to any difference that may exist between industrialized and nonindustrialized countries. If, however, engineering graduates are expected to play a major role in the technological development of developing countries, then curriculum design must be subject to engineering as well as educational criteria. Thus, it is important to examine the relevant engineering industry and the directions it may take within the next 5-10 years.

It is worthwhile to examine the type of engineering education given at universities. In general, engineering curricula are modelled after those found in Europe. When the Department of Civil Engineering was



started in Nairobi, it was, in fact, offering external degrees of the University of London. Since that time, the format has not changed significantly. In general, little attention is given to design, i.e., the creation of structures to fulfill a function. The implicit objective of university courses seems to be the production of researchers. The appointment and promotion of staff is based upon research criteria and it is almost impossible to appoint experienced engineers because they seldom have research qualifications. The objective is, naturally, to emphasize the importance of research to the role of the university. As long as this continues to be the primary objective, it will be very difficult for engineering faculties to take into account the needs of the engineering industry when designing their curricula. It is worthwhile, therefore, to examine the differences between science and technology and the application of research-oriented motivations to the needs of developing countries.

The objective of science is the furtherance of knowledge. Its methods are analytical and its central theme is research. The end product is a research paper. After which the scientist has no further responsibility. A good research paper, adding to existing knowledge, brings kudos to all concerned, even if the knowledge is of no practical value.

Technology, on the other hand, is concerned with designing, constructing, and maintaining objects that will serve the people. The methods are synthetic, in the main, and the central theme of technology is design. The technologist is also concerned with the economics, utility, and management of projects. The technologist's responsibility ends when the project is completed and functioning properly.

This means that the motivation of a technologist is quite different from that of a science and engineering graduate who is given a largely analytical education and emerges with the approach of a scientist. If adequate industry does not exist to reeducate these graduates, this attitude will remain and the engineering graduates will find it difficult to execute projects. The civil

engineer in a developing country covers a wider range of subject matter (because there are few specialists) but generally in less depth (because there is less sophistication) and must possess considerable knowledge about materials (because the supporting industries providing these materials are usually very poor in terms of quality control). Designers in developing countries, therefore, if they are to use locally available skills and maximize the use of local materials with poor quality control, must take this into account when designing projects. This is more difficult and time consuming than creating designs for use by highly skilled technicians using good-quality materials. It is probably for this reason that overseas consultants prefer to use international contractors and imported materials, if possible.

The analytically trained graduates currently emerging from universities cannot execute projects without sound practical training and it seems fairly certain that facilities capable of providing such training are inadequate and are decreasing in number. The long-term consequence will be poorly trained engineers, considerable wastage of money, and probably, an increasing number of unemployable graduates.

### **Current Method of Producing Professional Engineers**

The student who is admitted to the Department of Civil Engineering at the University of Nairobi is exposed to a reasonably wide and sound analytical engineering education. During vacation periods, the student may or may not be able to obtain employment within engineering firms. In recognition of the need for practical training in engineering education, the 4th practical training term was introduced to act as a basis upon which future practical training could be developed. Due to a lack of facilities and staff, however, this objective has not been achieved.

After successful completion of the degree course, the graduate engineer joins industry

to receive practical training. In some cases the graduate undergoes well-organized and well-supervised practical training; in other cases the training may be haphazard or nonexistent. Regardless of the quality of the practical training received, the graduate's immediate goal is to pass the professional interview for registration or for corporate membership in a professional body in the shortest time possible. In many countries, including Kenya, the shortest period during which the graduate is expected to have acquired the necessary practical experience for registration is 3 years.

Because this method of producing professional engineers has been operating in Kenya for some time, it is possible to determine the degree of its success. In this method the employer is responsible for providing the necessary practical training and developing the graduate engineer according to the requirements of the industry. In some cases, however, the employer may not be equipped to provide adequate training facilities and an effective continuous assessment system to ensure proper utilization of the training period. As a result, cases of graduates who have spent 3 years in the field and cannot produce a technical drawing they can call their own are quite common.

### **Integrated Engineering Training**

In general, integrated engineering training may be achieved by either incorporating the practical training component into the undergraduate course, thereby lengthening the duration of the degree course, or by introducing academic sessions during the postgraduate training period.

#### **Introduction of Practical Training into the Undergraduate Course**

In this system of engineering education, practical training is considered as an integral part of the undergraduate program. After a certain period of academic training, students are assigned to industries to receive practical training. Guidance and supervision are undertaken by staff from the university and industry. The practical

training is assessed and considered as part of the degree course. The practical training periods are organized such that the training is related to the subjects already covered in the academic course. The length of the practical training periods allows for sufficient coverage of practical aspects of the academic subjects already covered.

The advantages of this method are: (1) undergraduates undergo a streamlined practical training program where close supervision, proper guidance, and assessment of the quality of training are ensured; (2) each undergraduate has the opportunity to get involved in a variety of schemes; and (3) the graduate is able to adjust to the requirements of industry relatively quickly due to the experience gained during the practical training period.

The disadvantages of this method are: (1) the length of time required to obtain the degree would be increased, thereby implying that the time (and hence financial) input toward producing a graduate would be high; (2) it is difficult to find industries with suitable practical training facilities and training officers; and (3) undergraduates are normally concerned with passing their examinations and, therefore, tend to view the practical training exercises for their academic value rather than how they relate to future practical applications.

#### **Introduction of Academic Sessions into the Postgraduate Training Period**

In this system, the undergraduate undergoes the usual academic training in the university and after graduating joins industry for practical training. During the practical training period, the graduate would attend courses offered by institutions either during evenings or for full-time periods, each of which may last several weeks. These courses would normally be designed to expose the graduate engineer to the latest techniques of the profession. The courses may be general or specialized in nature.

The advantages of this method are: (1) the graduate engineer is more professionally mature at this level of training and appreciates the necessity of acquiring new

techniques; and (2) the graduate is able to appreciate and discuss case studies more easily as a result of having been involved in similar projects during the practical training period.

The disadvantages of this method are: (1) not all graduates are likely to have the same experience base; (2) many industries would not be anxious to part with graduates for extended periods of time once they have started being productive; (3) organization for such courses is difficult because experts from many fields would normally be required for the courses to succeed; and (4) because examinations, based on course material, cannot be given easily, there is a likelihood of laxity developing on the part of the graduates.

### **Specialized Training in Water Supply and Sewerage**

In 1970, the Kenyan government established a goal of bringing the benefits of a safe water supply, sufficient to meet the requirements for livestock and domestic consumption, to the entire population by the year 2000. By 1977, about 30 percent of the entire population had access to an improved water supply. The total water development expenditure in the current development plan (1978/79-1982/83) is estimated at K£200 million (U.S.\$548 million). Although this target may not be achieved, it shows the government commitment to this basic infrastructure.

The ministry's total manpower requirements, excluding casuals and trainees, are projected to increase from 7800 to a staff of 14 110 over the same period. The key cadres in which there will be major increases are engineers, geologists and hydrologists, accountants and personnel staff, water inspectors, water bailiffs, surveyors, and many subordinate staff categories including, in particular, patrolmen, pump attendants, water operators, drivers, artisans, clerks, storemen, water guards, and mechanics.

### **Courses Offered Within the Department of Civil Engineering**

#### **Undergraduate Courses**

During the undergraduate program previously described, the following basic courses are offered as components of the B.Sc. degree: hydrology and public health engineering; and public health engineering II, which includes microbial processes, chemical processes, and physical processes as related to water supply.

#### **Postgraduate Courses**

The department is currently running two courses in the field of water supply and wastewater disposal: a 2 year M.Sc. course was started in 1976 and a 1 year diploma course in water and wastewater engineering was started in 1979. There are 17 students currently registered in the two courses.

#### **Ongoing Research**

With the assistance of several donor agencies, the department is involved in the following research activities: slow-sand filtration; stabilization ponds; defluoridation; and solar distillation. Both staff and students participate in the research work.

### **Conclusions**

In designing a curriculum for both undergraduate and postgraduate studies, it is essential to make a thorough appraisal of the country's level of technology and its specific requirements in terms of manpower. Failure to do so may result in the training of personnel who contribute very little to the technological development of the country, in spite of the relatively large financial investments required for university education. Also, efforts should be made to incorporate practical training into all levels of university education because the graduates are, in most cases, expected to become productive very soon after graduation.

## **Training: Discussion**

### **Planning and Organizing**

The discussions on planning and organizing for training centred mainly on the subject of manpower development surveys. These surveys in the water supply and sanitation sector usually include the following information: (1) present training capacity and output; (2) manpower needs of the present and projected needs for the future; and (3) proposals to expand training programs to meet any difference between manpower requirements and available manpower. Thus, manpower development surveys define the need for enlargement of training programs.

In most countries manpower surveys have already been carried out. Some of the main issues discussed in this regard were:

(1) To what degree should countries seek outside assistance in carrying out manpower surveys? It was agreed that the best solution would be to conduct these surveys locally to meet locally defined needs, although outside assistance may be useful at the beginning.

(2) How does one evaluate the efficiency of a manpower survey? Evaluation is an extensive undertaking, long term in nature, and it is often a neglected exercise.

The question of bonding candidates who leave the country to study was also discussed. There are difficulties in enforcing this, but such a procedure is necessary to restrict the brain drain from developing countries.

### **User Education**

It was agreed that it is important to know the composition and cultural interrelationships within a community before one can intelligently plan a user education program.

The villagers' education should depend upon communal participation of the adults as this approach will likely be compatible with their traditional African methods.

Some participants felt that traditional beliefs should not be allowed to stand in the way of bringing new technologies into a village; others felt that participation by the villagers, whether in training or maintenance activities, could be overdone. The villagers may either be too busy with other volunteer efforts or may want to spend more time on activities planned by themselves.

The role of women in the user education process was again debated. It was stated that studies have shown that women are no less intelligent than men and are, therefore, capable of learning about rural water supply operation and maintenance or any other subject. Cultural conditioning, however, often prevents women from participating in training programs. The answer seems to be to make educational opportunities available to women at all levels. The role

of the Ministry of Education is indeed crucial in the education of the future users and maintainers of water systems, but one shouldn't expect the children to quickly change the thinking of their parents. Parents are not likely to change their way of thinking based upon what their children learn in school — at least not immediately.

It was agreed by all that user education was crucial. If one gets clean pure water from a rural water supply system and it is then stored or used in an unsanitary manner, the main purpose of the new system is lost.

## **Workshop Resolutions**

The workshop resolutions given below are the result of deliberations in the working groups, discussion in the plenary session, editorial revision, and final approval by working group chairmen.

It will be seen that these resolutions do *not* contain specific revised curricula. As the workshop progressed, more realistic goals evolved. In the first stages of planning these workshops, an overall curriculum revision was envisaged. This later was reduced to proposed revisions of portions of curricula. At the workshop, it was realized that detailed curriculum revision requires extensive time and discussion with one's colleagues in one's country. Therefore, rather than present a superficial attempt at curriculum revision it was decided to present guidelines for curriculum revision, which could be taken back to the individual countries to assist in the training program reviews that would have to be tailored to each individual country.

### **General Resolutions**

(1) Having reviewed the existing curricula, it has been realized that they are urban water supply system oriented. Further realizing that the world is currently in the midst of a serious energy crisis and that practically every nation is trying to use renewable energy resources, it is recommended that the following technologies identified in this workshop should be introduced and emphasized in the training programs: (a) gravity-fed systems; (b) rainwater catchment systems; (c) shallow well/hand pumps; (d) wind-power pumping; and (e) simple water treatment methods.

(2) Realizing that not all technical disciplines are offered at the different training centres, and that some countries do not have an adequate number of instructors, it is recommended that student exchange programs be promoted. In addition, curriculum development should be carried out with regional cooperation.

(3) Foreign entry requirements such as the City and Guilds should be discouraged in favour of formulating specific requirements tailored to national conditions.

(4) Whereas international assistance to this sector has been mainly for equipment, at the expense of training personnel, the time has come to recognize support for training programs as a necessary component of donor assistance programs.

(5) Upgrading courses should be set up, preferably in the national water institutions, for special training in the water sector.

(6) A curriculum is not a static thing and should be flexible in order to accommodate the changing level of technologies.

(7) Opportunities for women to enter training programs should be increased at all levels.

(8) Health education should be a component of technical training at all levels.

## **User Education**

(1) Users are all the people in the community who depend upon the water supply system, including the water attendant, who is responsible for general maintenance, and the local water management committee. Education programs aimed at users should reflect the general concerns of the community. Specifically, they should provide information on the health and economic benefits that water systems can provide.

(2) The water attendant should be given a working knowledge of the pumping system and should assist in educating the community.

(3) A water committee should be set up at the local level and have overall responsibility for the water system. This committee should provide leadership training, project management, simple maintenance and community education, and oversee the protection and cleanliness of the system.

(4) Teaching methods should include lectures, demonstrations, and discussions. Participation of schools, churches, and existing educational groups should be encouraged. Normally, the water attendant and the water committee will be trained by a technical assistant. The community as a whole can then be trained by the committee with the aid of the technical assistant and water attendant.

(5) Regular community evaluation based on visits, interviews, and follow-up research is required to assess the community's state of knowledge of the water system, hygiene, and general health. Based on the results of these surveys, modifications should be made to improve the content of the training program and the methods being used.

## **Technical Assistant Level Training**

(1) A technical assistant is a skilled craftsman or mechanic who performs a specific practical job. Training should be given by the technician and should emphasize practical knowledge, as well as providing some theoretical input. At the same time, the technical assistant should be provided with information on community development.

(2) The duration of training should be as short as possible while still producing a competent and practical worker. The length of this training period should be evaluated periodically and amendments made to increase effectiveness as required.

(3) Entrance requirements should be carefully tailored to the knowledge required for successful training and the training should be specific to the job the person will do when the training is completed.

(4) Because of the specific nature of the training required, the following points should be emphasized in various programs: (a) drilling: drilling techniques, geological formations, pump testing, knowledge of machines and tools, administration; (b) shallow wells: well siting, geological formations, well construction, pump installation, community participation, administration, well hydraulics; (c) pump attendant: pump operation, fault identification and repair, preventative maintenance; (d) gravity-fed schemes: plumbing, construction work, welding, water treatment, community organization, hydraulics, map reading, leveling, tools; (e) plants: plumbing, mechanical work, installation techniques, tools, welding and soldering; (f) electrician: installation of electric

pumps, welding, plumbing, tools, fault identification and repair; and (g) liaison officer: health aspects, simple water technology, community development, extension and communication.

### **Technician Level Training**

(1) The role of a water technician is to supervise construction, carry out equipment testing, and organize operation and maintenance of a water scheme.

(2) Water technicians must have a thorough knowledge of water hygiene to avoid waterborne diseases.

(3) Within the existing curricula in technical institutes, it has been noted that subjects such as political science, general studies, and management are being taught. Within these subjects, technicians should learn the social, cultural, and economic factors that influence the life of water consumers in a community.

(4) To ensure proper practical training, the teachers themselves must be involved in the supervision of on-the-job training during the course.

(5) Safety precautions during construction, maintenance, and operation should be stressed during the training of technicians.

### **Engineering Level Training**

(1) The role of an engineer is to apply the principles of science. This involves applied research, design, and field supervision.

(2) Facilities for the training of manpower to work in the fields of water and wastewater should be expanded to meet increasing demands.

(3) A 4 year undergraduate course would seem to be necessary to cover all of the broad aspects of water and wastewater engineering.

(4) Teachers in the university should keep in touch with current practices and be involved in actual field project design.

(5) It is desirable to set up and strengthen postgraduate (Master of Science (M.Sc.)) level courses in environmental health engineering. The syllabus of this program should include (a) water-related diseases; (b) social organization and management; (c) economics and planning; and (d) low-cost sanitation methods as an alternative to traditional sewage treatment. Training at this level should be carried out at African institutions.

(6) Applied research in relevant technologies should be encouraged and supported by national governments. Research facilities should be strengthened.



## Country Action Plans

Whereas the workshop resolutions give guidelines for revision of training programs, the follow-up action plans present specific plans for action. These were the result of deliberations by the country groups. They were formally presented on the last day of the workshop.

### Ethiopia

(1) The resolutions of the workshop will be presented immediately to the Ethiopian Water Resources Authority (EWRA).

(2) Through the mechanism of the EWRA, efforts will be made to ensure that all resolutions relevant to Ethiopia are implemented.

(3) Effective communications will be made with the proper authorities at the University of Addis Ababa (engineering and engineering-aid education) and the Ministry of Health and Ministry of Education (user education) concerning implementation of workshop resolutions.

(4) As most training in other areas of rural water supply training is carried out within the EWRA, useful resolutions such as emphasis on low-cost renewable energy technology, sanitation, community participation, and user education will be accommodated as much as possible in the training curriculum.

(5) The EWRA has had plans to establish a Community Participation Promotion Unit. These plans were reinforced as a result of this workshop when practically all working groups, in one way or another, emphasized the need for making water systems as socially acceptable as possible to users. Therefore, plans to implement this unit on a pilot scale in one or two regions, and expanding it to other regions depending upon initial success, will be carried out. Some of the initial activities needed for this unit are (a) develop a training curriculum; (b) train community participation promotion workers; and (c) define work roles of everyone involved. The setting up of this unit indicates Ethiopia's desire to put strong emphasis on community participation.

(6) Ethiopia hopes to continue to study other countries' experiences in order to learn from them.

(7) Ethiopia seeks increased cooperation with international agencies to accelerate the rate of rural water development.

### Kenya

(1) Kenya's first follow-up action will be to report the results of the workshop to the higher authorities in the Ministry of Water Development.

(2) As a result of this workshop, Kenya hopes to put increased emphasis on wind-power water pumping.

(3) Kenya hopes for International Development Research Centre (IDRC)

assistance in training instructors for its M.Sc. program in environmental engineering at the University of Nairobi.

## **Tanzania**

(1) Tanzania plans to pursue a revision of the curriculum of the Water Resources Institute to include low-cost renewable energy technologies.

(2) It is planned to include a training program in the existing shallow wells program in Tanzania.

(3) Tanzania plans to hold a national workshop to discuss the above training programs.

(4) Village contractors training: The Tanzanian delegation intends to formulate a policy paper proposing the concept of implementing small water schemes by trained village contractors. A training program will likely be necessary for village contractors.

(5) The delegation endorses the preparation of training manuals to give guidance about the operation and maintenance of simple technology schemes.

(6) Refresher courses should be instituted to train graduates from the Water Resources Institute.

## **Malawi**

(1) Malawi hopes to convene a national workshop as soon as possible. It is hoped that as a result of this national workshop a national action group will be formed to persuade government to revise training curricula to be more appropriate.

(2) Malawi also plans to set up a Water Training School to train personnel who will work within the Department of Lands, Valuation and Water.

## **Botswana**

(1) Botswana has recently purchased 8 windmills and 20 hand pumps and plans to set up a training program in these technologies. There is a possibility of sending two trainees to Kenya for about 1 month to participate in a proposed IDRC sponsored project there in wind-power pumping. Additional training could be coordinated with the Rural Industries Innovation Centre (RIIC) at Kanye.

(2) Botswana also hopes to conduct a manpower survey within the Water Affairs Department. This will serve as a basis of future training activities within the sector.

Some of these action plans, particularly those of Ethiopia, Tanzania, and Malawi, represent resolutions that were in the planning stage before this workshop. The workshop has given additional momentum to the training emphasis in these countries. Thus, the workshop should be seen as part of the process to place new emphasis on training in low-cost technologies, operation and maintenance, and community participation.