THE UNITED REPUBLIC OF TANZANIA

Ministry of Water, Construction, Energy, Lands and Environment, Zanzibar

Department of Water Development

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ZANZIBAR URBAN WATER SUPPLY DEVELOPMENT PLAN 1991 - 2015

Plancenter Ltd

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ANNEXES

MAPS

ABBREVIATIONS

AC	Asbestos Cement
ADB	African Development Bank
ADF	African Development Fund
BH	Borehole
CI	Cast Iron
CLE	Commission for Lands and Environment
DWD	Department of Water Development
ERP	Economic Recovery Programme
FAO	World Food and Agriculture Organization
FINNIDA	Finnish International Development Agency
GI	Galvanized Iron
GOZ	Government of Zanzibar
HDPE	High Density Polyethylene
LPCD	Litres Per Capita Per Day
O & M	Operation and Maintenance
PVC	Polyvinyl Chloride (plastic pipes)
SFPC	State Fuel and Power Corporation
UAW	Unaccounted for Water
UWS	Urban Water Supply

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- Ministry of Water, Construction, Energy, Lands and Environment
- Ministry of Agriculture and Livestock Development
- Ministry of Education
- Ministry of Trade and Industry
- Chief Minister's office and its Departments
- Ministry of Health, Finance and Planning

Other organizations were the Zanzibar Municipal Council, the Zanzibar Meteorological Unit and the University of Dar es Salaam.

1. EXECUTIVE SUMMARY

General Programme

The preparation of the Zanzibar Urban Water Supply Development Plan took place during November 1989 - December 1990.

The work was undertaken as a consultancy project by M/S Plancenter Ltd, in close cooperation with the Department of Water Development (DWD) of the Ministry of Water, Construction, Energy, Lands and Environment, Zanzibar.

The plan covers Zanzibar Town on Unguja Island and the three towns on Pemba Island, Chake Chake, Wete and Mkoani. The plan period covers the years 1990 to 2015. The total population coverage will be 232,000 and 590,000 in 1990 and 2015, respectively.

The planning phase, November 1989 - December 1990, consisted of Financial Analysis, Institutional Study, Water Resources Study, Physical Planning and Environmental Impact Assessment. These various components are compiled in this report. Separate more detailed reports were drafted on Institutional Study, Water Resources Study and Environmental Impacts Assessment.

Population Projections

The annual population growth is estimated to remain at the same level as in the last ten years, i.e. 3.8 %, during the whole planning period.

The population of Zanzibar town is estimated to increase from the present 190,000 inhabitants to 483,000 by the year 2015. Almost 40 % of the population is expected to live in urban fringe areas in future.

The population of the Pemba urban areas is estimated to increase from 42,000 to 107,000 inhabitants by 2015. The population is expected to concentrate in the urban centres and along the main roads near the towns.

Water Demand

Water demand in urban areas in Zanzibar is likely to increase drastically during the next few decades, due to rapid population growth The total water demand will increase from the present 15,400 m^3/day to 720,000 m^3/day by the year 2015.

The water demand of Zanzibar town is estimated to increase from 13,000 m^3/day to 60,000 m^3/ day by 2015. Pemba's urban water demand will increase from 2,400 m^3/day to 12,000 m^3/day.

Utilization of Water Reserves

The drawing of large quantities of groundwater from Zanzibar Islands is justified on the basis of the initial hydrogeological studies and calculations. There are enough potential groundwater aquifers to meet the water demand of Zanzibar Town, Chake, Wete and Mkoani up to the year 2015.

Ground water will be drawn from borehole wells and natural springs. The location of the new and existing intakes will be within a radius of 6 - 7 km from town centres.

The surface water resources are not feasible alternatives for urban water supplies.

The total artificial discharge in Unguja by 2015 would be about 10 % of the recharge. In Pemba the respective figure would be less than 5 %. The discharge of ground water should be limited to the excess capacity of the aquifers. The natural ground water storage should not be disturbed permanently.

The ground water resources will also be needed for rural water supplies and for irrigation purposes. The use of ground water is to be submitted under inter-ministerial coordination, with the Department of Water Development, together with the planned Urban Water Supply Authority, playing the leading role. Other relevant parties would be, the Department of Irrigation, the Commission for Lands and Environment, the Municipality Council and the Private Sector.

Water Quality and Environmental Issues

Almost all the water intakes of urban water supplies in Unguja and Pemba are bacteriologically polluted, as were consequently the networks as well. The pollution may also take place within the network due to pipeline leakages and unhygienic storage tanks. The microbiological pollution of drinking water can be considered the most acute water-related health problem for the public at the moment.

The chemical quality of groundwater is generally good. There is a risk of intrusion of sea water into the groundwater, but no alarming results were found at present. One chemical identified from the water samples of the Zanzibar Town supply scheme has been chromium, which may be due to chemical pollution from industrial waste waters. The effects of agrochemicals on the quality of groundwater need to be studied.

There are also some other chemical aspects, such as the existence of calcium, which is mainly a technical and aesthetic problem, but may also be of significance to health. Iron and manganese are high in some sources.

The environmental issues should be considered and environmental monitoring (including water quality monitoring) should be continuous. The existence of adequate laboratory facilities is of great importance. Chlorination of the water systems is recommended to ensure the microbiological safety of drinking water.

The surroundings of the existing and new water intakes and all open water sources should be protected. The geological formation of the islands does not offer adequate protection against aquifer pollution. Regulations should be set for use of fertilizers, pesticides and other chemicals and for handling of wastes and effluent in the catchment areas.

The coastal areas, where the water table is not much above the sea water level, should be avoided while locating new drilling areas.

Economy and Finance

Zanzibar's economy is dominated by agriculture and depends on export of cloves as a main source of foreign exchange (over 90 %). Due to major falls in clove prices on world markets the Zanzibar economy has been badly affected. The Government is continuing to pursue a comprehensive economic recovery programme which was commenced in 1987.

The objective of the Government is to have an efficient sustainable supply of safe water at a price which the beneficiaries can afford to pay.

Currently water is charged only to industrial and business users. Water tariffs should be developed gradually and coherently with improvements in service level and according to the benefit received. Cross subsidization from the richer section of the community and other sources of income, such as selling services, should be considered.

The revenue collection has to be supported by legislation which discourages waste of water, encourages conservation and penalizes illegal use and non-payment. A free standing parastatal with access to sufficient revenue from customers and with sound financial, institutional and operational management is considered a basic prerequisite for the viability of the urban water supply.

It is expected that by the year 2001 with major improvements in the water supply distribution system and provided that the economy flourishes the revenues generated by the urban water authorities will be sufficient to cover the expenditure of an efficient and effective water organization.

Institutional Development

There are 12 ministries with about 28,000 civil servant posts in the GOZ at present. The Department of Water Development has 291 employees in Unguja and 220 in Pemba.

The autonomy of the DWD is insufficient to conduct water supply affairs efficiently. It is recommended that an Urban Water Supply Authority will be established. It should start as a section of the DWD, and later on it could be separated from the department to form a parastatal organization. The Authority should be provided with a legal basis for operation and sufficient independence to carry out the tasks entrusted to it. Inter-ministerial coordination in water resource issues is proposed for implementation by a special body on which the relevant parties are represented.

The new organizational charts, along with proposals for staffing patterns and guidelines for management system development are suggested.

Human Resources Development

The DWD have limited possibilities for providing their staff with the skills required in their jobs. There is a shortage of qualified administrative, financial and technical staff.

It is recommended that the manpower management and staff development functions will be strengthened within the DWD. Incentive schemes and other employee benefits are needed.

Strategies and measures are proposed for planning and implementation of training. Training should cover each staff group and employee, and offer opportunities for career development.

Training should be planned and implemented on a continuous basis, in close cooperation with local training institutes. Their capacity to take care of vocational training will be improved.

Community Participation

There is no past experience of systematic community participation in connection with water supply or sanitation in Zanzibar. However, there is willingness among urban households to contribute to improvement of the water supply. Further studies are needed to develop procedures for community participation. The willingness to participate might differ in different areas, according to the degree of urbanization. The institutional capacity of the Urban Water Supply Section should be improved by carrying out participatory activities.

Opinions about water charges vary in different town areas, and there were also differences between Unguja and Pemba. About half of the households were willing to pay for a reliable water supply. About one fifth had no opinion on this matter or did not want to express it.

Community Education

The interaction between the beneficiaries and the water authorities is inadequate at present. Understanding of water issues seems to be quite limited among the urban population.

Workable institutional mechanism for consumer services and public information activities should be created within the Water Department. Cooperation with water supply, environmental and health education authorities should be increased.

Mass media, especially radio, should be utilized more as a communication media.

Physical plan

The urban water supply systems are 40 - 60 years old. The designed capacity of the systems is inadequate for the present population, and the gap keeps on increasing.

The service level target of the Development Plan is adequate water supply in terms of quantity and quality to urban consumers, including domestic, industrial and commercial users.

The most urgent aim of the Plan is to rehabilitate the existing urban water supply system to maximum capacity. Gradual improvement will take place in the service level. New well fields will be connected to the network during the last implementation phase.

All existing water supply structures (networks, intakes, booster stations and reservoirs) are rather deteriorated and need to be rehabilitated in a few years' time.

Zanzibar Town and Chake Chake are priorities in the initiation of works. Simultaneously, every effort - including training - is made to support the satisfactory daily running of all urban schemes.

The implementation of works in Pemba is to be considered on a larger scale only after the national electricity supply operates reliably.

The physical plan is connected to the institutional and financial development. The time schedule for implementation of the technical plan will depend on the progress of the institutional development. Moreover, the physical plan is to be revised if changes occur in land use plans, population growth trends or water demand.

Phasing

The Water Supply Development Plan covers three major phases, as follows:

1. Implementation Phase 1991 - 1994
2. Implementation Phase 1995 - 2000
3. Implementation Phase 2001 - 2015

The 1991 - 1994 programme emphasizes policy, economic and institutional development of the water supply authorities of Zanzibar. Community education and environmental development also play important roles.

The technical part of the first phase will consist of the most urgent repair works to the existing system and technical planning for the subsequent phases.

Contracts on system rehabilitation could be considered in 1992, depending on the progress of the institutional changes and the availability of personnel who are professionally capable and competent.

The programme for 1994 - 2000 emphasizes the economic viability of the programme. Donor support, if available, is used for investment and for construction and renovation costs. The water authorities will become self-reliant with regard to operation and maintenance.

Rehabilitation and construction will be carried out by both local and foreign contractors, depending on the local and foreign funds available. The water authorities, along with advisers, are supervising contractors and producing plans as required.

At the end of this phase (2000), the authorities may be considered financially self-supporting. If found necessary, a few experts may need to be retained to assist the authorities in technical and advisory issues.

During the post-2000 phase, the financial system would be further strengthened. Financing would come from local income generating systems. Investment costs would be covered mainly by soft international loans or grants.

The local water authorities will independently supervise construction and rehabilitation works carried out by local contractors. The use of foreign contractors should be considered only when special expertise is required.

The water authorities may be strengthened by the assistance of some foreign experts.

2. BACKGROUND

2.1 Geography and Climate

Unguja and Pemba are two islands in the Indian Ocean on the east coast of Equatorial Africa. Because of their physical and human characteristics, as well as their historical and political connections, the two islands form a unity, Zanzibar.

The island of Unguja is situated between latitude 5° 40' and 6° 28' south of the equator. It is about 35 km off the mainland of Tanzania. Unguja is the larger of the two islands, with an area of 1660 square kilometres and with dimensions of 85 km north to south and 35 km east to west. The location of the islands is presented in Figure 1.

The island of Pemba is situated 40 km to the north-east of Unguja. The area of Pemba is about 980 km^2. Pemba is greener and more hilly, with more trees and less bush and more intensive land-use.

The two islands were formed out of a large delta formation from the Ruvu River. They emerged from the ocean during the drift faulting of the coastal areas. Unguja is separated from the mainland of Tanzania by a shallow ocean floor and Pemba by the 700 m deep Pemba Channel.

The rainfall is strongly seasonal, related to change of monsoon and movement of the tropical convergence zone. The season of heavy rains (Masika) comes during March - May. The relatively cool and dry season (Kusi) takes place during June - September. A lesser rain season (Vuli) occurs during October and December. The north-east monsoon (Kaskazi) occurs during January and February and the weather is dry and hot.

In Unguja and in Pemba, the average annual rainfall varies between 1,000 - 2,250 mm. Unguja and Pemba have an average weather temperature of 27 °C in January and 24 °C in July. The average annual temperature is 26 °C.

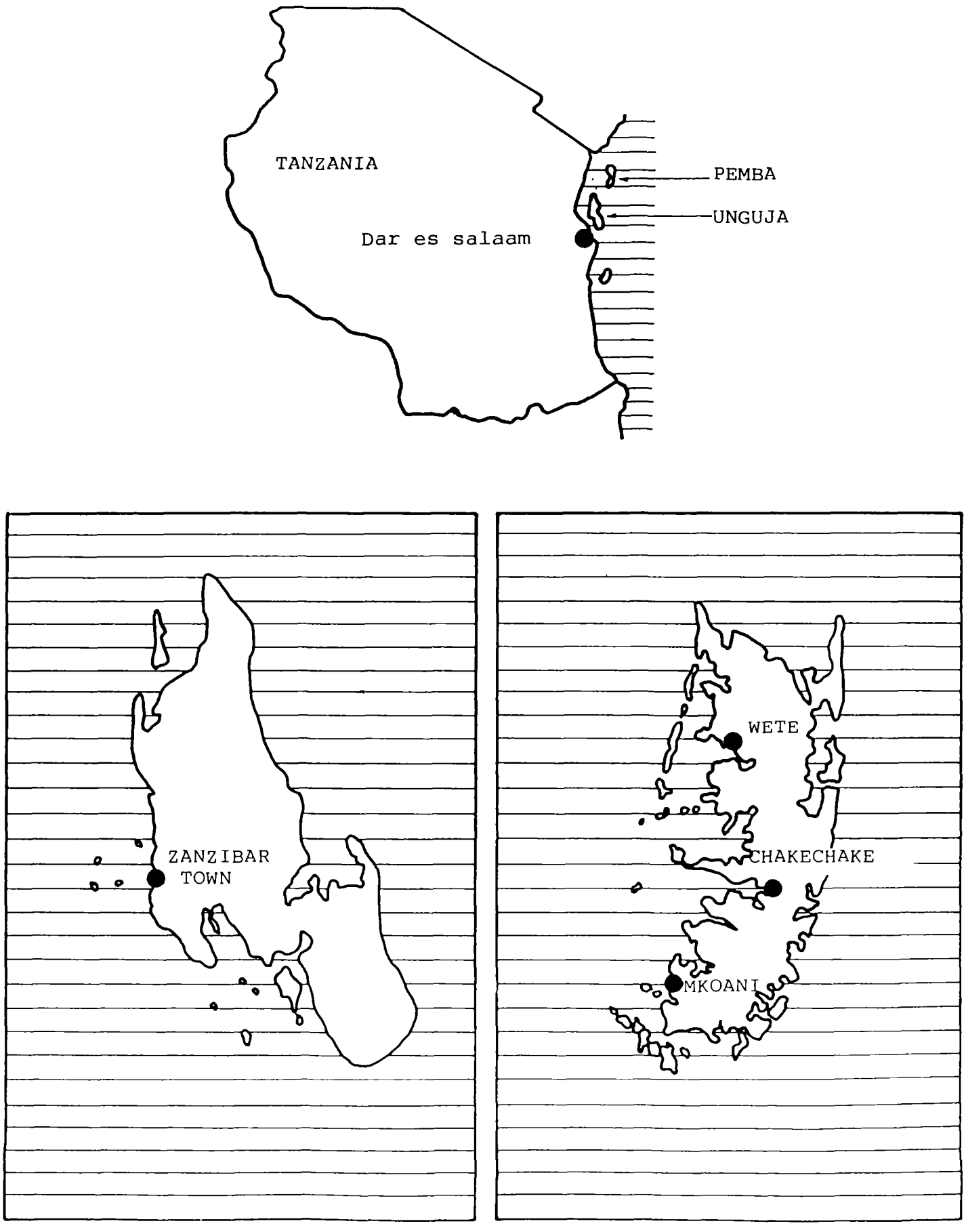
2.2 Population and Urbanization

The latest population census held in Zanzibar in 1988 gave a total population of 652,467, of whom 387,428 are in Unguja and 265,039 in Pemba. If the growth rates of 1978 -88 are applied, the projected population by the year 2015 would be 936,800 and 530,100 in Unguja and Pemba, respectively

There are three small towns in Pemba; Wete, Chake Chake and Mkoani, and one larger town in Unguja, Zanzibar Town. The population of Zanzibar Town would grow from 176,231 in 1990 to 483,000 people in 2015. The respective growth figures would be from 20,080 to 54,800 in Wete, from 14,380 to 36,500 in Chake Chake and from 7,400 to 15,600 in Mkoani.

The high population growth rates, particularly in Zanzibar Town (3.8%), with the limited space available, would lead to a more congested area, high unemployment and unfavourable living conditions. Zanzibar has to be able to support the forecasted population increase. Leaders, including religious leaders should be approached concerning population restraint. Detailed population projections for urban areas are given in Chapter 6 of this report.

Figure 1. Map of Zanzibar



2.3 Political and Economic Backgrounds

Since 1964 Zanzibar has been an integral part of the United Republic of Tanzania. However, Zanzibar has considerable autonomy, with own Constitution, President and Government.

The Revolutionary Government of Zanzibar has a centrally planned economy and almost total public ownership, including public ownership of land.

Zanzibar's economy is dominated by agriculture, which accounts for between 50 % and 60 % of G.D.P. This heavy dependence on agriculture is made more significant by the fact that the economy depends on the clove crop as the main source of foreign currency (over 90 %). Apart from cloves, the remaining agriculture activity is subsistence farming.

Overproduction of cloves by Indonesia, Brazil, Comoro and Madagascar have caused major falls in clove prices on world markets, and the Zanzibar economy has been badly affected. Inflation has risen steeply and services have deteriorated more rapidly. Consumer prices have risen at a rate of more than 20 % per annum since 1982, with prices doubling between 1987 and 1989.

The price of imports significantly affects domestic prices. The combined effect of rising import prices and a major depreciation of the Tanzanian Shilling (from TAS 65 equal to one USD in mid 1987 to TAS 190 equal to one USD at the end of 1989) have led domestic prices to rise rapidly.

All these factors have had a major impact on the finances of the Government and parastatal bodies, with the result that they are unable to generate sufficient revenue to meet their expenditure needs.

Recognizing the seriousness of the situation, the Government is continuing to pursue the comprehensive economic recovery programme which it initiated in 1987.

2.4 Water Supply Institution

The Town Water Works in Zanzibar is about 70 years old. During colonial times, the water works consisted of water supply, harbour drainage and sewerage. The sector was headed by the District Engineer, who was answerable to the Director of Public Works Department under Zanzibar Township Authority. The activities were regulated by the Zanzibar Town Water Works Rules introduced in 1935 and the amendments made to them over the years. In 1963 the Water Work Rules were supplemented with the Zanzibar Municipal Council By-Laws (House Refuse Collection and Disposal, and Streets and Open Places).

The water supply system was a small, reliable town system. It was technically, financially and managerially sound. Since it was formed, water affairs have been put under many different ministries.

Soon after the Revolution in 1964 the Public Works Department was converted into the Works, Roads and Technical Department and remained such until 1975, when the Department was split into the Ministry of Water and Power, the Ministry of Housing and Construction and the Ministry of Communication and Transport. In 1984 the Ministry of

Water and Power was merged with the Ministry of Housing and Construction to create the Ministry of Water Construction and Energy.

Two years later, drainage and sewerage functions were vested in Local Government and Town Councils, established by the Local Government Act that come into force in 1986.

In November, 1990 the Commission for Land and Environment was merged with the Ministry of Water Construction and Energy and the Ministry was named as Ministry of Water, Construction, Energy, Lands and Environment. The role of the Department of Water Development remained as earlier.

The Ministry of Water, Construction, Energy, Lands and Environment, through the Department of Water Development, has the full responsibility for water production and delivery in rural and urban areas in Unguja and Pemba. The Ministry has a unit in Pemba and the Pemba Department of Water Development is administratively subordinate to it. Functionally the Department acts under the DWD in Unguja.

2.5 Water Supply System

G.M. Stockley 1951 states: "Zanzibar Township Water Supply is almost world famed for its purity and taste. The spring of Mtoni (Chem Chem) have been used for drinking purposes literally for thousands of years - it is said that records are known dating to before the birth of Christ. It is therefore desirous that this unique and old established water supply should continue its reputation undiminished."

During the early stages of Zanzibar Township Water Supply in the 1920's, Mtoni and Bububu springs were developed for urban water supply sources. In Pemba, Gawani spring in the town of Wete was developed in 1944 - 45 for use as an urban water supply. At Mkoani, Kiguuni spring was developed in 1932 and at Chake Chake Miembeni spring, located in the town area, was developed in the early 19th century. Later on, borehole wells were drilled for town water supplies and new springs were developed as well.

After 1960, the water demand increased rapidly. To cope with the situation, the water department developed new water sources. The number of boreholes in Unguja and Pemba is today more than 150. The boreholes have been drilled either by the water authorities for urban and rural water supplies or by FAO or the Department of Agriculture for irrigation use.

By 1990, ten boreholes, seven springs and one cave were used as urban water supply intakes the two islands. About 13,000 m^3/day and about 2,000 m^3/day of ground water was pumped to the urban areas in Unguja and Pemba, respectively. Zanzibar Town and Pemba urban water schemes include totally 260 km of pipe lines, four booster stations and 13 reservoirs with a total storage capacity of 9,050 m^3.

The location and a detailed presentation of the urban water supply infrastructure is given in Chapter 11.

2.6 Previous Studies

A number of reports on the geology and hydrogeology of Zanzibar have been published since 1928. Studies on the physical geology of both islands (Kent & AL., 1971), on the hydrogeology of the early eighties on Unguja (Johnson, 1984) and a hydrogeological map of Zanzibar (UNDP/FAO, 1987) are among them.

The mission report to the islands of Zanzibar (Solares, 1986) offers a fairly ready - made groundwater ordinate which can be modified in the present situation.

Several previous reports on environmental issues have been of good use. Especially R.B. Smith's report, "An Environmental Policy and Programme for Zanzibar" (1990), benefitted the environmental impact assessment carried out by the Programme.

The most useful engineering studies have been those carried out in the 1980's by the Chinese city team for Zanzibar Town Plan, and engineering and management studies executed by the Rural Water Supply Project.

Among the studies related to economic, institutional and training issues, the most important one is the Economic Recovery Program of GOZ (1987) and its revision (1990). The institutional review of the Rural Water Supplies Project and a couple of reports on education and on the situation of children and women in Zanzibar have been useful material as well.

More detailed information on previous studies utilized by the Development Plan is presented in Annex 1.

3. SITUATION IN THE MANAGEMENT OF LANDS AND ENVIRONMENT

The Commission for Lands and Environment was established in 1989. It is an independent central coordinating body under the Ministry of Water Construction, Energy, Lands and Environment. The Commission is in charge of coordinating land related matters throughout the Zanzibar administration, and is an advisory body for the Government concerning all land development, land related problems and conflicts as well as environmental protection and monitoring.

There is an on-going project on lands and environmental management that is supported by FINNIDA. The Project Document for the Integrated Land and Environmental Management states:

- No overall land use plan has ever been prepared to direct the development of Zanzibar. Neither has there been any authority appointed before 1989 to be overall in charge of land use development of the islands. All land development has taken place through sectoral implementation programmes and projects without overall coordination. This has created many conflicts between various implementing organizations. Typical conflict areas exist in the outskirts of urban areas, where agriculture and urban development are in conflict or in forest plantation areas, where farmers may protest against planting forest on their farms. Lack of coordination and planning has, in many cases, contributed to wastage of scarce public funds, particularly through duplication of efforts.

- The existing land administration has been capable of carrying out approximately 30 - 60 % of the urban development in 4 towns, but not in rural areas. Urban development is directed by 5 existing but outdated Master Plans, prepared by the Chinese team some 9 years ago. The local urban planners have prepared subdivisions according to which hundreds of new plots are annually given to local people. A considerable uncontrolled squatter development continues in the urban areas.

This Development Plan is based on the Masterplan drawn up by the Chinese, which has been applied and modified to facilitate the overall water supply plans. The water supply plans were made known to the land management planners already at an early stage in 1990.

The planned intake, well field and catchment areas were made known to the Commission of Lands in order to facilitate gazetting them for urban water supply use. Special standards for latrine construction, local well construction, waste disposal, use of fertilizers etc. have to be introduced in these areas. House construction in the catchment areas of the major natural springs has to be restricted.

4. CONSTRAINTS

Constraint analysis was made for the overall programme and for the community participation and environmental issues. The constraints analysis charts are presented in Annex 2.

The progress of the UWS Programme as a whole depends on the progress of economic, institutional and legislative development. The period of time required for the fulfilment of external preconditions cannot be estimated precisely at this stage, and the process may include political elements not yet visible.

Advisers with multi-disciplinary skills are needed to assist in the balanced handling of technical, institutional, economic, financial, social and environmental aspects. Quite significant inputs of staff, commitment, motivation and prioritization for the programme on the part of the executing and participating organizations will be required.

The plan proposes a system which seems to be affordable over the suggested time span of 25 years. However, due to many external conditions, it is realistic to consider the proposed system as an objective to be reached, but not necessarily within definite time limits. The pressure for quick physical development would be eased, if serious consideration were given to population restraint.

The technical solution of this report can be implemented if the good prospects for economic recovery materialize. The annual per capita operation and maintenance costs of the proposed system would be about TAS 500 (USD 2.5), which should be collected from the beneficiaries or should be provided by the government.

5. GENERAL DEVELOPMENT OBJECTIVES

The Government of Zanzibar adopted an Economic Recovery Programme in 1988. It comprises a combination of measures and strategies to revive the productive sectors of the economy of Zanzibar. By improving the quality and continuity of the water supply, the GOZ aims at securing efficient industrial production and tourism development as well as the health improvement of the population. Thus the development objective of Zanzibar is to provide adequate water facilities to all water users on both islands, in order to fulfil the needs of the expanding economic activities and an increasing population.

The Urban Water Supply Development Plan aims at providing a sustainable, cost effective supply of safe water to the urban population and industries. The environmental risks are taken into account, and the water authorities would be provided with the institutional capability and professional skills to operate, manage and maintain the facilities.

The development objectives can be specified as follows:

Economic and institutional development

- Contribution to the development of a clear-cut policy and strategy for urban water supply and achievement of economic efficiency, as well as improved financial performance and institutional capacity. Consumers involvement in water issues will be encouraged.

Water supply development

- The establishment of adequate and safe urban water supply systems appropriate to prevailing economic and functional conditions.

Water resources and environmental development

- The conservation of groundwater resources. An adequate share of water resources to be gazetted to urban water supply.

- Improvements in the health of population by improving the water quality and promotion of environmental wellbeing through project activities.

6. WATER RESOURCES

6.1 Introduction

The following studies were carried out in connection with the assessment of the groundwater resources in Zanzibar. Further details are given in the separate Water Resources Study (WRS) and Environmental Impact Assessment Report (EIAR).

Studies:

- Study on existing reports and data
- Survey of existing water intakes, including surface geology and environmental aspects (Map 1A,B,C,D)
- Pumping tests at all borehole intakes (WRS)
- Survey of availability and quality of filter sand (WRS)
- Geo - electrical sounding survey (Annex 3)
- Survey of local wells in catchment areas of potential water intakes (Map 1A,B,C,D)
- Monitoring of water levels and electrical conductivity in borehole wells, springs and local wells
- Identification of natural springs in Pemba (Map 1B,C,D)
- Survey of rivers and surface water resources (Map 1A,B,C,D)
- Evaluation of Meteorological Stations. Collection of meteorological data (WRS)
- Drilling Technology Study (WRS)
- Environmental impact assessment (EIAR)
- Water quality study

6.2 Climate and Meteorological Data

There are sixteen and fourteen meteorological observation stations in Unguja and Pemba, respectively. The location of the stations is presented in Figure 2.

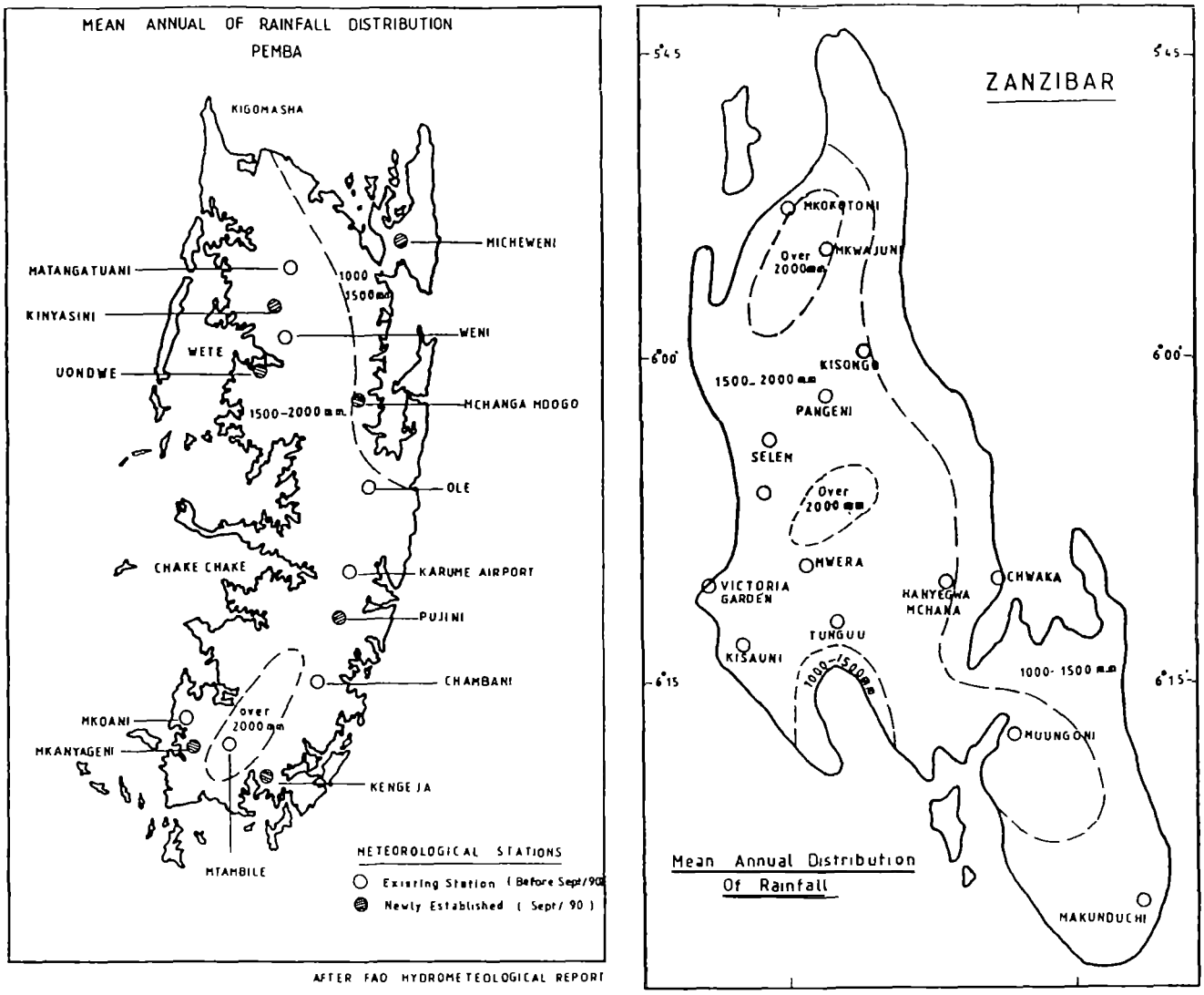
Johnson's report 1984 summarizes climatical and meteorological data from the two islands until the year 1984. Some new data have been gathered since 1984. Summaries on the old and recently obtained precipitation data were made. The reliability of the meteorological monitoring stations is assessed in the separate Water Resources Report.

In Unguja and in Pemba, the average annual rainfall varies between 1,000 - 2,250 mm. The mean annual rainfall, based on the data obtained is presented in Figure 2.

The average annual rainfall is about 1,700 mm per year in Unguja. In Pemba, the respective figure is slightly higher. As for planning purposes, a total annual rainfall of 1,500 mm is applied in Unguja and 1,600 mm in Pemba.

The total average precipitation contributing to ground and surface water development is roughly 2,490 x 10^6 m^3/year in Unguja and 1,570 x 10^6 m^3/year in Pemba.

Figure 2. Location of meteorological stations and mean annual rainfall distribution



6.3 Surface Water Resources

6.3.1 Streams, Unguja

There are no perennial rivers flowing from Unguja inland to the sea. Rivers which have perennial sections or sections which do not dry up every year are:

1) Mwera
2) Zingwe Zingwe
3) Mwanakombo - Mahonda
4) Tinga Tinga - Kipange

Monitoring of the quantities of stream flow was beyond the possibilities of the Project. The water tables were monitored at Mwera river and its branch, Kianga river. It appears that the rivers have a few hours, peak flow after the rainstorms.

The Mwera river is seen as the only feasible surface water source, and it should be developed for irrigation use. The estimated dry season flow of the Mwera River in 1990 at the Mwera bridge was 15,000 m^3/day.

6.3.2 Streams, Pemba

The streams in Pemba are more numerous and perennial more often than in Unguja. Seasonal and perennial rivers in the vicinity of urban areas were identified; they are presented in Map 1A,B,C,D.

Water tables were monitored in the following four biggest streams in Pemba:

1) Mangwena River
2) Weni River
3) Machengwe River
4) Kwapweza

The upstream parts of the rivers reach their peak flow rates soon after the actual storms and dry up in a few hour's time.

Although there was no actual flow rate reading, it is here assumed that about 25 - 30 % of the precipitation is returned by rivers and streams directly to the sea. The percentage is in accordance with global average discharge rates.

The use of river water for urban water supplies is not recommendable, owing to water quality constraints. Irrigation use could be considered.

6.3.3 Lakes and Ponds, Pemba

A number of water logged ponds have developed in the flat lying areas of the eastern parts of the island. Eroded silts and mud have developed water - tight basins on the topsoil. The ponds are recharged by rainwater and discharged by evaporation. These ponds are often polluted by snails carrying schistosome parasites, which cause bilharzia. The lakes and ponds have no real significance as drinking water supply sources.

6.4 Ground Water Resources

6.4.1 Ground Water Potential

General

Ground water will be the only feasible alternative to meet the water demand of the municipalities in Unguja and in Pemba. The ground water resources will also be needed for rural water supplies and for irrigation purposes.

Almost all the geological formations of Unguja possess some aquifer potential. As to drawing large quantities of water for urban water supplies, the corridor zones offer a feasible alternative. The aquifers have been found to be unconfined and interactive all over the island (Johnson, 1984). From the study results of this programme, it may be concluded that some confined aquifers also exist in Unguja.

The precipitation in Unguja gets fairly totally infiltrated or evaporated, and rather little of the water is drained as surface flow. It is estimated that about 25 -30 % of the rain water infiltrates to the ground water in the favourable conditions of the Unguja island. The infiltration takes place fairly rapidly in many areas. Some perched water aquifers seem to have started to develop in the intensively irrigated areas.

The potential ground water areas, together with some ground water flow features in Unguja, are presented in Figure 3.

The hydrogeological situation in Pemba is a typical one of a small island, where a freshwater lens lays on the saline seawater. It is estimated that the freshwater aquifer are adequate for today's water demand and for the next 25 years.

There are three different axis of hydrogeological interest passing through the island of Pemba in the north - south direction. The topographical high axis and the main water divide play a key role in definition the groundwater behaviour in Pemba. The anticline axis has minor hydrogeological interest. The three axis are presented in Figure 4.

Evidently the top formation on the eastern side of Pemba possesses a better capacity to absorb storm water than the top soil of the western side. During storms, excess precipitation drains from the sandy plateau. So-called sheetwash water is channelled into rills or rivulets and continues along the small valley inlets to the major valleys. The infiltration of water is estimated to be approximately 25 % in the inner parts of the island. No major rivers are formed, and later on the silty downstream valleys absorb a great deal of the drainage water.

The location of existing water sources and potential ones in Pemba are given in Map 1. They are located within a radius of 10 km from the centres of the towns.

Figure 3. Potential groundwater development areas, groundwater flow direction and location of corridor zones, Unguja

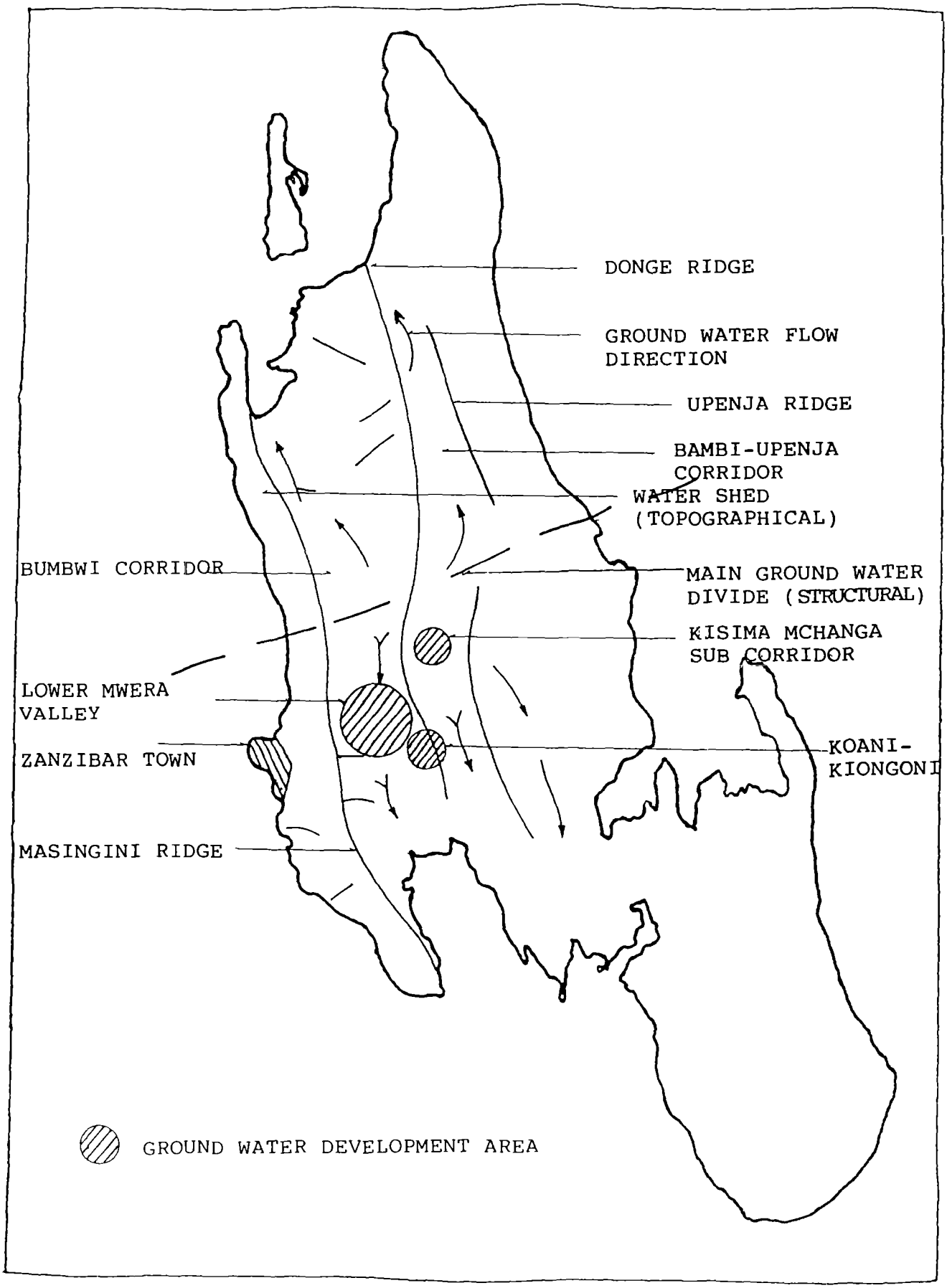
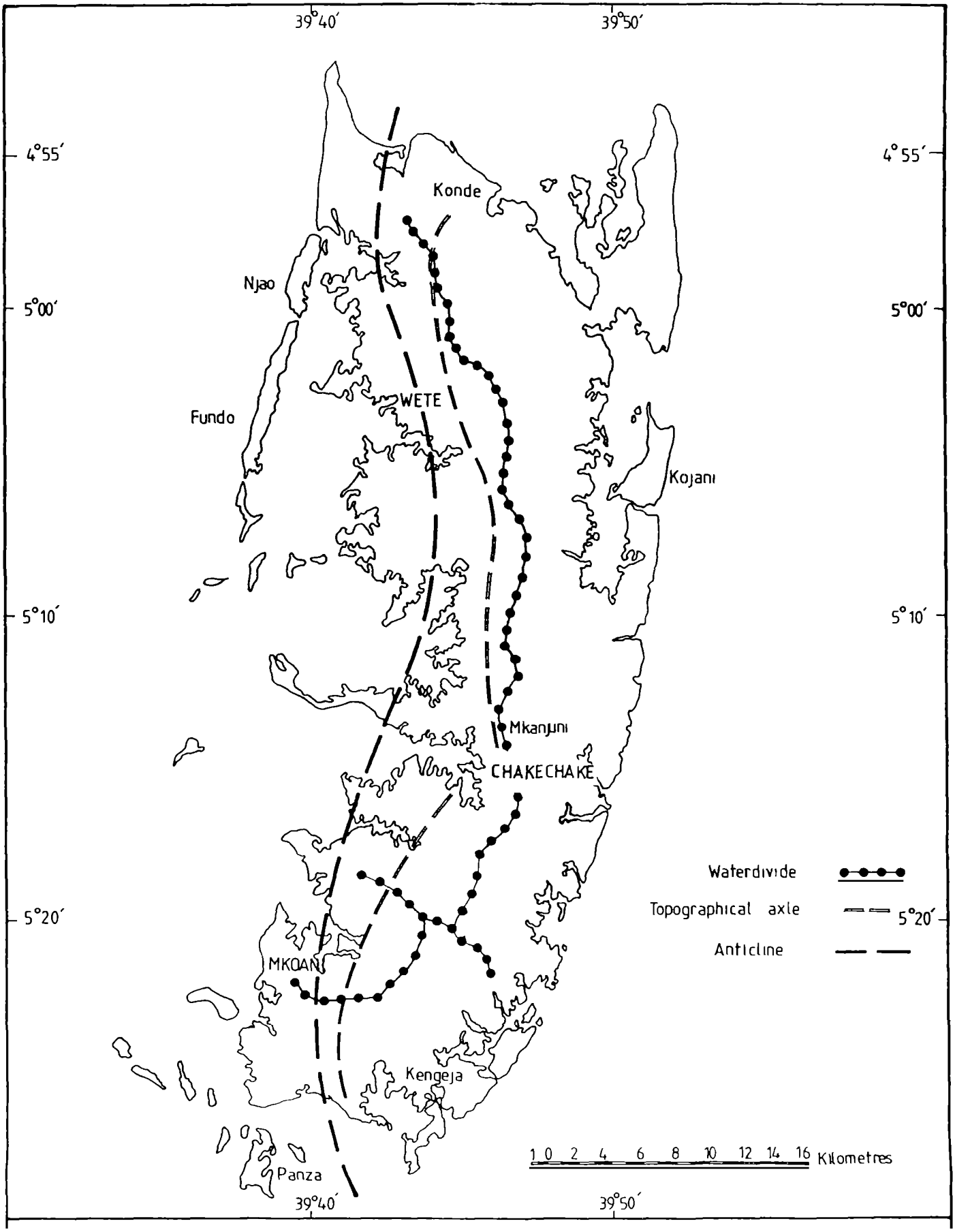


Figure 4. Approximate location of water divide, anticline and topographical axis, Pemba



Seawater Intrusion Risks

There are no long-term hydrogrammes on the groundwater behaviour under the present discharge conditions. The discharge rates do not seem to be alarming in any respect.

The locations of existing boreholes are presented in Map 1.

As to the danger of seawater intrusion, the most critical pumping sites in Unguja are the Kaburi Kikombe and Chunga C8 boreholes. Kaburi Kikombe clearly has some indications of seawater influence and the area should gradually be given up as a source of high quantities of groundwater. Although the pumping tests from Chunga C8 borehole gave no evidence of any salinity increase, the monitoring must continue intensively, especially after another Chunga borehole is taken into use and after utilizing the borehole field on the southern side of Welezo.

There are some previous studies which indicate that the Ghyben-Hertzberg principle (1:40 height/depth relationship of freshwater lens) holds in Unguja. However, there is no proof of the applicability of this principle outside the western hydrogeological province. In the coastal aquifers, the water table contours do not much exceed the sea level, and the freshwater lens may be disturbed if water discharge is not controlled.

The risks of seawater intrusion in Pemba vary from borehole to borehole and has to be monitored and further studied during the implementation of the plan.

Artificial Discharge, Unguja

The artificial discharge of ground water for urban and rural water supplies and irrigation on Unguja is estimated to be as follows:

Water Demand (m^3/day) in 2015

Urban	60,000 - 90,000
Rural	6,000
Irrigation	40,000 - 50,000
Total	106,000 - 146,000

Ground water potential calculations were already completed by Johnson (1984). The calculation were revised and supplemented with new information during the preparation of the Urban Water Supply Development Plan. The calculations are presented in more detail in the Water Resources report.

An average annual rainfall of 1,500 mm is applied for planning purposes in Unguja.

The total available recharge to essential aquifers in Unguja would be 600 x 10^6 m^3/year. The maximum total discharged quantity, 25 years from now, is estimated to be less than 160,000 m^3/day. The total discharged quantity would be about 10 % of the total ground water resources available.

Drawing of large quantities of ground water from Unguja island is justified by hydrogeological studies and calculations. Water discharge has to be controlled with continuous monitoring of the well fields and recharge areas.

Artificial Discharge, Pemba

Groundwater potential calculations in Pemba can be done only on a rather vague basis. However, indicative figures are obtained by defining the groundwater reservoir as a function of freshwater recharge, transmissivity of the formations, evaporation, above ground drainage and artificial discharge.

An average annual rainfall of 1,600 mm may be applied for planning purposes. Estimating a typical evaporation loss of 50 %, and an above ground flow of 50 %, (i.e. 25 % recharge), the total recharge to essential aquifers (60 % of total recharge area) would be 260 x 10^6 m^3/ year.

The total artificial discharge by the 2015 would be projected as follows:

Water demand (m^3/day) in 2015

Urban Water Supplies	12,600 - 18,900
Rural Water Supplies	5,200
Irrigation	-
Total	17,800 - 24,100

The total artificial discharge in 2015 would be less than 5 % of total recharge.

6.4.2 Availability of Ground Water

Zanzibar Town

The observed rise of the water table during the two rainy seasons in the corridor area was from 3 to 3.5 m. Some additional water level rise takes place in the interim period as there seem to be at least 5 rainy days every month. A total of three metres recharge is assumed in the calculations. According to the hydrogeological map, the area of 30 % storativity on the southern side of the Bumbwi water divide is about 20 - 28 km^2. Consequently, if the recharged quantity of water is utilized, 70,000 m^3 per day may be pumped from the lower Mwera Valley. This figure does not include recharge from the underlying miocene formation.

Bububu Spring and Mtoni Spring are located just near Zanzibar Town centre. Both of them could yield up to 5,000 - 10,000 m^3/day and therefore would be very economical sources. Mtoni spring, however, has some problems with water quality, which have to be solved first.

The Bumbwi-Corridor, crossing the Unguja island in the northsouth direction and passing a few kilometres east from Zanzibar Town, offers a feasible ground water development area for drawing water to the town, at an approximate daily quantity of 70,000 m^3/day.

Further potential source could be the Kisima Mchanga subcorridor (20,000 m^3/day), which lies at a distance of about 15 - 25 km away from Zanzibar Town. This distance can be considered a rather uneconomical pumping distance. Another potential source is the Koani - Kiongoni area, a distance of 6 - 8 km away, which could yield up to 10,000 - 20,000 m^3/day.

The feasibility of different alternatives is to be studied in more detail during 1991 - 1994, through test drilling and test pumping programmes. The overall location of the proposed ground water development areas is presented in Figure 3. The approximate locations of potential test boreholes sites and well field areas are given in Map 1. The planned water discharge quantities from different areas are summarized in Annex 4.

There are very little or no contradicting interests on the use of ground water from the concerned areas. The areas are therefore to be gazetted as areas restricted for ground water exploitation and development for Zanzibar Town. Possible contingencies of available water resources may be allocated for rural and irrigation use, to be decided by the proposed water board in due course of time.

The water quality in the corridor areas is suitable for domestic purposes. There is a theoretical chance for sea water intrusion from the southern end of the Bumbwi Corridor, as the potentiometric gradient decreases to only +2 m above the mean annual sea water level. However, the recently obtained test pumping results show that large quantities of ground water can be pumped from this area without changing the water table conditions too much.

The Town of Chake Chake

The Kwapweza spring would offer a source to supply up to 50 %, i.e. over 50 m^3/h, of today's water demand for Chake Chake area. Three to four test/production boreholes should be drilled at Kwapweza and Mzingeni area to determine the available additional ground water potential. Based on very tentative estimates, a total of about 10,000 m^3/day of ground water could be developed from the Kwapweza valley.

According to geo-electrical sounding results, high yielding boreholes - over 50 - 100 m^3/ hour - can be drilled in the Kiziwamaji area, about 4 km north-east of Kwapweza.

The valley, where the Jamvini C7 - borehole is located is a continuation of the Kwapweza valley, and it offers the first alternative well field location, able to yield 3,000 - 6,000 m^3/day.

The Changaraweni borehole valley could yield about 4,000 m^3/day. This area requires careful monitoring and detailed study, as there is a chance that sea water may intrude. The water contains iron compounds and has to be treated. Changaraweni should not be considered as a priority area in future well field plans.

The Town of Wete

The nearest potential groundwater development area is the Weni river valley on the eastern side of Wete. The geo-electrical sounding along the valley show a presence of a flat lying sandstone formation at an approximate depth of 20 - 50 m. The limestone is overlaid by

silts. This sandstone is evidently recharging from the upper lying areas and may possess groundwater with artesian pressure, which remains to be studied by test drilling.

It is concluded on the basis of the project studies that boreholes with a yield of about 500 -1,000 m^3/day could be drilled in the Weni valley. Taking into account the estimated recharge, the total groundwater production capacity of the valley could be over 5,000 m^3/day. Possible interaction with other aquifer areas could increase the estimated groundwater potential. Thus about 5 - 10 boreholes can be drilled in a properly planned field. It is suggested that the depression cones of the boreholes would overlap in the water level depression area of 1 m. This suggestion is in accordance with the proposal of the Bumbwi Sudi well field design proposal of Johnson (1984).

The discharge rate of the Gawani spring was 53 m^3/h during the early dry season. Total obtained drawdown was 3.7 m. The transmissivity of the aquifer formation was estimated to be approximately 200 m^3/d. To sustain the water table above sea level, and to avoid sea water intrusion, the maximum long- term discharge should not exceed 40 m^3/h, i.e. 1,000 m^3/d, from the Gawani spring valley.

The pumping rate of 75 m^3/day was producing a total drawdown of 2.5 m for the Bungumi spring. Based on rough estimates derived from the studies carried out, it may be concluded that the Bungumi valley could yield about 6,000 m^3/day from a properly designed borehole field. There would not be any major concern of possible sea water intrusion. However, the water quality has to be monitored regularly in this respect, if discharge from the area is increased.

A constant rate pumping test was performed at Masipa borehole, with a discharge rate of 58 m^3/h. Drawdown reached the level of 6.8 m during 270 minutes of pumping. No recharge boundaries were observed. The aquifer seems to be unconfined. The aquifer transmissivity was about 200 m^3/day, enough for a production borehole.

The Masipa area is a suitable groundwater development area and may yield about 1,000 m^3/km^2. If more boreholes are drilled in this area, the groundwater potential calculations that have been done must be verified, using actual hydraulic data from more than one borehole.

The Town of Mkoani

The water supply for Mkoani has to be collected from several different points. Makombeni valley near the town has some potential for groundwater development.

There is an artesian borehole just near the sea, on the beach near the harbour and the Makombeni valley. The aquifer with low artesian pressure, is at the depth of 10 - 20 m. The aquifer layer could be followed and penetrated by several shallow boreholes. The artesian overflow could be collected along a collection pipeline and pumped to the town.

The overflow in the existing borehole is rather small, and the artesian yield might hardly be enough for pumping the water to the town. The yield could be increased by pumping from the boreholes but keeping the potentiometric level well above sea level. Depending on the continuity of the aquifer, it is estimated that up to 300 m^3/day could be developed from Makombeni valley.

The borehole nearby Uweleni Waterworks could be rejuvenated. The estimated maximum yield from this site could be about 150 m^3/day. Special attention should be paid to the borehole design because there are silt problems in this area.

The Changaweni pumping station should be maintained and further developed. According to test pumping results, about 300 m^3/day can be developed from Changaweni. Silt problems also exist in this area.

The main part of the Mkoani water supply, over 1,000 m^3/day, may be developed from the newly discovered Melinne spring. The natural spring area is located on the northern side of the main road. If the area proves not to be suitable for such a quantity, an additional supply can be developed from the valley in Mtambile.

At a distance of about 8 km from town, the Sisimizini spring was found during the spring identification programme. The spring overflow was about 1,100 m^3/day. This spring could be considered as an alternative to the Mtambile intakes. A final decision should be made after test drilling in Mtambile.

Another potential spring, although very far away, is located at Mgelema area. The tested yield was 900 m^3/day with a 70 cm drawdown.

6.5 Condition of the Existing Boreholes

Well casing and Borehole Diameter

In the existing wells, the well casing diameter has been from 8 to 12 inches. Generally, the diameter at the piped section has been 12 inches for the core-method, 16 inches for the cable tool method and 14 inches for the direct rotary method.

Casing Material

The well casing material has usually been iron, jointed by threads or by welding. Only a few wells have been piped with PVC well casings.

Well Depth

The existing boreholes can be regarded as rather shallow. The drilling depth has been varying from 30 to 90 metres and the average depth has been 53 metres.

Well Screens

The type most commonly used has been hand-made torch-cut screen. The disadvantages of these screens have been the limited percentage of open area (4 - 6 %) and the variable slot size (1 - 6 mm). The cutting surface has been highly exposed to corrosion. Due to the limited open area, the screen length has been 40 - 60 % of the borehole depth.

A small number of wells have been fitted with bridge-slotted or continuous-slotted screens. The open area for the bridge-slot is up to 30 %. The material of bridge-slotted screens is galvanized iron and that of continuous slotted galvanized or stainless steel.

Abandoned Boreholes

A number of boreholes has been abandoned for various reasons, e.g.

- the collapse of the well casing or screens
- the caving of the boreholes during drilling
- the boreholes sites were not ascertained, and therefore they never produced water
- poor quality of water due to poor gravel pack, etc.
- too much siltation in the boreholes (no equipment for cleaning)
- jammed pumps inside the borehole (no equipment to fish them out)

The loss or abandoning an already drilled well is an expensive exercise. Measures should be taken to avoid such incidence during the implementation phase of this programme.

Filter Pack

The characteristics of filter pack have varied very much. Often the purpose of filter pack has been only to fill the annular space between the well casing/screen and the hole. The grain size used has been from sieved beach sand to limestone chipping (from 3 - 6 mm to chipping). Depending on the drilling method, the filter pack thickness has been 40 - 50 mm.

A study on the availability of filter pack material was carried out. It was discovered that reasonably good filter sand material is available on the western coast of Unguja Island. A more detailed report on filter sand availability is presented in a separate Water Resources Report.

Condition of the Existing Boreholes

There is a total of thirteen boreholes in the vicinity of Zanzibar Town. The oldest boreholes were drilled in the 1960's and the latest in the end of the 1980's. At the, moment five wells are under pumping, yielding a total amount of 11,000 m^3/day. This figure is an estimation based on the capacities of the pumps, and should be reviewed by continuous flow measurements. In addition to these wells, there are three boreholes in fairly good condition, but these are unfortunately without pumps. The remaining five holes can be used only to monitor the water level.

The condition of boreholes is summarized in Table 1. From the table it can be concluded that the state of boreholes is fair rather than good. The field visits and depth measurements indicate that the following problems exist; high corrosion of well casing and screens, in - filling, reduced yield and silt pumping.

Proposals to avoid these problems are given in the production well design criteria, which are given in the Annex 5.

Table 1. Condition of the existing boreholes, Unguja

AREA BH NO.	DRILLING YEAR	DRILLING DEPTH (m)	PRESENT DEPTH (m)	POSITION OF THE SCREEN (m)	STATE OF WELL	YIELD AFTER DRILLING m3/h	PRESENT YIELD m3/H	POSSIBLE USE REMARKS
KABURI MTONGBE								
BH NO. 2	*	*	23.50	*	POOR	*	-	OBS HOLE
BH NO. 10	-74	45.15	25.85	23.00-44.00	POOR	145	-	(INTAKE, NOTICEABLY INFILLED
BH NO. 14	-88	42.00	*	12.00-36.00	**	72	68	INTAKE
OBS. HOLE	*	*	26.30	*	POOR	*	-	OBS. HOLE
KIJITO UFELE								
BH NO. 13	-85	42.76	27.15	*	FAIR	72	-	INTAKE
CHUNGA								
BH NO. 8	-74	45.20	42.40	24.00-42.00	GOOD	120	-	INTAKE
BH NO. 9	-74	45.20	*	16.45-40.75	**	160	100	INTAKE
MWEMBE MCHOMEKE								
BH NO. Z1	-62	46.43	21.15	21.42-46.43	POOR	DRY	-	ABANDONED
BH NO. ZD	-61	67.10	24.40	26.20-50.90	POOR	45	-	OBS. HOLE
BH NO. ZA	-61	70.30	59.75	29.70-65.15	GOOD	144	143	INTAKE
KIANGA								
BH NO. ZB	-61	53.40	*	13.50-39.95	**	160	133	INTAKE
MWERA								
BH NO.	*	*	16.23	*	POOR	*	-	OBS HOLE
MBWENI								
BH NO.	-83	22.00	*	*	**	40	27	INTAKE

* NO RECORD

** CAN BE DETERMINED AFTER MEASURING THE PRESENT DEPTH

6.6 Design of Boreholes

The condition of the existing water intakes is rather deteriorated and all the existing borehole intakes need to be rejuvenated in a few year's time. The drilling of borehole wells can be done by the proposed urban water supply section of the DWD. Contractor services can be used for major drilling exercises.

Design criteria for the production wells are given in Annex 5. Cable-tool and direct rotary drilling have been found to be appropriate drilling technologies in Zanzibar.

6.7 Ground Water Quality and Environmental Aspects

The detailed analysis of the environmental and water quality conditions of each existing and some proposed water sources of Zanzibar's urban water supply as well as the urban water supply network are presented in the separate reports: Water Resources Report and Environmental Impact Assessment Report. A summary on water quality analyses is presented in Table 2 and in Annex 6.

6.7.1 Ground Water Quality

Most of the health problems in Zanzibar result from or are caused by poor environmental conditions. They are mostly related to such factors as socio-economic status, climate, cultural practices, poverty, rapid population growth and inadequate and unsanitary living conditions, including the inadequate quality of drinking water and the inadequacy of personal hygiene habits.

Historically, the ground water sources and water supply of Zanzibar has had a very good reputation for its cleanliness and good taste. The first results of the household survey, which was done during the planning phase also showed that the quality of water of Zanzibar town supply is considered good. People seem to trust that some "medicine" has been applied to the tap water. That is why people in urban areas do not care to boil their drinking water, which would be very important.

Almost all the water intakes of urban water supplies in Unguja and Pemba were found to be bacteriologically polluted, and therefore also the whole network. Even faecal pollution seems to take place. The sources are not usually covered or protected, and therefore any kind of pollution is possible. The pollution may also take place within the network trough leakages of pipelines and unhygienic storage tanks. The shallow wells too appeared to be polluted. The microbiological pollution of drinking water can be considered the most acute water-related health problem for the public at the moment.

The physical and chemical quality of the ground water is generally good. One problem could be the intrusion of sea water into the ground water. Thus special attention was paid to checking the salinity of water, but no alarming results were found. In a few sources the conductivity and chloride levels were somewhat high, but not exceeding WHO or Tanzanian Standards. The water quality has to be carefully followed in future as the use of ground water becomes more effective.

Table 2. Quality of Water in Existing Water Sources in 1990

Water quality

Water source	CHEMICAL			BACT.		
	Satis-factory	Suspicous	Not satis-factory	Satis-factory	Suspicous	Not satis-factory
UNGUJA						
Zanzibar Town:						
Mchomeke B/H ZA	x					(x)
Kianga B/H ZB	x				x	
Chunga B/H No 9	x					(x)
Kaburi Kikombe B/H No 14		(x)				(x)
Kaburi Kikombe B/H No 2			x			(x)
Mbveni B/H	x					(x)
Bububu Spring		(x)				(x)
Mtoni Spring	x					(x)
Dimani Cave			(x)		x	
Fuoni Spring			(x)			(x)
Bumbwi Sudi B/H 2	x				x	
Bumbwi Sudi B/H 4	x					(x)
PEMBA						
Chake Chake:						
Miembeni Spring		x				(x)
Kwapweza Spring		x			(not analyzed)	
Changraweni B/H			x		(not analyzed)	
Changuo B/H			(x)			(x)
Jamvini BH 7			(x)		(not analyzed)	
Clove factory B/H	x				(not analyzed)	
Wete:						
Gawani Spring		(x)				(x)
Bungumi Spring		(x)			(not analyzed)	
Masipa B/H	x			x		
Miti Ulaya Spring		(x)			(not analyzed)	
Bubujiko Spring			(x)			(x)
Mkoani:						
Changaweni B/H	x				(not analyzed)	
Kiguni Spring		x				(x)
Cofegar B/H		x				(x)

Satisfactory: clearly below (or within) the WHO or Tanzanian standards

Suspicous: some parameter(s) higher than generally in the area or less than total coliform bacteria present

Not satisfactory: exeeding (or not within) the WHO or Tanzanian standards

(x): cross in brackets means that there is inly one parameter which makes tha water suspicous or not satisfactory (e.g. manganese, or in case of bacteria, it means that no fecal coliforms occur but only total coliforms)

One chemical identified from the water samples of the supply sch
was chromium, which may be derived from chemical pollution by i
The effects of agrochemicals on the quality of ground water need to

There are also some other chemical aspects, such as the existence o
mainly a technical and aesthetic problem but which may also have so
health. The iron and manganese contents are high in some sources.

6.7.2 Risks for the Quality of Ground Water

In Zanzibar the soil is generally very permeable (owing to sand and coral), and therefore any waste materials or chemical discharged into the ground without treatment can easily pollute the groundwater, thereby creating a health hazard.

The waste and solid waste disposal system of the towns of Unguja and Pemba at the moment is poor. There is no centralized sewage system and the sewers are blocked due to poor maintenance and misuse. Waste water is usually lead to the sea. However, often the waste waters do not reach the sea, but seep into the ground, therefore causing a problem of ground water pollution. In future the increased amount of domestic waste water due to expanded water supply systems may even add to the problem of poor waste water disposal. This can be avoided by proper planning and coordination of the activities of the programme with the forthcoming sanitation project, due to be carried out with German agency.

One possible risk to the quality of ground water is the pesticides and fertilizers used in agriculture, especially rice cultivation, in which abundant use is made of herbicides to control weeds. Rice is cultivated almost all over Unguja and Pemba islands, and very often the cultivation is concentrated to areas where the main ground water reserves are located. In forestry the chemicals are used only in the nurseries, which limits the problem to a few small areas. Nothing definite can be said about the effect of agrochemicals on water supplies without proper studies and analysis of them in ground water.

Obviously, the level of chemicals used in industry in Zanzibar is not high. However, there are some potential pollution risks - especially because the disposal of waste waters and other wastes are without any control. One chemical identified from the water samples of Zanzibar town supply scheme has been chromium, which may indicate chemical pollution by industrial waste waters.

The remarkable increase in the use of ground water for the future town water supplies, together with other uses such as irrigation and probably the increased use of water due to the development of tourism, may cause some problems in the future. The possible deprivation of the water table will first affect the shallow wells, which will dry up. The compensation measures for the rural people suffering from these effects should be discussed.

The possible intrusion of sea water to the ground water will be another risky issue connected with the effective use of ground water.

6.7.3 Protection of Water Sources, Environmental Issues

The continuous monitoring of ground water storage will guarantee that no damage is done to the natural water reservoirs. Even if some damage does occur, it would be of a temporary nature. The natural balance would soon return if pumping is reduced.

The aquifers in Unguja are often covered with permeable sandy formations and a number of unprotected local wells are located in the catchment areas. If polluting waste is released within the catchment areas or if the local wells are polluted, the geological formation does not offer adequate protection against aquifer pollution.

The surroundings of the existing and new water intakes should be protected. For instance, trees could be planted in the vicinity of the intakes. The intakes should also be fenced. Appropriate standards should be introduced for pit latrines and garbage pits in the catchment areas.

Regulations should be set for use of fertilizers and pesticides in agricultural production as well as for chemicals used in industry and for the handling of wastes and effluent in the catchment areas.

The coastal areas where the water table is not much above the sea water level should be avoided when specifying locations for the new drilling areas.

The construction activities of the programme may have some indirect environmental impacts, such as landscape degradation and beach erosion due to the use of rock and sand. Possible hazards to ground water caused by construction activities should also be taken into account. Care should be taken to avoid to creating water storage places at construction sites, which can be breeding places for mosquitos. The programme may add to the problem of unplanned expansion by creating new job opportunities. It may also promote tourism, which again has its adverse impacts on the environment. These and other possible risks, which might seem small at this stage, should be considered throughout the implementation of the programme. Awareness of the possible environmental risks must be increased among the authorities and relevant personnel.

The consideration of environmental issues and environmental monitoring (including water quality monitoring) should be continuous The existence of adequate laboratory facilities is of great importance. The chlorination of the water systems is recommended to ensure the microbiological safety of the drinking water.

Environmental awareness among the authorities, project implementors and communities should be increased, as should cooperation with water related sectors.

6.8 Water Resource Management

The planned increased pumping of ground water for urban water supplies (113,000 - 159,000 m^3/d) will evidently be accompanied by the increased use of water resources for irrigation (50,000 m^3/day) and for piped rural schemes (1,500 m^3/day). In some cases, the water discharge tends to concentrate in rather limited aquifer areas on the islands. This would, no doubt, at some stage lead to a situation in which the optimum use of the natural resource, water, needs to be determined, on the basis of use priorities and availability of

the resource. Therefore, the recent efforts of Government of Zanzibar to formulate a general water policy and legislation, including ground water management ordinates, are seen as a most positive development, and they should be strongly supported.

The use of ground water is to be submitted under inter-ministerial coordination, in which Department of Water Development, together with the planned Urban Water Supply Authority, will play a leading role. Other relevant parties would be the Department of Irrigation, the Commission of Lands and Environment, the Municipality Council and the Private Sector.

Water policy statement supported by a Water Act should be formulated. As a provision of this Act, the Minister should delegate to appropriate officials in the water administration the task of determining the water conservation areas and handling of related technical issues. An administrative lands and water tribune/court should be established to handle any violations against the water legislation.

Control over safe yields, based on scientific surveys and monitoring, would be required to protect the aquifers from deprivation of water tables and from sea water intrusions in the coastal areas. The watersheds should be protected from environmental deterioration.

The proposed exploitation of ground water for urban water supply can start only after authorization from the relevant national authority to do so. Otherwise the drilling may be considered to have no legal grounds.

All pumping records and future pumping plans from all programmes and private users should be gathered by the Water Department and deposited in a simple database developed for this purpose. Preparation of a simple database was initiated during the planning period.

Supply of drilling materials during the course of the Urban Water Supply Programme should be conditional, in accordance with the availability of hydrogrammes and monitoring data. No facility to draw large quantities of ground water should be provided without proper monitoring.

There is no river management for the time being. It is estimated that, with proper management and maintenance, the river flow in many cases could be increased by about 20 %. River management would be useful if river water is used, for instance, for irrigation purposes.

Water resource management is considered in more detail in the Water Resources Report.

6.9 Further Proposals

All the conclusions and ground water development plans of this report have to be verified through further test drilling, longer pumping tests (1 - 3 weeks) and longer term hydrogrammes.

The planned database programme would automatically produce hydrogrammes from the collected data. After gathering more data and after increasing the discharge from the aquifers, consideration could be given to preparation of a mathematical hydraulic model of the aquifers.

After collection of the actual hydraulic data, the future programme should produce the necessary detailed hydrogeological maps, hydrogrammes and hydraulic models for long - term follow up and further planning.

The potential water intake areas identified by this Programme should be gazetted for urban water supplies. Drilling at lower Mwera valley should be permitted only for urban water supply purpose. The recent proposals to drill for irrigation in this area should be abandoned.

Geo-electrical sounding are a useful and cheap means for determining the geological formation and for obtaining some indications of the salinity of ground water or the maximum yield from individual boreholes.

Environmental impact assessment should be continued during the season of heavy rains, and a regular water quality monitoring system should be established. The need for stricter control of pesticides will be verified through pesticide analysis of water.

7. EXISTING WATER SUPPLY SYSTEMS

7.1 Water Supply System of Zanzibar Town

The existing water supply system of Zanzibar Town functions in two separate pressure zones, high- and low pressure. The low pressure system covers the network between the Saateni water works and Bububu and Mtoni springs and from Saateni to the harbour. The high pressure network covers the rest of the system. The major components of the system are listed below. The components are also presented in Map 3A.

1) Dimani Cave Intake and Overhead Reservoir
2) Mbweni Tractor Workshop Intake
3) Kaburi Kikombe Water Intake
4) Kijito Upele Water Intake
5) Mnara wa Mbao Water Works
6) Chunga Water Intake
7) Mwembe Mchomeke Water Intake
8) Kianga Water Intake
9) Mtoni Spring Intake
10) Bububu Spring Intake and Booster Station
11) Saateni Water Works
12) Welezo Reservoir Site

A detailed description of each component is presented in Annex 7.

The main part of the existing high pressure network is well looped and consists of 100 - 450 mm pipes with a total length of 145 km. Most pipe materials are either cast iron (C.I.) or asbestos cement (A.C.). The C.I. pipes with a total length of 26 km, were constructed mainly during the years 1930 - 1950, and the A.C.pipes with a total length of 100 km, during years 1950 - 1975. In recent years, the network has also been enlarged by some 100 - 150 mm PVC pipes with a total length of 7 km. Additionally, the network includes approximately 16 km of smaller unlooped (50 - 75 mm) house connection pipelines made of galvanized iron (G.I.) or A.C..

The high pressure water distribution system does not work properly owing to the inadequate water supply and structural shortfall of the system. Also the network leakage may influence the system to a greater extent larger scale than is assumed in Chapter 6. Saateni Water Works are boosting spring water of Bububu and Mtoni from three underground reservoirs, with a total volume of 4,250 m^3, to one 450 m^3 overhead tank. This tank is in a reasonable condition. Because the supply is insufficient compared to the demand, the overhead tank is never filled, and water is merely passes through the tank. The other overhead tank, volume 450 m^3 leaks very badly, and it has been out of order since 1970.

Kaburi Kikombe, Mbweni and Kijito Upele boreholes as well as Dimani cave intake pump water straight to the distribution network.

The Welezo reservoirs have problems similar to those of Saateni. All water pumped from Mwembe Mchomeke, Chunga and Kianga merely passes through the two reservoirs, volumes 450 and 2,250 m^3. The present situation can thus be described as living from hand to mouth, without any water being stored to cover the periods of operational failures.

Fortunately, almost all of the new private buildings, enterprises and institutions have installed their own overhead tanks in order to prevention of unexpected failures.

The existing low pressure mains were constructed of C.I. pipes, sizes 100 - 600 mm during 1920 - 1945. The length of the network is 13.5 km. The low pressure network from Saateni to Zanzibar Port may be in satisfactory condition for future utilization as high pressure mains.

7.2 Water Supply System in the Town of Wete

The existing water supply system of Wete includes the following major components (Map 4A):

1. Gawani Spring Intake
2. Masipa Water Intake
3. Bungumi Spring Intake
4. Mtemani Reservoir Site
5. Distribution Networks

A detailed description of each component is presented in Annex 7.

The existing network of Wete has been constructed since the 1940's. The pipe material, 50 - 200 mm in size, is mainly A.C., but there are also some G.I. and C.I. pipes. The total length of the network is 19.2 km. The distribution system functions in two pressure zones, thee prevailing pressure being supplied through two water storage located at Mtemani reservoir site, with a total volume of 370 m^3. The third reservoir, 150 m^3 in volume, is erected too high fort the existing booster pumps to fill the reservoir.

Masipa and Bungumi intakes pump water to Mtemani reservoirs. Gawani intake conveys water straight to the low pressure network.

Water distribution does not work properly, owing to the inadequate water supply and shortfall of the system as well as to the inadequate electrical supply. The irregular power supply mainly influences intakes, and whenever water is pumped to reservoirs, the water is conveyed immediately to consumers. There is usually no water stored for operational failure.

Water quality is unsatisfactory, owing to the lack of any operational disinfection system.

7.3 Water Supply System in the Town of Chake Chake

At the moment, the Chake Chake water supply system is the largest urban scheme in Pemba. It includes the following components (Map 5A):

1. Miembeni Spring Intake
2. Machomane Water Works
3. Kwapweza Spring Intake
4. Jamvini Water Works
5. Fidel Castro Water Works
6. Distribution Network

The distribution network of Chake Chake has been built since the 1940's. The pipe material, 75 - 300 mm in size, is mainly A.C., but there are also some PVC pipes. The total length of the network is 27.1 km. The major part of water distribution functions in one low pressure zone. Only water supply of a few multistorey building's is separated from the low pressure network by boosting water at Machomanne Water Works to one overhead reservoir (80 m^3 in volume).

The Miembeni spring intake is located in the middle of the town, close to a drainage ditch. This spring is already polluted, and it should be abandoned as an urban water source as soon as possible.

The Kwapweza intake pumps water straight to Machomanne main reservoir (540 m^3 in volume). Jamvini and Fidel Castro intakes convey water first to ground level storage located between the intakes and Machomanne. Further on, water is boosted from these storage to the Machomanne ground level reservoir.

The distribution network does not work properly, owing to the size of some main lines being too small. Also, the water quality of Jamvini borehole has reduced pipe sizes; there is logged calcium stone inside the raising pipe and distribution main between Jamvini and the town centre.

In addition, inadequate water quantity and shortfall of both the system and the electricity supply cause problems with distribution. The irregular power supply mainly influences on intakes and booster stations. Whenever water is pumped to reservoirs, the water is conveyed immediately to consumers. There is usually no water stored for operational failure.

7.4 Water Supply System in the Town of Mkoani

At the moment the Mkoani water supply system is the smallest urban scheme in Pemba. It includes the following components (Map 6A):

1. Changaweni Water Intake
2. Uweleni Water Works
3. Kiguuni Spring Intake
4. Distribution Network

A detailed description of each component is presented in Annex 7.

The existing network of Mkoani has been constructed since the 1930's. The pipe material, 50 - 100 mm in size, is either A.C. or C.I. The total length of the network is 6.7 km. The network is quite simple, with long unlooped pipelines along with main roads.

The Changaweni intake pumps water to Uweleni overhead reservoir (180 m^3 in volume). The Kiguuni spring intake and Uweleni borehole, which have been used earlier as urban intakes, have already been abandoned because of their unsatisfactory water quality and low yield.

The water supply of Mkoani does not work properly owing to the limited yield of Changaweni boreholes, inadequate distribution network capacity and the irregular power supply. Whenever water is pumped to reservoirs, it is conveyed immediately to consumers.-

There is usually no water stored for operational failure. Also, the water quality is unsatisfactory, owing to the lack of any operational disinfection system.

7.5 Present Electrical Installations

The condition of the existing electricity fixtures is poor in most of the pumping stations.

At the moment, the old 11 kw lines supply the urban water supply boreholes and pumping stations with electrical power. The physical condition and power transmission capacity of these lines would not be enough to serve the future needs of the water supply system.

It would be advisable to install new 33 kw lines to pumping stations, in accordance with the presently constructed power supply distribution network.

7.6 Existing Operation and Maintenance System

The existing operation and maintenance system (O&M) is not satisfactory. The DWD carries out daily O&M, but the lack of tools, machinery, transport, workshop facilities, spare parts, skilled labour and supervisors has hindered O&M activities for a long period. Also the lack of budgeted money and of foreign currency has caused obstacles and difficulties for efforts to improve the daily O&M practices. During the last ten years, there has been no preventive O&M system or activities.

8. POPULATION PROJECTIONS

Population figures and estimates are based on the population censuses carried out in Zanzibar since 1948. The most recent information available is that of the 1988 Population Census (Bureau of Statistics, Dar es Salaam, 1990) and of the tentative population report prepared by the Commission for Land and Environment (CLE), 1990.

Zanzibar is divided into census zones according to population densities, housing conditions and overall population development prospects. The division was introduced by the Town Master Plan, 1982 (prepared on Chinese contribution) and is also used in the tentative population report mentioned above.

The urban area of Zanzibar Town, including the suburbs, consists of 12 zones which all are covered by the Development Plan. On Pemba the Plan covers altogether 13 census zones, three of which are rural areas (2 in Chake Chake and 1 in Mkoani). The location of the zones is presented in the Maps 2A, 2B, 2C and 2D.

8.1 Population Growth in the Urban Areas of Zanzibar

Zanzibar Town

The population growth in Zanzibar Town since 1910 is presented in Table 3.

Table 3. Population Growth 1910 - 1988, Zanzibar Town

Year	Population	Annual Growth %
1910	35,362	0.7
1924	38,713	0.7
1948	45,284	2.8
1957	57,923	1.7
1967	68,490	4.4
1978	110,506	3.8
1988	157,661	

Sources: Zanzibar Town Master Plan Report of 1982 and
Tanzania Population Census of 1988

Since 1967 the growth has been rapid, although the 1988 census shows that the growth rate has declined somewhat when compared with the 1978 census. The fast pace of growth indicates continuous substantial migration from rural areas to Zanzibar Town.

Pemba Urban Areas

The population growth in Pemba urban areas since 1921 is presented in Table 4.

Table 4. Population Growth in Pemba Urban Areas

Year	WETE	Chake Chake	MKOANI
1921-24	1641	2840	1572
	(3.1)	(0.2)	(2.4)
1948	3502	3010	877
	(7.9)	(9.1)	(8.5)
1958	7507	7167	1977
	(-5.9)	(2.4)	(1.6)
1967	4469	8868	1714
	(10.1)	(0.8)	(11.5)
1978	12874	9643	5678
	(4.1)	(3.8)	(2.6)
1988	19196	13972	7327

(Annual growth rate in brackets)

Source: Zanzibar Population Census Reports

Since 1978 the growth has ranged in Pemba urban areas from 2.6 % to 4.1 %. The average growth on the whole island was 2.6 %. This indicates some level of migration from rural areas to urban centres.

It is evident that the same trend will continue in future, and will be more substantial in Mkoani after the rehabilitation of the Mkoani Harbour. The future growth rates applied in this report are 4.1 % in Wete, 3.8 % in Chake Chake and 3.0 % in Mkoani.

8.2 Population Projections for 1990 - 2015

Zanzibar Town

The average 3.8 % rate of growth will continue in Zanzibar Town according to the above mentioned population report (CLE). The rate of population increase is expected to be lower than 3.8 % in the densely populated zones 1 - 8 and higher in the urban fringe zones 9-12. Zone-wise town population growth rates for the eight zones are presented in Annex 8.

The total population of Zanzibar Town is projected to increase from 190,000 inhabitants today to 483,000 inhabitants by the year 2015. A total of 296,000 inhabitants (61.3 %) of the population is estimated to live in the actual town area and the rest to reside in the fringe areas.

Pemba Urban Areas

The detailed zone-wise population projections are presented in Annex 9. The growth in some zones varies between 0.5 % and 6.2 %, depending on the type of area.

By the year 2015, the total population of Pemba urban areas will increase in Wete, Chake Chake and Mkoani, the increase being 2.7, 2.5 and 2.1 times, respectively. The population is expected to concentrate in the urban centres and along the main roads near the town.

9. WATER DEMAND ESTIMATES FOR 1990 - 2015

9.1 Present Water Consumption

Present water consumption is estimated according to field measurements at intakes and booster stations. The figures are not very accurate because the DWD has only recently started to record the water quantities pumped and house connections to all consumers are installed without water meters. Additionally, Pemba is suffers from a continuously irregular power supply.

An overall estimate of daily water consumption in litres per capita per day (LPCD), including all water use and losses can be made for each township (Table 5).

Table 5. Estimated Daily Consumption in Zanzibar Town and Pemba Urban Areas

		Estimated Daily Consumption	
Town	Population	m^3/d	LPCD
Zanzibar Town	190,000	13000 - 20000	68 - 105
Wete Town	20,100	600 - 1300	30 - 65
Chake Chake Town	14,400	400 - 1000	28 - 69
Mkoani Town	7,400	100 - 250	14 - 34

9.2 Specific Water Demand Criteria

Domestic use

Domestic use varies according to the type of supply to consumers. For this reason the census areas were classified into four categories by the consultant, according to the major type of water connection existing in each area. The placement of a census area into a category was based on a sampling survey carried out by the project and on housing categories presented in town plans. Commercial, institutional and industrial users are supplied by house connection irrespective of these supply areas.

The supply areas are furnished with the proportional composition of water connections as presented in Table 6.

Table 6. Types of Water Connection in Various Supply Areas

Supply area	Type of water connection		
	house connect.	yard connect.	stand post
- A	100 %	-	-
- B	75 %	25 %	-
- C	40 %	40 %	20 %
- D	20 %	40 %	40 %

Only Stone Town in Zanzibar Town falls into category A. The B and C areas are situated in town centres or centre extension areas. The D category consists of urban fringe zones. Graphical presentations on water demand estimates for 1990 - 2015 are given in Annex 10.

The average domestic water demand according to supply areas is presented in Table 7 and Annex 10.

Table 7. Estimated Domestic Use according to the Type of Supply Area

Type of Supply Area	Domestic Use, LPCD		
	1990	2000	2015
- A	50	80	100
- B	45	70	88
- C	34	51	64
- D	26	38	48

Commercial and Institutional Use

Owing to the lack of information on actual water consumption rates and of comprehensive financial and functional plans of institutions and enterprises, the principle of specific use cannot be applied in the calculations.

For this reason, commercial, institutional and industrial water demand is estimated as a proportion of total water demand based on overall observations.

The proportional figures used in the estimates are shown in Table 8 and Annex 10.

Unaccounted-for water

Unaccounted-for water consists of supply and distribution losses (e.g. leaks) and also of intended use of water for various purposes, such as flushing of the distribution network and sewers, street cleaning, fire fighting, irrigation of public parks, etc.

Unaccounted-for water use varies considerably, depending on the condition of distribution network, maintenance practices of networks and streets, etc. Typical figures are 10 - 50 % of total actual use. Unaccounted-for water is estimated to be 30% in 1990, 25% in 2000 and 20% in 2015. The targeted reductions of losses are fairly challenging.

During the next project phase i.e. in 1991 - 1994, a leakage detection programme will be carried out to clarify the actual quantity of unaccounted-for water.

Total specific water demand

Relative total water demand in relation to domestic use is presented in Table 8 and Annex 10 (domestic use = 70 units)

Table 8. Proportional Water Demand for different purposes

Type of Use	Year		
	1990	2000	2015
- domestic	70	67.5	65
- commercial	15	15	15
- institutional	12.5	10	10
- industrial 2.5	7.5	10	
Total actual (%)	100	100	100
- unacc. for water	30	25	20
Total demand (%)	130	125	120

9.3 Total Specific Water Demand

The specific water demand (LPCD), including unaccounted-for water and calculated from the previous estimates, is presented in Table 9 and in Annex 10. For the sake of comparison, figures for Specific Domestic Water Demand are also shown in the table.

The figures for Pemba urban areas are slightly less than those for Zanzibar Town.

Table 9. Total Specific Water Demand (LPCD) Including Unaccounted for Water

Year	Total Specific Water Demand (LPCD)	
	TSWD*	SDWD**
ZANZIBAR TOWN		
1990	69	37
2000	99	54
2015	123	67
WETE		
1990	60	31
2000	87	47
2015	123	67
CHAKE CHAKE		
1990	56	30
2000	86	46
2015	122	61
MKOANI		
1990	54	28
2000	81	41
2015	109	60

*) Total specific water demand, including domestic, industrial, institutional, commercial and unaccounted- for water.

**) Specific domestic water demand

9.4 Water Demand Estimates for 1990 - 2015

Total water demand estimates for each town are based on the population projections presented in Chapter 6, on land use plans outlined in Chapter 3 and on the specific water demand criteria of Chapter 7.2.

Information on water demand was also received from a number of enterprises and institutions in Zanzibar Town. The data, however, proved to be inadequate for reliable calculations. It was utilized as comparative material for general observations.

Estimates were calculated for average specific water demand. Commercial, institutional and industrial water demand is included in figures for domestic demand.

The growth of water demand over the course of years is assumed to be linear. Water demand estimates in detail for 1990 - 2015 is presented in Table 10 a and b.

Total Water Demand Estimates

Table 11 and Annex 10 show the summary of water demand estimates for urban centres.

Table 11. Summary of Total Water Demand Estimates for the Urban Areas of Zanzibar

	1990	2000	2015
	Total water demand, 1000 m³/d		
Zanzibar Town	10.1	21.8	49.6
- UAW	3.0	5.5	9.9
Total	13.1	27.3	59.5
Wete	0.9	2.1	5.7
- UAW	0.3	0.5	1.1
Total	1.2	2.6	6.8
Chake Chake 0.6	1.4	3.4	
- UAW	0.2	0.4	0.7
Total	0.8	1.8	4.1
Mkoani	0.3	0.6	1.4
- UAW	0.1	0.2	0.3
Total	0.4	0.8	1.7
Grand total 15.25	32.5	72.1	

UAW = unaccounted-for water

According to the estimates, the total water demand in Zanzibar Town would double by the year 2000, and would be about 3-4 times the present demand in the year 2015. On Pemba, the total water demand would double in each town of Pemba by the year 2000 and would be about 5.5, 5.0 and 4.2 times the present demand by the year 2015 in Wete, Chake Chake and Mkoani respectively. The differences in water demand between towns on Pemba are due to unequal population growth rates.

Graphical presentations related to water demand estimates are given in Annex 10.

10. DESIGN CRITERIA

10.1 Water Consumption

Planning criteria are based on water demand estimates for 1990 - 2015, which were dealt with separately in Chapter 6: "Water Demand Estimates for 1990 - 2015".

For dimensioning of the water supply system, the following extreme fluctuations in water consumption are assumed

- peak day factor (k1) 1.35
- peak hour factor (k2) 1.20

The above-mentioned peak factors k1 and k3 have been chosen on the basis of typical, generally applied factors for a town of the same size as Zanzibar Town. In order to simplify the calculations, Zanzibar Town peak factors are also applied for the townships of Pemba. The peak hour factor k2 is smaller than that used conventionally. The low peak hour factor is based on the assumption that consumers with indoor and yard taps will install an elevated water tank on their housing premises. This criteria has to be approved by UWSA during the preparation of public water rules in future. Service connections convey water to the private tanks. The house reservoirs will supply additional water to houses, if necessary, during the peak fluctuations of the public distribution system.

10.2 Water Discharge

10.2.1 Water Sources

Groundwater resources will be utilized as water sources. Borehole wells are preferred, but springs will also be used.

10.2.2 Water Quality and Treatment

The physical and chemical quality of water shall match the standards applied in Tanzania for drinking water (Annex 6).

Water is considered bacteriologically safe if it contains no coli bacteria.

Nowadays, water for consumption is delivered without undergoing any treatment.

Disinfection of water by using chlorine shall be arranged centrally at water storage points before distribution. Some smaller disinfection facilities are needed at intakes that convey water to the distribution network directly and not through the central disinfection facilities.

The water intake surroundings have to be protected. No land use which would cause environmental or water quality risks shall be allowed.

10.2.3 Water Discharge Facilities

Water discharge capacity is dimensioned according to the peak day demand based on average daily (low) water demand (QdL), i.e. discharge = 1.35 * QdL

To obtain the planned capacity, it is assumed that the water supply is operational for 24 hrs/day.

The use of QdL as a base of dimensioning the discharge facilities partially ascertains water supply under unfavourable circumstances, e.g. during prolonged drought seasons of moderate intensity.

Pumps for water discharge are standardized to three categories, according to pumping capacity.

- Type I 35 - 45 m^3/hr
- Type II 65 - 75 m^3/hr
- Type III 130 - 140 m^3/hr

All intakes where the prevailing pumping head will be more than 50 m W.H. will be equipped with a special pressure reduction valve against the water hammer.

The designed pumping capacity shall to be obtained when the efficiency rate of the pump and motor is over 70 %.

Each well field will be divided into units of 1 - 3 boreholes and will be provided with water meters and operation, monitoring and controlling devices.

Detailed criteria for borehole well design is given in the Water Resources Study Report.

10.3 Water Transmission and Distribution

10.3.1 Water Transmission Lines

Transmission pipelines will convey water from discharge areas to storage.

Water transmission pipelines are dimensioned to match the full capacity pumping of 24 hrs/day.

The velocity of flow in transmission lines is 0.9 - 1.8 m/s, depending on the diameter and length of pipeline.

Long transmission pipe lines between intakes and reservoirs will be furnished with double orifice air valves, located on all highest elevations of pipelines.

The proposed transmission pipelines are dimensioned by the Loop-Network Programme.

The pipe material for new transmission lines will be Tyton jointed ductile cast iron with cement mortar lining inside.

10.3.2 Distribution Pipelines

The proposed distribution networks were tentatively checked by the Loop Network Programme. Calculations were carried out for the years 1994, 2000 and 2015. The daily maximum peak hour consumption, i.e. Qd Low x 1.35 (K1) x 1.20 (K2), was used as the water demand in the calculations. Pipe sizes were chosen so that the average head loss in pipeline does not exceed 5 m/km. The results of Loop calculations are not included in this report, but they have been filed for future use.

The pipe material for distribution mains, size 200 mm and over, will be Tyton joined ductile iron with cement mortar lining.

For smaller pipe sizes, standardized PVC or HDPE pipes can be considered. Under main roads and in areas where erosion can be expected, ductile pipes are recommended. All connections for private consumers will be made of 150 mm or smaller pipes. In all cases where the distribution main is 200 mm or over, a parallel 50 - 100 mm house connection line will be installed. The parallel house connection line will be separated from the main line by a gate valve.

The distribution network will be installed with the necessary accessories, such as gate valves, section valves, air valves, wash outs, fire hydrants etc. according to local standards.

10.4 Water Storage Capacity

Water storage capacity is required for

- balancing fluctuations in consumption
- overcoming pumping interruptions (optional)
- fire fighting reserve

The principle for calculating the required additional storage capacity is presented in Annex 11. The required storage volume for balancing hourly and daily fluctuation is:

17.5 % * QdL = ave. daily (low) water demand

The optional provision for pumping interruptions equals a 3 hr failure during the highest hourly demand, and is:

17.5 % * QdL

The fire fighting reserve complies with Tanzanian planning criteria and is:

1.0 % * QdL

The total water storage capacity needed is thus:

18.5 % * QdL - 36.0 % * QdL

In addition to enhancing the reliability of the water supply, a larger storage capacity also allows major part of pumping to take place during night-time. This reduces peak-loads in

electricity supply and the costs of power generation which eventually has a positive effect on the operation costs of the water supply.

To keep public investments in constructing of water reservoirs within reasonable limits, consumers who have indoor or yard taps supply are requested in future to erect private elevated tanks to which service connections are made. The minimum capacities of the tanks are:

Domestic use	
- detached/semi-detached houses	200 l/household
- multi-storey houses	15 % of av. daily use
Commercial use (hotels, restaurants, laundries etc.)	30 % of av. daily use
Institutional use (schools, hospitals, army bases etc.)	30 % of av. daily use
Industrial use	30 % of av. daily use

Private water tank capacity is taken into consideration in calculating the storage capacity requirements for the water supply systems. The water storage capacity requirements for different schemes are presented in Annex 11.

In each town, the water storage capacity will be developed to reach the required level. According to Annex 11 there will be no need to construct more storage capacity in public distribution system for daily fluctuations, pumping interruptions and fire fighting.

Water Reservoirs

All the existing reservoirs need overhauling.

All main reservoirs sites will be provided with the following structures and equipment:

- control/office room, either new or rehabilitation of the existing one
- mechanical water level gauge
- flow rate meter
- central disinfection equipment
- areal fencing
- sanitary facilities

10.5 Pressure Requirement

The pressure requirement depends on the height of floors in the houses to which water is supplied and whether there is a water meter or not, as follows:

No. of floor	Pressure Requirement (m. W.H.)	
	with meter	without meter
I	16	11
II	19	14
III	22	16
IV	25	20
V	28	23
VI	31	26
VII	34	29

The pressure requirement figures include provisions for head loss due to service connection (5.0 m. W.H.), height of building (3.0 m.W.H./floor) and the discharge flow (3.0 m.W.H.). A head loss of 5.0 m.W.H. in the water meter is used.

The ground elevation at each house shall be added to the abovegiven pressure requirement figures, in order to obtain the total pressure requirement at each service connection.

The pressure level in networks shall not be increased more than what is necessary to supply to the highest buildings. Brake pressure arrangements are proposed for the following schemes:

- Zanzibar Town, between Welezo and the main distribution network
- Mkoani Town, between the existing high pressure zone and the proposed low pressure network

The pressure control will be arranged by brake pressure valves. The specifications of the valves are:

- stepless adjustable type, 30 - 65 m.W.H.
- adjustable energy against water pressure

11. URBAN WATER SUPPLY SYSTEMS

11.1 Water Supply System in Zanzibar Town

11.1.1 Proposed Water Supply System

The future water supply system will be established only as high pressure distribution network, where Welezo reservoirs/ break pressure will maintain the pressure level. Main borehole fields will be located on the eastern side of Welezo. From these water sources, water will be pumped to consumers through a central disinfection unit at Welezo (Map 3B -3D).

The Saateni Water Works in the centre of the town will be rehabilitated to disinfect and distribute the total recharge of Bububu and Mtoni.

Of the present borehole intake sites, Chunga, Mwembe Mchomeke and Kianga will be further developed. At Kijito-Upele, new boreholes will be drilled to meet the capacity of the existing transmission pipelines.

All the intake structures will be renovated to match the quality requirements of today, including environmental aspects, building structures and electrical/mechanical standards. To fulfil these requirements, almost all existing structures have to be demolished and complete new structures shall be constructed. New equipment has to be installed and environmental protection to be paid attention to.

Kaburi Kigombe and Mbweni boreholes will be utilized for Zanzibar Town until new intake structures are constructed.

The Welezo water reservoirs need rehabilitation. The 450 m^3 steel tank as well as the two other steel tanks in Saateni are to be dismantled in pieces; after overhauling they shall be rebuilt on the same plot as the Welezo concrete reservoir. The 2,250 m^3 concrete reservoir needs to be inspected and repaired before it can safely be filled up to the HW level. A central disinfection unit and an office building are needed at the Welezo reservoir site in the near future.

After renovation, Saateni and Welezo will have a total reservoir volume of 7,850 m^3. In addition there are some private industrial reservoirs of approx. 4,500 m^3, which means 13,350 m^3 total volume to protect against operational failures and fluctuations in demand, and for private reserve.

The pressure circumstances will change once the Welezo reservoirs have begun to function better as planned. The pressure level will rise from the present absolute 1 - 2 bars up to 5 - 6 bars if no action is taken. To avoid overly high pressure and unnecessary water losses, either adjustable brake pressure valves or/and brake pressure tanks will be installed between Welezo reservoirs and the distribution network. The rehabilitation of the existing distribution network should take place as soon as possible.

The planned water supply system configuration is based on computerized hydraulic calculations. The programme used for calculations was the UNDP developed 'LOOP'

simulation programme for looped water distribution networks. The results of these calculations are not included in this report, but they are organized in files for future use.

11.1.2 Proposed Water Supply System, Phasing

The existing water supply system of Zanzibar Town was described in Chapter 7.

The future water supply system emphasises training of urban water supply authority staff and development of the existing system to maximum capacity as a matter of priority in the implementation of schemes for rehabilitation or construction.

The physical development is planned to be carried out in three phases. A short presentation of each phase is given below.

Depending on economic and institutional development, some parts of the scheduled works may be postponed to later phases.

PHASE I, 1991-1994 (Map 3B)

The main target for phase I is to concentrate on rehabilitation of the existing water supply system, test/production borehole drilling, renewing of the existing intakes and construction of a new head office for the DWD. Works which will be carried out are listed below:

- Saateni Water Works rehabilitation

- To increase the quantity of water pumped, the potentiometric level in Mtoni and Bububu spring will be lowered by installing high capacity pumps in the springs. As an ultimate alternative, test/production drilling may be tried in the catchment areas.

- Rehabilitation of Mtoni and Bububu intake buildings.

- Drilling of test/production boreholes in Kijito Upele I-II, Chunga, Mwembe Mchomeke, and Kianga and test production borehole drilling in Mwembe Mchomeke II and Kianga North I (Map 1A). Intake construction for the same intakes.

- Rehabilitation of Welezo concrete reservoir

- Overhauling of three steel reservoirs, two at Saateni and one at Welezo and reconstruction of them at the Welezo site.

- Installation of brake pressure valves or/and brake pressure tanks between Welezo reservoirs and the distribution network.

- Construction of site office and chlorination buildings at the Welezo site, and installation of chlorination equipment.

- Construction of Head Office premises with an office, workshops, laboratory and store facilities.

- Construction of distribution pipelines in urban and urban fringe areas (9.5 km).

PHASE II, 1995 - 2000 (Map 3C)

Phase II tasks will be to continue rehabilitation of the existing network and to concentrate on construction of the new transmission and distribution network. Drilling work will continue. Intake construction will go on, and a new pumping line will be installed at Saateni booster station.

The main works for Phase II are:

- Construction of a distribution network for urban and urban fringe areas (31.4 km)
- Construction of a transmission pipeline from Mwembe Mchomeke II to Welezo (2.5 km)
- Mwembe Mchomeke II, intake construction
- Installation of a new pumping line at Saateni booster station, depending on the increase in water quantity available at Bububu and Mtoni springs.

PHASE III, 2001 - 2015 (Map 3D)

Phase III includes borehole drilling for new intakes and intake construction with transmission pipelines. Distribution network extension and pump replacement to existing intakes are also included in this phase.

The main works for Phase III are:

- Pump replacement in Chunga, Kijito Upele I-II, Mwembe Mchomeke I-II, Kianga, Mtoni, Bububu and Saateni
- Production borehole drilling and intake construction in Kimara, Kianga North I-II and Kizimbani I
- Transmission pipeline construction for the intakes mentioned above (10.1 km)
- Construction of distribution pipelines for urban and urban fringe areas (48.2 km)

11.2 Proposed Water Supply System, Wete

The future water supply system in Wete will function with two pressure zones. Mtemani reservoir, Gawani and Bungumi intakes as well as the main distribution network have to be rehabilitated to meet today's standards. New water sources will be developed in the Weni River Valley, Kwale area, north-east from the town (Maps 4B - 4D).

Masipa intake will be engaged for urban water supply only until new water sources are constructed. Afterwards, Masipa will be handed over for rural use.

At Mtemani reservoir site, there are reservoirs at three different levels. The hydraulic calculations show that it is possible to get adequate pressure for high - level flats from the reservoir R3. It will be possible to design the new system at two pressure levels only. Before implementation this solution needs to be studied more carefully. Pressure levels in the network have to be observed after the pipes have been filled with an adequate quantity of water.

High-level and low-level reservoirs will be maintained at Mtemani. The booster station, chlorination units and also the office building, with daily storage facilities, will be located at Mtemani.

The hydraulic calculations for the existing distribution network were completed. At the moment the network capacity seems to be enough for the first implementation phase. The geometric shape of the network should be made more looped, to make it function in a reliable way during operational failures.

The phasing for the proposed water supply development is given below:

Depending on economic and institutional development, some parts of scheduled works may be postponed until later phases.

PHASE I 1991 - 1994 (Map 4B)

The target during Phase I is to concentrate on rehabilitation of the existing water supply system and maintenance of the distribution network. Drilling of test/production boreholes at Bungumi and at the future intake site at Kwale is included in the programme. The works to be carried out are listed below:

Mtemani Water Works

- rehabilitation of reservoirs R1, R3 and R4
- demolition of reservoir R2
- rehabilitation of booster station
- construction of an office building
- installation of chlorination facilities
- area protection and installation of lights

Gawani Intake

- ehabilitation of the intake
- spring protection and areal fencing and installation of lights

Bungumi Intake

- rehabilitation of the intake
- drilling of test/production borehole
- spring protection, fencing of the compound and installation of lights

Kwale I

- drilling of test/production borehole(s)

PHASE II 1995 - 2000 (Map 4C)

The target for Phase II will be to increase future water discharging facilities and to construct new transmission and distribution pipelines in the urban and urban fringe areas. The major works for Phase II are:

- Intake construction at Kwale I for the boreholes drilled during phase I
- Construction of transmission pipeline (1.5 km) between Kwale I and Mtemani reservoir site
- Construction of a distribution pipeline (4.1 km) in urban and urban fringe areas

PHASE III 2001 - 2015 (Map 4D)

The main objectives of Phase III will be the same as during the previous phase. In addition pumps in the existing intakes/booster station will be replaced.

The major works are:

- Test/production borehole drilling and intake construction in Kwale II - III
- Construction of a transmission pipeline from Kwale II - III to Kwale I (1.5 km)
- Construction of distribution pipelines (11.4 km) in urban and urban fringe areas
- Replacement of pumps in Gawani, Bungumi, Mtemani and Kwale I

11.3 Proposed Water Supply System, Chake Chake

At Chake Chake the Water Supply System will change considerably from the present situation. The eastern part of the system, i.e. Fidel Castro and Jamvini Water Works will be maintained for urban use for a few years only. Once new water sources in Kwapweza-Kiziwamaji area have been developed, Fidel Castro and Jamvini Water Works will be handed over to rural schemes, or abandoned. The Miembeni spring intake will be abandoned in the near future. The proposed water supply system is presented in Maps 5B - 5D.

The proposed water supply system configuration is based on computerized hydraulic calculations. The programme used for calculations was the LOOP simulation programme developed by the UNDP for looped water distribution networks. The results of calculations are organized in files for future use.

Kwapweza intake rehabilitation for supplying water to Chake Chake will be the first priority of this scheme. Simultaneously with Kwapweza water source development, the Machomne Water Works are to be rehabilitated.

The main distribution line (150 A.C.) between Machomane reservoir and the centre of town has to be renewed, owing to clogged calcium store inside the pipelines. In the northern part of the town, the water pipeline (75 A.C) is too small and a parallel new pipeline needs to be constructed along the main road.

In future the distribution network will be augmented and made into a well looped system.

Machomane Water Works rehabilitation includes dismantling, overhauling and reconstruction of the reservoirs. Disinfection facilities will be arranged at the ground level tanks. The booster station will be rehabilitated. The boosting system can be considered to be changed into a pipeline boosting system instead of using an elevated reservoir. The existing high level reservoir could be reconstructed at ground level.

The UWSA head office in Pemba is proposed to be located at Chake Chake. The construction of a head office with workshop and laboratory facilities is included in the Pemba Urban Water Supply Programme.

The phasing for the proposed water supply development is given below. Depending on the progress of economic and institutional development, some parts of the scheduled works may be postponed to later phases.

PHASE I 1991 - 1994 (Map 5B)

The main target of Phase I is to develop the water supply to meet the present water demand in Chake Chake. The rehabilitation of Machomanne water works and renewing the worst parts of the distribution network will be carried out simultaneously. The construction of UWSA Pemba head office facilities is scheduled to take place during Phase I.

The works for Phase I are listed below:

Kwapweza I intake

- Drilling of test/production borehole(s) in Kwapweza I and intake construction for the same

Machomanne Water Works

- Dismantling, overhauling, and reconstruction of reservoirs R1 and R2
- Rehabilitation of the booster station, construction of the site office and installation of disinfection equipment
- Areal fencing and installation of lights

Distribution Network

- Construction of the main distribution pipeline (2.2 km) from Machomanne reservoir site to the West and to the North.

Head Office Construction

The head office will be located at Chake Chake. The works will thus include construction of a new premises or rehabilitation of existing ones for the proposed the Urban Water Supply Authorities.

The study on the possibilities to construct this office at Machomanne reservoir site will be carried out.

PHASE II 1995 - 2000 (Map 5C)

During phase II, some works omitted from Phase I may be finalized. Target for this phase is to continue with the development of new water sources and the distribution network.

Works for Phase II are listed below:

Kwapweza II intake

- Drilling of test/production borehole(s) in Kwapweza II and intake construction for the same

- Construction of transmission main (1.1 km) between Kwapweza I and II.

Distribution Network

Construction of 7 km of the distribution network in urban and urban fringe areas.

PHASE III 2001 - 2015 (Map 5D)

The target of Phase III is to improve the service level in urban areas by introducing new water sources and distribution facilities.

The following works are proposed to be carried out during this phase:

- Drilling of test/production borehole(s) in Kwapweza III and intake construction for the same.

- Construction of transmission main (1.1 km) between Kwapweza II and III.

- Replacement of a portion of 1.4 km of existing raising main (2 x 150 mm) between Kwapweza I and Machomanne with a 300 mm pipe.

- Replacement of all worn-out pumps at Kwapweza I-II intakes and Machomanne booster station.

- Construction of about 15 km of distribution pipeline in urban and urban fringe areas.

11.4 Proposed Water Supply System, Mkoani

The proposed water supply system of Mkoani aims at developing the existing system for future needs. During the first phase, the works emphasize rehabilitation of water sources in Changaweni and Uweleni. A new water source in Ng'ombeni, just 0.5 km from the town to south, will be test drilled and constructed if successful. The proposed water supply system is presented in Maps 6B - 6D.

Uweleni water works will be rehabilitated simultaneously with the developing of the water sources. The high - level reservoir will be dismantled, overhauled and rebuilt. Disinfection facilities will be installed at the Uweleni site. The office facilities will be rented in town or a new office building will be constructed at Uweleni for the staff of the proposed UWSA in Mkoani.

Later on, the distribution network will be augmented and new water sources are to be developed in Mailinne area about 4.0 km from the town to the south-east. The distribution network will be looped and extended in the urban and urban fringe areas. At the lower elevation on the coastal side, a low pressure distribution network will be constructed. The pressure will be adjusted either by the brake pressure valve or/and brake pressure tank installed in the main transmission line. A new raising main will be installed from Mailinne to Uweleni.

The hydraulic calculations are based on the UNDP's LOOP programme mentioned earlier.

The phasing for proposed water supply development is given below. Depending on economic and institutional development, some parts of the scheduled works may be postponed until the later phases.

PHASE I 1991 - 1994 (Map 6B)

The main target of phase I is to increase the water supply to meet the demand by developing intakes in the vicinity of the town. The rehabilitation of Uweleni water works, with arrangements for office facilities, will be carried out.

Works for Phase I are listed below:

Uweleni Water Works

- Drilling of test/production borehole and intake construction for the same
- Dismantling, overhauling and reconstruction of the overhead reservoir
- Installation of disinfection equipment
- Rehabilitation of areal fencing and installation of lights
- Construction of a site office or renting an office in town for the UWSA's O&M staff

Changaraweni Intake

- Drilling of test/production borehole(s) and intake construction for the same

Ngombeni Intake

- Drilling of test/production borehole(s) and intake construction for the same

- Construction of 0.6 km of new distribution pipeline (150 mm) to improve water transmission to Magombeni.

PHASE II 1995 - 2000 (Map 6C)

During phase II some works possibly omitted from phase I will be finalized. This phase is to continue with the development of new water sources and the distribution network.

Works for Phase II are listed below:

- Drilling and construction of spring/borehole intake in Mailinne

- Construction of a raising main (3.5 km) from Mailinne to Changaweni

- Construction of a part of the low pressure distribution network and extension of high pressure pipelines (total 8 km) in urban and urban fringe areas

PHASE III 2001 - 2015 (Map 6D)

The task of Phase III is to extend the distribution network and to increase the water supply according to water demand.

The following works are proposed to be carried out during the Phase III:

- Increment of the Water Supply by constructing more discharging capacity at Meline.

- Construction of a raising main from Changaweni to Uweleni.

- Extension of both the high and low pressure distribution network (4.1 km).

- Replacement of pumps in Uweleni, Changaweni, Ngombeni and Mailinne.

11.5 Electrical Installations

The costs of the master plan are calculated for electrical fixtures from the high voltage lines to boreholes and pumphouses. It is assumed that the high voltage lines will be erected to the pumping station and well field areas by electrification programmes.

The necessary installations, equipment and all work should be carried out in close cooperation between the Urban Water Supply Programme and the State Fuel and Power Corporation.

Electrical installations on the 0.4 kV side of the transformer up to the main distribution board and starters will be carried out by the Urban Water Supply Programme, in cooperation with SFPC. A part of this work can be handled by private subcontractors.

All installations will be in accordance with international and local regulations. The ambient temperature (40 degree centigrade) will be taken into account.

There is a project in progress for building new power transmission lines around both islands. These lines can easily be extended to new pumping stations. It would not be feasible to build the needed power transmission lines as a part of the Urban Water Programme, neither economically nor with regard to manpowerwise. It is thus strongly felt that the power supply project could consider the above - mentioned extension of work. To build a new 33 kW O.H. line costs about 4.5 mil. TAS or USD 23,000 per one kilometre. The price includes all costs according to the information obtained from the electrification project.

Transformers can be purchased locally from TANELEC. Prices range from 1 mil. to 2.5 mil. TAS per unit, depending on the capacity needed. Tentative plans and phasing for electrical power supplies to pumping stations are presented in Annex 12.

11.6 Proposed Operation and Maintenance System

During the implementation phases the rehabilitation of existing network and yearly maintenance for the whole water supply system will be carried out under the supervision of the proposed Urban Water Supply Authorities' Operation and Maintenance Section. The proposed organizational chart is presented in Chapter 12.4.2.

The proposed O & M system includes the following main components:

i. Workshop
   - pumps and generators
   - maintenance of civil works
   - automobile

ii. Water Supply/O & M
   - maintenance
   - water works

Workshop services cover the activities related to the field and workshop premises.

The water supply organization takes care of the running and maintenance of the systems. In Zanzibar Town the work is distributed among two units. In Pemba towns, where the systems are smaller than at Zanzibar, only one combined unit will operate in each town.

In Zanzibar Town, it is planned that one maintenance unit will carry out the network operation and maintenance, such as leakage repairs, pipeline replacements and installation of house connections. The other maintenance unit will be responsible for daily running of intakes, booster stations and reservoirs and also on-the-job training during rehabilitation works at water works.

The task of O & M in the near future is to improve the existing water supply systems, so that they operate at full capacity. This will be a challenging target for the proposed organization. In the beginning the maintenance will concentrate on rehabilitation and reconstruction of existing networks, intakes and reservoirs. Some of these tasks may be carried out by contractors but UWSA staff will also perform maintenance and rehalibitation works under the on-the-job training programme. Once the existing systems reach an adequate operational level the emphasis of maintenance will become preventive maintenance.

11.7 Alternative Technical Options

Implementation of the proposed water supply system would lead to an overall improvement in service level. Although the costs and technology are selected on the basis of the minimum daily water demand alternative, there is concern as to whether the proposed system is affordable in the suggested time span of 25 years. It is therefore realistic to consider the proposed system as an objective to be reached, but not necessarily within definite time limits. The pressure for quick physical development would be eased if serious consideration were given to population restraint. Zanzibar may not be able to support the forecasted population increase.

The technical solution of this report can be implemented if the good prospects for economic recovery materialize. The annual per capita operation and maintenance costs of the proposed system would be about TAS 500 (USD 2.5), which should be collected from the beneficiaries or should be provided by the government.

The time reserved for preparation of the Zanzibar urban water supply development plan did not allow calculation of optional technical solutions. It is felt that alternative options, based on non-continuous functioning of pumps and on substantially lower per capita consumption figures, need to be calculated. Options where the pressure level is lower and reservoirs are not centrally located in Weleso could be studied in detail. These calculations can be completed during the first implementation phase, prior to making major investments for augmentation and construction of new pipeline networks. The programme is phased and planned to facilitate reviews of the plans in due course of time.

As a first alternative option, a combined break pressure/ground level reservoir could be constructed down from Welezo between the existing reservoirs and the distribution network at an approximate altitude of 50 - 55 m a.m.s.l. (Welezo at 70 m a.m.s.l.). Water would be conveyed from the eastern intake areas via Welezo ground level reservoir and the new break pressure reservoir to the distribution network. The existing steel reservoirs at Saateni and Welezo could be abandoned. This option could as well be the second phase of the original plan. The first phase would include only a break pressure valve. The decision concerning a new ground level reservoir could be made in due course of time depending on the increase in water consumption and pressure conditions at that time.

A second alternative option would be to abandon Welezo and bring the water around the Welezo hill to the break pressure tank/ground level reservoir. The reservoir could be dimensioned so that the Saateni and Welezo steel reservoirs could be abandoned. This option would lead to cheaper pumping costs, but would require more expensive, longer transmission pipes and a larger ground level reservoir.

As a third alternative option, the network could be divided into two different pressure zones. The Saateni steel reservoirs would remain in Saateni instead of moving them to Welezo. The low pressure zone (Saateni) would cover the centre of the town, and the high pressure zone (Welezo) would cover other parts of the network.

According to the studies made during the planning period the surface water resources are not feasible alternatives for urban water supplies nor do the hand dug local wells yield enough for machine pumps.

12. INSTITUTIONAL DEVELOPMENT

12.1 Institutional Framework and Development Needs

Institutional Framework

The Ministry of Water, Energy, Construction, Land and Environment, through the Department of Water Development, bears full responsibility for provision of water supplies. The DWD is the sole national authority for all kinds of water undertakings on the two islands, including issuing of permits to drill boreholes for agricultural purposes.

Zanzibar Municipal Council (ZMC) has the sole responsibility for the drainage and sewerage system of the Zanzibar Town. The drainage for the towns of Pemba is also under the respective town councils.

The Ministry of Health in Zanzibar occasionally undertakes water quality monitoring. A water quality monitoring laboratory was recently established at the DWD premises; it is run by the DWD.

The Ministry of Finance and Planning approves and allocates the budget, and the Price Commission of the Ministry approves taxes and rates. Since 1982, only commercial and industrial consumers such as hotels, factories and ships are charged for water.

The DWD consists of two divisions, one on each island and these are divided into six sections. The organization chart is presented in Figure 5.

Other relevant ministries, departments and institutions associated with the water programme are:

- Ministry of Education, Zanzibar (training)
- Ministry of Trade and Industry, Zanzibar (development forecast for industry and trade)
- Commission for Land Use and Environment
- Institute of Marine Science, Zanzibar
- Department of Agriculture, Zanzibar
- Municipal and Town Councils

Needs for Institutional Development

The outline for institutional development is based on the results of the following studies carried out during the planning phase:

- Institutional assessment of the DWD
- Review of the present organization and manpower
- Review of educational systems and training institutes
- Household survey

The studies and their conclusions in detail are compiled in a separate Institutional Assessment and Human Resources Development report.

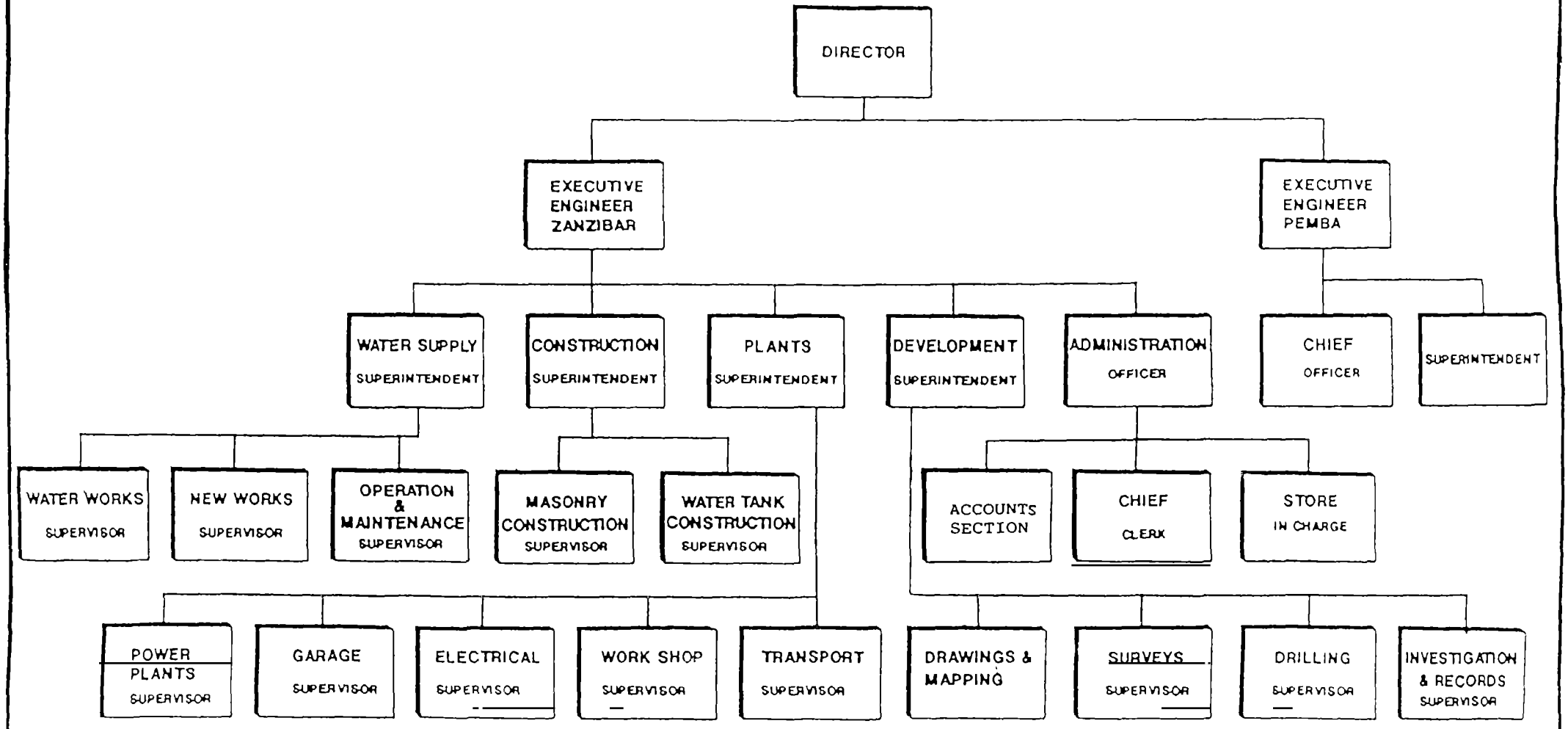


Figure 5. Organization chart of Department of Water Development

The strategies for the development of various institutional aspects are a series of the means proposed for coping with the following major problems brought out by these studies:

- The autonomy of the DWD is insufficient to conduct water supply affairs effectively. There is a need for legal grounds in terms of politically accepted guidelines for developing the water supply and sufficiently independent organizational status is needed.

- Several government departments carry water - related responsibilities. The activities of these institutions should be coordinated better in order that a coherent water policy could be implemented by the water authorities.

- The DWD's freedom of movement in establishing staffing levels and employee compensation for increasing productivity and motivation is too limited.

- The basic managerial tools to direct operations and appraise work performance are lacking. The DWD's functions should be expanded from the day-to-day activities of maintenance and operation to securing the long-term sustainability of the water supply system.

- The DWD's possibilities for providing the staff with skills required in jobs are limited. There is a shortage of persons with higher education in economics or financial matters. The ratio among the staff of high and medium level technical personnel is too small.

- There is no past experience of systematic community participation in the water sector in Zanzibar. A workable institutional means, through which consumers can interact with the water authorities, and suitable patterns for participative activities in urban areas should be developed.

- Information on water issues seems to be quite limited among the urban population.

12.2 Outline for Institutional Development

12.2.1 General

The Urban Water Supply (UWS) Programme as planned will provide reliable and adequate services of safe and clean water at a moderate price to the water users in Zanzibar urban areas. A reliable supply of good quality water to the urban population is to be provided at a satisfactory service level, without overpumping the water resources, which are available in limited quantities. The achievement of the set goals depends on the cost-effective utilization of properly trained available manpower, and of technical and financial resources.

According to the institutional studies carried out during the planning phase, the following three issues should be resolved to guarantee successful further development:

1) Water ordinances and legislation should be introduced to regulate the use of water sources and the development of water supply

2) The Urban Water Supply Authority (UWSA) should be established on a financially sound basis with adequate institutional authority. Cost-recovery through revenue collection should be introduced. The UWSA should be supported by appropriate legislation.

3) The institutional set-up and management system should be well organized for the efficient and cost-effective accomplishment of the duties of the Urban Water Supply Authority. The staff size should be optimized in relation to the work load. The key posts should be filled with properly trained and qualified people.

The measures proposed in this report should be implemented gradually. The Urban Water Supply organizational system should be developed step-by-step towards sufficient autonomy in accordance with the development of legislation and financial systems, and with improvements in service levels.

12.2.2 Integration of Activities

Utilization of the limited numbers of highly qualified staff could be optimized if different institutions with similar expertise needs were to maintain close institutional ties. For instance, possibilities for better cooperation with the State Fuel and Power Corporation should be studied.

The conformation of water supply, sewerage and drainage authorities would facilitate the sharing of administration and engineering resources between the two institutions. This would optimize the use of the limited human resources.

However, new components such as sewerage and drainage should not be added to the planned Urban Water Supply Institution until the institution is performing well and has some excess capacity enabling new functions.

12.2.3 Organizational Form of the Urban Water Supply Authority

Water is a politically and culturally sensitive commodity. It is essential to people's well-being, and public opinion would not easily accept the provision of water on a clearly profitable basis. Therefore there are only two possible options for an organizational form of the UWSA in the Zanzibari setting - a government department or a public enterprise.

The present organizational status as a government office does not enable entrusting the UWSA with the necessary managerial autonomy and financial independence. Therefore a public enterprise is felt to be the only suitable legal framework for the Urban Water Supply Authorities.

Under the Public Enterprise Decree, a parastatal organization can be trusted with necessary managerial authority. The decree provides a legal basis for the operations of the parastatal organization and defines the relationship between the Urban Water Supply Authority and the Government. A parastatal institution is considered to be realistic organizational option in the Zanzibari contex.

12.2.4 Organizational Reform

The transfer towards parastatal status should take place step by step. During the first implementation phase a separate Urban Water Supply Section should be formed within the Department of Water Development. The institutional structure and internal managerial and financial systems of the section should be created, in such a way that the transfer to parastatal status in the future is anticipated. Necessary preparations for the establishment of the public enterprise should be commenced simultaneously with the completion of the first institutional reform of the department.

The establishment of an institution is always a dynamic process, in which various activities and contradictory targets and interests shall be kept in balance. It is assumed that the institutional set-up will undergo dynamic development lasting at least a couple of years before it settles down. Even later on, there should be room for organizational revisions if needed. Regular appraisals of institutional performance should give further guidelines for necessary corrective changes.

12.2.5 Relations between Unguja and Pemba

The institutional structure to be proposed should be based on the following outlines of cooperative relations between the Unguja and Pemba units:

- joint institutional policy
- coordinated planning and budgeting
- operational independence and financial accountability
- similarity of monitoring and controlling systems
- joint personnel policy
- joint specialized facilities and services and
- joint use of available expertise.

The Pemba unit will form a branch of the Urban Water Supply Section. It would be entrusted with operational independence, but functionally and administratively it will be subordinate to the Unguja section. This arrangement would anticipate the parastatal setting and is in accordance with other recommendations made in the development plan.

12.2.6 Water Resources Management

An interministerial Water Board is to be established to coordinate the establishment of organized water resources management. The board would coordinate cooperation between different sectors using water resources. The establishment of the water board does not depend on any other institutional arrangements. It is necessary that operation of the water board begins as soon as possible.

12.2.7 Importance of Human Resources Development

Human resources development will play a vital role in the development process. The means of manpower management and training will be used for materializing the suggested institutional reforms. Through training programmes, the staff will be provided with the skills and knowledge required for completion of their duties in the new institution.

12.3 Functional Targets of Urban Water Supply Authority

The Urban Water Supply section would become as financially self-reliant a unit as possible. Revenues would be collected. Water and installation charges in local and foreign currency would be introduced. After the set productivity targets have been achieved, sales of planning, drilling and laboratory services to other programmes and institutions would form another source of revenue. The Urban Water Authority would maintain a bank account of its own and would operate on sound economic principles.

The Urban Water Supply would aim at self-reliance in current operational activities. Large, periodic or occasional works would be contracted out.

Renovation of the existing schemes and improvement of the reliability of water delivery will be a priority activity. The emphasis of maintenance operations will be shifted from corrective to preventive maintenance.

The UWS section will carry full responsibility for personnel management. Staffing requirements and employee qualifications will be set within the institution. Recruitment of new staff and salary levels will be decided on independently.

The following activities will be introduced:

- contracting out activities
- operational and financial planning, controlling and monitoring
- consumer services including consumer participation, education and public relations
- monitoring of groundwater use and water quality

12.4 Urban Water Supply Organization

12.4.1 Criteria for Making the Organizational Chart

The institutional development is outlined in Chapter 10.2. The criteria for making an organizational chart is as follows:

i) Scope of the Urban Water Supply

Everything connected with the urban water supply network is considered to be a part of the Urban Water Supply.

ii) Service Level

The set service level aims at securing an adequate daily supply of water for all urban inhabitants and other water users. Water will be provided through house connections, yard taps and standpipes. Interruptions of supply, and delays in repairs are to be minimized in order to maintain a constant service level regardless of the type of connection.

iii) Manning Ratios

The manning ratio will be kept initially at the current level, i.e. one employee per every 1000 beneficiaries. The ratio is targeted to change so that there will be one employee per every 1400 beneficiaries in 1994. This would require a substantial increase in the productivity of the organization.

The number of vocationally and professionally qualified staff is expected to increase over the course of time. Targets for higher educational standards of the staff are set in Chapter 10.4.2.

12.4.2 Proposal for the Organizational Chart

The proposed organizational charts and staffing for the urban water supply in Unguja and Pemba are shown in Figures 6 and 7.

At the beginning, it is recommended that the Urban Water Supply Section functions under the Director of the DWD.

The Manager of the Urban Section, like the Director of the DWD, should have a Master's Degree in Water Supply or some relevant field of engineering.

The Section would have a branch in Pemba. It should be headed by the Deputy Manager and carry independent responsibility for operation and maintenance and for auxiliary functions related to them. Due to scarce human resources and for economic reasons, technical planning and design, as well as research and development work, including geophysical and

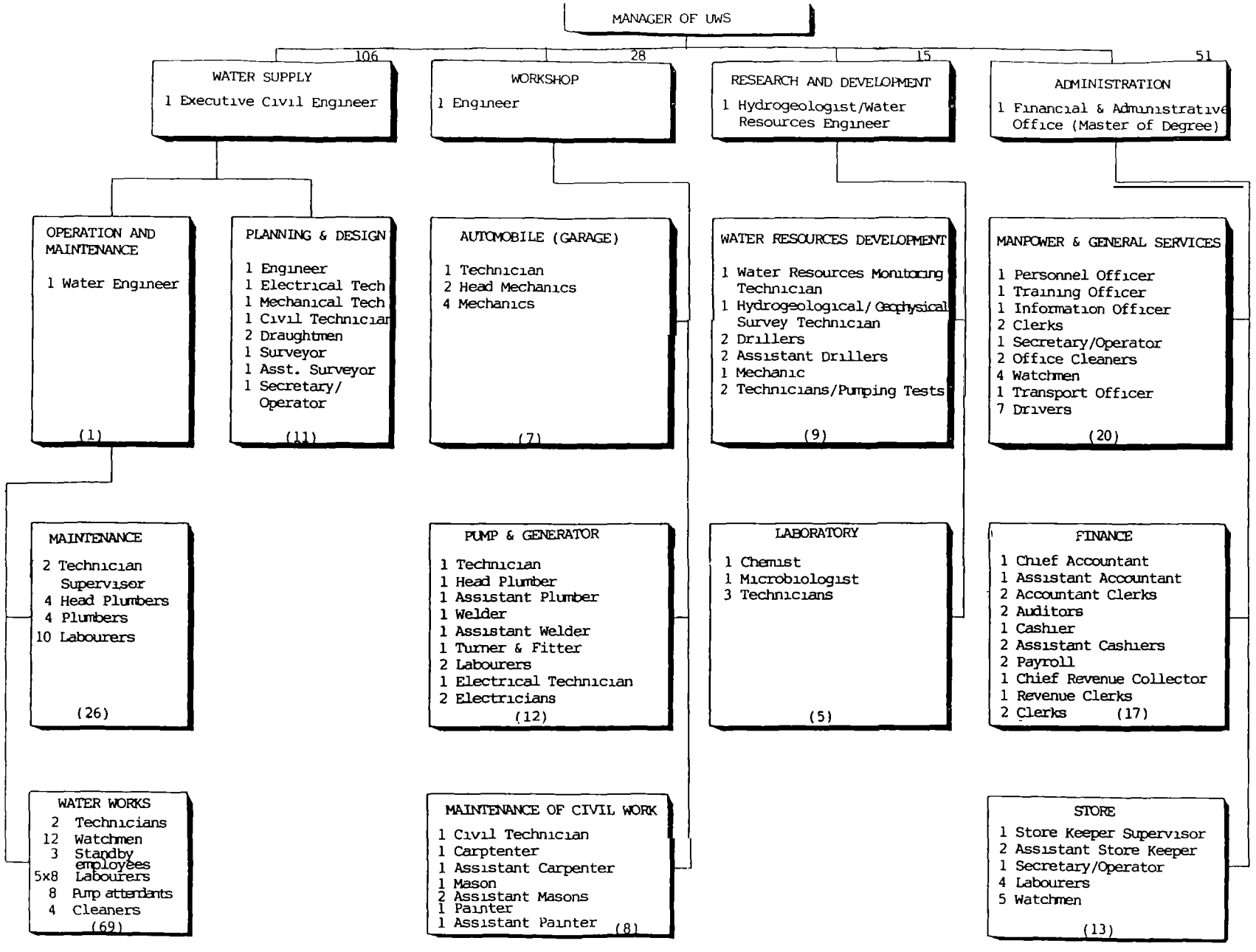
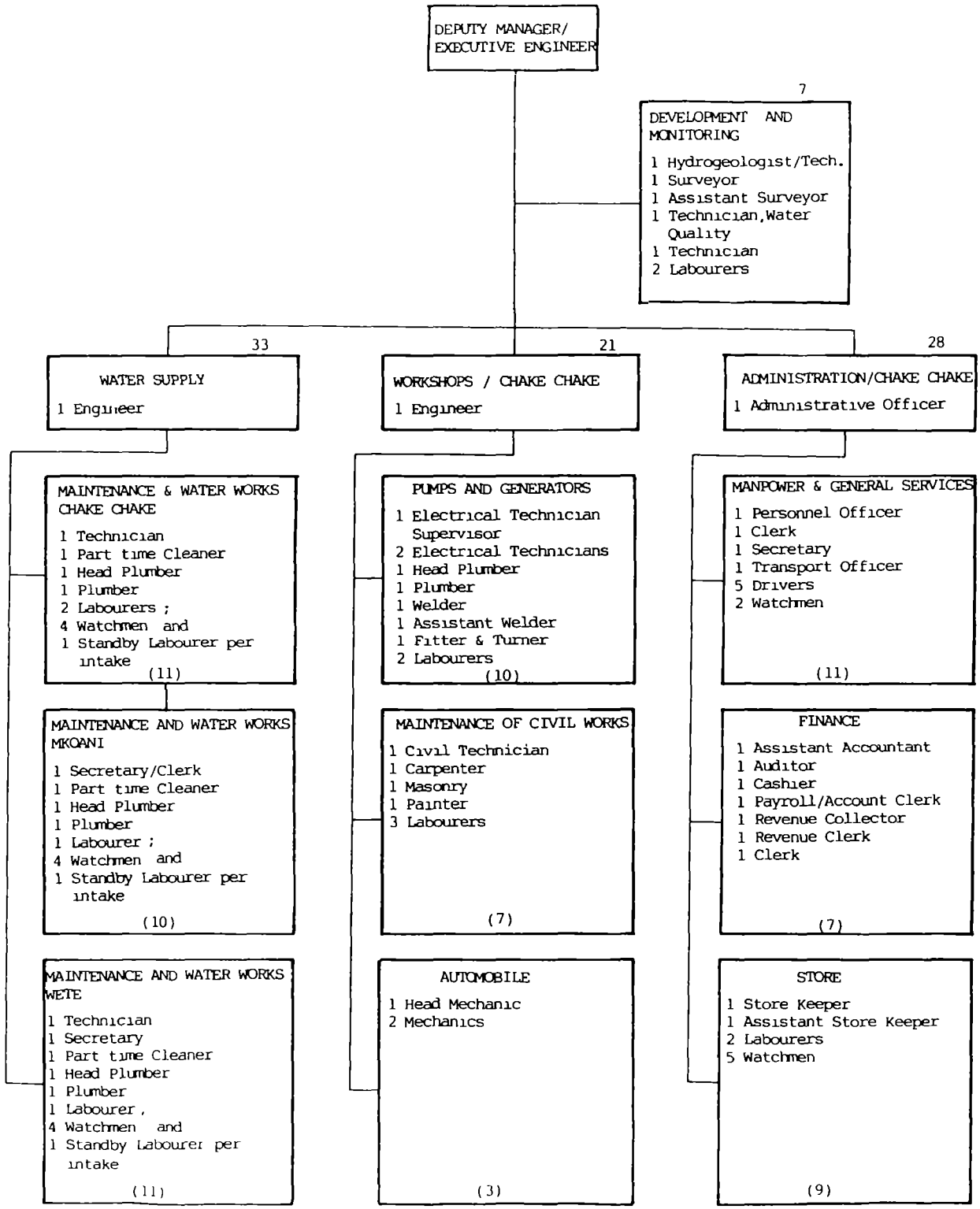


Figure 6. Proposed organization chart for Urban Water Supply Section, Ungula

Figure 7. Proposed organization chart for Urban Water Supply Section, Pemba



hydrogeological surveys and drilling, will be executed by the respective units of Unguja. However, small local units with limited activities are proposed to be established in Pemba, for the implementation of those activities. The proposal also includes the establishment of a laboratory. It might not be justified only on the basis of the needs of urban water supply alone, but a laboratory could sell laboratory services to other institutions as well.

The Urban Water Supply Section in Unguja consists of sub-sections for Water Supply, Workshops, Research & Development and Administration. The units for Operation & Maintenance and Technical Planning & Design are under the Water Supply. The sub-sections are further divided into smaller units with the intention of forming functional entities of proper sizes.

12.4.3 Tasks and Staffing Patterns of the Urban Water Supply Section

It will be of utmost importance to clarify the duties of subunits and staff in the organization and to define clearly the line and functional responsibilities. The relationship between the administration and other units needs to be sound, and efforts should be made to avoid time-consuming bureaucratic administrative procedures.

The main responsibilities of the sub-sections are outlined as follows:

Water Supply

i. The Operation & Maintenance unit consists of the Maintenance Unit and Water Works Unit. The Maintenance unit is responsible for installation and maintenance of house connections as well as network maintenance. All intakes and water works will function under the Water Works unit. Saateni will be developed into a central station. It will have supervision responsibility over Bububu and Mtoni intakes. The Welezo station will supervise the borehole intakes.

   The staffing of the borehole and spring intakes includes staff for security, cleaning and emergency reporting. The intake personnel is supported by regular visits of inspection teams from Saateni and Welezo stations.

ii. The Planning & Design unit is responsible for technical planning and design, construction activities, preparation and supervision of contracts, as well as surveying and preparation of drawings.

Workshops

Workshops consist of units for repairing and maintaining vehicles, pumps and generators, as well as buildings and other civil works.

Research & Development

Research & Development is responsible for ground water issues involving hydrogeological and geophysical surveys, monitoring of water quality of water intakes and network, borehole design construction, drilling, and laboratory services.

Administration

The administration unit is responsible for manpower supply and development, customer services, financial planning and controlling and money transactions as well as general office services. Vehicle management has been placed under Administration, although other solutions would also have been possible. Each unit needs transport for staff, materials, spare parts and tools; one unit perhaps continuously, another occasionally or seasonally. In any case, cars and their drivers should be used economically, and they should be available where most needed. The Administration section will be responsible for records and for the monitoring and evaluation of the performance of the fleet of vehicles. In some cases vehicles and drivers can be placed into the sub-sections permanently.

Stores and purchasing shall be under Administration. However, it must be emphasized that lists of material and spare part requirements for annual work programmes are to be made by the respective sub-sections. Procurement decisions are made by the head of the sub-section concerned. The procurement budget is defined in the annual budget of the UWS-section.

It is recommended that the major activities of the Pemba Branch focus on daily operations and maintenance, as discussed earlier. Design and development work will be carried out in Unguja, in close cooperation with Pemba. Qualified staff from Unguja should work in Pemba from time to time, when necessary.

It is also recommended that Administration and Workshops at Pemba be located centrally at Chake Chake. Wete and Mkoani would have Operation & Maintenance units with officers incharge. They would be answerable to the head of the Water Supply at Chake Chake. The officers should be responsible for operational duties, administrative affairs and spare part supplies on a small scale. In these tasks, the officer would be assisted by a clerk or secretary, who would also serve customers in the office.

The arrangements proposed above will function properly only if the Pemba Branch is provided with sufficient telephone communication and transport equipment.

Management Team

The day-to-day operations of the system are to be decentralized and the role of the heads strengthened. In order to secure sufficient coordination between the units and adequate understanding of common targets and operational principles, it is suggested that the heads of the section form a permanent internal management team with the following mandate:

- preparation of institutional strategies and long-term plans
- preparation and monitoring the annual budgets and plans of action
- development of standard objectives for the institutional performance of the whole organization and for each unit separately
- monitoring and evaluation of the financial and functional performance of the sub-sections and making decisions on corrective actions when necessary
- coordination of the activities of the sub-sections
- approval of job descriptions prepared by the subsections
- outlining proposals for manpower policy

- handling important personnel affairs
- development of management procedures and systems

The Team would be chaired by the Director of the Department, and the Manager of the UWS section would act as the vice chairman. The Management Team would have regular meetings. The meetings should be called together by the chairman, at the request of the Manager of the UWS section. The agenda for the meetings should be prepared by the Manager together with the Director. The Management Team would have a secretary to take minutes. The Management Team should specify the scope of their authority and define the issues to be handled by the Team.

The Deputy Manager of Pemba should attend the meetings whenever common affairs of the islands are dealt with and whenever budgets, annual plans or other policy or development matters are to be handled.

The Pemba Branch should have a management team of its own with a similar mandate in Pemba. The Pemba Team would also prepare suggestions and initiatives for the joint meetings of the section's Management Team.

12.5 Recommendations and Strategies for Implementation of Institutional Development

12.5.1 Legislation and Policy Making

Providing the Urban Water Supply Authorities with the required managerial authority, financial independence and legal basis for its operation is the responsibility of the Zanzibari political bodies and authorities. It would be necessary to draw up and approve new policies and rules to support the UWS- authorities. The UWS authorities would be able to contribute here by participating in preparatory works on committees, as well as drafting proposals and making estimates. The GOZ and concerned ministries would be responsible for finalizing the suggestions and for making decisions.

It is suggested that the following measures be taken:

i) An interministerial Water Board should be established for the coordinating of water resource related activities and the development of water legislation

ii) Proposal for Water Legislation

Useful work in this field has already been done by Solares in 1986 under the commission of GOZ, assisted by the United Nations.

It is recommended that a small committee of experts would draft a proposal, under the guidance of the Water Board, for political decision-makers.

iii) Preparation of Water Work Rules in Zanzibar

Existing Water Work Rules, dating back to colonial times are, to some extent, still applied in practice. These rules could be utilized as source material while new rules are being prepared.

A Table of Contents for Urban Water and Wastewater Utility Rules was drafted during the planning phase. The draft aims at summarizing the vital issues to be included in the Rules.

A small committee consisting of a Zanzibari water engineer, a Zanzibari lawyer and a consultant is proposed to be set up for drafting a proposal as instructed by the UWSA. The proposed Water Board should guide the committee in water resources and water quality related issues.

iv) Water Policy for Zanzibar

A committee has been established to prepare a proposal for Water Policy in Zanzibar. The committee should be encouraged to produce guidelines for the further development of Urban Water Supply as soon as possible.

12.5.2 Institution Building

Urban Water Supply Section

The Urban Water Supply Section should be set up within the Department of Water Development under the Ministry of Water, Construction, Energy, Land and Environment.

Preparations for the transfer of the Urban Water Authorities to a parastatal status should be commenced under the Public Enterprise Decree along with the reform of the existing organization. The concerned local authorities should decide on appropriate procedures and should make preparations for the institutional transfer.

Recruitment of the Urban Water Supply Staff

After the approval of the new organizational structure for the Urban Water Supply and the nomination of the heads for the various functions, the recruitment of the rest of the staff can be commenced. The following procedures and principles are suggested.

The staff will be recruited by using the current recruitment system in Zanzibar. The vacant posts will be advertised and the applications handled in normal order. The Management Team of the Urban Water Supply Section should be appointed by the Principal Secretary. The Management Team would then be responsible for all appointments.

The key posts which cannot be occupied by qualified persons should remain vacant. The lack of qualified staff can be compensated for temporarily by increasing advisory contributions and by using consultancy services until an eligible candidate for the post has been trained.

The UWS-section might interest qualified personnel because of its better working conditions and the new equipment to be provided in the near future. However, it would not be justified to attract specialists into the UWS-section from other sectors where they are needed just as desperately. The manpower needs of the rural water supply sector, in particular, must be taken into account, because the majority of UWS - section staff is likely to be recruited from the existing DWD staff. It may therefore take some time until all the proposed vacant posts are filled with qualified staff.

Management Systems Development

The objective of management systems development is that the UWS-section is capable of improving their management and operational activities on the basis of feedback from the management information system. The basic strategy will be the improvement of institutional performance. Training will be a key tool for achieving the objectives.

It is suggested that management systems development be organized as an institutional development component of the programme. Management training would be included in the programme. The institutional renewal will last intensively for the next four years. The performance of the Urban Water Supply institution should be evaluated at the end of the four year period.

Management systems development should start shortly after the nomination of the staff of the UWS-section. The results of the institutional assessment study should be utilized in the detailed planning of the management systems.

The management development component should start with the top managers, and later on should involve lower levels of hierarchy. The proposed Management Team shall be responsible for the planning and progress of the activity.

The core areas of the management systems development will be systems and procedure development:

- management development
- systems and procedure development
- provision of facilities, necessary equipment and accessories
- training systems development and training of skills
- institutional performance and organizational adjustments
- personnel management including the development of manpower planning system and incentive schemes among other issues of staff policy

It is recommended that the management development component form a sequence similar to a training programme. Individual learning and systems development should dovetail and build upon one another. Short courses, demonstrations, workshops and seminars should be used to introduce concepts and skills to be applied in actual working situations. The progress of management development will coincide with technical development. The new systems and procedures should be worked out together with the staff.

Written manuals, forms and checklists for the essential phases of operations are to be produced by the supervisors and staff. It is assumed that it would be easier for the supervisors and staff to apply their own suggestions. The strategy aims are at improving the employee's work performance while being trained in skills and in developing his own working practices.

The issue of incentives would be a crucial part of personnel policy. A properly functioning incentive scheme should be implemented in order to motivate employees to improve work performance.

The strategy for management systems development remains open ended. Changes should be subject to continuous review. Measurable performance indicators should be produced in the course of the programme. Further development of the organizational structure of the Urban Water Supply section and the management systems should be accompanied by a follow-up of the performance indicators.

Use of Advisers and Consultants

Advisers may be used to bring in ideas and experience, to support the top management of the UWS in the development of managerial and operational systems.

It is recommended that the management expertise available in the Water Resource Institute in Dar Es Salaam and Karume Technical College in Zanzibar Town should be connected with the planning and implementation of the programme. They could conduct short courses or workshops linked with different components of the programme.

The benefits of cooperation would be mutual. On the one hand, the institutes could utilize their experience and become familiar with management problems in a real water supply organization. This may be valuable for further development of their own management training programmes. On the other hand, the UWS programme would benefit from local management expertise and teaching in the Swahili language. The cooperation could be arranged as consultancy work at a standard rate.

12.6 Training

12.6.1 General

Training systems are partly associated with managerial systems, and can be created together with them. However, it is worthwhile to handle training issues separately, due to their great importance to the sustainability of development efforts and to their special characteristics.

It should be emphasized that training is not a sufficient prerequisite for success. Performance problems that stem from the surroundings or from management problems or personnel policy probably will not be solved by training.

Theoretical studies, carried out in universities, colleges and other institutes, should be supported by managers and should be supplemented by on-the-job training. Training should contribute the achievement of institutional targets by providing personnel with actual skills and knowledge needed in carrying out their tasks.

The training systems should secure the sustainability of knowledge and skills although personnel, institutional goals and technology employed may change.

Major targets during the first phase are those of establishing flexible mechanisms for skill and knowledge transfer and improving the training abilities of the institution.

12.6.2 Strategy for Development of Training System

The Urban Water Supply Section along with the Pemba Branch will be responsible for the development of training systems, for the regular assessment of training needs, for annualand

long-term training plans, for budget estimates, for an internal team of trainers and training materials, and for cooperation with relevant training institutes.

The following measures and principles are recommended for the development of training systems and their implementation:

- The establishment of training systems should be started by nominating a training officer and organizing the training of internal trainers. The team of trainers together with the training officer would be responsible for the development of the training system. Training tasks should be included in the job descriptions of relevant professional staff. The role of supervisors and foremen should be strengthened and clarified and their abilities to assess training needs along with their subordinates improved.

  The Pemba office should have its own in-service training system. Upgrading and supplementary courses would be common for both offices.

- Work manuals will be prepared together with the staff, in connection with the development of management systems, for the guidance of work practices. These manuals will be further developed for training purposes by the team of trainers together with local experts. If necessary, the additional training material can be produced by outside specialists, available in the local training institutes.

- Professional knowledge available within the UWS-section should be utilized in the internal training to the greatest possible extent.

- When a course is conducted in Zanzibar, relevant employees from the rural water supply sector could attend.

- Training can be conducted as on-the-job training, internal courses, or studies outside the UWS institute.

  The courses will be arranged in Zanzibar if an adequate number of trainees is available. Relevant personnel should also be sent to courses on the mainland.

- Vocational courses will be executed in cooperation with local training institutes. The cooperation will be arranged on a contractual basis. The UWS-section would determine the objectives of training and participate actively in the preparation of syllabuses.

  If any training of trainers for teachers in these institutions is needed, it will be carried out along with the Water Resource Institute.

12.6.3 Strategy for Professional Training

The objective of professional training is to provide the UWS-institution with a sufficient quantity of properly qualified staff for carrying out professional duties and for development activities.

Plans for professional training are derived from manpower estimates and deficiencies in current staff composition. From the personnel situation of the DWD and the estimated manpower needs of the UWS-section, it can be concluded that there will be shortages of qualified administrators, economists, chemists, engineers, etc. Once all staff required by the UWS-section has been recruited, detailed training plans can be prepared.

Professional training will be financed by the UWS-Programme. The training plans made for the UWS-section cannot be implemented by the Ministry of Education, due to the fact that their potential for financing studies is very limited. The following procedure for arranging professional training is recommended:

- Scholarships in relevant fields will be made available by the programme. The scholarships will be announced by the Ministry of Education according to standard practices. The studies should take place in Tanzanian institutes for higher education

  In exchange for a study place, a candidate should agree to work with the UWS-section for a moderate minimum period of years. The length will be considered case by case.

- Needs for post-graduate studies on the mainland or abroad will be assessed each year, in connection with the preparation of annual and long-term training plans. Studies can be sponsored by the Programme when they are necessary for the accomplishment of tasks of the UWS section and in line with the priorities of activities. Studies overseas are to be considered only if the desired training is not available in Tanzania or in other African countries.

  The relevant institutes for professional and higher education in Dar Es Salaam are Dar Es Salaam University, the Water Resource Institute, the Technical College, Ardhi Institute, the Institute of Finance Management and the School of Accountancy. The Institute of Development Management in Morogoro and Karume Technical College in Zanzibar are also relevant institutes.

12.6.4 Strategy for Upgrading and Supplementary Training

The objective of upgrading and supplementary training is to improve the vocational skills of the staff to the level required for the proper accomplishment of the required tasks. It aims at updating the employees' existing vocational education or skills acquired through working experience.

One of the important tasks of the planned UWS-section is to prepare job descriptions for each employee, based on a task analysis. The job descriptions will also benefit the assessment of training needs.

Supplementary training is of a continuous nature, and concerns all staff groups. With junior employees, theoretical knowledge should be applied in actual working situations by combining theory with actual problem solving. The supplementary training should transmit up-to-date information on professional and vocational issues and on general scientific development to the trainees. Those without formal education would obtain relevant knowledge for improvement of their work performance. Introduction of new technology,

tools and administrative systems in the future must be supported by effective and systematic on-the-job training.

Supplementary training can be conducted in various ways. It may include internal or external courses tailored or ready made for certain staff groups, individual training by sending a person for a short course elsewhere, seminars, excursions or inservice training of different forms. The choices of means depends first of all on the objectives of training and the number of trainees.

The majority of craftsmen and clerical staff in the DWD have learned their jobs through practice. The need for the upgrading of skills within all trade groups was evident, according to the institutional studies of this Development Plan. There is no reason to assume that the staff recruited by the UWS-section in the future possess more updated skills and knowledge than the existing staff of the current DWD. A comprehensive training programme will thus be needed, and it must cover each staff group and employee.

Before the contents, methods and sequence of training activities can be specified, detailed task and skill analyses should be carried out. Each task will be analyzed in order to identify the skills, the knowledge and the abilities required from a worker for mastery of a job. Because the UWS-section is not yet established and staffed, the actual objectives and forms of training cannot be determined yet. Further information will be produced in connection with the management systems development.

As stated before, upgrading and supplementary training will be planned and implemented on a continuous basis, in close cooperation with local training institutes. In the long term, this cooperation will improve the competence of Zanzibari training institutes in carrying out supplementary training in various fields related to water or administration. Obviously, these joint efforts could have a positive impact on the development of the basic schooling system in these institutes.

Vocational courses and seminars for the upgrading of skills and the knowledge of craftsmen will be arranged in cooperation with Karume Technical College and the Water Resource Institute and, as far as clerical staff is concerned, with the Civil Service Training Institute in Zanzibar.

Anyone whose completion of the vocational courses conducted by Karume Technical College and/or Water Resource Institute has been approved should be awarded a graded certificate. Training should foster chances for promotion within the UWS, and should support the employee's career development plans.

Finally, the vocational training should be timed in accordance with technical development. It should be closely linked with the application of new technologies at working places. The course should include a substantial on-the-job component, to be supported by internal trainers and other arrangements.

13. COMMUNITY EDUCATION AND PARTICIPATION

13.1 Introduction

The Programme carried out a household survey in order to gather information, in particular, for the basis of community participation patterns and educational programme. Preliminary results are presented in the separate report Institutional Arrangements and Human Resources Development.

There is no past experience of systematic community participation in water or sanitation sectors in Zanzibar. The DWD consults consumers before repairs or installations are done, but workable institutional means through which consumers can interact with the water authorities are lacking.

The responses of the urban households revealed that they are very willing to contribute (work or money) to improve the water supply, but at the moment channels to do so do not function well. Obviously, patterns for participation should differ from those implemented in rural areas. The degree of participation might also differ inside the town area, according to the degree of urbanization.

Water has been free of charge for domestic users since 1982. This together with intermittent supply appears to have created practises which indicate some carelessness and overuse of water. Intermittent supply also seems to lead a number of practises for storing and handling of water which can easily involve health risks.

The household survey indicated that the great majority of knowledge about water is transmitted by radio. At the moment, water, health and education authorities do not appear to play any role in communication recognized by the people. Information on water issues seems to be quite limited among the urban population.

13.2 Goals and Approaches

The goal of community participation and education is to create a sense of responsibility amongst urban residents for their water sources, so that they would take care of their water supply systems and understand the close relationship between water, sanitation and health. In practice, this means encouraging people to adapt and maintain practices which protect water sources and prevent water from becoming contaminated. They need to take good care of their water connections and maintain consumption habits which favour the economical use of water.

There are very many means available for working towards these goals. Obviously none of them would be enough alone. As to the question of changes in people's attitudes and behaviour, different approaches are necessary. An educational element should be included in all participatory activities. Instruction also aims at improving people's general knowledge about water.

The information available at present is insufficient for specifying in detail what educational activities are necessary or what patterns for community participation suitable. Therefore it is suggested that the next two years be used for providing the Urban Water Supply Section with better knowledge of this field. This can be accomplished by collecting relevant data

and initiating experiments and studies. The proposed measures will focus on activities which can generate new information and be promoted by UWS-section.

All activities should include an investigative aspect, so that the effects of interventions can be measured and conclusions drawn from the results. A strategy for communication and community participation will be outlined by the end of the first implementation phase.

The role of the Urban Water Supply Section is proposed to be that of promotion and cooperation, but actual work should be conducted by authorities of specialists in the field concerned. Local consultants will be very vital in communication issues.

13.3 Recommendations for Measures

The operations proposed below are meant to create prerequisites for the improvement of communication functions and starting points for experimentation. Among the beneficiaries, women and teachers have been chosen as target groups, due to the key role they play in education. Mass media, especially the radio, should also be invited to plan and broadcast regular information spots on water issues, based on consumer contributions.

Capacity Building of the UWS

The institutional capacity of the Urban Water Supply Section should also be improved in terms of organizational methods and participatory activities. It is recommended that the following measures be taken:

i) The post of Information Officer should be established in the Urban Water Supply Section. He or she would be responsible for developing workable mechanisms for public communication, education and consumer information services, and for coordinating these activities.

ii) The USW should create cooperative relationships with health and education authorities in environmental education, and should invite town councils and local governments to cooperate in improving knowledge about water among urban residents and in developing participatory procedures in the water sector.

iii) The UWS should produce a Citizen's Water Guide on the basis of the Water Work Rules as proposed earlier. The Guide should clarify to an ordinary consumer his rights, duties and responsibilities in relation to the water authorities.

Cooperation with Other Institutions

Small-scale experimental actions in order to produce and test educational methods and materials should be promoted. Pilot studies should be carried out with the institutions which reach the key target groups of planned activities. The following measures should be taken:

i) The preparation of an orientation programme for teacher trainers in conjunction with the Ministry of Education and Teachers' Training Institute. The programme should also include a teaching material component, which could be tried in a couple of pilot schools before being finalized as proposals for schools.

ii) The preparation of an orientation programme for health staff working with mothers at maternity clinics in conjunction with the Ministry of Health. Joint activities should be carried out as a pilot study including preparation of instruction materials which should be produced and tested in the course of the study.

iii) The UWS should take the initiative of producing and broadcasting regular information spots on water issues on the radio, and should start negotiations with the Zanzibar Broadcasting Company.

Community Participation

It is suggested that the following approach for community participation be chosen:

i) The Urban Water Supply Programme should take the community participation aspect into account in the planning and implementation of each operational phase. The plans should include separate consideration regarding this component.

ii) Small-scale pilot programmes should be conducted in order to work out proper procedures for community participation in different kinds of urban areas.

14. FINANCIAL AND ECONOMIC ANALYSIS

14.1 General

14.1.1 Economic Position of Zanzibar

The Government of Zanzibar is continuing to pursue a comprehensive Economic Recovery Programme which it undertook in 1987. The main targets of this programme are:

- to reduce subsidies on imported food and stimulate home production
- to control government spending
- to develop the private sector, especially nonagricultural
- to liberalize trade by the removal of state controls.

The implementation of the ERP was reviewed in the beginning of 1990. According to the review, recent economic performance shows a number of encouraging signs, but at the same time fundamental problems remain.

The economy is still heavily dependent on the production and sales of cloves, inflation is at a very high level and there is still a lack of foreign exchange for spares and imports. Credit is growing at a high rate but is concentrated on sustaining the public sector while leaving very little over for the private sector to invest. A fundamental reform in the public sector is still needed to transfer resources to essential public services.

The GOZ and state-owned enterprises account for a large part of economic activity in Zanzibar. The findings of the ERP review reveal that the GOZ itself and the existing parastatals are in positions of heavy accumulated debt. Although total revenue has increased by 25 % over the years 1987 - 89, the GOZ's revenue position is less sound. A proportion of these revenues are levied from parastatals which can only afford to pay them by borrowing from the PBZ. While parastatal contributions are declining as a proportion of Government revenue (from a third of the total in 1984/85 to only a tenth in 1988/89) the parastatals themselves are in a state of severe indebtedness.

The approved Government's 1991/92 budget is totals 19,373.4m/- of which recurrent expenditure is projected at 7,363m/- and capital expenditure 12,009.9m/-,of which 9,038.9m/- will come from external sources. Revenue collection is envisaged to reach 7,363m/- during the year under review. The budget has a deficit of 1.4bn/- which will be covered by grants and credits from local and external sources.

The GOZ's external debt stands in 1991 at US dollars 95.6 million on which the annual interest payment was US dollars 18.8 million. At the same time Zanzibar's annual export earnings were US dollars 15 million of which food imports consumed more than 80 % in 1990/91. The GOZ has announced it is seeking a total of US dollars 800.5 million to finance its economic recovery programme.

However, it must be realized that budgeted expenditure make a poor guide to actual spending. The considerable underspending of budgets is as a rule due to fiscal management systems which are unable to produce accurate and timely information on actual expenditures. Consequently the preparation of each year's estimates is based on in the previous year's estimates.

It can be seen that the economy of Zanzibar continues to rely heavily on grants and loans from abroad. At the same time, however, donors are requesting more often the implementation of measures adopted in the ERP. Among them, the most vital from the point of view of water supply development are the following measures considered urgent in the ERP:

- curtailment of government functions that are either unessential or could be provided more appropriately by the private sector
- implementation of cost recovery measures so that economic services such as utilities (including water) are charged at their full economic cost, although on a phased basis
- parastatal reform including reform of taxation, of setting parastatal prices and of systems for monitoring and supervising parastatals.

The GOZ has stated that during the 1991/92 period emphasis will continue to be placed on infrastructural rehabilitation to improve feeder and interdistrict roads, water and electric supplies to boost agriculture and manufacturing and tourism.

14.1.2 Economic Projections

According to recent budget speeches the GOZ is optimistic about the economic development of the Isles. The GOZ has decided to make Zanzibar a trade centre for East and Central Africa. The GOZ will see to the building of electricity, water and telecommunication facilities for business activities and for the real estate business of Zanzibaris and foreigners. At the moment the GOZ is reviewing the 1986 private investment protection code to offer more incentives to investors. The incentives include tax relief on imported technology and reasonable levels of dividends to be repatriated by investors. The emphasis would also be placed on raising the technical and managerial capability of state enterprises.

Also the ERP review of 1990 states that there is undoubtedly a feeling of improvement in many areas of the economy as a result of the liberalization, while evident interest from foreign and mainland Tanzanian investors is encouraging. However, the review goes on to say that there are also some crucial areas in which very little progress has been made and that a sense of urgency is required to tackle deep seated problems. The financial situation of the GOZ remains a major area of concern as does the lack of a proper banking framework to facilitate credit and enable private enterprise to flourish.

It is evident that improved water supply would very much benefit economic development in Zanzibar. It is also clear that the GOZ will be unable to improve water supply services and simultaneously continue to deliver water free of charge.

14.2 Prerequisites for Cost-recovery of Urban Water Supply Institution

The Development Plan suggests for the urban water supply an institutional status for a parastatal enterprise. Commercial operation is necessary and appropriate for the production and distribution of water, but the controlling of the operation due to the monopoly situation is also necessary. Water has no substitute as a commodity and does not require any marketing efforts, still having a fairly steady and predictable demand. Water also has important social dimensions in terms of public health and hygiene.

Although the urban water supply meets the criteria set by the ERP to justify the establishment of a parastatal enterprise, the risks of establishing another illiquid and indebted parastatal must be realized. The GOZ policy towards parastatals over the past few years has been in principle to try to make parastatals more commercial in their operations. According to the findings of the ERP review, there has been little progress towards significantly improving performance in practice. Most of the parastatals have long term debts to the People's Bank of Zanzibar. The ERP review (1990) estimates that parastatals absorb around 70 per cent of available credit within a PBZ loan ceiling of Tsh 2.6 billion. Most of the loans have been used to finance losses and have been accumulated over a long period.

Major reasons for the prevailing situation analyzed by the ERP and its review are existing parastatal taxation and price policy on the one hand and inadequate financial management, planning and control systems of parastatals on the other. The Urban Water Supply Programme shares these views and emphasizes that the following reforms stated by the ERP are vital for any cost-recovery and self-financing operation of the proposed Urban Water Supply Authorities; that:

- a parastatal is allowed to operate in a commercial fashion with sufficient control over its own resource and access to adequate capital to meet investment cost

- management teams and parastatal boards have sufficient power and authority to manage operations effectively. The costs incurred through any ministerial interference in day-to-day operations should be compensated for.

- revision of parastatal taxation so that it is paid on actual profits in arrears and at a rate that takes into account the activities of a particular parastatal

- parastatals should be able to recruit their own staff

- prices charged by parastatals should be based on reasonable costs and profit margins; prices should be set annually according to a formula agreed with each parastatal

- parastatals which directly earn foreign exchange should be allowed to retain a proportion in the same way as private sector companies are allowed to do under the export retention scheme.

These external factors vitally affected the economic viability of the urban water supply organisation, although they are not affected by the Programme itself.

The Project carries the responsibility for the development of effective financial management and accounting with a budgeting system including training of staff in these issues. A proposal for a financial and administration system is presented in Annex 13.

The conversion into a parastatal enterprise is supposed to occur gradually in the course of five years. In the event that progress in the creation of necessary external conditions for cost-recovery is not positive, the viability of a parastatal status should be reconsidered and the option of a private enterprise be taken into consideration.

14.3 Existing Tariff Policies and Cost-recovery

14.3.1 Energy Tariffs

Zanzibar State Fuel and Power Corporation (SFPC) was established in 1978. There are 13,000 customers in Unguja and 2,000 - 3,000 in Pemba. All customers are metered in Unguja. Meters are read every month by 8 meter readers and customers billed monthly. In Pemba customers come to the office to pay. If they do not pay they are disconnected.

Unit charges are scaled into 7 tariff classes according to the type of consumer and the amount of consumption. Charges vary from Tshs 1/70 to Tshs 9/20. The basic principle of charging is that when consumption increases the rate decreases. Domestic users pay Tshs 2 per unit and consume 53 % of the total amount of electricity. Large consumers (industrial and commercial premises, and street lighting) pay an additional power charge based on the kVA indicator reset monthly.

The tariff was last set in September 1987. Several approaches have been made to the GOZ and its Price Commission since then for approval to increase the charges. These approaches have been unsuccessful although the ERP of 1987 required the price to be increased by 200 per cent in order to meet the costs.

The Corporation gets 80 % of its electricity by submarine cable from the Mainland. On Unguja, oil is used only as standby power. Pemba, however, is dependant upon oil-generated power on the island for its base load. The generator cost in Pemba is 15 Tshs/unit. However, the same out-of-date tariff applies to both islands.

The DWD is the main consumer of electricity. The other large clients are hospitals, street lighting and Cortex (the textile factory). The SFPC is in severe financial difficulties mainly due to the fact that the largest consumers do not pay the charges. Despite nonpayment, for social reasons, they are not disconnected.

An institutional review of the Corporation is about to take place, probably funded by the ADB. The SFPC has also under consideration a tariff structure which penalises high energy users. This would apply to both domestic and non-domestic users.

However, it can be concluded that if the major problems, the nonpayment by the largest consumers and out-of-date tariffs, remains, any progress in the financial position of the SFPC can hardly be expected in future.

14.3.2 Water Tariffs

During pre-independence and for nearly two decades after independence, water charges were collected in Zanzibar. Charges were based either on ratable value of the premises or on metered consumption.

Ratable value of houses was 10 % of the construction cost of the house. Water rate per month was defined as 5 % of the ratable value. The water rate was valued at about Tshs 3 - 50 for private houses. The industrial users were charged more ie. Tshs 100 - 150 per month. Ships were charged at a rate/m^3. Schools, hospitals, government buildings, religious buildings etc. were free of charges.

The consumers could opt to pay monthly or yearly in advance. Upon payment in advance, two months were given free.

Revenue collection continued after the Revolution. There has been only one revision of rates, soon after the Revolution. The minimum rate was increased from Tshs 3 to 4.5. At present the unit price of the same real value ought to be around 200 Tshs per cubic meter.

Rates applied during early independence are said to be adequate to cover all recurrent costs. Gradually, as the tariffs were not revised according to the inflation, the revenue lost its economic value. In 1980 the GOZ abolished domestic charges and took the full financial responsibility for water supply.

At present water charges are collected from private and state-owned enterprises, restaurants, hotels, guest houses, gardens and cafes. There are about 350 consumers, whose charges are based on estimates and not related to the actual consumption. On average Tshs 2.5 million are collected per year, which makes about 10 per cent of the DWD's recurrent budget. Collected revenue is remitted to the Treasury and is not available the expenditure by the DWD.

Because of deficiences in the customer register and of widespread illegal connections, the amount of uncollected revenue cannot be calculated. Anyway, it is clear that the level of revenue is far too low for any cost recovery based operation.

14.4 Existing Operation and Maintenance Costs

At present the demand for water is far beyond what can be supplied by a system which for many years has been starved of funds for operation and maintenance. The rapidly increasing population together with a shortage of skilled manpower and lack of spare parts has led to a system where supply is frequently disrupted. Evidently the present situation has reached a point where the water supply in all major centres is unbearable for domestic consumers and may also be a critical factor for development efforts by commercial and industrial activities. Notably the potential tourism industry is one which cannot develop without adequate and reliable water supply.

The funds available for the operation and maintenance of the network are allocated for the DWD by the GOZ. The estimated and actual budgets of the DWD for 1989/90 and 1990/91 are presented in Annex 14.

In total the funds are quite inadequate for what is required to support the system, with the result that 69 % of the money went on salaries in 1989/90 and as much as 79 % in 1990/91. The actual budget was 94 % of the estimated Tshs 23,428,110 in 1989/90 and 87 % of 26,665,091 in 1990/91. Operation and maintenance costs formed 28 % of the total actual budget in 1989/90 and only 19 % in 1990/91. Electricity bills have not been paid for years. By the end of March, 1991 the debt amounted to Tshs 32.1 million which, however, the SFPC intends to collect straight from the Treasury.

The budget is set according to a Civil Service pattern which is unrelated to what needs to be achieved with the money. The actual recurrent costs can hardly be calculated either, owing to the fact that real water production is not known. A further point as well is that items properly chargeable to the accounts are not in fact charged. One reason is that the

accounts are prepared on a cash basis i.e. depending on what money has passed through the account books in the accounting period. Because of this lack of a full accounting system with debtors and creditors, the true cost of the service cannot be ascertained. Consequently, the present unit price of water can be estimated only very roughly.

It can be estimated that the budget allocation for water supply means a Government subsidy of 2 - 3 Tshs per cubic meter of water excluding energy costs, which at the present price level would mean the addition of 1 - 2 Tshs per cubic meter. Hence, the gross cost of water is for the time being 3 - 5 Tshs per cubic meter. Taking into account the revenue collected, the net cost is about 2.5 - 4.5 Tshs per cubic meter.

The only way out of this situation is to determine a unit price for water which covers the actual production and distribution expenses and provides adequate maintenance funds.

14.5 Predictability of Consumers' Contribution

14.5.1 Major Findings of Household Survey

A household survey was carried out during the planning phase in order to get more comprehensive qualitative information on people's opinions about water-related issues. The survey was based on the random samples of 200 households in Zanzibar Town and of 100 households in Pemba towns. Preliminary findings of the survey are given in the separate Institutional Report.

The major findings of the study were as follows:

Average size of a household: 7 persons

Average water consumption per capita per day:

Unguja	regular source	60 l
	alternate source	7 l
Pemba	regular source	40 l
	alternate source	19 l
In total		60 - 70 l

63 % of Pemba urban households collected rainwater regularly and 4 % never. The respective figures for Zanzibar Town were 21 % and 53 %. Alternate sources include buying water from vendors, which seemed to be more common in Unguja.

Average distance to water source:

Zanzibar Town	61 %	distance	0
	29 %		under 250m
	10 %		more than 250 m, of which
	3 %		more than 1000 m

Pemba towns	45 %	distance	0
	28 %		under 250 m
	27 %		more than 250 m, of which
	5 %		more than 1000 m

Water costs:

Installation costs declared for connections varied mostly from Tshs 500 to Tshs 2000. Private water pumps are common, but there is no information on costs. Water vendors charge Tshs 20 /40 litres, which would make at least Tshs 80 - 100 per family per day.

Average income:

Data on cash incomes of households must be assessed very hesitantly. The question was responded to by 65 % of the households in Zanzibar Town and 50 % in Pemba. The declaration of income is also affected by several unknown factors. The average seems to lie around Tshs 5,000 per month, but the variation within each occupational class was great. Standard deviation from the average was Tshs 3,500 in Unguja and Tshs 5,300 in Pemba. Those who worked with business had clearly greater income, with the maximum income declared being Tshs 60,000.

In general, income tends to be underestimated. Hence, actual average monthly income may lie between 5,000 - 7,000. However, it is also clear that there are many low income groups which would have problems with water payments. Most of those 22 % in Pemba and 37 % in Unguja who were reluctant to pay gave the reason as inability to pay.

14.5.2 Willingness to Pay

The majority of people are prepared to pay for reliable and better water supply services. Pemba urban residents are more willing to pay than those in Zanzibar Town, probably due to greater water problems in Pemba.

Among different occupational groups the 'yes' answers varied between 30 % - 60 % in Unguja and 50 % - 67 % in Pemba.

The survey also asked householders what level of charge they would be prepared to pay for a good reliable service. This showed, that among those willing to pay for water, the average payment for Unguja was 87 Tshs per month and for Pemba Tshs 76 per month. Maximum amounts per month mentioned by respondents were Tshs 500 per month in Unguja and Tshs 200 in Pemba.

These figures, however, must be interpreted with great caution. It is generally assumed that a respondent would attempt to influence the results of a survey by answering 'strategically' and giving an answer designed to serve his own interests. For example he might feel that his answer influences the amount he would be charged or, alternatively, whether or not an improved water system would be constructed. This error is more likely in this survey, which did not concentrate solely on the question of willingness to pay. It is clear from the survey results that households place a high value on improved water service and are

certainly willing to contribute what for them are substantial amounts of cash toward the operation and maintenance costs of the urban water supply.

It is also interesting to note that only one respondent regarded water supply as the Government's duty, as something which should not be paid for. Although some referred to the fact that they were not used to paying for water, their answers did not include any wishes regarding the Government.

It can be concluded that the restoring of water charges would not have any shock effect. People seem to think that no payment means no service also in the water sector. In fact, deterioration of water services is a recent phenomenon and coincides with the abolition of water charges.

14.6 Financing the Urban Water Supply Development Plan

14.6.1 Investment and Operation & Maintenance Costs

Water production is typically one of those capital intensive industries with a long investment recovery period but also with a long time of amortization of production facilities. However, in Zanzibar the heaviest investments have been made in the course of a long period and the schemes as they are now do not carry any capital expenditure.

The existing facilities still have, however, a substantial utility value and will constitute the major structure of schemes even in future. Hence, investment costs anticipated for rehabilitation work during the first phase of the Plan are substantially lower than if virtually new supply systems were constructed.

Expected costs for the years 1991 - 94 covering rehabilitation are in total around USD 7 million or Tshs 1,400 million, equivalent to USD 30 - 50 per capita, while for complete new systems this figure would easily be ten times as high.

The major part of investment (90 %) is covered by a grant from FINNIDA and the rest is the share of the GOZ, amounting to Tshs 600 - 1000 per capita input.

Still this would be substantially higher than the present annual allowance for the DWD. The annual actual budget of the DWD has been recently around Tshs 21 - 23 million and it must be almost doubled if the GOZ is to meet its commitments. Obviously, this is a big burden for the GOZ, as some money also has to be allocated for operation of urban and rural water supplies.

The net expenditure of the GOZ will be somewhat lower, as the already-estimated annual revenue paid by a few large consumers is annually almost Tshs 3 million and some increase in that can be expected when water charges are revised and reintroduced.

The average unit price of water for the years 1991 - 2015 is Tshs 35 per m^3 including the construction cost of Tshs 25 per m^3 and Tshs 10 for operation and maintenance.

The following relates the construction cost and the annual operation and maintenance costs to the quantity of water consumed. Water unaccounted for is assumed to cover leakage and public use like washing of streets, firefighting etc.

The costs are total costs without any donor's share. The construction cost includes both new construction works and rehabilitation. The value of the existing water supply system and the inflation rate have been excluded.

1991

Annual construction cost	Tshs 55,150,000	
Annual O & M cost	Tshs 94,335,000	
Total annual cost	Tshs 149,485,000	
Water consumption	14,520 m^3/d	
Unaccounted for water (22%)	3,250 m^3/d	
Chargeable water	11,270 m^3/d =	4,113,550 m^3/year
Construction cost	Tshs 13 per m^3	
O & M cost	Tshs 23 per m^3	
Total unit cost	Tshs 36 per m^3	

1994

Annual construction cost	Tshs 460,900,000	
Annual O & M cost	Tshs 108,986,000	
Total annual cost	Tshs 569,886,000	
Water consumption	18,780 m^3/d	
Unaccounted for water (21%)	4,000 m^3/d	
Chargeable water	14,780 m^3/d =	5,394,700 m^3/year
Construction cost	Tshs 85 per m^3	
O & M cost	Tshs 20 per m^3	
Total unit cost	Tshs 105 per m^3	

2000

Annual construction cost	Tshs 259,750,000	
Annual O & M cost	Tshs 99,152,000	
Total annual cost	Tshs 358,902,000	
Water consumption	27,300 m^3/d	
Unaccounted for water (20%)	5,500 m^3/d	
Chargeable water	21,800 m^3/d =	7,957,000 m^3/year
Construction cost	Tshs 33 per m^3	
O & M cost	Tshs 12 per m^3	
Total unit cost	Tshs 45 per m^3	

2015

Annual construction cost	Tshs 220,900,000	
Annual O & M cost	Tshs 119,650,000	
Total annual cost	Tshs 340,550,000	
Water consumption	59,500 m^3/d	
Unaccounted for water (17%)	10,100 m^3/d	
Chargeable water	49,400 m^3/d =	18,031,000 m^3/year
Construction cost	Tshs 12 per m^3	
O & M cost	Tshs 7 per m^3	
Total unit cost	Tshs 19 per m^3	

These figures are largely indicative, but they do reflect the order of magnitude. The required investment costs, especially as to the unit price of water, are not very high.

14.6.2 Sources of Funds

The proposed investments are required to rehabilitate the existing network and to extend and enhance the quality and quantity of the piped water supplied to fulfil the needs of a rapidly increasing urban population on both islands and also expanding economic activities. Where possible the customer should contribute to the cost of providing a water supply. Cross subsidization might be necessary from the richer sector of the community and by seeking other sources of income.

The basic principle of charging the customer is generally accepted to be in relation to the benefit received. It is recommended that this is applied in the case of industrial users, hotels, businesses and domestic customers. In respect of domestic customers the exception should be where such a practice conflicts with public health and the common good.

In addition, there should be sufficient flexibility to take advantage of other sources of funds which may be available or at times become available. The following possibilities should be scrutinized:

1) Broadening the circle of customers

At present only industrial and commercial customers are charged. Government offices, hospitals, mosques etc. get water free of charge although they are obliged to pay for electricity. Introduction of charges for them should be considered simultaneously with restoring water fees for domestic consumers.

2) Charges to property and tourism industry

Property and tourist development is heavily dependant upon water, and charging at rates in order to cross subsidise poorer customers can be seen as having potential.

3) Selling services

According to the Plan the Urban Water Supply Authority will be provided with laboratory and drilling equipment, and a separate unit will be established for research and development of water resources. These facilities could be utilized at least by the Ministries of Health and Agriculture as well as in rural water supply and charged at their full economic cost. This arrangement would benefit other government offices and any overlapping investments could be avoided.

4) Selling water at the harbour

Zanzibar has historically been a watering place for ships. It is worth studying if there is any demand of this kind nowadays. Charging ships for water could be a source of desperately needed foreign currency.

14.6.3 Alternative Tariff Structures

Tariff Structures

A completely new charging system for both domestic and non-domestic customers will have to be developed which clearly identifies every customer and recovers costs in a way that its customers are both willing and able to pay.

A system of charges should be indexed automatically to the rate of inflation in order that tariffs continuously reflect the true costs. This and the power to cut off and to prosecute for nonpayment and illegal use will have to be supported by legislation. It is anticipated that the legislation would also allow for the recovery of all the costs of financing by charges levied on individual consumers.

From consumers' point of view a fully metered system might be the fairest one as every consumer would pay according to his actual consumption. This system, however, requires substantial investments in Zanzibar where metering has not been applied; and maintenance of meters brings in new costs, too.

Nevertheless, it should be worth considering the introduction of a metering system step by step. Firstly, large consumers could be provided with meters. Secondly, new premises could be obliged to install meters by legislation. Additionally, meters could be installed at the request of a customer. The rest would pay a flat rate charge, which could also vary according to size of household.

If tariffs are based on measurement of actual consumption, there are generally some additional charges such as meter rent or other fees. The proportion of these fixed charges is usually some 5 - 20 % of revenue.

Water would be supplied in the urban areas of Zanzibar through house connections, yard taps or standpipes, which will mean different service levels in various town areas. This system allows for the introduction of a type of customer choice related to ability to pay. Progressive fixed charges or different unit prices according to the type of connection might be worthy of consideration.

The introduction of water charges will require careful planning, the identification of all customers, training of meter readers, installation and maintenance of meters, and careful monitoring of consumption, billing and collection of water charges.

Tariff Estimates

The average unit price of water would be Tshs 35 per m^3 for 1991 - 2015 when investment costs are included and donor's aid excluded. The share of operation & maintenance costs in this total price is Tshs 10 per m^3 (see Chapter 9.6.1).

As estimated earlier, an average family of 7 members consumes about 70 l per day water per capita. It means a total consumption of 15 m^3 per month. Assuming that the unit price is fully charged for, their monthly water bill would be about Tshs 500. If only operation & maintenance costs were charged, the bill would come to Tshs 150 per month.

A general recommendation of the World Bank is that water charges should not exceed 5 % of monthly earnings. If the average monthly income were between Tshs 5,000 - 7,000 the former revenue calculated above would be 10 - 6 % and the latter 3 - 2 % of average monthly income. Bearing in mind that foreign aid has not been taken into account in these calculations, a moderate water price appears to be possible to define.

In the first implementation phase the work is capital intensive and front end loaded. For the years 1991 - 2000 the average unit price of water is Tshs 36 - 105 per m^3. Initially, domestic consumers could pay only part of the investment costs in which case they would be charged for example Tshs 200 - 300 per month per connection. The rest of the investment costs should be covered by the GOZ's and the donor's funds.

Industrial and commercial users should be charged according to real price of water, i.e. Tshs 35 per m^3. It must be noted that the long-term average presented here does not include any impact of inflation which, however, should be added to the price of water annually.

Setting a price for water is also a political issue. What is an acceptable or affordable price may be a subject of speculation as well. It is important, however, that the work undertaken be consistent with the available resources. Otherwise the programme will become unviable and there will be a failure to undertake maintenance of the improvements which have been achieved. Anyway, either the consumers or the Government will have to meet the costs if water services are to improve.

14.6.4 Cost Containment and Financial Management

The containment of costs in order to keep the burden of charges to an absolute minimum is crucial in the case of Zanzibar. Although major funding in the form of grant aid is available, the scheme proposed will require strong cost containment and cost recovery controls in order to extract the greatest benefit from the resources deployed.

If there is a shortfall between the funds from all sources and the cost of implementing the proposals, a rescheduling of the work over a longer period of time may be a solution. Furthermore, in the present situation a change in overall Government priorities may be needed, so that a greater portion of the budget is allocated to water.

This situation also calls for great attention to the development of a financial scheme suitable for water management covering financial planning procedures, programme budgeting, financial accounting and financial management, as per the proposed financial and administration system, presented in Annex 13.

14.7 Cost Recovery

In any case a charge should not be levied until it is known that the service is satisfactory in both quality and reliability. Any billing should therefore be delayed until this is the case, and cash inflows and outflows should take this into account.

A cost recovery model for a phasing-in of charges as the service standard targets are attained is proposed as follows:

1) The Urban Water Supply Section is established and trained in operations, maintenance, finance and management. A basic form of customer charging is introduced in line with improvements to customer service.

   Present water charges are revised according to real price of water, and the efficiency of fee collection is increased.

   Charges collected are allocated to the account of the Urban Water Supply Section.

   Installation of meters to large consumers is commenced and tested.

2) Operational costs are monitored and the technical performance of the system compared with specification. Level of customer satisfaction is monitored.

   Tariff structure is designed in the light of operational experience.

3) Staffing the organization is reviewed and staff performance appraised.

   A charging system related to benefit received is designed and a pilot charging scheme is tested.

   Charges related to benefit received are applied.

4) Over a period of time the circle of customers is extended and charges are gradually increased to recover a higher proportion of the running costs, with the long-term objective of the revenues for replacement, renewal and extension of the water system being generated from customer charges.

In the early years the Plan will require a financial guarantee from the GOZ to meet any shortfall in revenues. However, by the end of the first implementation phase of the Plan the proposed Urban Water Authority will be capable of establishing tariff policy and billing system so that actual production costs can be fully recovered by revenue collection provided that the GOZ makes the necessary decisions.

15. COST ESTIMATES

Cost estimates include the implementation and operation and maintenance cost for the physical plan described in chapter 14. Specified costs are estimated for the Zanzibar Town Water Supply. For the Pemba towns, Wete, Chake Chake and Mkoani, the cost estimates are calculated tentatively by applying the per capita cost figures of Zanzibar Town. The final cost calculations for Pemba Urban are under processing.

The summary of water supply costs in different phases is presented in Table 12.

Table 12. Summary of Water Supply Cost

ZANZIBAR TOWN

PHASE	Physical Development			Operation & Maintenance		
	FIM	TAS (in million)	USD	FIM	TAS (in million)	USD
1991-1994	28.4	1720	7.1	7.9	395	2.0
1995-2000	31.2	1560	7.9	11.4	570	2.9
2001-2015	66.3	3315	16 6	30.5	1525	7.6
GRAND TOTAL 1991-2015	135.9	6295	31.0	49.8	2490	13.5

PEMBA TOWNS: WETE, CHAKE CHAKE AND MKOANI

PHASE	Physical Development			Operation & Maintenance		
	FIM	TAS (in million)	USD	FIM	TAS (in million)	USD
1991-1994	6 3	315	1.6	1.8	88	0 44
1995-2000	8 4	420	2.1	2.5	135	0.63
2001-2015	14.6	730	3.7	6.7	335	1.70
GRAND TOTAL 1991-2015	29.3	1465	7.4	11.0	558	2.77

Cost per capita figures for Urban Water Supply both in Unguja and Pemba will be as follows:

PHASE	CAPITA COST/ANNUM		
	FIM	TAS	USD
1991-1994	43.2	2161	10.8
1995-2000	28 3	1415	7.1
2001-2015	17.5	875	4.4

The detailed cost calculations are presented in Annex 15.