

# UNITED REPUBLIC OF TANZANIA

DANISH INTERNATIONAL DEVELOPMENT AGENCY • DANIDA

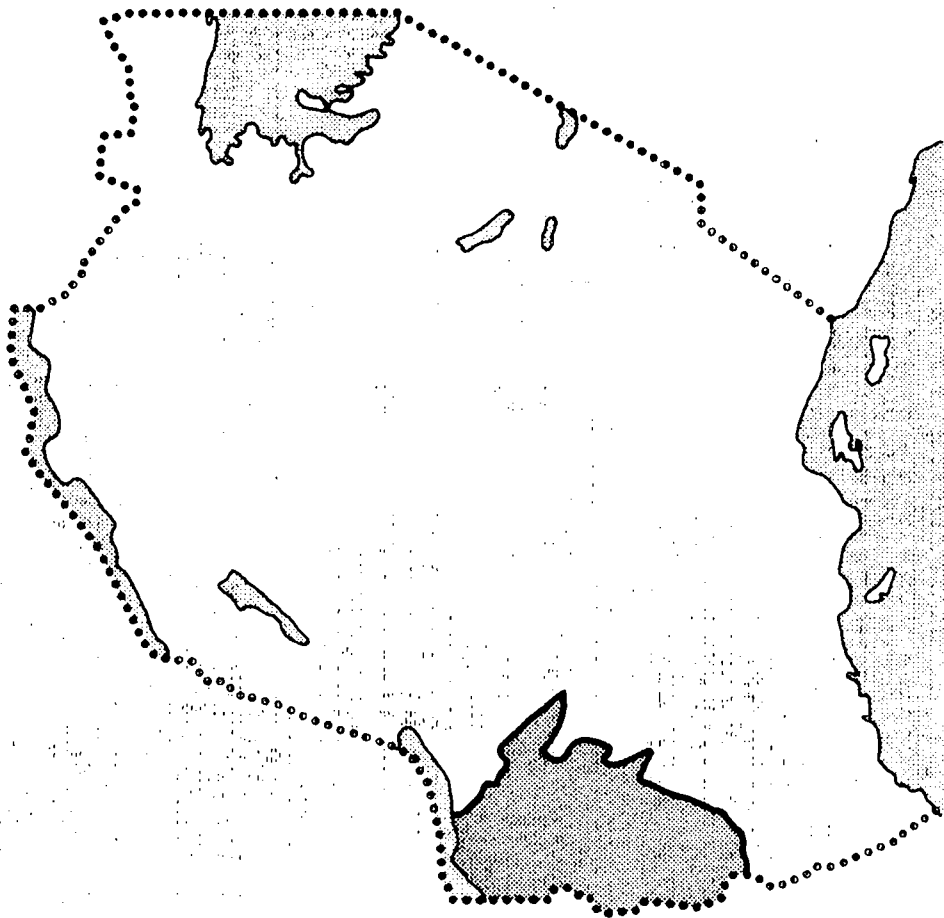
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## RUVUMA WATER MASTER PLAN

INTRODUCTION  
VOLUME 1



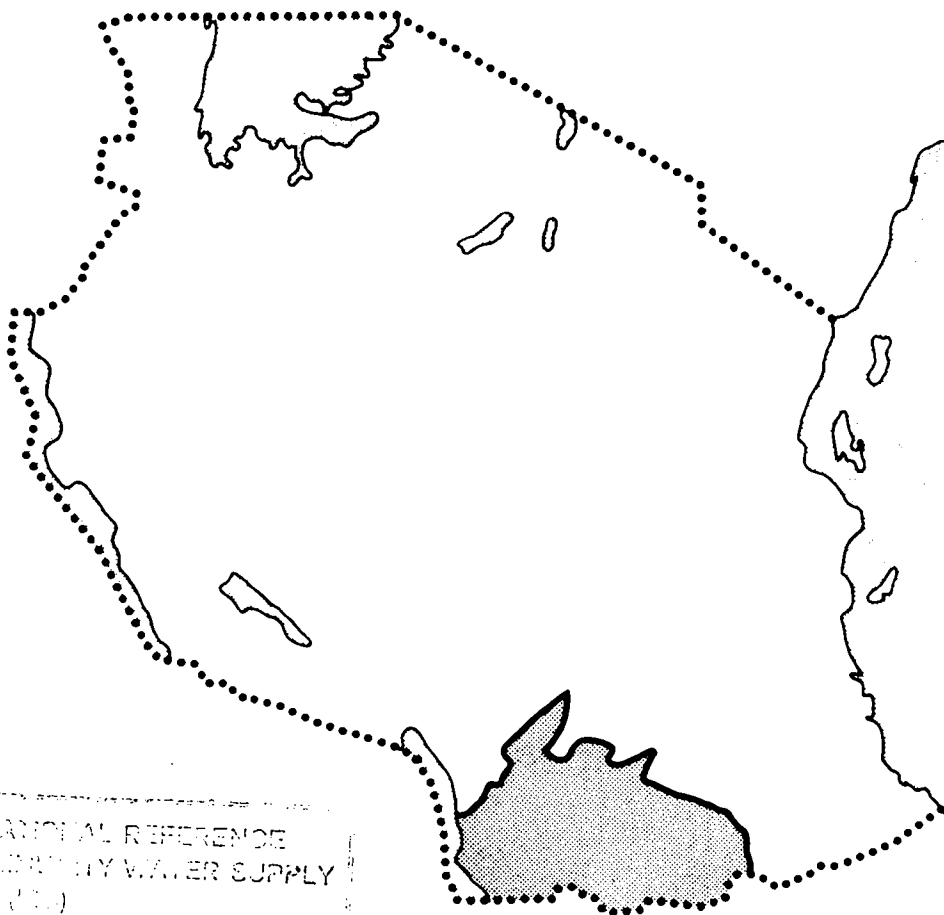
# UNITED REPUBLIC OF TANZANIA

DANISH INTERNATIONAL DEVELOPMENT AGENCY • DANIDA

## RUVUMA WATER MASTER PLAN

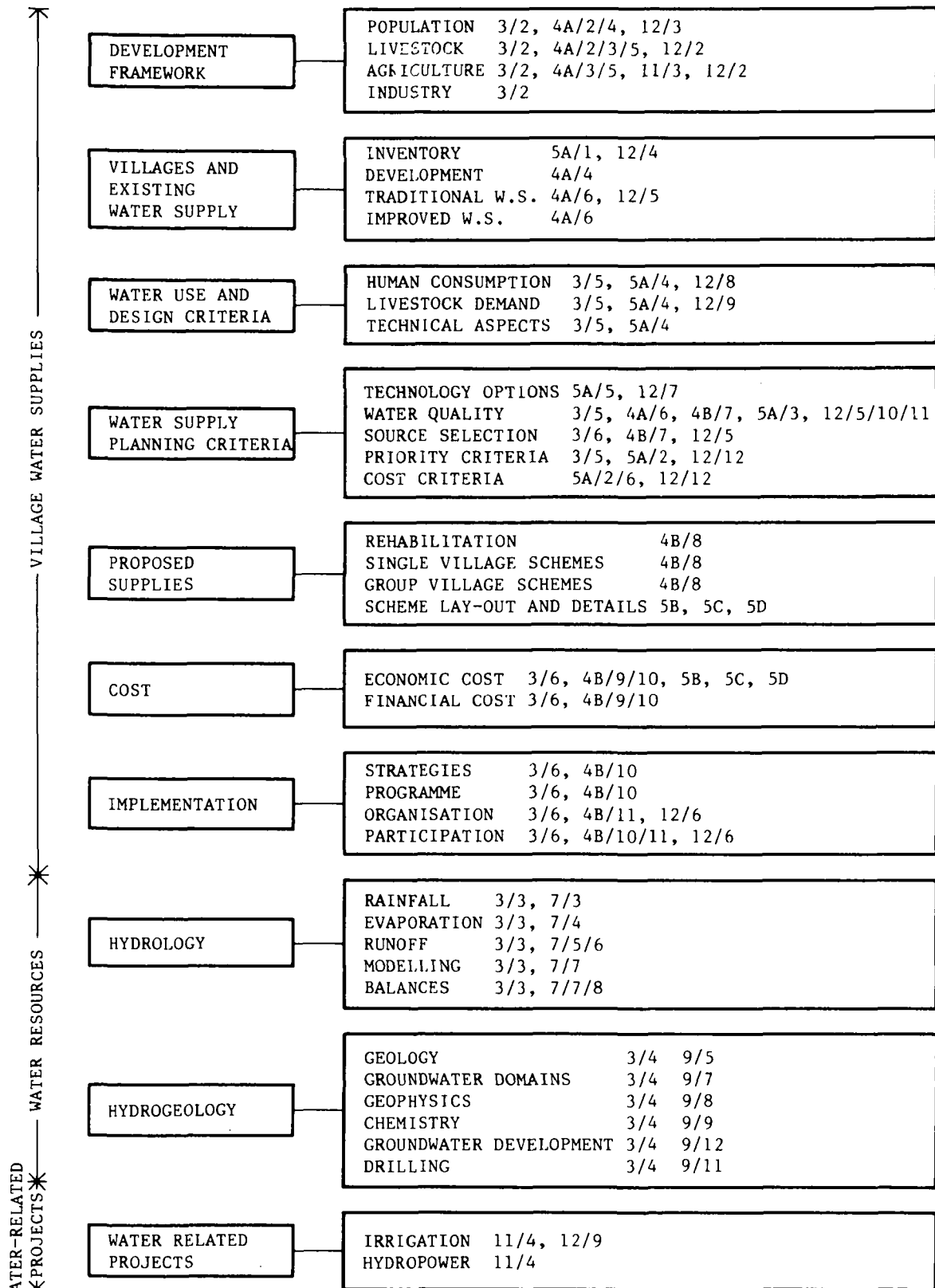
INTRODUCTION

VOLUME 1



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GUIDE TO RUVUMA WATER MASTER PLAN



NOTES

THE CHAPTERS REFERRED TO ARE THOSE WHERE THE MAIN DESCRIPTIONS APPEAR.  
THE REFERENCE CODE 5A/6 MEANS, VOLUME 5A, CHAPTER 6.

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## 1. GENERAL

### 1.1 The Scope of the Water Supply Problem

The provision of water to the rural population is a main concern of the Tanzanian Government. This is part of the policy of improving the living conditions in the villages, thereby trying to reverse the trend of the migration from the rural to urban, areas.

A major Government policy decision was taken in 1971 regarding water supply that:

- a piped water supply will be provided to the rural areas so that by 1991 all Tanzanians will have ease of access to a public domestic water point.

This statement is of course quite generalised and to make it operational interpretations will have to be made. Officially, ease of access has been interpreted as a walking distance of 400 m.

The efforts in terms of accelerated villagisation made the Government review its targets and in 1975 one more major policy decision was taken stating an objective of providing:

- a source of clean, potable and dependable water within a reasonable distance of every village by 1981 as a free basic service.

Both of the above targets were very ambitious and major inputs of resources in terms of capital and manpower are required, even to partly reach the targets.

When looking at the present water supply situation for the villages in Iringa, Ruvuma and Mbeya Regions it appears that out of a total of 1509 villages only 321, or less than 22%, are served by water schemes at present. Other villages are dependent on traditional sources. Out of the present water schemes and improved supplies approximately 56% are gravity schemes based on streams or springs, 25% are schemes pumping from streams or springs while the remaining part comprise lakes, boreholes and shallow

wells. Taking into account that only about 60% of the schemes are in working condition it seems quite clear that a formidable task lies ahead when planning to reach the targets. Not only construction of new schemes shall be undertaken but equally important is the operation and maintenance of the schemes on a continuous basis and an initiation of a rehabilitation programme.

### 1.2 The Benefits of Village Water Supplies

A reliable supply of wholesome water is essential to the stability of life in the villages. Settlement patterns have always been closely related to the possibilities of obtaining a reliable supply of water and the villagization programme and a continued cementation of the cooperative villages is certainly dependent on the water supply as one of the major factors.

The tangible benefits to the people of the villages would be:-

- shorter walking distance to water points
- reliability of water supply
- health improvement (potential)

The implications of those benefits can be discussed at length. This is in particular true for the health aspect as improvement of water supply is only one out of several factors which influence the health conditions. It is however generally agreed that water is a necessary, although not sufficient, condition for improvement of health. Other influencing conditions would be for instance improved hygienic practices and improved sanitation.

### 1.3 Water Master Planning in Tanzania

Recognising the need for a well programmed approach to the provision of water to the villages as well as for other purposes the Tanzanian Government has initiated water master planning efforts on a regional basis. The regional plans are later to be used for the formulation of a National

Water Master Plan giving recommendations for a rational and phased utilization of Tanzania's water resources with due respect to competing demands like domestic water supply, livestock, irrigation, industry and hydropower.

The first regional water master plan preparation was started in 1971. Since then activities have been continued and the latest water master plans are those covering Rukwa, Kigoma and Iringa, Ruvuma and Mbeya Regions in 1982. The Water Master Plans for Iringa, Ruvuma and Mbeya Regions have been prepared following a request from the Tanzanian Government to DANIDA for project execution under bilateral cooperation.

The establishment of the Water Master Plan Coordination Unit within MAJI in 1980 signaled the start of efforts towards compilation of a National Water Master Plan.

#### 1.4 Acknowledgements

The Water Master Plan preparation has involved a large number of authorities and private persons at all levels. The collection and interpretation of data and the formulation of plans and recommendations have only been possible due to the extremely cooperative attitude of the persons encountered. The opportunity is taken here to express our sincere gratitude. The contacts have been so numerous that it would be impossible to mention all persons who have been helping during the planning exercise. However, some of the involved authorities are to be mentioned and it is hoped that the persons who were involved will feel that not only the authorities and institutions have been thanked for the cooperation but that our gratitude extends to the individuals as well.

The staff and officers of MAJI Headquarters have offered valuable help and guidance during the study and the ever present assistance of the MAJI staff at Ubungo is highly appreciated. Also the MAJI drilling section needs mentioning. In the regions only little progress could have been made without the indefatigable support of the Regional Water Engineer's Office. The Regional Steering Committees comprising also Regional Development Authorities created an important forum for exchanges of ideas and views and have substantially contributed to the communication between the parties and to the regional involvement.

The District Water Engineers and their staff have provided valuable comments and proposals for water schemes in their districts and have been extremely helpful during the visits made by the Consultants' staff.

When visiting the villages valuable help and willingness to supply information have been registered and highly appreciated.

The staff of the Danish Embassy and the DANIDA Mission have provided assistance in many administrative matters and the DANIDA Steering Unit has greatly contributed to the outcome of the study through their constructive comments and active support.

The Socio-Economic Group comprising staff from both the Centre of Development Research in Copenhagen and the Bureau of Resource Assessment and Land Use Planning at the University of Dar es Salaam which carried out a study parallel to the Consultants' have provided very valuable information. Through discussions and seminars several ideas have been developed which have proved of great benefit to the Water Master Plan.

Apart from those mentioned above a number of other ministries, parastatal organisations and other institutions have provided valuable input. Among these were the Ministry of Agriculture (KILIMO), the Bureau of Statistics, the University of Dar es Salaam, the Ministry of Lands, Housing and Urban Development, the Rufiji River Basin Development Authority (RUBADA), the Directorate of Meteorology (DOM), the Ministry of Health, the Tanzania Electricity Supply Company (TANESCO), the National Agricultural and Food Corporation (NAFCO) and the Food and Agriculture Organisation (FAO).



## 2. TERMS OF REFERENCE

### 2.1 General

The Terms of Reference for the Water Master Plan were prepared by a DANIDA appraisal mission in close collaboration with MAJI. The Terms of Reference are quoted below.

Combined with the financial constraints of the budget for the Water Master Plan preparation the Terms of Reference formed the guidelines for the study. A continuous process of developing the interpretation of these guidelines has been going on through the cross-fertilisation of the ideas of DANIDA Steering Unit representing the Client and the Consultants. This process has resulted in an even greater emphasis on the village water supply than envisaged from the beginning of the study. Only the technical part of the Terms of Reference is quoted.

### 2.2 Terms of Reference

#### " 2. OBJECTIVES AND SCOPE OF WORK "

The objective of the study is to provide the Government of Tanzania with firm recommendations for the development of the water resources of Iringa, Ruvuma and Mbeya Regions over the period 1981-1991, and in brief outline for an additional 10 years. Although the utilisation of water resources for all relevant purposes shall be considered, particular attention is to be given to the supply of water to villages for human and livestock use. Reliable low cost sources of quality acceptable to Tanzanian Authorities are to be identified for every village within the regions.

In order to arrive at such recommendations the study shall include, but not be limited to, the following activities:

- a. Collection and study of all relevant existing maps and aerial photographs, hydrological, hydrogeological and land use data, information and records.
- b. Evaluation of the available hydrological and meteorological information and assessment of the surface water resources on the basis of this material in relation to quantity, reliability and quality. Preparation of rehabilitation and extension plans for the hydro-meteorological observation network, and organisation of its implementation in order to acquire data for an inventory of the surface water resources; preliminary studies of characteristic hydrological relationships.
- c. Evaluation of the available hydrogeological information as well as additional hydrological and hydrogeological studies in the regions sufficient to estimate the quantity, reliability and quality of groundwater in different (hydrological) areas; recommendations for the methodology and procedure to be used in detailed groundwater investigations, as well as in routine hydrogeological observations.
- d. Survey and assessment of all existing water supply installations in the regions; study and evaluation in outline of all existing projects concerning the exploitation of water in collaboration with the relevant authorities.
- e. Study of the distribution and rate of growth of the population and livestock in the regions, the location of existing and planned villages and plans for their development; preparation of schedule of water requirements in the regions for all relevant purposes, for the planning period (1981-1991) as well as in brief outline for an additional ten years.
- f. Preparation of water balance maps in suitable scale indicating locations and probable magnitudes of potential surpluses and deficits of water in the regions.

- g. Recommendations for appropriate water quality criteria for all relevant purposes, with particular reference to human consumption.
- h. Recommendations as to priority water supply projects including recommendations relating to the rehabilitation and extension of existing water supply systems. Preparation of priority criteria, that is, the criteria which will govern the order of implementation of water supply schemes, shall take place in cooperation with the socio-economic study group. The criteria shall consider, in addition to basic water supply needs, the possible water requirements for livestock, irrigated agriculture, industrial development etc., all with due regard to technical aspects, installation costs and operating costs.
- i. Training of personnel to the extent necessary to continue study activities as indicated under b. and c. above, see also Section 3.7.
- k. Suggestions in regard to how the different types of water supply systems after their installation may be operated by the users, including training programmes, tools and spare parts required for maintenance and repairs.
- l. Suggestions in regard to improving the operations and maintenance capacity of the existing regional water administrations, including required stocks of spare parts and vehicles, etc.
- m. Having regard to the findings under b., c., d., e. and f. above, identify sources and make recommendations concerning the possibilities of other water utilisation and water control in the regions, including but not limited to irrigation, hydropower development, industry, fishing, flood control and swamp reclamation. Special emphasis is to be given to all water supply requirements in already prepared Integrated Rural Development Plans for the regions.
- n. Preparation of draft regional Water Master Plans to serve as guides for an optimal and integrated development of the water resources for the three regions.

- o. As part of n., preparation of implementation plans for the three regions for the supply of adequate water to villages for human and livestock use before the end of the year 1991, including timing, financing and man-power plans for each phase. Low cost and labour intensive construction methods and procedures, as well as low operation and maintenance costs, shall be given priority. (Experience gained from WHO and World Bank survey of water supply projects in Tanzania indicate average implementation costs of T.Shs 240 (1976) per design capita).

### "3. SCOPE OF CONSULTING SERVICES"

#### 3.1 General

The Consultants shall perform all technical and administrative studies, economic and financial studies, field and laboratory investigations and related work herein described, as required to achieve the objectives set forth in "Section 2" above.

In the conduct of this work, the Consultants shall cooperate fully with the Government and other public authorities involved, which will assign counterpart personnel and provide the data, studies, services and facilities outlined in Section 5. (Not quoted).

The cooperation and coordination between the Consultants, the socio-economic study group, the Government and Danida will be formalised through the DANIDA Steering Unit in Dar es Salaam. The cooperation between the Consultants, the socio-economic study group and the local regional administrations will be formalised through the establishment of Steering Committees for each region. These Steering Committees will have the Regional Planning Officer as Chairman, the Regional Water Engineer (RWE) as Secretary and among others the Project Manager from the Consultants, the head of the DANIDA Steering Unit, and a representative of the socio-economic study group as members. All cooperation and coordination between the Water Master Plan study and other projects as indicated below shall be arranged through the Regional Steering Committees.

The Consultants shall collaborate with the staff of the simultaneously ongoing socio-economic study, and observe to the highest degree possible the recommendations as well as data supplied by the research project. The practical cooperation shall initially include preparation of questionnaires for data collection in the villages (see Section 3.3).

The proposed coordination between the Water Master Plan study and the research project as recommended by the Joint Appraisal Mission is described in Attachment A/1 - page 20. (Not attached).

It is expected that the Consultants and the socio-economic study group will share office facilities in each of the regions.

The Consultants shall be solely responsible for the analyses and interpretation of all data and information received by the Consultants, and for the findings, conclusions and recommendations contained in their reports.

The selection of competent sub-contractor(s) shall be made by the Consultants but is subject to prior approval by the Government of Tanzania and DANIDA. Such sub-contractor(s) shall work under the supervision of the Consultants, who have the sole responsibility for the performance of the sub-contractor(s).

All equipment and supplies for the work shall be furnished by the Consultants and/or their sub-contractors except the items mentioned in Section 5.3 below (not quoted), which will be furnished by the Government. Equipment and supplies purchased under this contract for the purpose of this study shall become the property of Tanzania upon completion of the study.

Additional information pertaining to the tasks to be performed by the Consultants is given below.

## "3.2 Water Resources Inventory"

### 3.2.1 Surface Water

Surface water resources are expected to play a significant role in the future water supply of the three regions, particularly in the form of gravity schemes from perennial mountain streams upstream of human settlements. Desirable characteristics of such schemes include low cost (capital as well as operation and maintenance), labour-intensive construction methods, the possibility of community participations, good water quality and flexibility with respect to future expansion. However, due to significant variation in dry-season discharge from year to year the reliability of such schemes shall be thoroughly investigated.

Similarly, due attention shall be paid to the direct utilisation of water from protected springs as an alternative low cost supply source of good quality water.

The use of storage facilities (dams etc.) in the supply from streams with significant seasonal discharge variations is expected to play a minor role in domestic village water supply, primarily because of high cost and problems associated with maintaining adequate water quality. Additional problems may arise as a result of sedimentation of reservoirs. However, storage of surface water may be more appropriate for other purposes (e.g. irrigation, hydropower development, flood control etc.).

In addition to the evaluation of available information and data supplementary hydrological investigations shall be performed, particularly discharge measurements in streams.

Existing observation series of both surface and groundwater resources are generally speaking too short and too scarce. The possibility of extending some of the stream flow records by utilising long existing rainfall records as input to rainfall-runoff models shall be considered. In addition consideration may be given to more detailed hydrological investigations in selected areas for the purposes of preliminary studies of characteristic hydrological relationships, such as infiltration, evapotranspiration, groundwater recharge, etc.

Planning and organisation of the rehabilitation and extension of the hydro-meteorological observation network shall be closely coordinated with the Norwegian sponsored hydro-meteorological survey of Western Tanzania.

### 3.2.2 Groundwater

Groundwater resources are expected to provide a low cost supply of good quality water in areas where the direct utilisation of surface water in gravity schemes is not possible, but where productive and reliable shallow wells can be constructed. The use of shallow wells shall be considered with due regard to costs, labour-intensive construction methods and community participation.

Groundwater production from deep boreholes is expected to play a minor role in the rural water supply because of the relatively high costs involved in the development as well as in the operation and maintenance of such schemes.

The aim of the hydrogeological studies is to assess these resources to the extent possible on the basis of available information, supplemented by geophysical and drilling investigations in the study period. Potential areas for continued detailed investigations shall be identified and recommendations made for their implementation.

Airborne geophysical methods of groundwater investigations have been applied in the three regions, and material resulting from these investigations will be made available to the Consultants. A memo on the airborne geophysical method is enclosed as Attachment A/2 (not attached).

### 3.2.3 Presentation of Results

The report shall include an overall assessment of water resources with maps showing zones of potential surface and groundwater development, with regard to both quantity (at a specified level of reliability) and quality. Standardisation with similar maps prepared for neighbouring regions, in particular where common catchments are involved, shall be given some consideration. The same applies to the representation and recording of other data.

### 3.3 Existing Water Supply Installations and Projects

The purpose of the survey of existing water supply installations and projects is:

- to collect data on the existing supply situation, both traditional and supplies built by the Ministry of Water, Energy and Minerals/MAJI and other agencies, in order to provide a base on which to assess further needs,
- to give preliminary assessment of rehabilitation requirements, operation and maintenance deficiencies, proposals for further extensions, cost estimates etc.

It is recommended that data be recorded through the completion of a simple questionnaire for each village. Data collection could be undertaken on a regional basis, but has to be coordinated with RWE and the socio-economic study group. The survey shall basically include collection of information on demography, health, education, economic activities, sources of water supply schemes and projects.

Water supply data, needed by the Consultants, consist among others of the following items:

- water source - location, reliable yield, quality
- distribution area - names of the villages, their population, water consumption
- reservoirs - locations, capacities, sedimentation
- pumping stations - water treatment, reservoirs
- distribution systems - rising main, reservoirs, boosting stations, domestic points.

Descriptions of some water supply projects in the three regions - completed, under construction and ready for implementation - are given in Attachment A/1 - page 28 - 35 (not attached).



### 3.4 Water Requirements

The forecasts of domestic water requirements is mainly founded on the size of the population and its livestock, the expected growth rates and areal distribution, and the expected social and economic patterns. Water requirements for all the towns in the regions shall be included.

The 1978 population census can be used as a basis for the population estimates.

Design criteria for village water supply schemes shall be established in the Regional Steering Committees in collaboration with the Government/MAJI. Recommended standards are contained in "A Note on Design of Water Supply Projects" published by MAJI in February 1975.

Determination of water requirements for other purposes, such as irrigation and hydropower development (small scale as well as large scale), industry, fishing etc., shall be based on the evaluation of existing data and information, and on the results from the village survey. Information on soils, land use and hydropower potential, natural resources and the potential economic development in the regions shall be evaluated in relation to the demands on water resources.

The term "water requirement" refers to a quantity of water of acceptable quality for a specific purpose. Thus recommended water quality criteria (chemical, biological and bacteriological) for all relevant purposes (human consumption, livestock watering, irrigation etc.) must realistically reflect Tanzanian conditions and requirements.

The sewage disposal and source contamination aspect of water supply planning shall be studied in close cooperation with the simultaneously ongoing socio-economic study. Recommended design criteria for various types of water supply projects (pipe schemes, shallow wells etc.) shall incorporate the findings of the research project in this respect.

### 3.5 Proposed Regional Water Master Plans

Based on the inventory of water resources, the survey of existing water supply schemes and the study of future water requirements, draft Regional Water Master Plans shall be prepared. These will include general plans for the utilisation in stages of water resources in the regions, as well as collected material concerning water resources and water requirements.

### 3.6 Implementation Planning

As part of the draft Regional Water Master Plans, and on the basis of a careful priority assessment of water supply projects in cooperation with the authorities of the regions concerned, implementation plans shall be prepared. Manpower, organisational and financial requirements of operation and maintenance costs shall be determined, as well as proposals for improvement of existing office facilities, workshops, stores and transportation. Recommendations with respect to methods and procedures for construction of works shall be included. Recommendations concerning purchasing procedures for materials and supplies shall be included in order to minimize delays in the implementation of water supply projects. However, the detailed planning and design of such works are beyond the scope of this study.

The WMPs shall e.g. include general guidelines for the implementation of the different types of water supply schemes, such as gravity, shallow wells and deep bore holes, giving suggested type(s) of pipelines, pumps and case elements for shallow wells. Guidelines shall be made in regard to manufacturing of any of these items in Tanzania, locally or centrally.

The implementation plans establish guidelines of how to provide adequate water for people and livestock in the rural areas before the end of the year 1991. (The towns of Iringa, Mbeya and Songea are to be excluded from the implementation planning performed under this study.)

Tentative plans shall be prepared for the extension of water supply schemes to meet domestic water requirements for an additional ten years.

In the preparation of the implementation plans priority shall be given to low cost projects which benefit a maximum number of people and to projects which will serve areas with development potential. Low costs refer

to capital as well as to operation maintenance. The average implementation cost per design criteria of TShs. 240 (1976) mentioned in Section 2 shall be governing in this respect.

Community participation shall be considered in relation to design and cost estimates. Labour intensive methods and local materials, where applicable in the construction of water supply systems, shall be given priority. However, community participation may in some few cases not be the most appropriate solution.

### 3.7 Training and Education

An important aspect of the Water Master Plan study is the education and training of local staff, including village operators. Three main categories of training programmes are envisaged:

- Field data collection personnel.

The continued control and operation of the hydro-meteorological observation network to be planned and organised during the study period requires the training of local personnel for routine observations, discharge measurements etc.

Guidelines for the methodology and procedure to be used in detailed hydrogeological investigations in selected areas are part of the study recommendations. Personnel capable of performing these investigations, as well as routine hydrogeological observations shall be selected and trained during the study period.

- Water resources study and planning personnel.

Counterparts will be assigned to work with the Consultants (see Section 5.2 below), for the purpose of becoming capable of supervising the continuation of study activities and work with the regional water administrations in the detailed design and implementation of water supply projects.

- Operation and maintenance personnel.

An important prerequisite for the successful operation and maintenance of water supply systems is the training of local staff for this purpose. Required training and education shall be recommended for village operators as well as for regional water administration staff. Coordination with similar efforts in neighbouring regions shall be undertaken.

The need and possibilities for graduate level education of local staff under scholarships in Denmark or other countries shall be investigated.

### 3.8 Water Master Plans

When the Government of Tanzania, the regional authorities and DANIDA have commented on the draft and decided between the different alternatives, the Final Water Master Plans will be prepared. These will include development programmes of the water resources in stages and will present all essential data acquired during the studies, including the inventory of ground and surface water resources.

### 3. ORGANISATION AND COOPERATION

#### 3.1 Project organisation

The Consultants were organised in a consortium CCKK comprising three major Danish engineering companies - Carl Bro, Cowiconsult and Kampsax-Krüger. The Danish Hydraulic Institute(DHI) was retained by the group for services within their fields of specialisation, namely hydrology, hydraulics and computer techniques.

The group of consultants were headed by a Management Committee which dealt with the major policy issues. The work in Tanzania as well as the work done in Copenhagen was coordinated by the Project Manager stationed in Dar es Salaam. The Project Manager was also responsible for the contacts to DANIDA as well as to central authorities in Dar es Salaam.

The administrative and support functions in Dar es Salaam were undertaken by the Project Administrator.

In each region a Regional Manager/Water Supply Engineer was appointed. The Regional Managers took care of the organisation of the work at a regional basis and provided the day to day administrative capacity. Furthermore, they provided the link to the regional development authorities and, of course, to the Regional Water Engineers Office. Also the daily contacts to the Socio-Economic Group were undertaken here.

The Regional Managers/Water Supply Engineers were directly in charge of the daily regional water supply activities, while the overall technical planning of the work was done by the Chief Water Supply Engineer.

Apart from the water supply activities which were confined to single regions, other activities were carried out on an interregional basis. This was the case for hydrologic and hydrogeologic studies and for some other highly specialised fields, like irrigation, hydropower and economy.

The overall planning of the work within the hydrology studies was undertaken by the Chief Hydrologist, and likewise the Chief Hydrogeologist undertook the planning within the hydrogeologic sector of the study.

The Consultants' organisation<sup>for WMP</sup> is outlined in Figure 3.1.

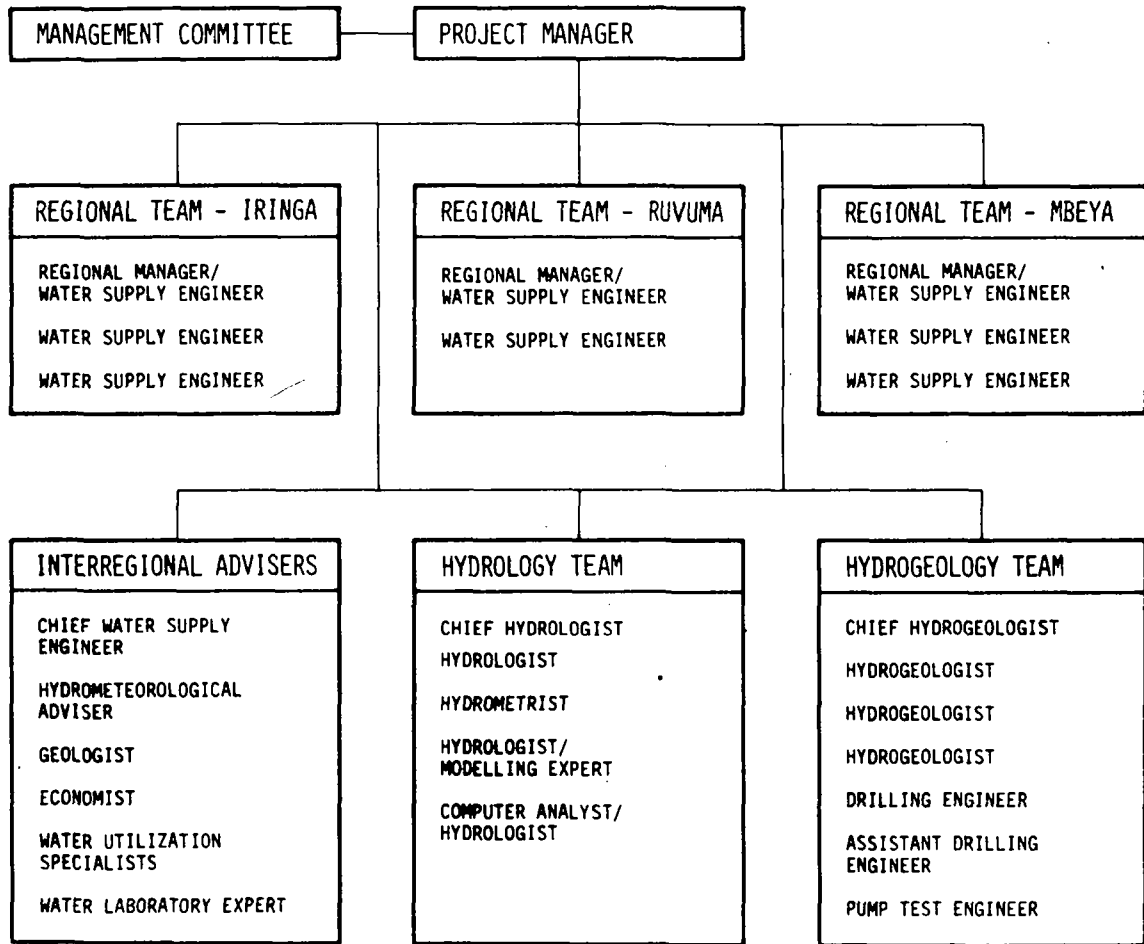


Figure 3.1 - Consultants' organisation

### 3.2 Relations and cooperation

#### 3.2.1 The Client

The direct contact to the Client was established in Dar es Salaam between the Project Manager and DANIDA Steering Unit. This unit was set up by DANIDA in order to provide support and guidance for the Water Master Plan study and aid the coordination between the Consultants, the Socio-Economic Group and other water master plan teams as well as the central and regional authorities. Further, the DANIDA Steering Unit undertook activities parallel to the Water Master Plan through implementation of village water supply schemes designed and selected by the Regional Water Engineers' Office.

#### 3.2.2 Central MAJI and Water Master Plan Coordination Unit

The relations to MAJI were established at a very early stage, and the DANIDA Steering Unit was involved whenever other than day to day matters were discussed.

The matters which in particular were referred to discussions with MAJI were for the Water Supply Sector:-

- Interpretation of national water policies
- Availability and interpretation of existing records
- Design criteria
- Appropriate technologies
- Report presentation and content
- Community participation.

Within the Hydrology Sector particular issues were:-

- Instrumentation
- Selection of index catchments and priority stations
- Computerisation of hydrologic data base
- Transfer of computer programmes and technology
- Types of analysis to be performed.

As regards hydrogeology the main issues were:-

- Drilling programme preparations and techniques
- Applicability of geomorphological framework
- Interpretation of pump test data.

Within the MAJI structure a Water Master Plan Coordination Unit was formed in early 1980 as a first step towards the formulation of a National Water Master Plan. This group was consulted at crucial stages of the Consultants' work and involved in several discussions on the above topics.

### 3.2.3 Regional authorities

A major factor in the close collaboration with the regional authorities were the establishment of Regional Steering Committees. These were set up on DANIDA's initiative and the permanent members of the committee were:-

- Regional Planning Officer (Chairman)
- Regional Water Engineer (Secretary)
- Central MAJI Representative
- DANIDA Steering Unit Representative
- Regional Manager/Project Manager, CCKK
- Socio-Economic Group Representative.

The regular meetings, which were held at intervals of approximately two months, were often attended by representatives of Water Master Plan Coordination Unit, District Water Engineers and members of the Consultants' resident staff.

The cooperation at the technical level was undertaken through the daily contacts to the Regional Water Engineers Office on whose premises also the Consultants' staff were working. The District Engineers were all consulted at the stage of preparing specific proposals for the village supplies.



#### 3.2.4 Socio-Economic Group

The cooperation with the Socio-Economic Group took place through the daily contacts in the Project Offices. These facilities were shared by the Consultants and the Socio-Economic Group. The particular aspects of the Water Master Plan which were the main topics of cooperation comprised.

- Preparation of village inventory forms
- Population forecasts
- Priority criteria for selection of villages for implementation
- Water requirements and water quality aspects
- Design criteria
- Community participation
- Operation, maintenance and training aspects
- Health and sanitation.

#### 3.2.5 Seminars

During the course of the Water Master Plan Study a number of seminars have been arranged in order to bring together a larger number of professionals for discussions than possible at the regular meetings and during the daily contacts.

These seminars were arranged in cooperation with DANIDA Steering Unit and the Socio-Economic Group. The first seminar was held at Mikumi in January 1981 with participation from the Consultants, The Socio-Economic Group, DANIDA Steering Unit and Water Master Plan Coordination Unit.

The main topics discussed were:-

- Villagers participation
- Priority criteria
- Design criteria
- Water quality aspects.

These topics were supplemented by discussions on the interrelation between the hydrologic and hydrogeologic studies and the selection and evaluation of water sources.

Another important seminar was held in Iringa in September 1981. The participants represented the Iringa Regional and District Development, Planning and Water authorities, MAJI, The Consultants, DANIDA Steering Unit and the Socio-Economic Group. The main topics discussed were:-

- Priority criteria and their application
- Decisionmaking at regional level
- Community participation
- Operation and maintenance
- Water master planning.

The seminar issued a series of resolutions and thus greatly contributed to the Consultants' understanding of the opinions held at various levels on the above topics.

The last seminar held during the project period was organised in Mbeya in November 1981. The participants were representing the Mbeya Regional and District Development Planning and Water Authorities as well as MAJI, the Consultants, DANIDA Steering Unit and The Socio-Economic Group.

The topics discussed were:-

- Practical aspects of community participation
- Organisational aspects of implementation
- Organisational aspects of operation and maintenance
- Village contribution to operation and maintenance.

The seminar was concluded with a number of resolutions giving important opinions on the role of the village in the implementation phase. These opinions have been taken into consideration during the formulation of the conclusions and recommendations of the Water Master Plan.

## 4. PROJECT STAFF

4.1 General

The staffing of project was a combination of the Consultants' expatriate staff, staff from the Danish Hydraulic Institute (DHI), Tanzanian professionals, technicians and clerical staff. The Tanzanian staff was allocated from MAJI, the Regional Water Engineers Office, and covered the following categories:-

- Counterpart engineers
- Counterpart hydrologists
- Counterpart hydrogeologists
- Water technicians
- Laboratory technicians
- Laboratory assistants
- Secretaries
- Draughtsmen
- Drill crews and foremen
- Drivers
- Clerical staff.

4.2 Expatriate staff

A list of expatriate staff and their positions on the project is given below:

<u>Position</u>	<u>Name</u>
Project Manager	H.Lehd, relieved by
Project Manager/Chief Hydrologist	J.Hassing
Deputy Project Manager	
Chief Water Supply Engineer	M.Burton
Regional Manager, Iringa	D.P.Grace
Regional Manager, Ruvuma	D.P.Ede, relieved by
Regional Manager, Ruvuma	I.Dyrnum
Regional Manager, Mbeya	M.T.Girling
Water Supply Engineer	J.B.Hansen
Water Supply Engineer	L.Jensen
Water Supply Engineer	J.B.Jakobsen

Water Supply Engineer	C.W.Rasmussen
Hydrometeorologic adviser	B.Sletaune
Hydrometrlist	C.Fog
Hydrologist	T.J.Clausen
Hydrologist/Computer Expert	J.C.Refsgard
Geologist	B.Pulawski
Chief Hydrogeologist	Z.Haman
Hydrogeologist	K.Ambo
Hydrogeologist	J.L.Wahlstrøm
Hydrogeologist	H.Rørdam
Drilling Engineer	M.J.Jones
Assistant Drilling Engineer	T.Svensson
Pump Test Engineer	M.Jensen
Mechanic	F.G.Yallop
Chemical Engineer	J.C.Blandfort
Irrigation Expert	J.Lund
Hydropower Expert	K.Mathiesen
Economist	T.Bøjlund
Administrator	O.H.Kraul, relieved by
Administrator	A.A.Hansen

In addition to the expatriate staff above there has been management back-up from the headquarters in Copenhagen. Also the hydrologic computer-analysis has involved additional specialist staff.

#### 4.3 Tanzanian counterpart staff

The input from the Tanzanian staff has been substantial. The following list gives the names and positions of counterpart staff permanently attached to the Water Master Plan Team.

<u>Position</u>	<u>Name</u>
Water Supply Engineer	D.E.Nkinda
Water Supply Engineer	E.Itumbili
Water Supply Engineer	A.P.Lyimo
Water Supply Engineer	C.K.Lwakiromba
Water Supply Engineer	S.K.L.Babala
Water Supply Engineer	W.Mandia
Hydrologist	I.E.Mwakalinka

Hydrologist	W.Mwaruwandu
Hydrologist	C.Isinika
Hydrogeologist	F.Massawe
Hydrogeologist	H.Tesha
Hydrogeologist	O.Karumba.

The five first mentioned Water Supply Counterparts participated during the whole Water Master Plan exercise and were contributing to the synthesis and reporting in Denmark. Two hydrologists Mr. W.Mwaruwandu and I.E.Mwakalinka participated in the Hydrologic Computer Analysis at the Danish Hydraulic Institute.

#### 4.4 Staff distribution (WMP)

The Consultant's staff has amounted to a number of 30 persons out of which 19 have been stationed in Tanzania for a longer period, while the remaining 11 persons have been attached as short term experts.

The average staffing at the Consultant's offices in Tanzania has been as outlined in Table 4.1. Variations in these figures have of course occurred as a function of the work load.

Staff category	Location			
	Iringa	Songea	Mbeya/ interregional	Dar es Salaam/ interregional
Expatriates	2	2	7	5
Counterparts	3	3	6	-
Technicians/ clerks/drivers	14	3	13	3
<b>Total</b>	<b>19</b>	<b>8</b>	<b>26</b>	<b>8</b>

Table 4.1 - Average distribution of staff at Consultant's offices in the three regions.

The above table does not take into account the Tanzanian drilling crews and the crew for the test pumping operation which amounted to 17 members in the final phases of the drilling programme.

## 5. APPROACH AND TECHNICAL PROGRESS

### 5.1 General

The approach developed by the Consultants and elaborated upon in co-operation with the DANIDA Steering Unit has been shaped to fulfill the objectives as outlined in the Terms of Reference. Briefly, the study has been divided into two main parts, one dealing with water supply and one dealing with the resources for the supply as well as for other uses. The water supply part is dealing with the village water supply only and is not taking into account the supply for urban areas. However, all demands as reflected in the water right appropriations made by MAJI has been taken into account during the study of water balances and also the development potentials has been compared to areas of surplus resources.

The water resource assessments have had a dual purpose. For one thing they had to provide a basis for decisions on water supply sources at village level. Secondly, the resource assessments should give the overall picture of the availability of water in the three regions, and thus serve as a basis for large scale water resources planning. The irrigation and hydropower studies are the first steps in that direction.

### 5.2 Approach

#### 5.2.1 Water supply

The village water supply studies were planned and carried out with the following general guidelines in mind:-

- Village inventories combining interview information with the water engineers' field observations form the basis of the decisions on the future supplies.
- Water quality aspects are treated through chemical and bacteriological analyses from each possible source.

- Cost aspects to be included in the preliminary system proposals at a general basis and later revised when further detailing has been done.
- Source selections are referred to the resources teams (hydrology and hydrogeology) for further assessments/comments before final planning of schemes is carried out.
- Involvement of Tanzanian Project Staff in all phases of work including decision-making and preparation of plans.
- Close contact to Regional and District Water Engineers regarding scheme proposals and local preferences.
- Close contact to the Socio-Economic Group on all aspects of population forecasts, development of design and selection criteria as well as community participation and contribution.

The details of the approach as well as the development of design and selection criteria are given in Volume 5.

#### 5.2.2 Hydrology

The hydrologic studies which both covered regional aspects and source evaluations for village water supplies were carried out based on the following main principles.

- Establishment of an updated conveniently structured data-base for rainfall has been given priority as a basis for studies of the rainfall regime as well as for providing a base for future MAJI studies.
- Evaporation studies shall serve as a basis for water balance calculations and for agricultural potential assessments.
- Runoff studies shall concentrate on low-flow assessments and updating of the hydrological data-base taking into account the need for compatibility with existing facilities at MAJI.



- Computer modelling of catchment runoff through application of deterministic models.
- Involvement of MAJI staff and Tanzanian standard procedures in all phases of work including computer data-base.
- Training of counterpart hydrologists in computer techniques.

The details of the approach, the work carried out and the conclusions are given in Volume 7.

### 5.2.3 Hydrogeology

The hydrogeologic studies which again covered both regional and village oriented activities has been carried out by following the main approach outlined below:-

- Defining the framework for the groundwater assessment i.e. the geomorphology of the regions.
- Checking the applicability of geomorphologic framework to groundwater resource assessment through drilling at selected sites and analysis of existing well data.
- Geophysical surveys to supplement knowledge on geology and to evaluate usefulness in the siting of wells.
- Giving some preference to the drilling of wells in the earlier unexplored formations of Karoo age.
- Involvement of MAJI personnel in all operations including drilling.
- Drilling programme to be carried out following rehabilitation of MAJI rigs.

The details of approach and work carried out are given in Volume 9.

### 5.3 Technical Progress

The various activities has resulted in the progress appearing from Figure 5.1.

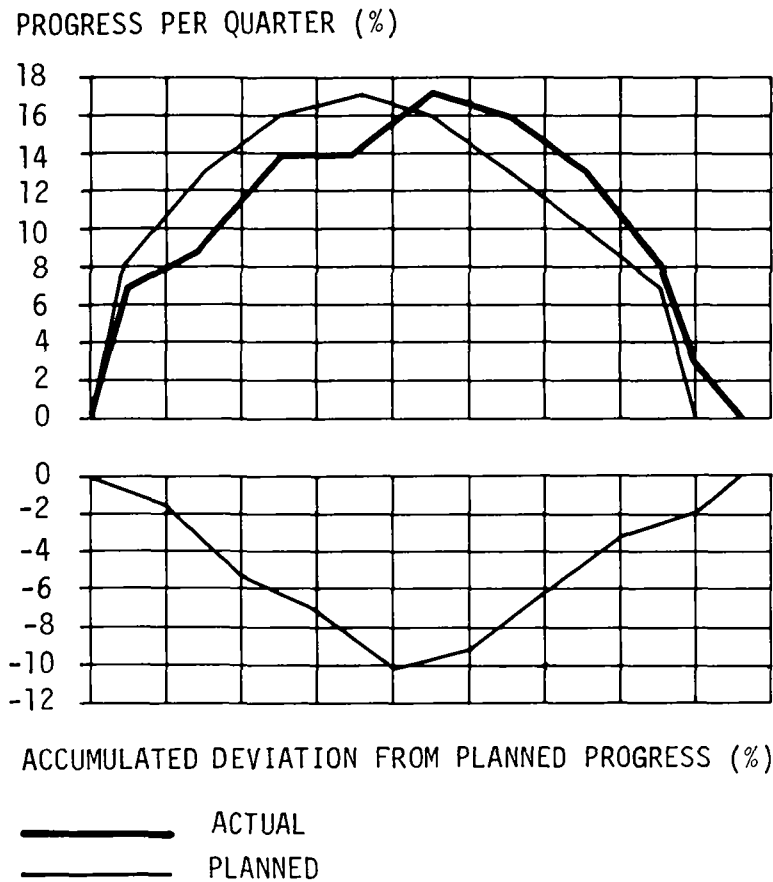


Figure 5.1 - Technical progress in each three month period of study (Quarter). Starting date 1980.02.01.

The figure shows that the study was considerably delayed during the first four quarters while from the fifth quarter onwards the gaining of the lost progress started.

A few figures may give an impression of what the technical progress involved in terms of workload.

The water supply part of the study dealt with:-

- 1,509 villages, of which 616 were in Iringa, 302 in Ruvuma and 591 in Mbeya Region.
- The village questionnaires covered approximately 250 items each and including the proposed schemes a total of 300 items per village had to be treated. In total approximately 450,000 bits of information were all manually collected and coded before computerisation.
- The water supply engineers drove on an average 55,000 km each, mainly on unpaved roads during an average field period of say 10 months.
- Approximately 3,500 water samples were taken and analysed both chemically and bacteriologically.

The hydrologists i.a. dealt with:-

- Rainfall records from 289 stations with a total record length of 3,700 stationyears.
- Runoff records from 74 permanent stations with a total record of 1,047 stationyears.
- Inspection of all permanent hydro stations.
- Data from 20 evaporation pans out of which 6 were installed by Consultants.

The hydrogeologic team dealt with:-

- Data from 140 existing wells.
- Existing test pumping measurements from 33 wells.
- Drilling of 70 wells and pump testing of 30 out of these.
- Geo-electrical sounding at 210 locations.
- Seismic profiling at 50 locations.

## 6. REPORTS AND DATA BASE

### 6.1 General approach

The Water Master Plan documentation has been based on a three-level approach. The three levels represent various degrees of detailing and technical complexity. The report is thus aiming at three user groups.

The first group comprises individuals who are mainly interested in a very short account of the Water Master Plan exercise, and who are further interested in some key figures and principles of implementation. This group of persons will probably comprise i.a. central government officials, politicians and general planners.

The second user group comprises those interested in the details of the plan and those going to develop the results of the planning further. This group will probably comprise i.a. Central MAJI Staff, Regional and District MAJI Staff, other water sector technical staff and Regional Development Authorities.

The third group of users comprises those interested in further analysing the basic data from the study and those interested in the highly specialised topics like hydrology and hydrogeology. This group will probably comprise i.a. staff from the Hydrology Section of MAJI Ubungu, the Water Master Plan Coordination Unit, the MAJI Drilling Section in Dodoma and a number of people professionally related to water resource studies and utilisation.

The structure of the report has been designed in a way that should accommodate the needs of the three groups.

The volumes have been divided into text volumes and data volumes.

The text volumes present the results of the studies, the conclusions drawn and summarises the steps leading to the results. The text volumes are combined into a Summary Volume. The Summary is in turn presented in a very short form in a separate volume called "Synthesis".

The data volumes give detailed descriptions of strategies and methodologies, major tables, detailed drawings and parts of the data base to the extent that this can be limited to a size that can reasonably be incorporated in a normal volume.

More extensive data bases are contained in computer tapes, which are presented in formats compatible with the present MAJI utilised systems.

### 6.2 Report schedule

The report schedule designed to fulfill the needs of the various user groups is presented in Table 6.1.

IRINGA WATER MASTER PLAN	KUVUMA WATER MASTER PLAN	MBEYA WATER MASTER PLAN
1. INTRODUCTION	1. INTRODUCTION	1. INTRODUCTION
2. SYNOPSIS	2. SYNOPSIS	2. SYNOPSIS
3. SUMMARY	3. SUMMARY	3. SUMMARY
4.A VILLAGE WATER SUPPLY STUDIES	4.A VILLAGE WATER SUPPLY STUDIES	4.A VILLAGE WATER SUPPLY STUDIES
4.B VILLAGE WATER SUPPLY IMPLEMENTATION	4.B VILLAGE WATER SUPPLY IMPLEMENTATION	4.B VILLAGE WATER SUPPLY IMPLEMENTATION
5.A VILLAGE WATER SUPPLY - DATA	5.A VILLAGE WATER SUPPLY - DATA	5.A VILLAGE WATER SUPPLY - DATA
5.B VILLAGE WATER SUPPLY - DATA	5.B VILLAGE WATER SUPPLY - DATA	5.B VILLAGE WATER SUPPLY - DATA
5.C VILLAGE WATER SUPPLY - DATA	5.C VILLAGE WATER SUPPLY - DATA	5.C VILLAGE WATER SUPPLY - DATA
5.D VILLAGE WATER SUPPLY - DATA	5.D VILLAGE WATER SUPPLY - DATA	5.D VILLAGE WATER SUPPLY - DATA
5.E VILLAGE WATER SUPPLY - DATA		
6. SELECTED DRAWINGS	6. SELECTED DRAWINGS	6. SELECTED DRAWINGS
	7. HYDROLOGY	
	8. HYDROLOGIC DATA	
	9. HYDROGEOLOGY	
	10.A HYDROGEOLOGIC DATA, TREATMENT, METHODS AND GEOPHYSICS	
	10.B HYDROGEOLOGIC DATA, BOREHOLE DATA	
	11. IRRIGATION AND HYDROPOWER	
	12. SOCIO ECONOMIC STUDIES	

Table 6.1 - Water Master Plan Report Schedule.

The table gives volume titles.

It appears from the schedule that the volumes are divided into two main groups. The first group comprises volumes that deals with one region only, while the second group deals with all three regions in each volume. This division has been designed realizing that topics like hydrology, hydrogeology and water related development are best covered, not under administrative units, but rather taking into account physical boundaries like catchments, mountain ranges and geomorphologic units.

#### 6.3 Introduction. Volume 1.

This volume "Introduction" serves to present the study background, the Terms of Reference which has been the basis for preparation of the water master plans, the organisation of the work and the various cooperating agencies, staff details, the general approach of the study, the progress, the report schedule and an account of the content of each volume of the report. A key to the contents of the report and a chapter on the utilisation of the Water Master Plan Report as a reference are given. The three introduction volumes are identical except for and the key to the report which only deals with the particular region.

#### 6.4 Synopsis. Volume 2.

The Synopsis is designed to meet the needs of the first user group and gives in broad outline a summary of the very main issues of the Water Master Plan for the particular region. The emphasis is on economic and financial aspects.

#### 6.5 Summary. Volume 3.

The Summary is designed to give the user a closer knowledge of the overall aspects of the Water Master Plan. All major aspects are summarised here like development context, water resources availability, water use and design criteria as well as the plans for water schemes, their implementation and costs. Organisational aspects, training, operation and maintenance are also topics of major importance which are dealt with in the Summary.

#### 6.6 Village water supply studies. Volume 4A.

The village water supply studies as described in this volume aim at giving the user an account of the context in which the Water Master Plans were developed. The availability of existing data and sources of information in terms of maps, aerial photos, village registration, population and livestock is summarised. Further, the development context as expressed through the strategies of the Tanzanian Government on topics like agriculture, livestock and industries is described along with the implications for the utilisation of the water resources. The assumptions and adopted figures on population growth and village development are given. The more specific figures on present agricultural production and livestock are given. Finally, the information from the village inventories is analysed to give a comprehensive picture of the present village water supply situation. The analysis covers such topics as traditional supplies, water collection practices, source protection, reliability of supply, villagers attitudes, present improved supplies, the use of the water supply schemes and the general aspects of rehabilitation.

#### 6.7 Village water supply implementation. Volume 4B.

The village water supply implementation described in this volume comprises an account of the principles of the source selection done and gives the details of the proposed water supplies. The cost of each scheme is given as well as the principles underlying the cost estimates. The priority rating is given and its implications for the implementation programme are described. The implementation programme is outlined in such a way as to represent a flexible tool for further reference and review in light of possible new developments. Finally the organisational structure and the manpower requirements for the implementation are stated. The water scheme information is extensively tabulated for easy reference. Also the necessary rehabilitation is tabulated.

#### 6.8 Village water supply data. Volume 5A.

The village water supply data constitute a vast amount of material and are presented in separate volumes. Volume 5A has as an objective to provide a detailed back-up for Volumes 4A and 4B. The volume presents detailed accounts of village inventory methodology, the selected priority criteria, the background for selection and the water quality criteria applied for source evaluation. The statistic background of the selected criteria is given as well. Construction methods are summarised, and their applicability to village water supply is evaluated. Finally, the cost basis is given in terms of unit prices and the results of sensitivity studies as applied during selection of main implementation policies. The chapters of this volume constitute separate entities and can be studied independently.

#### 6.9 Village water supply data. Volumes 5B, 5C, 5D.

These data volumes hold a detailed index of the villages, the village sketches and the outline of the group schemes. Further, a village data summary sheet is contained.

#### 6.10 Selected drawings. Volume 6.

A selection of drawings depicting major topics of the Water Master Plan has been made and is presented in this volume together with a short explanatory text. The aim is to give the user an impression of some physical features and the basic geographic distribution of some main parameters of the Water Master Plan.

#### 6.11 Hydrology. Volume 7.

The Hydrology volume covers all three regions and describe the investigations and deductions leading to the evaluation of the water balance elements, rainfall, runoff and evapotranspiration and their variability in time and space. The surface water resource assessment has been synthesised from these evaluations and water balances on a catchment basis have been derived. Particular emphasis has been placed on low-flow as this is critical to the source development as impounding dams are generally not desirable for the village water supplies. Water appropriations, and thus the surplus water available for water-related development, has been studied and described as well.



6.12 Hydrologic data. Volume 8.

This volume supports the Hydrology Volume by presenting the data and descriptions in more detail. It is intended that it should be used as a reference for Volume 7. The main contents are the detailed station lists, hydrographs from discharge gauging stations and results of station analyses.

6.13 Hydrogeology. Volume 9.

The Hydrogeology volume covers all three regions and describe the investigations and studies leading to the assessment of the groundwater resources. The geologic background, the geomorphologic processes and the geomorphology of the study area are described. The analyses of borehole data pumping tests and geophysics lead to area-wise assessments of groundwater potentials and recommendations for development. The performed drilling operations are described.

6.14 Hydrogeologic data. Treatment, methods and geophysics. Volume 10A.

This volume is a support volume for the Hydrogeology Volume. It aims at providing the background for the understanding of the various deductions from the specialised investigations. Explanations of the more complicated hydrogeological terms are presented together with extensive data bases from the geoelectric and seismic investigations.

6.15 Hydrogeologic data. Borehole data. Volume 10B.

This volume presents the borehole data from all boreholes in the regions along with locational details and results of chemical analyses of the groundwater.

6.16 Irrigation and hydropower. Volume 11.

This volume, which covers the irrigation and hydropower aspects of the three regions, purports to give an outline of the present activities and future potentials.

6.17 Socio-Economic studies. Volume 12.

This volume, which is written and edited by the Socio-Economic Group discusses and summarises the studies on the socio-economic aspects of village water supply in the context of the three regions. The opinions and results express the points of view of the Socio-Economic Group, which, however is shared by the Consultants in most cases. The volume is included in the Water Master Plan report schedule i.a. in order to emphasise the close and fruitful cooperation that has taken place and the integration of the socio-economic findings.

## 7. INDEX

7.1 General

The volumes of the Water Master Plan are each provided with a list of contents, or in the case of the village data volumes, a master index is inserted.

For each reference these lists of contents and master indices are given below.

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(Pending).

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Songea	SONGEA N - SHEET 1/3	17
Songea	SONGEA C - SHEET 2/3	74
Songea	SONGEA S - SHEET 3/3	104

Group Scheme Villages:

Group Scheme Reference	Name	Pages
S - 1	Mkongotema	1 - 2
S - 2	Mputa	3 - 5
S - 3	Libango	18 - 21
S - 4	Luegu	22 - 24
S - 5	Kumbara	25 - 26
S - 6	Namabengo	27 - 28
S - 7	Lugagara	29 - 30
S - 8	Peramiho "B"	31 - 33
S - 9	Likuyfusi	34 - 35
S - 12	Lipokela	36 - 37
S - 10	Namangole	75 - 76
S - 11	Njalamatata	77 - 80
S - 13	Litapwasi	81 - 82
S - 14	Mpitimbi "A"	83 - 84
S - 15	Njoomlole	85 - 86
S - 16	Muhukuru	87 - 88

Single Scheme Villages:

District	Ward	Reference	Pages
Songea	Matumbi	-/sma/R	6
	Wino	-/swi/R	7 - 11
	Mahanje	-/smh/R	12 - 13
	Mgombasi	-/smg/R	14 - 17

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District	Ward	Reference	Pages
	Kilagano	-/ski/R	38 - 40
	Gumbiro	-/sgu/R	41 - 42
	Namtumbo	-/sna/R	43 - 45
	Luegu	-/slu/R	46 - 47
	Msindo	-/sms/R	48 - 53
	Tanga	-/sta/R	54 - 57
	Maposeni	-/smp/R	58 - 63
	Litisha	-/sli/R	64 - 66
	Magagura	-/smg/R	67 - 71
	Matimira	-/smi/R	72 - 74
	Mkongo	-/smk/R	89 - 90
	Ligera	-/slg/R	91 - 92
	Magazini	-/smz/R	93 - 94
	Lusewa	-/sls/R	95 - 99
	Mpitimbi	-/smt/R	100 - 103
	Muhukuru	-/smu/R	104

## 7.8 Village Water Supply Data. Volume 5C.

Location Maps:

District	Reference	Preceeding Page
Mbinga	MBINGA N - SHEET 1/3	114
Mbinga	MBINGA C - SHEET 2/3	175
Mbinga	MBINGA S - SHEET 3/3	212

Group Scheme Villages:

Group Scheme Reference	Name	Pages
S - 17	Lipumba	115 - 116
S - 18	Liwundi	117 - 118
S - 19	Myangayanga	119 - 121
S - 20	Langiro	122 - 123
S - 21	Mango	124 - 126
S - 22	Tukuzi	127 - 128
S - 24	Puulu	129 - 131
S - 23	Miyao	176 - 177
S - 25	Lundo	178 - 179
S - 26	Buruma	180 - 181
S - 27	Chinula	182 - 183
S - 28	Mbambabay	184 - 185
S - 29	Kwambe	186 - 191

Single Scheme Villages:

District	Ward	Reference	Pages
Mbinga	Litumbandyosi	-/mlu/R	105 - 107
	Ruanda	-/mru/R	108 - 110
	Letuhi	-/mli/R	111 - 114
	Mbaha	-/mmh/R	132 - 134
	Matiri	-/mmr/R	135 - 137
	Kihangi/Mahuka	-/mkm/R	138 - 139

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District	Ward	Reference	Pages
	Kigonsera	-/mks/R	140 - 143
	Utiri	-/mut/R	144 - 145
	Mbinga	-/mmi/R	146
	Mkumbi	-/mmu/R	147 - 154
	Ukata	-/muk/R	155 - 157
	Ngumbo	-/mng/R	158 - 159
	Langiro	-/mla/R	160
	Litembo	-/mlt/R	161 - 168
	Kilimani	-/mkl/R	169 - 171
	Maguu	-/mma/R	172 - 175
	Mbangamao	-/mmg/R	192 - 196
	Nyoni	-/mny/R	197
	Mikalanga	-/mmk/R	198 - 200
	Lipingo	-/mlp/R	201
	Mbambabay	-/mmb/R	202
	Kingirikiti	-/mkg/R	203 - 205
	Liparamba	-/mlm/R	206 - 209
	Tingi	-/mti/R	210 - 212

7.9 Village Water Supply Data. Volume 5D.Location Maps:

District	Reference	Preceding Page
Tunduru	TUNDURU N - SHEET 1/3	228
Tunduru	TUNDURU C - SHEET 2/3	275
Tunduru	TUNDURU S - SHEET 3/3	302

Group Scheme Villages:

Group Scheme Reference	Name	Pages
S - 30	Namwinyi	213 - 214
S - 31	Matemango	215 - 217
S - 32	Msagula	229 - 230
S - 33	Nakayaya	231 - 233
S - 34	Machemba	234 - 236
S - 35	Naluwale	237 - 238
S - 36	Mchangani	239 - 241
S - 37	Mkasale	242 - 248
S - 38	Amani	249 - 251
S - 39	Muongano	276 - 277
S - 40	Marumba	278 - 280
S - 41	Chilundundu	281 - 283
S - 42	Mchoteka	284 - 285
S - 43	Mchesi	286 - 288

Single Scheme Villages:

District	Ward	Reference	Pages
Tunduru	Ngapa	-/tng/R	218
	Mindu	-/tmn/R	219 - 220
	Kalulu	-/tka/R	221 - 223
	Ligunga	-/tlg/R	224 - 228
	Nampungu	-/tnp/R	252 - 255
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District	Ward	Reference	Pages
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	Ligoma	-/tli/R	262 - 264
	Nakapanya	-/tnk/R	265 - 269
	Namasakata	-/tma/R	270 - 275
	Ntina	-/tnt/R	289 - 290
	Mbesa	-/tmb/R	291 - 294
	Marumba	-/tmr/R	295 - 297
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3. Present Livestock Distribution
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6. Location of Hydrological Stations and Mean Annual Runoff
7. 10-Year Minimum Runoff
8. Geology
9. Geomorphology
10. Groundwater Development Potential
11. Catchment Balances

7.11 Hydrology. Volume 7.

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- Drawing II-7 Streamgaugings

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Iringa  
Ruvuma  
Mbeya

APPENDIX 3. GEOPHYSICS

Iringa  
Ruvuma  
Mbeya

APPENDIX 4. SPRING RECORDS

Iringa  
Ruvuma  
Mbeya

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APPENDIX 1

Borehole completion records.

Iringa

Ruvuma

Mbeya

APPENDIX 2

Borehole location records.

Iringa

Ruvuma

Mbeya

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Iringa

Ruvuma

Mbeya

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**APPENDIX: METHODOLOGY**