BASIC DESIGN STUDY REPORT

ON

THE RURAL WATER SUPPLY PROJECT IN LINDI AND MTWARA REGIONS

IN THE UNITED REPUBLIC OF TANZANIA

JUNE 2003

JAPAN INTERNATIONAL COOPERATION AGENCY

KOKUSAI KOGYO CO., LTD.

PREFACE

In response to a request from the Government of the United Republic of Tanzania, the Government of Japan decided to conduct a basic design study on the Rural Water Supply Project in Lindi and Mtwara Regions and entrusted the study to the Japan International Cooperation Agency (JICA).

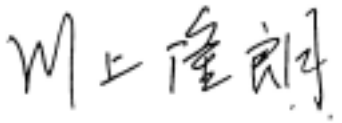
JICA sent to Tanzania a study team from the 22th November, 2002 to the 13th January, 2003.

The team held discussions with the officials concerned of the Government of Tanzania, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Tanzania in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the United Republic of Tanzania for their close cooperation extended to the teams.

June 2003



Takao Kawakami
President
Japan International Cooperation Agency

June, 2003

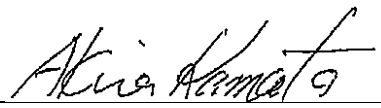
Letter of Transmittal

We are pleased to submit to you the basic design study report on basic design study on the Rural Water Supply Project in Lindi and Mtwara Regions in the United Republic of Tanzania

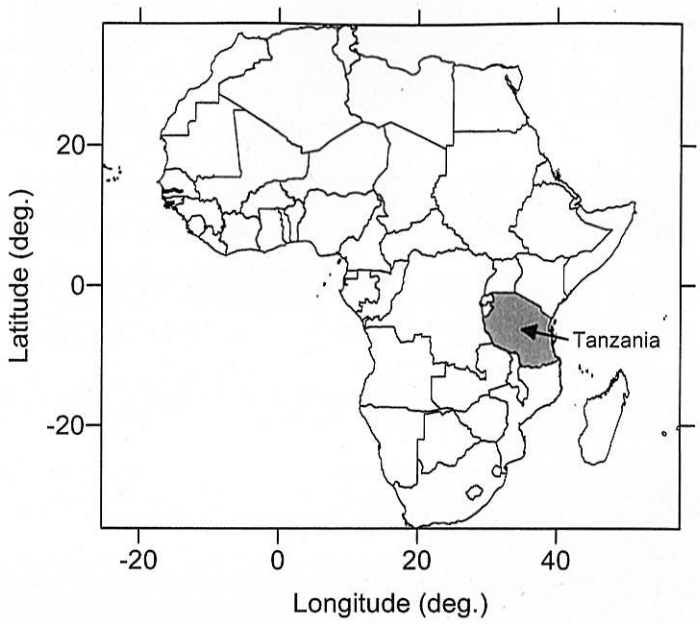
This study was conducted by Kokusai Kogyo Co., Ltd., under a contract to JICA, during the period from November, 2002 to June, 2003. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Tanzania and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

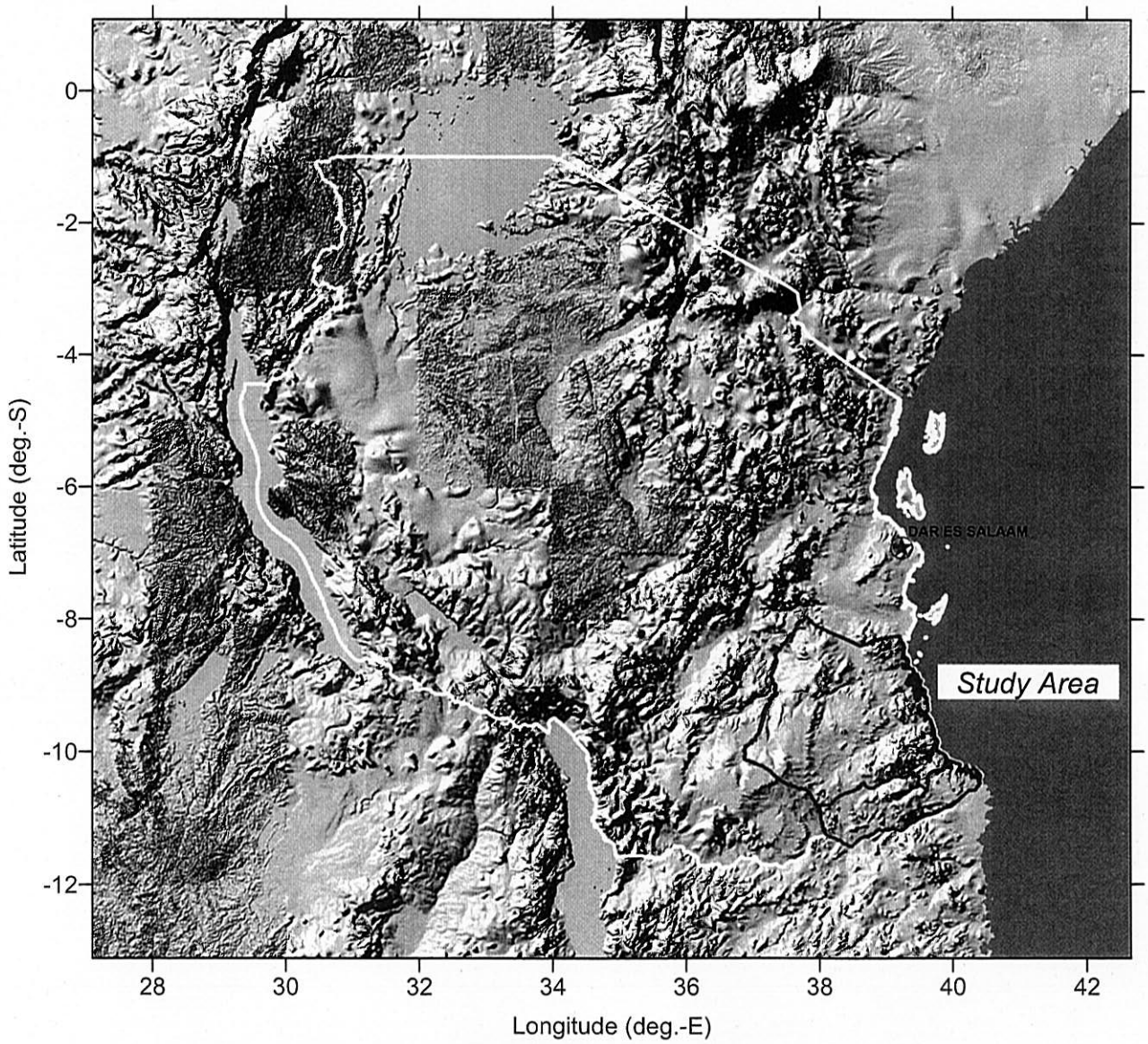
Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,



Akira KAMATA
Project manager,
Basic design study team on the Rural Water Supply Project in Lindi and Mtwara Regions in the United Republic of Tanzania
Kokusai Kogyo Co., Ltd.





LOCATION MAP OF STUDY AREA

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Abbreviations

AfDB :	African Development Bank
ATP :	Ability to Pay
CDSP :	Community Development Support Programme
CLIP :	Community Livelihood Improvement Programme
DDCA :	Drilling and Dam Construction Agency
DTH :	Down The Hole
DWE :	District Water Engineer Office
DWST :	District Water and Sanitation Team
EC :	Electric Conductivity
FS :	Feasibility Study
GDP :	Gross Domestic Product
KfW :	Kentucky Foundation for Women
MoH :	Ministry of Health
MoWLD :	Ministry of Water and Livestock Development
NWRSSP :	National Rural Water Supply and Sanitation Program
OM :	Operation and Maintenance
OJT :	On the Job Training
ORP :	Oxidation Reduction Potential
RWE :	Regional Water Engineer Office
VWC :	Village Water Committee
WPC :	Water Point Committee
WTP :	Willingness to Pay

Summary

The United Republic of Tanzania (hereinafter referred to as “Tanzania”) is located in East Africa between latitude 1° and 11°45' S and longitude 29°21’ and 40°25’ E with the Indian Ocean to the east and the Central African Highland to the west. It covers an area of 945,000 km^2 and has a population of 34,570,000 (2002 census). Tanzania is one of the least developed countries in the world. Its GDP has never reached US$300 since achieving full independence from the United Kingdom in 1961. It is estimated that more than half of the population make their living under the poverty line and around 80% live in rural areas. The economy is heavily dependent on agriculture, which accounts for around 50% of the GDP and employs 90 % of the work force. Social services including the supply of safe water in rural areas are poor compared with urban areas, so that the construction of infrastructure has high priority in rural areas. Above all, Lindi and Mtwara Regions (hereinafter referred to as “the southern two regions”), the project target areas, are underdeveloped in terms of economy and social services.

As an important aspect of rural development, the Government of Tanzania promoted a 20 year Rural Water Supply Program for two decades (1971-1991). However, water supply facilities have not been properly managed due to financial problems stemming from lack of resident participation and sluggishness of the economy in Tanzania. The residents were not used to paying for water because water had been supplied free of charge in the past according to the socialism policy.

Tanzania published the National Water Policy in 1991 as a guideline for water supply. It emphasized the promotion of resident participation in water supply, payment by beneficiaries, and the integration of water supply, sanitation and hygiene education. This policy was revised in 2002. The revised policy emphases the following six basic objectives:

1. To define the roles and responsibilities of various stakeholders in water supply and sanitation
2. To emphasize communities paying for part of the capital costs, and full cost recovery for the operation and maintenance of services
3. To depart from the traditional supply-driven to the demand-responsive approach
4. To manage water supplies at the lowest appropriate level as opposed to the centralized command control approach
5. To promote participation of the private sector in the delivery of goods and services
6. To improve health through integration of water supply, sanitation and hygiene education

Under such circumstances, the Government of Tanzania requested the Government of Japan to implement a study on the improvement of water supply. In response to this request, Japan International Cooperation Agency (hereinafter referred to as “JICA”) conducted the “Study of Water Supply and Sanitation in Lindi and Mtwara Regions” from February 2000 to December 2001. Based on the results of this study, the Government of Tanzania made a request to the Government of Japan for Grant Aid for the steady supply of safe drinking water by construction of deep wells. In response to the request, the Government of Japan dispatched a study team to conduct the Basic Design Study from November 23, 2002 to January 13, 2003.

After analyzing the results of the study, the Outline Report of the Basic Design Study was made. A study team was dispatched to explain the principle of the project and hold discussions with the Government of Tanzania from May 23, 2003 to June 3, 2003.

Basic Policy of Japanese side regarding the request of Tanzania is as follows;

(1) Scope of cooperation

This project shall construct water supply facilities in the prioritized 64 villages selected by the field investigation and laboratory analysis. There are some drilling sites that require deep drilling of more than 150m in the target area. In order to drill such deep wells, drilling equipment shall be procured. In addition, the necessary equipment for capacity building of RWE and DWE shall be procured. This equipment shall be utilized to improve the technical and management capabilities of RWE, DWE and the villages for the O&M of water supply facilities. A soft component program shall also be implemented in relation with the establishment of village ownership and the capacity building of RWE and DWE.

(2) Level of facility

Level 1 or Level 2 water supply systems shall be constructed in the 64 target villages. The facilities are mainly planned to be Level 1 systems considering the O&M conditions of Level 2 systems constructed in past years. However, the level shall be determined based on the willingness and ability to pay of the villagers.

(3) Equipment selection

Drilling equipment is selected considering geologic and topographic conditions, accessibility to the sites and the cost as well as the capability of DDCA and the operation rate of the machines provided by Japan in past years. Equipment for surveys and O&M is selected considering the role and capability of DWE and RWE, the present status of existing equipment, the intended use, accessibility to the sites and the cost.

Based on the result of the basic design study, target villages and water supply facilities were concluded as follows.

1. Facility plan

Components	Quantity
Deep well with hand pump	26 villages, 157 wells
Deep well with motorized pump	36 villages, 34 wells + 2 existing places
Spring water with motorized pump	2 villages, 2 springs

2. Equipment plan

Procured equipment is necessary for the construction of water supply facilities in 64 villages and their maintenance after the completion of construction. Major items are shown below.

	Equipment	Quantity
A. Drilling equipment	Spare parts of the existing drilling equipment owned by DDCA	1 set
	Drilling equipment and accessories	1 set
	Trucks	1 set
	Well testing equipment	2 sets
	Geophysical equipment	2 units
B. O&M equipment	Maintenance truck	2 sets
	Motorbike	9 units
	Well cleaning equipment	2 sets
C. Survey equipment	Water analysis device, vehicles etc.	2 sets

3. Soft component

Soft component activity will be conducted for 64 villages (191 deep wells) concerning the construction of water supply facilities and their operation and maintenance.

Operation and Maintenance	Support for capacity building of MoWLD, RWE, DWE and villages

The required periods for completion of works are shown below.

Works	Required period
Detail study and preparation for tender	15 months
Construction and equipment procurement	36 months
Soft component	19 months

After the completion of this project, the service rate of safe water will increase from the present rate of about 35% (2002) to about 42% in 2007 (the served population will be 200,000).

Based on the issues mentioned above, smoother and more effective implementation of the project can be ensured by the following.

1. The operation and maintenance of water supply facilities shall fundamentally be carried out by the local residents themselves (the beneficiaries), which is the basic principal of the “National Water Policy”. The implementing agency must ensure that the residents are fully aware of this principal and provide technical assistance on items that exceed the ability of the Village Water Committees

(VWC). Therefore, when implementing the project, the responsibilities and roles of both the implementing agency and VWCs need to be thoroughly discussed and by-laws for VWCs that can be self-enforced need to be formulated.

2. At each stage of the project (i.e. planning, construction, and operation and maintenance), the DWE shall provide guidance, educational activities and awareness-raising activities to the local residents on facility operation under instruction from the consultant. They shall also conduct training on facility maintenance and repair with the aim of establishing a permanent system of management by the VWCs. In the process, the DWE can receive support for capacity building from the consultant.

3. After completion of the facilities, the RWE and DWE should effectively use the equipment provided for operation and maintenance by conducting routine facility checks, educational activities, and training. It is also necessary to implement awareness-raising activities on community development and public hygiene in cooperation with government related organizations.

4. The various spare parts necessary for facility repair need to be stored at the RWE and DWE. Spare parts for minor repairs shall be kept at the RWE and provided to the VWC at a cost upon request. The equipment and spare parts for serious repairs shall be kept and used at the DWE. In order to support smooth operation and maintenance, it is essential to improve the technical level of the engineers on the side of implementing agency. Therefore, it is advised that the MoWLD plan and implement regular workshops and on-the-job training in skills for operation and maintenance on a nationwide scale.

Preface

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Summary

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[Appendices]

1 Background of the Project

The water supply situation in Tanzania is still poor, particularly in the rural area. About 50% of the population does not have access to safe and sanitary water. This situation has brought about a high incidence of water borne diseases, which is part of the reason for the high morbidity of children. The lack of adequate water supply facilities also forces women and children to take part in heavy water fetching work.

The water supply rate in the southern two regions increased to 75% in 1984 through the construction of water supply facilities assisted by Finland, a project that was executed based on “the Water Supply Master Plan” from 1976. However, after the withdrawal of Finish assistance in 1992, most of the facilities deteriorated and many of them were in disrepair. This brought about a sharp decline in the water supply rate to less than 40%, which is the lowest in the country as well as compared to other infrastructure.

In order to overcome such a situation, the Tanzanian government requested Japan to conduct a study on the improvement of the water supply conditions of the two regions. In response to the request, JICA carried out a development study titled “The Study on Water Supply and Sanitation in Lindi and Mtwara Regions” from February 2000 to December 2001. Based on the study results, the Tanzanian government requested grant aid from Japan for the construction of deep well water supply facilities to secure safe and stable drinking water for the two regions.

2 Contents of the Project

2.1 Basic Concept of the Project

2.1.1 Sector Goal and Project Goal

(1) Sector Goal

The revised water policy is built on the promotion of resident participation in the water supply project, the beneficiary-payment principle, and dissemination activities on safe water and sanitation. These policies were also the basis of the original water policy established in the 1990s. The final goal of the water policy is to improve the sanitary environment by supplying safe and clean water to all people. Therefore, the project is implemented under the national water policy and targets the southern two regions where infrastructure lags a long way behind the other regions. It is expected that the sanitary environment of the target area will be greatly improved after completion of the project.

(2) Project Goal

This project covers 64 villages in the southern two provinces and constructs water supply facilities consisting of 157 deep wells with hand pump, 34 deep wells with motorized pump and two spring developments. The project goal will be a sustainable supply of clean and safe water for the served population of about 200,000.

2.1.2 Outline of the Project

In order to achieve the goal, the project shall include the construction of water supply facilities in 64 villages and the procurement of equipment for well drilling, survey work and operation and maintenance.

＜Input and Activity＞

① Construction of Level 1 Water Supply Facility (26 villages: 157 deep wells with hand pump, 2 existing pilot wells)

② Construction of Level 2 Water Supply Facility （36 villages: 34 deep wells with motorized pump, 2 spring developments, 2 existing pilot wells)

③ Procurement of well drilling machine, O&M and survey equipment

④ Soft component (Support for O&M and hygiene education)

⑤ Consultant services (Detail design and supervision of construction work）

＜Expected Outcome＞

① Water supply facilities

- Safe water supply facilities in 64 villages completed.

- Served population increased to 200,000 and water service rate increased in two regions. (From the present safe water service rate 35% (2002) to about 42% in 2007)

② Procurement of equipment

- More than 150m depth drilling becomes possible and drilling techniques improved.
- Sustainable maintenance and repair performed.
- Well drilling program, water quality evaluation, survey and design, monitoring of O&M become possible

③ Soft Component

- Resident's O&M of organization will be established. Sustainable operation and maintenance carried out.
- DWE/RWE staff will be technically trained through OJT and able to handle a variety of water supply facilities in various site conditions.

Table 2-1 Project Design Matrix (PDM)

Name of the Project : **Water Supply Project in Lindi and Mtwara Regions, Tanzania**
Project Area : Lindi and Mtwara Regions
Target Group : Residents of the Target Villgaes in Lindi and Mtwara Regions

Summary	Indicators	Measure	External Constraints
Sector Goal: Improved sanitary environment	Decline in water borne disease rate	Statistical data on health	
Project Goal: Increase in served population and sustainable supply of safe and clean water for the target villages.	・ Service rate ・ Operational status of the facility	・ List of registered users in VWC ・ Records of operation	No substantial changes in the water policy.
Outcome 1. Water supply facilities constructed 2. Resident's O&M organization established and sustainable O&M carried out 3. RWE/DWE provide maintenance service 4. RWE/DWE technically improved in water supply construction 5. Resident's awareness of hygiene improved	1-1 Number of water supply facilities and service rate 1-2 Decrease in water fetching time 2-1 Activity of VWC 2-2 Water charge collection rate 2-3 Rate of utilization 3-1 Number of routine visits 3-2 Degree of satisfaction for service 4. Sucessful rate of borehole drilling 5-1 Rate of utilization in rainy season 5-2 Decease in frequency of water borne diseases	1-1 Social study, construction records 1-2 Questionnaire 2-1 Records of VWC 2-2 Records of water charge collection 2-3 Records of operation 3-1 Records of RWE/DWE 3-2 Questionnaire 4. Records of RWE/DWE 5-1 Records of water charge collection 5-2 Questionnaire	No rapid increase in population
Activities 1-1 Planning of water supply schemes 1-2 Procurement of equipment for well drilling, surveys and O&M 1-3 Well drilling and construction of water supply facilities 2-1 Establishment of VWC 2-2 Guidance for O&M 2-3 Monitoring of O&M by residents 3. Technical guidance for RWE/DWE staff 4. Training in construction management 5. Hygiene education	Input (Japanese side) ・ Construction ・ Drilling equipment ・ O&M equipment ・ Vehicles, spare parts ・ Pumping test equipment ・ Survey equipment ・ Soft component ・ Consultant service (Tanzanian side) ・ RWE/DWE staff ・ Land acquisition ・ Community involvement		No unforeseeable groundwater decline Prerequisite Residents have an incentive for implementing the project.

Implementing organizations: Regional Water Engineer's office (RWE) and District Water Engineer's office (DWE) in Lindi and Mtwara Regions

2.2 Basic Design of the Requested Japanese Assistance

2.2.1 Design Policy

2.2.1.1 Basic Policy

(1) Scope of cooperation

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2.2.1.2 Policy for Natural Conditions

(1) Climatic condition

Most of the rainfall concentrates in the rainy season from November to May the following year. From June to October, rainfall hardly occurs at all. The roads are generally not paved except for the national road from Mtwara to Masasi. Accessibility to the villages worsens in the rainy season. Accordingly, the implementation schedule must take climatic conditions into account. In addition, equipment must consider trafficability in the rainy season, usability and durability.

(2) Topographic and geologic conditions

The project area is topographically composed of plateaus, hills and coastal plains. The geology of the area consists of hard rock formations of Tertiary, Mesozoic and Proteozoic era. However, the surface layer is unconsolidated and the groundwater level is generally deep in the plateau. Therefore, appropriate

drilling efficiency must be considered in the design and the drilling machine must be capable of drilling both hard rocks and unconsolidated formations at the same site.

Hand pumps as well as motorized pumps must be applicable for deep groundwater levels. In order to improve the success rate of water well drilling, VES (Vertical Electric Sounding) shall be conducted at the detail design stage.

2.2.1.3 Policy for Social Conditions

(1) Willingness and ability to pay

The level of the water supply facility shall be decided based on the survey on WTP (Willingness to Pay) and ATP (Ability to Pay) of the villagers. As long as the hand pump is adaptable to the static water level, the Level 1 water supply system shall be the first choice.

(2) Water use and sanitary environment

Villagers have a tendency to fetch water at particular times of the day. The behavior of the villagers shall be taken into consideration in designing the facility. Villagers shall also be guided for adequate operation and maintenance throughout the soft component program. The facility shall also be designed considering the sanitary environment.

(3) Women and children

Women and children mainly fetch water. Therefore, the facility shall be designed with due consideration to easiness and safety of daily fetching work.

(4) Farming season

The main industry of the project area is agriculture. Most of the income is generated by cashew production, which is a cash crop. The busy farming season for cashews is from October to November every year. Therefore, the implementation schedule must consider this farming season in planning community participation, contribution to construction work, and hygiene education.

2.2.1.4 Policies for Local Contractors / Procurement

There are many contractors including drilling companies in Tanzania. These local contractors shall be utilized for the project. Equipment and materials are to be procured in Japan, Tanzania and third countries.

Equipment and materials shall be transported from Dar es Salaam, which is 500km away from the project sites. As the road conditions worsen in the rainy season, they are transported by domestic vessel from Dar es Salaam to Mtwara.

2.2.1.5 Policies for Procurement of Contractors

The project plans to incorporate the contractors in Tanzania and third countries into the construction plan in order to carry out the work efficiently and bring down costs.

2.2.1.6 Policies for Capacity Building

In order to effectively conduct O&M activities after completion of the project, guidance and training on O&M for the implementing organizations shall be carried out. This program is to be performed at three stages, i.e., before, during and after construction work. In addition, training for the village organizations on the operation, maintenance and repair of the facility shall be carried out during the construction stage.

2.2.1.7 Set up Policies for Grade of Facility and Equipment

The facility shall be designed as simple as possible with keeping costs down in mind. It must be easy to operate and maintain and durable for sustainable use.

The drilling equipment must be trafficable on unpaved, rough roads in the plateau and mountain area. You should be able to set it up in narrow spaces and on the sloping ground. In addition, it must have a high speed drilling capability for hard rock formations. Therefore, the drilling machine should be a truck-mount rotary rig in combination with DTH. The vehicles should be 4WD considering unpaved, rough roads.

The survey equipment should be necessary and appropriate for capability RWE and DWE technical staffs.

2.2.1.8 Policies on Construction / Procurement Method and Time for Completion

An appropriate construction method shall be employed with the utilization of local contractors in mind. In addition, the specifications of construction materials shall be decided according to the products available in Tanzania or neighboring countries as much as possible in order to keep the cost down.

The hand pump shall be installed and the platform and drain of the Level 1 facility shall be constructed upon competing the drilling of each well. However, for Level 2 facilities, well drilling shall be done in advance. After confirmation of the yield of the borehole, the motor pumps shall be procured in lump sum.

The work plan shall consider the priority and efficiency of each construction work.

2.2.2 Examination of the Requested Project

2.2.2.1 Outline of the Request

An outline of the request is shown in the follow table:

Table 2-2 Outline of the Requested Project

Request Item	Type	Contents
A. Facility Construction	Water supply facility Level 1 Water supply facility Level 2	Deep well with hand pump (18 villages, 76 sets) Deep well with motor pump (76 villages, 74 sets) Spring (6 villages, 6 sets)
B. Equipment	Well drilling machine	FSW-7T-L37 Spare Parts 1 set 300m class machine, supporting equipment and vehicles 1 set

	O&M equipment	4WD light vehicles	9	sets
		Maintenance tool kit	9	sets
	Survey equipment	Pumping test equipment	2	sets
		Well logging equipment	2	sets
		Well cleaning equipment	2	sets
		Geophysical equipment	3	sets
		Water analysis equipment	3	sets
		4WD light vehicle	2	sets
		Computer with accessories	8	sets
		Copy machine	2	sets
		Current meter	2	sets
		Land survey equipment	2	sets

2.2.2.2 Screening of the Requested Villages

It is difficult to construct a water supply facility for all the requested villages in view of the budget and limited construction time. Therefore, the villages were screened according to the procedure described below.

(1) Preliminary screening in the field

The requested villages were initially screened based on the field survey on topography, hydrogeology, water quality and socio-economics.

The criteria for screening were as follows:

1. Groundwater level

Groundwater can be pumped within the following groundwater levels by using hand pump or motorized pump technically, economically and without heavy work.

Hand pump[1]： Up to 60 m (Static water level)

Motorized pump： Up to 150m (do)

2. Water yield

The estimated water yield must be more than 5 l/min (hand pump) or 20 l/min (motorized pump), which will be a criterion for a successful borehole.

3. Water quality（Field measurement）

Electric conductivity： less than 150mS/m

Iron： less than the Tanzanian water quality standard（1.0 mg/l）

The preliminary screening results are shown in the following table.

[1] Maximum range of lift by using a counter-weight

Table 2-3 Results of Preliminary Screening

Region	District	Feasible	Maybe feasible	Not feasible
Mtwara				
	Mtwara Rural	9	7	1
	Tandahinba	0	6	5
	Newala	0	3	8
	Masasi	11	0	0
Mtwara Total		20	16	14
Lindi				
	Kilwa	1	2	6
	Lindi Rural	6	9	2
	Rwangwa	0	9	1
	Nachingwea	0	5	4
	Liwale	5	0	0
Lindi Total		12	25	13
Grand Total		32	41	27

(2) Final screening based on the laboratory analysis

Water samples were collected at the existing water sources in the requested villages during the field survey. The samples were analyzed using a spectro-photometer. The analysis results were evaluated based on the Tanzanian water quality standard and a final screening was conducted on the villages. Iron concentrations were not evaluated because iron can be removed using the appropriate field treatment device.

The villages excluded from the implementation plan are shown in Table 2-4. The water quality of these villages exceeds the Tanzanian standard in terms of manganese (Mn), chloride (Cl) and sulfate (SO_4).

Table 2-4 Villages excluded from implementation

Region	Number /Village	Exceeding Item (mg/l)	Tanzanian standard (mg/l)
Mtwara	22 Litehu	Mn (4.6)	Mn (1.5)
	26 Namindondi Juu*	Mn (2.9)	
	43 Chikoweti	Cl (5,250)	Cl (800)
		Mn (3.7)	
	44 Mlingula*	Mn (1.9)	
	50 Mitonji	Cl (5,650)	
Subtotal	5 (2*)		
Lindi	54 Pande Plot*	Cl (1,130)	
	70 Mnolera	SO4 (775)	SO4 (600)
	74 Kilolombwani*	Cl (1,045)	
	81 Mihewe	Cl (1,025)	
	89 Rweje*	Cl (1,045)	
	91 Chiumbali Miembe*	Mn (2.0)	
	100 Ngongowele	Mn (3.1)	
Subtotal	7 (4*)		
Total	12 (6*)		

* Preliminary excluded.

In addition, one village was excluded due to the groundwater level. The elevation of this village was modified based on the field survey and groundwater was estimated to be deeper than the possible pumping lift.

Mtwara region, Newara district, Likwaya village（No.35）：estimated groundwater level :190m

The number of “may be feasible” villages was 41 in the preliminary screening. However, 6 villages were evaluated “not feasible”. In addition, one village out of the “32 feasible villages” was evaluated “not feasible”.

Accordingly, the final screening results are shown in the following table. t t

Table 2-5 Results of Final Screening

Region	District	Feasible	Not feasible
Mtwara			
	Mtwara Rural	16	1
	Tandahinba	5	6
	Newala	2	9
	Masasi	8	3
Mtwara Total		31	19
Lindi			
	Kilwa	3	6
	Lindi	13	4
	Rwangwa	8	2
	Nachingwea	5	4
	Liwale	4	1
Lindi Total		33	17
Grand Total		64	36

2.2.2.3 Type of the Facility

A Level 1 water supply system for 18 villages (76 boreholes) and a Level 2 water supply system for 76 villages (74 boreholes) were requested originally. In addition, a Level 2 spring water supply system for 6 villages was requested. Based on the field survey, the Level 1 system was primarily taken into the plan, considering the actual O&M conditions of Level 2 systems constructed in past years.

A Level 1 system was applied to the villages where the groundwater level is shallower than 60m. This means a practical range of lift of the extra-deep hand pump. The groundwater level of the village was estimated by using a river level map. This may result in an increase of deep wells in large villages and the construction cost may exceed that of the Level 2 system. Accordingly, the construction costs for the two systems were estimated and compared with each other. As a result, it was found that the cost for the Level 1 system exceeds that of Level 2 if the number of hand pump wells is more than 10 and/or 11. Therefore, the Level 1 was changed to Level 2 in these large villages. However, based on the socio-economic study, a Level 1 system was applied in the villages where the O&M cost for a Level 2 system is difficult considering the WTP (Willingness to Pay) of the villagers for the O&M cost, although the number of deep wells increases.

A Level 2 spring water supply system was requested for 3 villages each in the Mtwara and Lindi regions, respectively. However, based on the site survey, the discharge of the springs in 4 of the villages was too small for constructing a water supply facility. Therefore, these villages were excluded.

2.2.2.4 Procurement of Equipment

Four WD light vehicles and maintenance tools were requested for each DWE and RWE office. However, in the plan, DWE should mainly conduct routine checks and give technical guidance on the facility, considering the present conditions of the staff, equipment and capability. Therefore, the requested equipment shall be assigned to RWE. RWE shall support DWE upon request from the villages in the event that major repair is required. Accordingly, DWE needs equipment for district level O&M, routine checks and technical guidance.

2.2.2.5 Soft Component

O&M of the facilities in the two regions constructed in past years has not been good. The Tanzanian side requested support for capacity building related to O&M of province, district and village organizations. The Tanzania government revised its "Water Policy" in 2002. It emphasizes the promotion of residents' participation, the beneficiary-payment principle and dissemination activities on safe water and sanitation. However, the residents are not fully aware of their ownership as well as the beneficiary-payment principle. The sector-related goal of the project is to improve the sanitary environment of the area. To achieve this goal, awareness on hygiene practices must be improved. The sustainable use of clean and safe water must be performed under adequate O&M conditions. In order to continue sustainable hygiene education and O&M activities after completion of the project, the following soft component is planned.

- Awareness raising for resident's participation
- Planning of O&M and technical training
- Monitoring and evaluation
- Hygiene education

2.2.2.6 Request and Alteration

Based on examination of the request, the basic design plan is shown in the following tables.

A. Facility

	Request	After examination	Reason
1	Level I: Deep well with hand pump（18 villages, 76 wells）	Deep well with hand pump (26 villages, 157 wells)	・ Based on the detailed field survey
2	Level 2: Deep well with motorized pump（76 villages, 74 wells）	Deep well with motorized pump (36 villages, 34 wells)	・ Based on the detailed field survey
3	Level 2: Spring water with motorized pump (6 villages)	Level 2: Spring water with motorized pump (2 villages)	・ Based on the detailed field survey

B. Equipment

	Request		Alteration		Remarks
	Name	Qty	Name	Qty	
1. Drilling Equipment	Spare parts for FSW-7T-L37	1 set	No alternation	1 set	Necessary for drilling works
	300m class drilling machine, supporting equipment & vehicles	1 set	200m class drilling machine, supporting equipment & vehicles	1 set	Necessary for drilling works
2. O&M Equipment	4WD light vehicle	9 units	Truck with crane (maintenance car)	2 units	For maintenance and repair of the facility; 1 set per region
	Maintenance tools	9 sets	Welder and maintenance tools	2 sets	For maintenance and repair of the facility; 1 set per region, loaded on the maintenance car
	Not mentioned		Motorbike	9 units	For visiting villages to check the condition of water supply facilities
	Water level meter	2 units	No alternation	2 units	Necessary for water level observation
3. Survey Equipment	Pumping test equipment	2 sets	Pumping-test-equipment (submersible pump, notch, generator)	2 set	Originally included in the survey equipment
	Well logging equipment	2 sets	Well logging equipment	1 set	ditto
	Well cleaning equipment	2 sets	Compressor for air-lifting and cargo truck (well cleaning equipment)	2 sets	Periodical well cleaning
	Geophysical equipment	3 sets	Resistivity survey equipment	2 sets	For groundwater investigation
	Water quality analysis equipment	3 sets	PH meter, ORP meter, EC meter	2 sets	Used in the field
	4WD Light Vehicle	2 sets	Pick-up truck	2 units	Transportation of survey equipment。
	Computer with accessories	8 sets	Computer, printer, UPS	2 sets	Utilized for O&M
	Copy machine	2 sets	-	0	
	Current meter	2 sets	No alteration	2 units	Data acquisition on stream flow
	Survey equipment	2 sets	No alteration	2 sets	For land survey

C. Soft Component

Request	Alteration	Reason
Support for capacity building of MoWLD, RWE, DWE and villages	No	It is necessary to support the capacity building of the O&M of organizations because of lack of skills and experience.

2.2.3 Basic Plan

2.2.3.1 Facility Plan

(1) Served Population

The census survey was conducted in 2002. However, the population of the target villages has not yet published. Therefore, the served population in year 2005 has been projected applying a population growth rate based on the development study in 2000.

1. Lindi region : 1.4%
2. Mtwara region : 1.7%

Table 2-6 Population Projection in the Target Villages (64 villages)

Region	District	2000	2001	2002	2003	2004	2005
Mtwara	Mtwara	54,290	55,212	56,150	57,106	58,077	59,063
	Tandahimba	12,543	12,756	12,973	13,194	13,419	13,647
	Newala	2,864	2,913	2,963	3,013	3,064	3,116
	Masasi	20,872	21,227	21,588	21,955	22,329	22,708
	Total	90,569	92,108	93,674	95,268	96,889	98,534
Lindi	Kilwa	10,270	10,414	10,560	10,708	10,857	11,010
	Lindi	52,491	53,226	53,971	54,726	55,493	56,270
	Ruangwa	15,545	15,765	15,986	16,209	16,437	16,667
	Nachingwea	12,280	12,452	12,626	12,803	12,982	13,164
	Liwale	5,899	5,981	6,065	6,150	6,236	6,322
	Total	96,485	97,838	99,208	100,596	102,005	103,433
Grand Total		187,054	189,946	192,882	195,864	198,894	201,967

(2) Per Capita Water Consumption

According to the water policy, 25 liters per capita per day (lcd) is the standard of the rural water supply. However, the actual amount of water consumed by residents was 4～8 lcd based on the development study. Considering an appropriate scale of the facility to reduce the O&M cost and an increase in water consumption brought about by dissemination activities, the proposed per capita water consumption of 20 liters/day is judged to be valid.

(3) Planned water supply rate

The water supply rate is different for Level 1 and Level 2 systems. In the case of a hand pump, it is estimated based on the possible discharge amount, as the capacity of the hand pump is small. The discharge amount of a motor pump is much greater than a hand pump. Therefore, the water supply rate depends on the yield of the well (specific capacity or critical pumping rate).

Water supply of the hand pump can be estimated as follows:

Pumping discharge 15 liters/min

Operational time 10 hours/day

Capacity usage 0.8

Q=15 liters/min x 60 min x 10 hrs x 0.8= 7,200 liters/day

Therefore, the hand pump can supply water for a population of 360 (7,200 divided by 20 lcd).

In principle, the Level 2 system includes one deep well per village (if the yield of the deep well is small, two or more wells). The pump capacity is estimated by multiplying 20 lcd by the served population. The capability of the pump, volume of the water tank, number of public faucets, and length of the distribution pipes are decided according to the served population and village type. The standard operational time of the pump is fixed at 10 hours/day.

(4) Selection of facility level

The facility level (Level 1 or 2) shall be selected based on the following conditions.

a) Hand pump facility

① In order to reduce the cost of O&M, the hand pump system is the first choice.

② The practical pumping lift capability of the extra-deep hand pump is about 60m. Therefore, the hand pump system is applicable in areas where the natural groundwater level is shallower than 60m.

b) Motorized pump facility

① If the groundwater level is deeper than 60m, the motorized pump system shall be applied.

(5) Water supply facility

a) Level 1 water supply facility

① Water level and hand pump

An extra-deep hand pump is employed. Draw down is estimated at 10m.

② Platform and drain

In order to avoid the occurrence of cracking due to unequal settlement, the platform is made of reinforced concrete. In addition, a drain of an appropriate length is constructed to prevent infiltration to the well directly from the platform.

b) Level 2 water supply facility

① Lifting range and water level

If the lifting range is large, the fuel cost for operation increases thereby the burden on the residents increases. Considering economical operation, the lifting range of the motorized pump is set at 200m

maximum. Moreover, the lift from the ground surface to the water tank is set at 10m and the draw down at 40m based on the test drilling conducted in the development study. Therefore, an applicable range of the natural groundwater level must be shallower than 150m.

② Well yield and pumping capacity

The maximum well yield is set at 150 liters/min. The pumping capacity is calculated based on the required water supply rate in each village. However, the maximum well yield of 150 liters/min is set at the upper limit of the pumping capacity.

③ Operational time and supplying hour

The operational time of the pump is set at 10 hours. The water supplying time is 12 hours. As the upper limit of the pumping capacity is 150 liters/day, the operational time is increased if the water requirement does not meet the supply.

④ Power

Electric power is supplied for only four target villages. Therefore, generators shall be installed in almost all target villages.

⑤ Generator house

The role of the house shall be the installation, operation and safekeeping of the generator. It is designed simply and small, and constructed of reinforced concrete and block masonry.

⑥ Water tank

The water tank shall have a capacity of half the daily water supply. In order to standardize the tank and avoid an excessive facility, the volume of the tank is categorized into four types, i.e. $20m^3$, $30m^3$, $40m^3$ and $50m^3$. The maximum capacity is $50m^3$. The target area is located close to the coast. Because of rusting, a steel structure is not appropriate in terms of durability. Therefore, a reinforced concrete structure shall be employed in principle. However, the tank itself shall be made of FRP considering sanitation and easiness of construction.

⑦ Distribution pipe

The standard length of the distribution pipeline is set at 500m in order to reduce the cost of construction and O&M. In villages where the population is less than 1,600, the pipeline shall not be constructed. The distribution pipe shall be made of SGP pipe to avoid failure, theft, etc.

⑧ Transmission pipe

Based on the land survey, the length of the transmission pipeline is estimated to be 1,000m in the case of spring water development. As for deep wells, however, it is desirable to drill boreholes at high places in the villages in order to distribute water by gravity. However, boreholes located at high places are not always successful, thereby 100m of the transmission pipeline is added.

⑨ Public faucet

A public faucet shall be installed at one place per 800 persons.

⑩ Spring water intake

Intakes shall be constructed of reinforced concrete.

⑪ Design criteria of the structure

There is no soft ground in the project area and the strength of ground is sufficient. The bearing capacity of the soil is estimated at 7 tons/m^2.

Earthquakes seldom occur in the southeastern area of Tanzania. But in the northwestern area of the country, they sometimes occur. Therefore, a seismic factor of 0.1 shall be considered.

(6) Structure of well

① Diameter

1. Deep well with hand pump

The standard diameter of the well casing shall be 4 inches. The drilling diameter shall 6.5 inches for the DTH method to secure clearance for gravel packing and filling of material to cut off water. In the case of mud rotary drilling, the diameter shall be 8 inches in order to insert the work casing to prevent the collapse of the bore wall.

2. Deep well with motorized pump

In order to secure sufficient pumping discharge, the well diameter shall be 6 inches. The drilling diameter shall be 8.5 inches for the DTH method and 10 inches for the mud rotary method.

② Casing and screen

1. Deep well with hand pump

PVC pipe

2. Deep well with motorized pump

It is preferable to increase the screen opening to pump up a large amount of groundwater. Accordingly, a stainless made Johnson type screen shall be employed, as it is durable and secures more than 15% of the screen opening. As many deep wells are more than 100m deep, the casing shall be made of steel.

③ Well depth

The well depth is estimated according to the test drilling of the development study. The distance between the aquifer and the static water level is 48.6m on average. Based on this, in all the target villages, 50m is decided. Additionally, 10m of coverage was considered. As a result, the drilling depth is estimated to be 60m below the static water level.

④ Criteria of successful well and rate

1. Water quality: As the target village was selected considering water quality, water quality criteria for successful wells shall not be applied.
2. Water quantity: In the case of deep wells with hand pumps, water quantity criteria shall be set at 15 liters/ min.
3. The well yield must meet the designed pumping rate at individual Level 2 facilities in the case of deep wells with motorized pumps.
4. Success rate : 80% (according to the test drilling)

2.2.3.2 Equipment Plan

(1) Drilling equipment

a) Spare parts of the existing drilling machine (FST-7T-L37) with vehicle and compressor

The drilling machine provided by Japan in 1997 drilled more than 200 bore holes by the end of 2002 (50 wells/year). The existing machine has been well maintained by using the provided spare parts. However, the stock has been spent and maintenance of the machine has become difficult recently. Accordingly, spare parts for the existing drilling machine with its vehicle and compressor will be procured.

b) Drilling machine

The nominal drilling capacity of the existing FST-7T-L37 is 150m. Since some target villages require deep wells more than 150m in depth (200m deep at maximum), it will be difficult to implement the project only with the existing machine and local contractors. Therefore, a new drilling machine that is capable of drilling up to 200m deep will be procured for the project.

c) Supporting equipment and vehicles

Standard accessories for the newly installed drilling machine, a high-pressure compressor and a cargo truck for transportation of equipment and material are necessary. The target villages are located far from the city area. Water and fuel are not available. Accordingly, water for drilling and fuel must be transported by water tank lorry and fuel truck. These supporting vehicles should be 4WDs considering the road conditions.

d) Equipment for well test

Although the pumping test and well logging equipment have been requested as the survey equipment, these shall be procured as equipment for the well test involved in the supporting equipment for drilling machine. They are necessary for confirmation of aquifer depth and possible pumping rate. The well logging equipment measures resistivity and spontaneous potential of the formations, thereby aquifer and screen position can be determined. Well efficiency and the pumping rate are also determined by the pumping test. Therefore, a motor pump, a generator and a triangle notch for hand pump wells and those for motor pump wells and one set of logging equipment will be procured.

e) Geophysical survey equipment

For drilling site selection, resistivity survey equipment is planned. The equipment is used for profiling and vertical soundings.

(2) Equipment for O&M

The original request included nine 4WD light vehicles for each DWE and RWE. As already mentioned, RWE shall give technical support for repair of the facilities in the project so a small-sized truck with a one-ton crane will be provided to each RWE. These vehicles will be utilized for the O&M and repair of the well, motorized pump and pipes. Therefore, a truck with crane is planned for lifting the rising pipe and transmission pipe, etc. For cutting and welding of the pipes, a welder will be provided with the vehicle. Maintenance tools including a pipe wrench and others will also provided with the vehicle.

a) Motorbike

DWE shall support O&M of the village throughout the technical and administrative guidance and routine checks of the facilities. In case of major repair of the facility, DWE will require technical assistance from RWE. One motorbike shall be provided to each DWE for the routine checks and guidance.

b) Water level meter

The water level changes over long periods as well as in every season. Observation of the water level is one of the most basic components of proper maintenance.

(3) Survey equipment

a) Well cleaning equipment

Well cleaning equipment is necessary for well development in the case of sand sedimentation in the screen. Equipment consists of an air compressor and a vehicle with a three-ton crane for transportation.

b) Water quality meter

In order to measure pH, ORP and EC in the field, a set of portable equipment including a pH meter, ORP meter and EC meter is planned for each RWE.

c) Pickup truck

This will be utilized for transportation of resistivity survey equipment and technical staff.

d) Current meter

The success rate of bore hole drilling can be improved by analyzing existing water sources in the vicinity of the target village. A current meter is necessary to measure stream flow.

e) Land survey equipment

This equipment will be utilized for the design and land survey of Level 2 water supply.

f) Computer with accessories

This is necessary for databases such as a well inventory as well as analysis of geophysical data. A well inventory will be made for planning the future water supply and recording O&M activities.

Table 2-7 List of Equipment

Division	Equipment	Purpose/Items	Qty	Remarks
A. Drilling Equipment	Spare parts for the existing drilling machine (FSW-7T-L37) with vehicle and compressor	Spare parts of drilling rig, vehicles and compressor provided in 1997. Used for maintenance.	1 set	
	Drilling machine	Truck mount rotary in combination with DTH, drilling capability 200m at 6-12 inches.	1 unit	
	Supporting equipment and vehicles	Hammer, bit, tools, compressor, cargo truck with 4ton crane, water tank lorry, fuel truck. Utilized for drilling and transportation of equipment and materials.	1 set	1 set each
	Well testing equipment	Well logging, motor pump, generator, notch for pumping test. Utilized for judgement of aquifer and possible pumping discharge	2 sets each	Well logging 1set
	Geophysical survey equipment	Resistivity survey equipment, with 12V24A batteries, cables and poles	2 sets	1 set for each RWE
B. O&M Equipment	Small-sized truck with crane	One- ton crane truck. A welder and maintenance tool set is loaded on the cargo. For repair and maintenance	2 sets	Do
	Motorbike	Routine check and technical guidance	9 sets	1 set for each DWE
	Well cleaning equipment	Compressor, cargo truck with 3-ton crane Utilized for well cleaning.	2 sets	1 set for each RWE
	Water level meter	With 200m cable	2 sets	Do
C. Survey Equipment	Water quality meter	Portable pH, ORP, EC meters	2 sets	Do
	Pickup truck	Transportation of equipment	2 sets	Do
	Current meter	For small stream	2 sets	Do
	Land survey equipment	Total station for Level 2 facility	2 sets	Do
	Computer with accessories	Desktop, printer and software, UPS	2 sets	Do