Potential area identified (Gross area in ha)			
Lower Ruvu	Middle Ruvu	Mgeta Plain	Total (ha)
24,000	30,000	30,000	84,000

5.2.3 Possible agricultural development projects

Following eleven (11) possible project plans were formulated based on the potential land resources, soil conditions, the project priority ranking by FAO, the policy of the Ministry of Agriculture and regional offices and the national policy;

1) Bagamoyo Irrigation Development Project
2) Low-lift Pump Irrigation Project
3) Makurunge Irrigation Project
   (Existing Pump Irrigation Scheme's Rehabilitation Project)
4) Ruvu National Youth Irrigation Project
   (Existing Pump Irrigation Scheme's Rehabilitation Project)
5) Kidunda Irrigation Project
   (Middle Ruvu Irrigation Development Project)
6) Ngerengere Irrigation Project
   (Middle Ruvu Irrigation Development Project)
7) Uluguru Mountain East Project
8) Mgeta Plain Irrigation Project
9) Mgeta Plain Mvuha Irrigation Project
10) Mlali Irrigation Project
11) Uluguru Mountain West Project

The above projects are outlined in Table 5.7 and the locations of these projects are illustrated in Fig. 5.3.

5.2.4 Priority ranking study

(1) General

The Ruvu River basin has vast potential for agricultural development. However, limitation of development fund and available water resources require step-wise development in accordance with the priority of those projects. In order to assess the priorities of the aforesaid 11 projects, they are evaluated from various aspects as discussed in the following Paragraphs.

(2) Criteria for selection of priority project

For the purpose of selection of the priority projects, the Study Team set up the following four (4) major selection criteria:

(a) Conformity with the Government Policy
- Long Term Perspective Plan 1981 - 2000
- National Irrigation Policy (draft)
- Priority Project Ranking Study by ISID

(b) Socio-economic Aspect
- Population served
- Accessibility

(c) Technical Aspect
- Water resources
- Soil condition
- Water quality
- Easiness for implementation

(d) Economic Aspect
- Construction cost
- Benefit
- Ratio of total benefit to total cost

(3) Project cost estimate

Construction cost of each possible project on a maximum development scale was preliminarily estimated for the purpose of selection of the priority projects. Prior to the cost estimate, design of irrigation and drainage system for each project was made on a preliminary basis in order to estimate the construction work volume.

a. *Preliminary layout of irrigation and drainage canal system*
The layout plan of the main and secondary canals was made based on the topographic maps at a scale of 1/50,000 for each possible project. In the layout, existing natural streams and rivers are planed to be utilized as drainage canals as far as possible. The general layout plan of each project is illustrated in Fig. 5.4.

b. Design discharge

The design discharges of irrigation canals and related structures are calculated by the unit water requirement, cropping patterns, crop intensities and the adjustment factor of the USBR design standard. Calculated unit irrigation water requirement and assumed cropping patters and crop intensities by the zone are as follows;

Zone	Dry Season	Rainy Season	Design discharge	Unit water requirement (peak in dry season)
Lower Ruvu				
	Paddy (40%)	Paddy(100%)	1.65 lit./ha	1.25 lit./ha
	Maize (20%)			
Middle Ruvu				
	Paddy (20%)	Paddy(100%)	1.86 lit./ha	1.15 lit./ha
	Maize (40%)			
Upper Ruvu				
	Paddy(20%)	Paddy(20%)	1.02 lit./ha	1.02 lit./ha
	Maize(40%)	Maize(40%)		
	Cotton(40%)			

The design discharge of drainage canal was estimated at 3.5 lit/sec/ha for fields in low lands and 5.0 lit/sec/ha for hilly and mountainous areas taking design rainfall and duration of on-field storage of excessive water into account.

c. Canal lining

Since no field survey along the proposed canals was carried out specifically for each of the possible projects, data on percolation of the canals were not available. Taking into consideration the situation, concrete canal lining was designed for 10% of the total length of the major irrigation canals and no canal lining was planned for the secondary canals.

d. Related structures

Density of the canal-related structures is assumed based on the following standard:

Structure	Density
Main canal-related structure	
Turnouts (outlet)	as per required by the canal layout
Regulator	at an interval of 5 km
Syphon	at an interval of 10 km
Culvert/Cross drain	at an interval of 2 km
Spillway	at an interval of 4 km
Secondary canal-related structure	
Turnouts (outlet)	as per required by the canal layout
Regulator	at an interval of 2 km
Syphon	as per required by the canal layout
Culvert/cross drain	at an interval of 1 km
Spillway	at an interval of 4 km

e. Work Quantity

The work quantity was calculated for each of the major work items such as earthwork and concrete works. The work quantity of main and secondary canal systems was calculated based on the canal layout plan. As for the on-farm canal system, the work quantity was calculated by the standard design with canal density of 80 m/ha. The work quantity of structures was calculated using the standard design of various types of structures.

f. Unit Construction Cost

Since no construction cost data on the irrigation projects are available, the unit cost of the "Kitivo Irrigation Project - Lusoto, Tanga " is applied to the irrigation and drainage works. The cost data on improvement and rehabilitation of rural road were collected from the Ministry of Works. These cost data are listed in Table 5.8.

g. Project construction cost

The project construction cost comprises direct construction cost, and costs for land acquisition, O & M equipment, administration (office and quarters), engineering services and physical contingency. The price contingency cost is not included in the project construction cost. The project construction costs of the possible projects on maximum development scale are summarized as follows:

(Unit : million TShs)

Project Name	Construction Cost	Total Cost	Unit Cost per ha (US$)
Bagamoyo Irrigation Development	1,371	1,768	3,543
Low-lift Pump Irrigation	57	72	3,135
Makurunge Irrigation	206	266	3,850
Ruvu National Youth Irrigation	420	540	5,875
Kidunda Irrigation	20,120	25,949	3,605
Ngerengere Irrigation	2,969	3,829	3,398
Uluguru Mountain East	4,801	6,191	5,130
Mlali Irrigation	583	752	4,089
Mgeta Plain Irrigation	9,091	11,725	3,641
Mgeta Plain Mvuha Irrigation	4,291	5,534	3,437
Uluguru Mountain West	3,195	4,121	4,479

More detailed breakdown of the above construction cost for each project is listed in Table 5.9.

h. Benefit

Net incremental benefit of the project is defined as the difference between the net production value under "with project" condition and the production value under "without project" condition. Net production value is further defined as the difference between the gross production value and the crop production costs in both "with project" and "without project" conditions. The benefit by project thus calculated is shown in Table 5.10.

(4) Selection of priority projects

The factors involved in the aforesaid selection criteria are numerically weighted in consideration of their importance as shown in Table 5.11. As the first step, scoring of each factor is carried out and summed up by criteria. The projects are further evaluated categorizing into 3 classes, namely Class A, B, C. Each class has the following priority:

Class A : High Priority
Class B : Priority
Class C : Low Priority

Following table shows the result of the priority ranking study.

	Project Name	Total Score	Class
1.	Bagamoyo Irrigation Development	71	A
2.	Low-lift Pump Irrigation	65	A
3.	Makurunge Irrigation	59	B
4.	Ruvu National Youth Irrigation	42	C
5.	Kidunda Irrigation	52	B
6.	Ngerengere Irrigation	51	B
7.	Uluguru Mountain East	53	B
8.	Mlali Irrigation	64	A
9.	Mgeta Plain Irrigation	49	C
10.	Mgeta Plain Mvuha Irrigation	48	C
11.	Uluguru Mountain West	73	A

The detailed evaluation sheet is presented in Table 5.12.

5.2.5 Assessment of the project priority

The agricultural development projects can be divided into the following two types from a point of view of the necessity of new water resources development to suffice the water requirement in the dry season:

Type I : Dam related project

Type II : Project which is independent of new water resources development

As a result of the priority ranking study, following 4 (four) projects are selected as the high priority project:

1) Bagamoyo Irrigation Development Project
2) Low-lift Pump Irrigation Project (Phase I : Pilot farm construction project)
3) Mlali Irrigation Project
4) Uluguru Mountain West Project (Mgeta traditional irrigation)

Among these projects, the Bagamoyo and Low-lift projects in the lower Ruvu are categorized into Type I project. The Type I project should wait for water supply from the proposed dam(s) for irrigation in the dry season. Hence, the Type I project should be implemented after construction of dam(s) proposed in this Study in order to enable the irrigation in the dry season.

On the other hand, the Mlali Irrigation and Uluguru Mountain West Projects are planned to intake irrigation water from a tributary of the Ruvu River or small streams in the Uluguru Mountains. These projects are categorized into Type II project, which will be able to be implemented independently of construction of the proposed dam(s).

In addition, the Mlali Irrigation and Uluguru Mountain West Project projects have important roles as pioneer projects in promotion of gravity irrigation, selling water to private sector and giving support to smallholder irrigation. Taking all above into consideration, we recommend *that the Mlali and Uluguru West projects are implemented prior to construction of the Type I* project.

It is also recommendable that a feasibility study should be carried out for the Mlali and Uluguru West projects soon after completion of the Study. The feasibility study on these two priority projects should be conducted together in a single package taking into consideration the development scales of these projects, the vicinity of their locations and the problem inherently common thereto, namely soil erosion in the western area of the Uluguru Mountains and siltation at the existing Mlalai intake site.

5.2.6 Agricultural development scenario

(1) Available water resources

After completion of the dam project(s) involved in the Development Scenario, available discharge in dry season for the irrigation purpose was calculated at 12.27 m^3/sec in the Scenario-1 and 0.23 m^3/sec in the Scenario-2 as summarized below and stated in the succeeding Chapter VIII.

Development Scenario	Dam(s) to be constructed	Available Discharge for Irrigation (m^3/sec)
Scenario-1	Kidunda dam	12.27
Scenario-2	Ngerengere dam + Mgeta dam	0.23

(2) Agricultural development plan for Scenario-1

a. Development plan for Scenario-1

In case of the Scenario-1, projects located downstream of the Kidunda dam will be targeted. In developing all of these project areas to the maximum extent, total water demand will amount to 16.4 m^3/sec in dry season. On the other hand, available water amount constantly released from the Kidunda reservoir was estimated at 12.27 m^3/sec. Therefore, an area equivalent to 4.13 m^3/sec of irrigation water needs to be excluded from that in case of the maximum development. In the rainy season, water amount released from the Kidunda reservoir is sufficient for irrigation of the whole areas.

Judging from the result of the priority ranking study, required project cost, project scale, etc., concerning the Kidunda irrigation project an area of about 10,500 ha is recommended to be developed out of the total project area of 15,600 ha.

The irrigation projects to be developed under the Development Scenario-1 (Kidunda Dam) are listed as follows;

	Maximum Development Case			Revised Plan	
Project Name	Project Area (ha)	Unit Water Requirement (l/sec)	Water demand (m3/sec)	Project Area (ha)	Demand (m3/sec)
Kidunda Irrigation	15,600	1.15	17.94	10,500	12.07
Bagamoyo Irrigation Development	1,100	1.25	1.38	1,100	1.38
Low-lift pump Irrigation	2,400	1.25	3.00	2,400	3.00
Ruvu National Youth Irrigation	200	1.25	0.25	200	0.25
Makurunge Irrigation	150	1.25	0.19	150	0.19
Total	19,450		22.76	14,350	16.89
Irrigation water right counted by scenario			-1.00		-1.00
Return flow from the Kidunda Irrigation Project area (30% of intake water amount)			-5.38		-3.62
Water Demand of Irrigation			16.38	Revised =	12.27

In addition to the projects mentioned above, the Mlali irrigation and Uluguru West projects should be developed as the independent project separately from those development scenarios.

b. *Project cost and benefit*

The project cost and benefit are estimated as follows:

Project Name	Project Area (ha)	Project Cost (million Tshs)	Benefit (million Tshs/Year)
Kidunda dam related project			
Kidunda Irrigation	10,500	17.416	2.009
Bagamoyo Irrigation Development	1,100	1.768	0.248
Low-lift pump Irrigation	2,400	3.461	0.441
Ruvu National Youth Irrigation	200	0.540	0.045
Makurunge Irrigation	150	0.266	0.030
Total	14,350	23.451	2.773
Independent Project			
Mlali Irrigation	400	0.752	0.068
Uluguru Mountain West	2,000	4.121	1.189

c. Implementation Program for the Development Scenario-1

As a first stage project, two high priority projects should be implemented as a pioneer or an experiment project. Although the low-lift pump irrigation project has also high priority, it involves a quite new concept in Tanzania. For the smooth operation of this type of the project, establishment of water users association of farmers is indispensable. Therefor, the project should be started for a pilot area of 50 ha after construction of the Kidunda dam. The proposed implementation program for the Development Scenario-1 is shown in Fig. 5.5.

(3) Agricultural development plan for Scenario-2

a. Development plan for Scenario-2

In case of the Scenario-2, only the Bagamoyo Irrigation Development Project with the highest priority could be implemented using existing water rights of the abandoned projects.

Project Name	Maximum Development Case Project Area (ha)	 Unit Water Requirement (l/sec)	 Water demand (m3/sec)	Revised Plan Project Area (ha)	 Demand (m3/sec)
Mgeta Plain Irrigation	7,000	1.02	7.14	0	0.00
Ngerengere Irrigation	2,450	1.15	2.82	0	0.00
Bagamoyo Irrigation Development	1,100	1.25	1.38	980	1.23
Low-lift pump Irrigation	2,400	1.25	3.00	0	0.00
Ruvu National Youth Irrigation	200	1.25	0.25	0	0.00
Makurunge Irrigation	150	1.25	0.19	0	0.00
Total	13,300		14.78		1.23
Irrigation water right counted by scenario			-1.00		-1.00
Return flow (30% of intake water amount)			-2.99		0.00
Water Demand of Irrigation			10.79Revised = 0.23		

b. Project cost and benefit

The project cost and benefit are estimated as follows;

Project Name	Project Area (ha)	Project Cost *(million TShs)*	Benefit *(million TShs/Year)*
Dam related project			
Bagamoyo Irrigation Development	980	1.575	0.221
Independent Project			
Mlali Irrigation	400	0.752	0.068
Uluguru Mountain West	2,000	4.121	1.189

c. Implementation Program for Scenario-2

The proposed implementation program for the Development Scenario-2 is shown in Fig. 5.5.

5.2.7 Recommendation on further study

Through the master plan study on water resources development in the Ruvu River basin, the huge potentials of agricultural development were identified. Taking into account the limitation in budget allocable to their implementation in the country, it is envisaged that they would be realized through a stage-wise development.

As a first step of the agricultural development in the basin, it is recommended that a feasibility study on the Mlali Irrigation Project and the Uluguru Mountain West Project be carried out in one package as stated in the succeeding Chapter X. These projects will be implemented separately from the water resources development in the basin and will become the pioneer projects in promotion of the gravity irrigation and in establishment of intensive and marketable irrigated farming technology. In addition, the Bagamoyo Irrigation Development Project is given a high priority, although it requires the water resources development in the basin so as to enable the irrigation in the dry season.

The present study on agricultural development was preliminarily carried out at a study level of master plan. Hence, it is recommended that more accurate and practical study be carried out in the future feasibility study of those priority projects with respect to the following items:

a) Selection of crops, crop intensities and cropping patterns
b) Farming practices with and without project conditions
c) Farm input and labor requirement
d) Marketing, price of crops and price prospects
e) Farm budget

CHAPTER VI

FLOOD MITIGATION PLAN

6.1 Flood Characteristics of the Ruvu River Basin

6.1.1 Previous large-scale flood in the Ruvu River basin

Through the review of flood records at the existing gauging station 1H8 on the Ruvu River (Morogoro Road Bridge), it was found that peak discharges of the 9 major floods which took place after 1965 mostly exceeded 500 m^3/sec. The flood peak discharge of 1,094 m^3/sec was recorded in April 1979. During the Study period, a flood with peak discharge of 820 m^3/sec occurred in April 1993.

6.1.2 Specific discharge of flood peak

As described in the foregoing Chapter III, the annual average runoff coefficients in the mountainous areas of the basin are more than 50 %, while it becomes very low in the lower reaches. At the stream gauging station 1H8, an annual runoff coefficient is derived to be about 12 %. Likewise, the specific peak discharges of the large-scale floods which took place at the other gauging stations in the lower reach show very low values.

As a typical flood in the basin, the 1973 flood was selected and studied. From the flood hydrograph at each gauging station in the basin as well as its topographic conditions and through the field reconnaissance performed by the Study Team, it is clearly understood that the floodplain along the Ruvu River between 1H10 and 1H8 functions as a retarding basin. The natural retarding basins in the other areas of the basin also create the swamp area during the wet season. The major floodplains in the basin are shown in Fig. 6.1 and summarized below:

- Kidunda Plain ; area along the Ruvu River between the proposed Kidunda dam site and confluence with the Ngerengere River
- Mgeta Plain ; area along the Mgeta River between the proposed Kidunda dam site and Kisaki
- Ngerengere Plain ; area along the Ngerengere River between the proposed Ngerengere dam and Ngerengere town
- Morogoro Plain ; area along the Ngerengere River near Morogoro municipality.

6.1.3 Present flow capacity of the Ruvu River

The flow capacity of present low water channel is estimated by means of the non-uniform calculation method and using the stage-discharge curves at existing gauging stations. The low water channel flow capacity in the lower Ruvu floodplain varies from less than 100 m^3/sec near the Kikongoni ferry to 300 m^3/sec near the Morogoro Road Bridge. The flow capacities at existing gauging stations vary from 50 to 600 m^3/sec. These flow capacities of the low water channel reveal that the flooding has caused in the floodplains of the Ruvu River and its tributaries every year.

6.2 Flood Survey and Flood Prone Area

6.2.1 Flood survey

In order to confirm location of flooding, flooding patterns and scale of flood damages or benefits in the basin, the flood survey was executed by the Study Team during the Phase 1 and 2 Field Works in 1993. Based on the topographic maps at a scale of 1 to 50,000, the survey areas were selected, where the significant flooding is likely to occur along the rivers and where people live. The survey areas were selected mainly in the lower reach of the Ruvu River.

6.2.2 Lower Ruvu floodplain

(1) Topographical features

Based on the topographic maps and cross sectional survey conducted by the Study Team in 1993, it was clarified that the floodplain is about 6 km wide at a location just upstream of the estuary and that it is gradually narrowed to about 1.7 km at Mafisi. Thereafter, it is widened at the confluences with the tributaries such as the Vianzi, Usigwa, Mkombezi, Mbiki, Misua and Dutumi on the left bank and Ngerengere and Dundanguru (Kitomondo) on the right bank as shown in Fig. 6.2.

The river course between the estuary and Mafisi is about 84 km long, while the meandering low water channel in this section is about 156 km long. Thus, the low water channel meanders in a range of 600 m to 1,500 m in width therein. In the lower reaches downstream of the Lower Ruvu Intake of NUWA, the change in the river course might take place several times, and many old river courses formed oxbow lakes. The bottlenecks of the Ruvu River were identified at the following locations where the river-related structure is laid:

i) Ruvu railway bridges with 7 bridges and 5 culverts,
ii) Morogoro Road Bridge with 1 bridge and 10 culverts, and
iii) Kivukoni ferry and road connecting Bagamoyo and Msata with 9 bridges.

(2) Life of people in the survey area

People living along the Ruvu and its tributaries know how to reduce the flood damages through their previous experiences as mentioned below:

- Houses are built in elevated lands
- Cultivation area in the flood prone area is given less input before the rainy season.
- In the cultivation area only the simple working shelters are built.

During the rainy season from March to May, people plant paddy at their own risk. If there is a big flood that submerges the growing paddy completely, they can get no gains. If the flood does not exceed the top of paddy stem under the flooding condition, however, they can gain more yield than that in the year with no flood. Even if all the planted paddy is damaged, peasants will start seeding maize after lowering of the inundation level and can get more yield than that in the year with no flood.

(3) River course

It was reconnoitered through the field investigation that there was no significant sand or silt sedimentation in the lower floodplain. As seen in the topographic maps at a scale of 1 to 50,000, there are many ponds for storing the flood water in the floodplain, some of which are disconnected with the Ruvu mainstream during the dry season. They are mainly located in the floodplain along the tributaries such as the Msmbiji and Dutumi Rivers. During the high river stage, water of these tributaries or lakes flows down into the Ruvu mainstream. As well, they are disconnected with the Ruvu mainstream during the dry season.

(4) Flood in April 1993

A big flood occurred in April 1993 when the Study Team was in Tanzania. According to the Study Team's field inspection and interview to local inhabitant, the inundation area by the flood has shown the same tendency as those by the other previous major floods in terms of location of flooding. The maximum water level rose to about 1 m below the Morogoro Road Bridge (stream gauging station 1H8), and about 0.8 m below the floor of existing pump station at the Lower Ruvu intake of NUWA or about 1.5 m below the water level of the 1979 Flood. Paddy field of the on-going Bagamoyo Irrigation Development Project was submerged in a depth of about 1 meter and the ferry service at Kikongoni was suspended for around 2 months.

6.2.3 Flood damages and benefits

Based on the flood survey, the flood damages in the basin were categorized as follows ;

1) Partial or perfect damage of planned paddy, which is seeded in January to March,
2) Damage to field shelter used for the field work of peasants, and
3) Indirect damages such as increase of prices of goods coming from outside the villages, less opportunity to communicate with other villages and towns.

On the other hand, some benefits accrued from flood are also identifiable in the Study Area. They are increase of production yield of maize which are planted after damage to paddy due to flood, and increase of prices of charcoal and fruits if they can be transported during the flood. Besides, the flood supplies the nutrition for maintaining the land productivity of inundation area so that less fertilizer could be used for cultivation.

6.3. Inundation Analysis

6.3.1 Methodology

In general, the inundation analysis is carried out by means of such methods as non-uniform flow calculation, unsteady flow calculation, hydraulic modeling. Among these methods the non-uniform flow method is adopted in the Study, taking into account the study level of the comprehensive master plan as well as the insignificant flood damages attributable to the lesser development and sparse settlement in the floodplain.

6.3.2 Topographic maps and cross sectional survey

The topographic maps at a scale of 1 to 50,000, prepared by the Survey Department of Tanzania for the period from 1954 to 1981, cover the whole Study Area, and the cross sectional survey along lower reach of the Ruvu River was executed by the Study Team in 1993. These cross sectional survey results were used for the analysis of flooding in the lower reach of the Ruvu River.

6.3.3 Tide effect

(1) Tide level observation

The water level and discharge in the lower reach of the Ruvu River, especially near its river mouth, are affected by the movement of sea water level. Sometimes the flow direction of the river changes in the lowermost reaches because of the tide level. Regarding the inundation analysis, the tide level is an important factor for determining the flood water levels along the river. In order to determine the mean sea water level and to relate the National Land Survey Datum with the high tide level during the flood, the Study Team performed the tide observation at the pier of the Mbegani Fisheries Development Center (MFDC) for the period from April 20 to May 20, 1993. The MFDC is located about 8 km southeast of Bagamoyo town or about 15 km distant from the river mouth of the Ruvu.

(2) Tide analysis

The National Land Survey datum (NLS Datum) was applied to the cross sectional survey conducted by the Study Team. The gauge datum at the MFDC's pier was surveyed through levelling so that the zero point was confirmed to be equivalent to -2.34 m in the NLS datum. According to the Tanzania Harbor Authority, the water level of the Tide Table 1993 is based on the Chart Datum. The Chart Datum is 1.83 m below the NLS Datum. As a result of the calculation performed by the Study Team, the mean sea water level at Dar Es Salaam Port was derived to be 1.54 m by the Chart Datum. Applying these information and data on the tide level of Dar Es Salaam Port, the observation results were analyzed to estimate the tide levels as follows:

Sea Water Level	Gauge Datum(m) at MFDC's pier	NLS Datum(m)
- Spring HWL	4.65	2.31
- Neap HWL	4.32	1.98
- MWL	2.41	0.07
- Neap LWL	0.56	-1.78
- Spring LWL	0.30	-2.14

6.3.4 Non-uniform flow analysis

Based on the results of the cross sectional survey and the tide level analysis, the non-uniform flow calculation was carried out to clarify the inundation areas in the lower Ruvu at the time of occurrence of 5, 10, 20, 50 and 100-year probable floods in the basin.

(1) River cross sections

The location of the cross sectional survey is shown in Fig. 6.3. The longitudinal profile of the lowest river bed elevation of low water channels, the high-water channel elevations on the right and left banks are shown in Fig. 6.2.

(2) Sea water level (starting water level for non-uniform flow calculation)

The high tide level of spring tide at Mbegani (Bagamoyo) was set to be the sea water level for the non-uniform flow analysis. Thus, sea water level of 2.31 m was used as a starting water level for the analysis.

(3) *Coefficient of roughness*

Coefficients of roughness of the low water channel and high water channel were determined based on the trial and error method with reference to the previous flood marks. As a result, they were determined to be 0.03 and 0.065 for the low water channel and high water channel, respectively.

(4) Flood discharge

The non-uniform flow analysis was carried out for the probable floods of the following 5 different return periods, which were estimated through the hydrological analysis explained in the foregoing Chapter III:

Return Period	Flood Discharge at 1H8 (Morogoro Road Bridge) (m^3/sec)	Remarks
5-year	640	
10-year	820	Apr./May 1993
20-year	1,005	Apr. 1979
50-year	1,260	
100-year	1,460	

The inflow discharges from the tributaries in the Study Area are not taken into account in the above analysis, because the traveling time of those peak discharges is estimated to be by far smaller than that of the Ruvu mainstream. The flood of 10-year return period has almost the same scale as the 1993 flood. The computed water levels for the flood were compared with the flood marks at the Morogoro Road Bridge, Lower Ruvu intake of NUWA and Kikongoni ferry terminal. As a result, it is verified that such values used for the non-uniform flow analysis as coefficient of roughness, hydraulic coefficients of bridges and culverts are in an adequate range.

6.3.5 Results of inundation analysis

The high water levels along the lower reach for each of the probable floods, which were worked out through the non-uniform flow analysis, are shown in Table 6.1 and plotted in Fig. 6.4. These calculation results show that:

- Approach road to the Kivukoni ferry will be inundated by the flood of more than 635 m^3/sec.
- Approach road to the Morogoro Road Bridge will be overtopped by the flood of more than 1,000 m^3/sec equivalent to a return period of 20-year, but the bridge itself will not be submerged even by the 100-year probable flood.
- Railway crossing the Ruvu River will not be submerged even by the 100-year probable flood.

Thus, the existing important river crossing facilities such as trunk road and railway bridges and intake facilities for water supply are appropriately designed in view of the protection against flood.

6.3.6 Flood risk map for the lower Ruvu floodplain

Based on the results of the non-uniform flow analysis, a flood risk map representing the inundation area in the event of the 100-year probable flood was prepared as shown in Fig. 6.3. The flood risk map reveals that the total inundation area is approximately 264 km^2 in the lower reach of Ruvu River in the event of the 100-year probable flood in the Ruvu River basin.

6.4 Planning of Flood Control Facilities for Agricultural Development Project

6.4.1. Objectives of flood control works

As a result of the flood survey, less flood damages were found out throughout the Ruvu River basin. Besides, it is noted that the land fertility is sustained by the sediment with nutrition transported from upstream area by periodical flooding.

Considering the present situation of flood damage in the floodplain, the flood control plan was set up focusing mainly on the protection of the proposed irrigation areas from flood. In order to realize and ensure the new agricultural development planned in the fertile floodplain of the Ruvu

River, the flood control works mainly by means of the construction of earth-fill dike was examined. The global river training and flood control plan was not considered for the Study Area taking into account the insignificant flood damage under the present condition as aforesaid. The locations of the new agricultural development projects identified through the Study are shown in Fig. 5.3.

6.4.2 Degree of protection

Considering that the paddy will be planted during the rainy season in the Study Area, it is decided to protect the paddy field against the 5-year probable flood from the economical viewpoint. On the other hand, referring to the design standards/manuals in Tanzania, the 100-year probable flood is adopted for design of the intake facilities for water supply.

6.4.3 Design flood

According to the preliminary plan of the Kidunda dam with respect its flood control space in the reservoir which is described in the foregoing Subsection 3.2.5, the dam can have an effective function of flood peak cut with surcharge volume in the reservoir. On the assumption that the Kidunda dam is planned to have a surcharge volume of about 310 million m^3, the 5-year and 100-year probable floods at the proposed irrigation areas and new intake sites for the municipal water supply to Dar Es Salaam, respectively, were estimated by the storage function method as shown in Fig. 6.5. The design flood discharge at the area was derived to be 360 m^3/sec for irrigation project and 910 m^3/sec for the intake facilities in case that the Kidunda dam is planned to have a surcharge volume of about 310 million m^3.

6.4.4 Plan for flood control facilities

Major flood control facilities planned for the agricultural development projects comprise earth-fill dikes and drainage facilities.

(1) Planning of flood dike

There are many methods for flood control, of which the most suitable one for the project needs to be selected in consideration of the location, development scale and importance of structures. Among the alternative flood control methods, the construction of dike along the rivers with earth material is adopted in order to protect the proposed irrigation areas from flood for every agricultural development project proposed in the Study. The freeboard of 0.60 to 1.00 m is secured above the design high water level corresponding to the 5-year probable flood.

(2) Planning drainage facility

Since the proposed irrigation areas are planned to be enclosed by the flood protection dike, the internal drainage system needs to be provided. The large-scale tributaries inside the protected area, if any, will be confined by the back dikes connected with the main flood dike along the Ruvu River so that flood water of the tributary will be drained directly to the Ruvu River. On the other hand, discharge of the small tributaries and the internal drainage channel is planned to be drained out through the drainage sluices to be newly provided. The drainage sluices to be provided in the box culverts beneath the flood dike are planned to be equipped with the flap gate in the river side and slide gate in the country side. The design discharge for drainage canal and tributaries are estimated applying specific discharges of 3.5 and 5.0 lit/sec/ha, respectively, taking into account design rainfall and duration of on-field storage of excessive water.

6.5 Design of Flood Control Facilities for Proposed Agricultural Development Project

6.5.1 Dike

The earth-fill dike is aligned along the river bank, being set back from the meandering low water channel, and it is connected to the hill or polder dike depending on the topographic condition and/or scale of tributaries. In consideration of stability of flood protection dike, the side slopes are set at 1 : 2 , and the crest is designed to have a width of 4 m to be used as the inspection road.

6.5.2 Drainage sluice

In order to ensure the smooth regulation of water level in the country side as well as the dike stability, the drainage sluice consisting of double section box culvert with the flap and slide gates is planned to be provided in the dike. The dimensions of drainage sluices are determined to enable the easier operation and maintenance.

6.5.3 Design of flood control facilities

(1) Bagamoyo Irrigation Development Project

- A total of about 13.5 km long dike with an average height of 1.60 m will be constructed.
- Crest of water supply intake facilities will be set at 2 m above the ground level.
- 14 units of drainage outlets will be installed at the end of two tributaries and drainage channel.

(2) Low Lift Pump Irrigation Project

- A total of about 11.5 km long polder dike, with an average height of 1.60 m, which is divided by the Mkombezi River, will be constructed.
- One unit of drainage outlet will be installed in each polder dike for internal drainage.

(3) Makurunge Irrigation Project

- A total of about 3.5 km long polder dike with an average height of 1.50 m will be constructed.
- One unit of drainage sluice will be installed for internal drainage.

(4) Ruvu National Youth Irrigation Project

- The existing polder dike will be heightened or strengthen to have an average height of 1.25 m for a total length of about 6 km.
- One unit of drainage outlet will be provided for the existing one and other one unit will be newly constructed.

(5) Other irrigation development areas

The flood control facilities required for the proposed agricultural development projects other than the aforesaid four ones in the lower Ruvu are summarized in Table 6.2.

6.5.4 Work quantities and construction plan of flood control facilities

The work quantities of flood protection works for the agricultural development projects are calculated for major work items such as earthwork, concrete works and gates. Those works are quantified applying the standard design of various dikes and drainage sluices for each of the agricultural development projects as summarized in Table 6.2. The flood control works need to be implemented as a part of the agricultural development project.

CHAPTER VII

POTENTIAL OF DAM DEVELOPMENT

7.1 Basic Policy for Water Resources Development

7.1.1 Necessity of new water resources development in view of municipal water supply to Dar Es Salaam

At present, most of the municipal water for Dar Es Salaam city is being supplied from the Ruvu River. As the Government's policy, the increasing water demand of the city is planned to be met through water resources development in the Ruvu River basin which comprise the provision of reservoir type dams because of its proximity to the city as compared with other surrounding rivers.

The municipal water demand in Dar Es Salaam city is forecast to reach about 11.2 m^3/sec or 969,000 m^3/day in the year 2020 as discussed in Chapter IV. While, a 95 % dependable discharge at the NUWA's Upper Ruvu intake site is estimated at about 9.1 m^3/sec based on the long-term mean daily runoff data at existing gauging station 1H8, which is situated at the Morogoro Road Bridge, about 80 km upstream of the Ruvu River mouth. Thus, it is envisaged that no urgent water resources development plan would need to be implemented to cope with the municipal water demand in Dar Es Salaam, if the entire river flow of the Ruvu River could be utilized for the municipal water supply.

On the other hand, it was confirmed through the field investigation in the Phase 1 Field Work that the water rights along the downstream reach of the Upper Ruvu intake site have already been officially registered by existing various kind of farms. A total of the required irrigation water supply for the downstream farms comes to be about 1.0 m^3/sec according to the water right shown in Table 5.2.

In addition to the irrigation water supply, it is essential to discharge down the river maintenance flow to the river mouth from the environmental aspects, in particular in order to safeguard the mangrove trees growing in the lowermost area as well as to avoid occurrence of salinity problems in the downstream cultivated lands due to intrusion of sea water. As mentioned in the succeeding Subsection 8.1.3, the required minimum river maintenance flow is derived to be 4.3 m^3/sec, which is equivalent to the minimum mean monthly discharge at the NUWA's Upper Ruvu intake site.

As a result, the minimum discharge to be released to the downstream reach of the Lower Ruvu intake sites is derived to be 5.1 m^3/sec by summing up the required net irrigation water supply (0.8 m^3/sec) in consideration of the return flow and the river maintenance flow (4.3 m^3/sec). Therefore, the discharge available for the municipal water supply to Dar Es Salaam city comes to about 3.94 m^3/sec with a 95 % dependability under the present condition. Thus, the available discharge is by far insufficient for the municipal water demand in Dar Es Salaam in 2020 and it is considered essential to develop the water resources in the Ruvu River basin, if it is possible to exploit the municipal water economically.

7.1.2 Overall assessment of development potential from geographic aspect

From the topographical and climatorogical aspects, the high land areas in and around the Uluguru Mountains differ from the other areas consisting mostly of the low and hilly areas. Hence, the potential of the dam development was assessed demarcating the Ruvu River basin broadly into these two areas as mentioned below:

(1) Low and hilly lands

From the climatorogical viewpoint, the Ruvu River basin is characterized by the comparatively distinct dry and wet seasons. During the dry season when the water needs to be exploited for the purpose of new development of municipal water supply and irrigation, the streamflow of the Ruvu mainstream becomes quite small. In particular, this hydrological phenomenon was verified in most of the tributaries in the Ruvu River basin except for those originating from the Uluguru Mountains which command the western part thereof.

The droughty condition in the low and hilly areas during the dry season is responsible for the lesser rainfall. Although the basin average rainfall is estimated to be around 1,080 mm/year as discussed in the foregoing Chapter III, the wet area blessed with annual rainfall of more than 1,500 mm/year is limited to the Uluguru mountain and its surrounding area. While, even at the Morogoro station with an altitude of 530 m, the annual evaporation amounts to about 1,800 mm/year with higher rate of more than 6 mm/day in the dry period. Thus, in the hilly and low land areas which occupy a large part of the Ruvu River basin, the annual evaporation exceeds the annual average rainfall by far.

On the other hand, the streamflow in the wet season is comparatively abundant as long as the hydrological data show. Therefore, the new water resources development requires the large-scale storage type dams to enable the seasonal regulation of the streamflow in order to augment the streamflow in the dry season.

Likewise, it is considered that the large-scale storage type dams are favorable, taking into consideration the relatively higher sediment yield in the basin. This is a reason why the small-scale dam without sufficient dead storage capacity will loose its function at the earlier stage after construction thereof so that it would necessitate the costly continuous dredging to restore the function of the reservoir.

(2) High land around the Uluguru Mountains

Concerning the high land areas around the Uluguru Mountains, the independent small-scale water resources development would be able to be developed utilizing streamflow with the relatively high specific discharge resulting from abundant rainfall in the Uluguru Mountains. However, the water exploitable in these high land areas is very limited due to the small drainage areas and would not contribute to the augmentation of water supply for Dar Es Salaam as well as new irrigation development in the lower reach in consideration of evaporation loss in the quite long river course. Therefore, the water resources development in these areas should be contemplated in the framework of the rural development, independently of the large-scale dam projects.

In those areas, on the other hand, the agricultural production is being activated by the local people at the limited scale as discussed in the foregoing Chapter V. At present, these areas face to the problems of the soil erosion as well as the transportation constraint in communicating with such major towns in the Study Area as Morogoro and Dar Es Salaam. Therefore, an emphasis is put on the watershed management as well as the improvement of the existing road system in addition to the small-scale agricultural development. It is expected that the watershed management would contribute to the reduction of sediment deposit in the large-scale dams planned to be constructed in the downstream reach.

(3) Overall principles of water resources development

Taking into account the aforesaid geographic conditions, it is determined that the water resources development in the Ruvu River basin is primarily established in accordance with the following principles:

- Low and hilly areas : Construction of large-scale of storage dams which enable to regulate the seasonal streamflow for new development of municipal water supply to Dar Es Salaam, and new irrigation schemes associated with the dam development.

- High land areas around the Uluguru Mountains : Small-scale water resources development including irrigation and mini-hydropower development with the watershed management and the improvement of existing road transportation system.

The development plans for the areas in and around the Uluguru Mountains are discussed in detail in the foregoing Chapter V in relation to the agricultural development.

7.2 Assessment of Dam Sites Identified by the Previous Study

7.2.1 Dam sites identified by the FAO's study

In 1961, the previous study carried out under FAO in relation to the water resources development in the Ruvu River basin identified 23 dam sites therein, whose locations are depicted in Fig. 7.1.

In succession to the FAO's study, the further study on the identified dam sites was made by the aid of the French Government in 1962 so that 4 dam sites, namely Mkombezi, Mgeta, Ngerengere and Kidunda, were retained as the priority ones among the 23 dam sites identified by the FAO's study. Moreover, the study report states that out of the four dams the Kidunda dam would enable the most efficient storage to regulate the river runoff for the purpose of flood control, municipal and irrigation water supply, hydroelectric power generation. Thereafter, the additional investigation on the Kidunda dam, which includes core drilling at the alternative dam sites, was carried out in 1964. The investigation results are summarized in a report titled "Selection of the Kidunda Dam Site, Ministry of Agriculture, Tanzania (1964)".

With regard to the aforesaid 23 dam sites, the preliminary assessment was made to screen out the prospective dam sites from the following aspects applying the project features proposed in the FAO's Report;

- Geological condition
- Hydrological condition
- Storage efficiency
- Accessibility to the dam site
- Topographic condition

7.2.2 Geological condition

On the basis of the site reconnaissance and geologic data collected, the geological assessment was made for each of the 23 dam sites in the Ruvu River basin, which were identified by the previous studies, as summarized in Table 7.1.

In case of the water resources development by means of providing the dam in the Ruvu River basin, it is detected that the following issues on the dam geology might come out;

1) Major fault
2) Seepage through dam foundation and surrounding mountains of reservoir
3) Insufficient bearing capacity of dam foundation

(1) Major fault

The active fault is one that has a possibility to cause movement of ground in near future. Concerning dam constructed on or near the active fault, there is a high possibility that it cause the dam failure when an earthquake takes place. Therefore, the dam needs to be constructed not adjacent to the active fault.

In the Ruvu River basin, there exists the major fault along the Mgeta River, southern section of the Uluguru Mountains, according to the geological maps collected during the present field investigation. The major fault delineates the Pre-Cambrian rock block and Quaternary alluvial deposit. Although the further study is required to clarify the extent of the major fault and geological movement in the next study, there is a possibility that the dam sites selected on the Mgeta River and its tributaries are to be affected by the major fault in view of the dam safety. Of the proposed 23 dam sites, the following five (5) ones are located close to the major fault:

- Mgeta
- M/LB/R1
- Mngazi
- Bwakila
- Dutumi

(2) Seepage through dam foundation and surrounding mountain of reservoir

In the Jurassic limestone, Calcareous rocks and Cretaceous marl and limestone distributing in the Ruvu River basin, there is a possibility that there exist a lot of holes in those rocks. At these sites, therefore, the reservoir could not store inflow discharge as expected, after construction of dam due to seepage along the foundation rock and surrounding mountain. Moreover, the dam body might result in failure due to piping and uplift in the foundation. Judging from the geologic maps, there is a possibility that the following dam sites are dominated by such geological condition;

- Kidunda (downstream alternative site investigated by the French study)
- Mkulazi
- LB/R1
- Mbiki

(3) Insufficient bearing capacity

It is considered that dam founded on alluvial deposits with insufficient bearing capacity would result in failure of dam foundation, provided that the dam is founded on the alluvial layer. Besides, the seepage through the dam foundation is expected to occur so that it may not function properly as expected. On the other hand, it is anticipated that the dam construction cost will increase remarkably, in case the dam is founded on the firm rock overlaid by the alluvial layer. On the basis of the geological data and site reconnaissance, it deems that the following dam sites are covered by the comparatively thick river deposits:

- RB/R2
- Banda
- Mbwawa
- Chomthe

7.2.3 Hydrological condition

As mentioned in the foregoing Chapter III, the high annual rainfall exceeding 2,000 mm takes place in the Uluguru Mountains areas located in the western part of the Ruvu River basin, while the relatively low annual rainfall of less than 1,000 mm is usually recorded in the eastern part thereof. Besides, the low runoff coefficients are obtained through the present hydrological analyses in the tributaries originating on the left bank side of the Ruvu mainstream. Using isohyetal map of annual rainfall which is explained in Chapter III, the basin average rainfall for the area covered by each of the 23 dam sites is estimated as shown in Table 7.2.

For each subbasin of the Ruvu River, the runoff coefficient is derived as explained in the foregoing Chapter III. The runoff coefficient in the entire Ruvu River basin is estimated at 12 %. The rather low runoff coefficient of less than 10 % is derived for the Ngerengere basin and the Lower Ruvu basin.

The following two (2) factors are applied to represent the hydrological features for each catchment of the 23 dam sites;

- Specific runoff depth ("IR" in mm/year/km^2) : IR=Ra x f/100
- Annual inflow volume ("IV' in Million m^3) : IV=A x Ra x f/1000

where,	Ra	: Annual mean rainfall in the catchment (mm/year)
	f	: Runoff coefficient (%)
	A	: Catchment area (km^2)

The factor "IR" shows annual average runoff rate per km^2, while annual mean gross runoff volume from the whole catchment is represented by the factor "IV". The larger values of "IR" and "IV" mean larger inflow volume that exhibits the high attractiveness from the hydrological viewpoint. Those factors for the respective dam sites are tabulated in Table 7.2.

7.2.4 Efficiency of reservoir

The storage efficiency factor defined below is used to compare with the efficiencies of the respective reservoirs:

Storage efficiency (SE) : SE=Vr/Ve

where,	Vr	: Reservoir storage capacity (Million m^3)
	Ve	: Embankment volume of main dam (Thousand m^3)

The factor "SE" exhibits a simple storage efficiency. The larger value means more efficient dam scheme. As shown in Table 7.2, the Kidunda dam reveals the distinguished high storage efficiency among the 23 dams.

7.2.5 Accessibility

In implementing the dam scheme, construction of the access road from existing trunk road to the dam site is indispensable. The approximate length of access rood required therefor is measured based on existing 1 to 50,000 scaled topographic maps and the site reconnaissance and with reference to aero photographs. The required access road is divided into two kinds, namely the section for which road is required to be newly constructed and that requiring only improvement works for existing road such as widening and/or pavement.

7.2.6 First screening of dam sites

The above factors for the respective dam sites are summarized in Table 7.2. As seen in the Table, the dam sites No. 11 to No. 22 show rather low runoff depth and inflow volume due to their extremely small runoff coefficients. Presumably, such unattractive hydrological features would be responsible for lesser annual rainfall in the catchment as well as geologic condition of the catchment. These dam schemes are considered to be not attractive from the hydrological viewpoint.

Out of the retained 10 dam schemes, 5 dam sites are located closed to the major fault as aforesaid. In this Study stage, however, the major fault is considered to be not necessarily critical issue to disqualify them as the unfavorable dam sites for the water resources development, although as a matter of course these dam sites require detailed geological investigation in the successive prefeasibility or feasibility study stage.

Concerning the Kidunda dam, the geological investigation including core drilling was performed for the downstream locations under the French aid, which covers a catchment area of about 5,760 km^2. Since the runoff at the downstream location is by far than that at the upstream site identified by the FAO's Study, it is determined that the further examination is to be made for the downstream sites. It deems that the downstream area of the proposed dam site is clearly composed of limestone judging from the geological maps and topographic features of both banks based on existing 1 to 50,000 scaled topographic maps. While, the bore holes drilled at the proposed dam site in the course of the French study encountered the sandstone and shale as well as mudstone with clayey layer. Although the Kidunda dam requires more detailed geological investigation in the next prefeasibility or feasibility study stage, it is retained as one of the candidate dam sites for the reason of the high reservoir efficiency as well as abundant inflow at the proposed dam site.

The results of the overall assessment on the 23 dam sites are summarized in Table 7.2. Although the Msoro dam site is given the highest rank of "A" in the Table, it is judged that the topographic condition at the dam site could not allow construction of a storage type dam. Hence, the Msoro dam is excluded from the candidate dams. As a result, the following four (4) dam schemes are selected as the candidate dams for the water resource development:

- Rudete
- Ngerengere
- Kidunda
- Mgeta.

7.3 Preliminary Optimization of Dam Development Scales

7.3.1 General

Four (4) dam sites have been selected as the candidate dam sites among the 23 ones through the first screening as aforesaid. These four dam sites include three dams out of four (4) ones selected by the French Report as the promising ones in the Ruvu River basin. In this Section, the optimization study to determine the most appropriate development scale is made for five dams which comprise the aforesaid four (4) candidates dams, and the Mkombezi dam for reference.

The development scale for each of five (5) dam schemes selected above is optimized through the following procedures:

- Preparation of reservoir storage curve showing a relation among reservoir water level, reservoir area and volume, and river cross section along dam axis
- Selection of alternative development cases with respect to dam height
- Reservoir operation for each case to estimate the available discharge
- Construction cost estimate for each case based on the dam embankment volume and required length of access road
- Determination of the least cost case for each dam scheme

The above procedures are explained in the following Subsections.

7.3.2 Reservoir operation study

(1) Reservoir storage curve and river cross section along dam axis

The reservoir storage curve was constructed based on existing 1 to 50,000 scaled topographic maps to be applied to the reservoir operation study for each of the five (5) dams. Besides, the river cross section along the dam axis, which was used to calculate the embankment volume for each dam, was prepared based on the 1 to 50,000 scaled topographic maps and river cross sections obtained through the topographic survey performed in the Phase 1 Field Work.

The reservoir storage curve and river cross section thus derived are shown in Figs. 7.2 to 7.6 by the dam scheme.

(2) Selection of alternative development cases for each dam scheme

a. Dead storage capacity of the reservoir

In planning the reservoir type development, at first, the dead storage capacity needs to be secured below the low water level of the reservoir. As stated in the foregoing Chapter III, the denudation rate in the Ruvu River basin is estimated to be between 0.2 and 0.4 mm/year. On the other hand, in case of the Lower Kihansi Hydropower Project whose construction is going to start soon, the denudation rate at the Lower Kihansi intake dam site with a catchment area of 590 km^2 was estimated at about 0.07 mm/year. Judging from those data, the value in the basin would be in a range of 0.1 mm/year and 0.5 mm/year, although it should be finally determined based on the elaborated suspended load analysis in the next study stage. The required dead storage capacity is determined to correspond to the sediment transport at the higher value of 0.5 mm/year for 100 years using the following equation:

$$Vd = Er \times Ca \times 0.1$$

Where, Vd : Required dead storage capacity (Million m^3)
Er : Denudation rate of the Ruvu river basin (mm/year)
Ca : Catchment area covered by the proposed dam (km^2)

b. Selection of alternative development cases

The low water level is determined taking into account the above dead storage capacity. To find out the least-cost case for each dam scheme, six alternative cases are selected by varying the Normal High Water Level (NHWL) which is set above the low water level for every case. Those alternative cases are shown in Tables 10.3 to 10.7 by the dam scheme.

(3) Reservoir operation study

Concerning each alternative case, the reservoir operation study was carried out to estimate the dependable discharge to be increased after regulating the natural inflow through the planned reservoir storage volume. The reservoir operation study was made applying the reservoir storage curve, long-term mean monthly discharges at the proposed dam site, which were obtained through the hydrological analysis, and monthly evaporation observed in the Ruvu River basin. The general equation for the reservoir operation is expressed by the following:

$$V_{n+1} = V_n - (A_n + A_{n+1}) \times Ev \times Nd \times 0.001 + (Qi - Qd) \times Nd \times 0.0864$$

Where,

Vn+1	: Effective storage volume at the end of the month (Million m^3)
Vn	: - do - at the end of the previous month (Million m^3)
An+1	: Reservoir area at the end of the month (km^2)
An	: - do - at the end of the previous month (km^2)
Ev	: Average evaporation from the reservoir surface for the month (mm/day)
Nd	: Number of days of the month
Qi	: Mean monthly inflow into the reservoir (m^3/sec)
Qd	: Dependable outflow from the reservoir

The inflow data for forty (40) years are worked out for the reservoir operation study through the hydrological analysis. The evaporation rate from the reservoir surface is adopted to be 70 % of the Pan-A evaporation records at Kibaha. The dependable discharge in each alternative case is estimated to enable a definite outflow throughout the available period of inflow data.

The results of the reservoir operation study are summarized in Figs 7.8 to 7.12. It is verified through the reservoir operation study that the dependable discharge doesn't increase in proportion to the effective storage volume when the Normal High Water Level rises, since rate of loss of water stored in the reservoir becomes larger according to enlargement of the reservoir area. Especially, this phenomenon is seen in case of the Kidunda dam. Thus, it is not necessarily economical to construct high dam taking into account the evaporation loss from the reservoir surface.

7.3.3 Preliminary construction cost estimate

To optimize the dam height, the construction cost for each alternative development case is estimated simply based on the dam embankment volume as well as that for access road to the dam site although the cost estimate for the selected dam project is made in detail in the Appendix-K of the Supporting Report. Taking into account the geological condition in the Study Area, the fill type dam is selected for every dam site. The dam embankment volumes were estimated applying the following criteria based on the river cross section at each dam site;

- Dam crest level is set at 5 m above the Normal High Water Level (NHWL), adopting a free board of 5 m.
- Upstream and downstream slopes of dam body are 1 : 2.25 and 1: 1.95, respectively.
- Depth of excavation for placing foundation of impervious core zone of embankment is assumed at 5 m below original ground surface, except for the Kidunda dam whose geological profile is made available through the previous French field investigation.

According to the Study on the National Water Master Plan in Kenya, the relation between the embankment volume and the dam construction cost is derived to be represented by exponential curve shown in Fig. 7.7. This formula is tentatively applied to estimate the dam construction cost. Besides, the construction cost of the access road is estimated using unit rates for new construction and improvement of existing road, respectively, with reference to the unit rates prevailing in Tanzania. Thus, the direct construction cost is estimated by summing up these costs.

The total construction cost is then estimated adding the engineering service/administration cost and physical contingency cost, which are assumed to be equivalent to 12.5 % and 15 % of the direct construction cost, respectively. The estimated total construction cost for each alternative case is depicted in Figs. 7.8 to 7.12.

7.3.4 Optimum development scale of dam

The alternative cases for each dam scheme are compared with one another in terms of the construction cost per dependable discharge, which is derived dividing the total construction cost by the dependable discharge. The values are depicted in Figs. 7.8 to 7.12. As a result, the optimum case for each dam scheme is determined by means of the least-cost criteria as shown below:

Name of Dam	Catchment Area (km^2)	Mean Inflow (m^3/sec)	Dam Height (m)	Effective Storage Volume (Mill. m^3)	Dependable Discharge (m^3/sec)
Rudete	247	3.03	35.0	15.9	1.40
Ngerengere	2,809	4.32	26.0	143.9	1.81
Mkombezi	603	1.13	25.0	40.2	0.36
Mgeta	939	12.63	40.0	110.1	7.11
Kidunda	5,761	48.97	26.0	690.2	25.39

As shown in the table above, the Kidunda dam exhibits the considerably low construction cost per dependable discharge for the sake of the distinguished reservoir storage efficiency, while the Mkombezi dam requires very high construction cost as compared with that of the Kidunda dam to develop the same quantity of water for the municipal water supply.

7.3.5 Features of selected dam schemes

The layout plans of the selected four (4) dams are shown in Figs. 7.13 to 7.16. From the above preliminary examination, the following results are derived for each dam scheme:

a. Kidunda dam

The Kidunda dam shows the lowest rate in terms of construction cost per dependable discharge exploitable, if there exists no fatal geologic problems in relation to the existence of limestone at the dam foundation and in the reservoir area. Furthermore, the Kidunda dam would be able to yield abundant water which exceeds the municipal water demand in Dar Es Salaam city in the year 2020. Accordingly, in case it is verified through geological investigation in the successive prefeasibility or feasibility study that the dam site and reservoir area are technically sound for construction of around 26 m high fill type dam above the river bed, the Kidunda dam is ranked as the most attractive one. In addition, the surplus water which exceeds the water demand in Dar Es Salaam City in 2020 enables to develop new irrigation areas spreading in the downstream areas of the dam site.

b. Mgeta dam

The Mgeta River is also blessed with abundant river flow whose source is mainly the high rainfall in the Uluguru Mountains area. The Mgeta dam is located very far from the NUWA's Upper Ruvu intake site, about 305 km downstream thereof. While, a wide area of potential irrigation areas spread downstream thereof. Therefore, it is anticipated that water to be yielded by the Mgeta dam is to be utilized for the irrigation development. On the other hand, the Mgeta dam is located comparatively close to the major fault running along the Mgeta River. Accordingly, the geological problem will have to be resolved in the next feasibility or feasibility study stage before implementing the Mgeta dam scheme.

The Mgeta reservoir can discharge downstream a comparatively large quantity of regulated flow throughout the whole period. In planning the Mgeta dam for the purpose of water supply to Dar Es Salaam, however, it is considered necessary to clarify the loss of water discharged from the reservoir, which may take place in the downstream floodplains on the way to the intake sites due to evaporation.

c. Ngerengere dam

The Ngerengere dam is located about 175 km downstream of existing Mindu dam on the Ngerengere River. Although the construction cost of the Ngerengere dam estimated in this stage is higher than those of the Kidunda and Mgeta dams, the water to be regulated by the Ngerengere dam would contribute to municipal water supply to Dar Es Salaam city. Besides, it is possible to utilize water to be exploited through provision of the Ngerengere dam for use of irrigation development in the downstream areas of the planned dam site.

d. Rudete dam

The Rudete River is a tributary of the Msoro River, draining the most western part of the Ruvu catchment. The Rudete dam site is located 15 km upstream of the confluence of the Rudete and Msoro Rivers or about 310 km upstream of the NUWA's Upper Ruvu intake site. Thus, the Rudete dam site is very distant from the Upper/Lower Ruvu intake sites as well as the case in the Mgeta dam so that there is a possibility that most of water released from the Rudete reservoir is loosed until it arrives at the downstream intake sites taking into consideration the smaller regulated flow, even though the dam scheme is planned to be developed for the purpose of municipal water supply to Dar Es Salaam. Therefore, it is foreseen that water regulated by the Rudete reservoir is to be utilized to irrigate the downstream areas of the dam site if there exists the promising potential irrigation areas therein.

e. Mkombezi dam

The Mkombezi dam is assessed to be unattractive in terms of the considerable high rate of construction cost per dependable discharge exploitable. Therefore, the Mkombezi dam is excluded from the candidate dam sites as verified through the first screening.

As a result of the above examination, three (3) dams of the Kidunda, Ngerengere and Mgeta are selected as the candidate dam schemes for coping with the municipal water demand in Dar Es Salaam up to the year 2020.

CHAPTER VIII

DEVELOPMENT SCENARIO AND PRELIMINARY ASSESSMENT

8.1 Water Balance for Water Supply to Dar Es Salaam

8.1.1 Principles for planning water resources development

As discussed in the forgoing Chapter VII. The Kidunda, Mgeta and Ngerengere dams are expected to constitute the prospective water resources in the Ruvu River basin for coping with the municipal water demand in Dar Es Salaam. In principle, the water resources development plan was established to meet the municipal water demand in Dar Es Salaam by the year 2020 by means of provision of those dams. The water balance was examined at the existing stream gauging station 1H8, the Morogoro Road Bridge site.

Since the streamflow of the Ruvu River varies seasonally throughout the year to a large extent and even year by year, it is necessary to construct a reservoir type dam to augment the dry season flow in order to enable the stable water supply to Dar Es Salaam city over the entire period.

The dependability of design discharge for municipal water supply and return flow from the irrigation area are set at the following figures in order to examine the water balance in the Ruvu River basin in connection with planning of the water resources development:

- Dependability of design discharge for municipal water supply scheme : 95 %
- Rate of return flow for irrigation scheme : 20 %

With regard to other water resources development than the municipal water supply such as irrigation and hydropower development, the water development plan is established so that the surplus water in excess of the municipal water demand in Dar Es Salaam city which may be exploitable through provision of the promising reservoir type dams in the basin will be utilized for the other development as far as possible.

8.1.2 River maintenance flow

In making the balance of water demand and supply, the river maintenance flow constitutes key component of water demand. The maintenance flow of a river needs to be determined taking into account various aspects such as navigation, fishing, picturesque scenery, salt water intrusion, clogging of river mouth, riparian structures, ground water table, flora and fauna, river water quality. In case of the Ruvu River, it is the most important to secure a river flow required to preserve mangrove trees growing in the lowermost reach. Besides, there exist various farms in the downstream reach of the NUWA's Upper Ruvu intake site, which register the water rights mainly for irrigation use of the river water. Therefore, the dams planned in the upstream reach have to be operated to release a certain discharge which is equivalent to a sum of the river maintenance flow and water requirement for existing farms.

To determine the river maintenance flow, the mean monthly discharges at existing stream gauging station 1H8 are compared with the probable minimum mean daily discharges thereat.

The lowest mean monthly discharge at the stream gauging station is derived to be 4.3 m^3/sec in November 1959 among the mean monthly runoff data for 31 years from 1959 to 1989 according to the simulation results. On the other hand, the water requirement in the downstream reach totals about 1.0 m^3/sec. Consequently, the minimum flow to be secured in the downstream reach is derived to be 5.1 m^3/sec taking into account the return flow from the downstream farms. While, the probable 10-year and 20-year minimum mean daily discharges at the gauging station 1H8 are calculated at 5.4 and 4.6 m^3/sec based on the observed annual minimum data. Thus, the river maintenance flow of 5.1 m^3/sec is considered to be in an appropriate range as the minimum requirement.

8.1.3 Development Scenario for coping with water demand in Dar Es Salaam in Year 2020

The 95 % dependable mean daily discharge at the NUWA's Upper Ruvu intake site is derived to be about 9.1 m^3/sec based on the long-term mean daily discharges observed at existing stream gauging station 1H8 which covers a catchment area of 15,180 km^2. By deducting the aforesaid minimum flow of 5.1 m^3/sec in the downstream reach from the 95 % dependable discharge, the water which can be supplied constantly from the Ruvu River under the present condition to Dar Es Salaam comes to about 3.9 m^3/sec. In case no upstream dams are developed, that is, under the present condition, the natural flow of the Ruvu would meet the municipal water in Dar Es Salaam up to the year 1994. Therefore, the natural flow in the dry season is required to be regulated by the upstream dams in order to cope with the water demand in Dar Es Salaam in the year 2020, which is forecast to be about 11.2 m^3/sec.

Thus, it is essential to provide the reservoir type dam(s) in the upstream reaches of the Ruvu River. The water balance is made concerning the discharges at the NUWA's Upper Ruvu intake site, the existing Morogoro Road Bridge. The surplus water available for irrigation was calculated by the following equation neglecting evaporation loss of the released outflow:

$$QI=\Sigma QDi + QR_{95\%} - Qm - Q_{2020}$$

Where,

QI	:	Discharge available for new irrigation development (m^3/sec)
ΣQDi	:	Regulated outflow from upstream dam(s) (m^3/sec)
$QR_{95\%}$	:	95 % dependable discharge for area not covered by the upstream dam(s) (m^3/sec)
Qm	:	Sum of river maintenance flow and irrigation water requirement in the downstream reach (m^3/sec)
Q_{2020}	:	Water demand in Dar Es Salaam City in the year 2020 (m^3/sec)

To make the above value of "QI" positive, the following two (2) development scenarios were selected to meet the water demand in the Dar Es Salaam water supply system in the year 2020:

Development Scenario		Dam(s) to be developed
Scenario -1	:	Kidunda dam
Scenario -2	:	Mgeta dam and Ngerengere dam

The water balance for each of these two Development Scenarios is summarized in Table 8.1. They are illustrated in Figs. 8.1 and 8.2, respectively.

8.2 Hydropower and Irrigation Development Plan

8.2.1 General

Following provision of the reservoir type dams, the regulated water will be able to be utilized for development of new irrigation area as well as hydropower generation. The former is planned to use the surplus water that exceeds the municipal water demand in Dar Es Salaam in the year 2020 out of water to be exploited through provision of the upstream dams. In case of the latter, electricity will be generated by harnessing a head created through provision of dam as well as regulated outflow, which is released downstream to be utilized for the municipal water supply to Dar Es Salaam.

8.2.2 Hydropower development plan

The daily power output of hydropower plant to be installed at each dam site will be controlled by discharge released from the reservoir for the water supply to Dar Es Salaam. The plant discharge is determined to be equal to the daily maximum discharge released from the reservoir. The rated water level of the reservoir is set at an elevation of normal high water level (NHWL) minus one-third of a difference between NHWL and low water level (LWL). The effective head is then estimated by deducting the tail water level and head loss from the rated water level.

The installed capacity and annual average energy output for each dam scheme which were worked out through the aforesaid procedures as summarized below:

Scenario -1		Scenario -2	
Name of Dam Project	Installed Capacity (kW)	Name of Dam Project	Installed Capacity (kW)
- Kidunda	3,900	- Mgeta	2,300
		- Ngerengere	400
Total	3,900	Total	2,700

Concerning the hydropower development, the installed capacity is comparatively limited to a small scale to harmonize with the municipal water supply to Dar Es Salaam, and the available head is small as a whole. Consequently, the construction cost per kW becomes comparatively high. It is expected that electricity generated by these hydropower plants will be utilized for the rural area and/or station use. On the other hand, the economical viability on the hydropower development would need to be examined in the next study stage.

8.2.3 *Irrigation development plan*

As explained in the foregoing Chapter V, there exist a vast potential irrigation areas downstream of the candidate dam sites. The irrigation development attained through the aforesaid two Development Scenarios is detailed in Chapter V and summarized below:

Name of Irrigation Project	Irrigated Area under the Development Scenario (ha)	
	Scenario-1	*Scenario-2*
i) Kidunda Irrigation Development	10,500	-
ii) Bagamoyo Irrigation	1,100	980
iii) Low-lift pump Irrigation	2,400	-
iv) Ruvu National Youth Irrigation	200	-
v) Makurunge Irrigation	150	-
Total	14,350	980

8.2.4 Flood control plan in the Kidunda Dam Project (Scenario-1)

The flooding damage in the Ruvu River basin is insignificant as a result of the field survey conducted in the course of the Study as discussed in the foregoing Chapter VI. On the other hand, the aforesaid new irrigation areas which mostly lie close to the floodplains along the river require the flood control works in order to ensure the stable agricultural production at a certain level.

The 5-year probable flood is adopted as the design flood for the flood control works. As seen in the deteriorated dikes in the lower reaches, it appears that it is rather difficult to economically obtain the earth embankment materials with good quality in the flood prone areas. Therefore, it is preferred from the technical viewpoint that a height of the dike should be limited to less than 2 m above the original ground surface. Taking into consideration such a situation, it was proposed that in case of the Development Scenario-1 the surcharge water level (SWL) of the Kidunda reservoir was set up to keep the outflow therefrom at a constant discharge of 150 m3/sec in the event of the 5-year probable flood in the basin so that the 5-year flood at the existing Morogoro Road Bridge decreases from 610 m^3/sec under the present condition to about 300 m^3/sec in the case with the Kidunda dam.

In case of the Development Scenario-1, thus, the flood control plan for the new irrigation projects consists of the one combined by the flood control works stated in the foregoing Chapter VI and the flood control by the Kidunda reservoir.

8.3 Preliminary Design of Dam Project

With regard to the three (3) dam projects, namely Kidunda, Mgeta and Ngerengere dam projects, the main dam and its appurtenant structures are preliminarily designed in accordance *with the following criteria and principles:*

(1) Main Dam

The main dam is designed to be of a rockfill type dam with a center core utilizing abundant rock materials exploitable in the neighborhood of the proposed dam site concerning every dam project. The upstream and downstream slopes are set at 1:2.55 and 1:1.95, respectively , for every dam as shown in Figs. 8.3 to 8.6. The cross section of main dam consists of impervious core zone in the central part, rockfill zone in the outer shell zone and filter zone in the intermediate part of the impervious core and rockfill zones.

The most promising alternative dam type to the rockfill type would be a combined type of the rockfill type dam and concrete gravity dam, in which the concrete gravity dam will be provided in the original river portion. In general, this type of dam reduces the construction cost for the diversion works due to the smaller design flood as compared with that for the rockfill type dam. As well, the civil work cost for spillway may be diminished to some extent. However, the concrete gravity dam requires more geologically superior dam foundation to that in the rockfill dam. Since the geological condition of the Kidunda and Mgeta dam sites is associated by the unknown factors as explained in Appendix-B of the Supporting Report, the study on the alternative dam type should be carried out in the next study stage after thorough clarification of the geological condition.

(2) Spillway

The gated type of spillway is selected in consideration of the rather moderate rise of the reservoir water level during the rainy season. The flood equivalent to 1.2 times of a 200-year probable flood at the proposed dam site is adopted as the design flood for spillway in accordance with the criteria for the fill type dam in Japan. On the other hand, the spillway is designed to pass the 10,000-year flood with a freeboard of 1m below the dam crest.

(3) Diversion facilities

The diversion facilities during the construction of main dam are designed for a 20-year probable flood at the proposed dam site. To use the diversion facilities as the outlet facility to release the water to downstream reach after completion of construction, the diversion method consisting of the provision of diversion tunnel and the upstream and downstream coffer dams was adopted for the purpose of diverting flood during construction of the main dam.

The intake structure for the outlet facility is aligned to be connected with the diversion tunnel and it is to be utilized as the permanent structure when the diversion tunnel is closed after completion of embankment work for main dam.

(4) Power facility

The power house and generating equipment for each of the dam projects are designed to have the aforesaid installed capacity. Taking into account the rated head and discharge, the type of water turbine for the Kidunda, Mgeta and Ngerengere power stations were determined to be of horizontal shaft S-type tabular, horizontal shaft Francis and horizontal shaft cross-flow, respectively.

The penstock line is aligned to connect with the powerhouse and diversion tunnel as shown in Figs. 8.3 to 8.5.

8.4 Construction Plan and Cost Estimate for Dam

8.4.1 Construction circumstances in the Study Area

(1) Access to the project site

The Morogoro road (Route A7) connecting Dar Es Salaam and Morogoro is asphalt-paved and functions as a trunk road in the Study Area. The Route B1218 from Chalinze to Msata is also an asphalt-paved road. B1212 road linking from Dar Es Salaam to Bagamoyo is in the poor condition concerning its road surface, although a part thereof is under improvement. Other roads, which branch off from those main trunk roads connected to each of the project sites, are unpaved and so often not passable during the wet season. Thus, the rural roads connected to the respective project sites will have to be improved before the commencement of the main construction works.

In addition to those trunk roads, two railway lines are available for the transportation purpose. One is operated by the Tanzanian Railway Corporation and another by the Tanzania Zambia Railway Authority (TAZARA). In transporting the construction materials and equipment by the TAZARA railway line, however, the off-loading equipment such as trucks and trailers is required at each station. The frequencies of operation of the railway are also limited.

(2) Dar Es Salaam port and inland transportation

The port of Dar Es Salaam, the main port not only for Tanzania but also for its surrounding countries, is capable of handling the equipment and machinery. On the other hand, heavy equipment and generators are commonly handled by the ship crane. Inland transportation from the port to the Project Area including Dar Es Salaam city area, the Coast Region and the Morogoro Region is commonly done by road transportation.

(3) Quarry site

Existing quarry sites are located at the Kunduchi, Mikese and Melela areas along the Route A7 and B1212 roads. As for the sand deposits, the river sands are mainly supplied from Mfiji, Kifus and Murram areas located along the Route B1212 road. The crusher dust produced by a crushing plant is also used as a stone sand. Embankment materials, especially red soil, are supplied from Kunduchi, Boko and Bunju areas along Route 1212 road. In general, however, the proposed project sites are located far from the existing quarry and borrow sites.

(4) Availability of construction material and equipment in the project area

Most of construction materials including the local products and imported materials are procurable in the local markets of Dar Es Salaam. The main local products usable for the construction works are cement, timber, aggregates, sand, nail, wire and structural steel. While the imported materials are gasoline, diesel, grease, lubricant, bitumen, plywood, reinforcement, structural steel, explosive, detonator, PVC pipe, steel pipe, valve, gate, machinery, electric goods, etc.

8.4.2 Construction plan and cost estimate

A construction plan of the dam project is prepared on the basis of the preliminary design described in the foregoing Section 8.3.

It is assumed that the construction works for the dam projects will be executed by the contractor selected by international competitive tenders, considering scale and kinds of the construction works involved therein.

Based on the rainfall records in the Study Area as well as Sunday and national holiday in Tanzania, the average workable day per month is assumed to be 20 days for embankment work and 22 days for excavation, concrete and grouting works.

The construction plan and methods for the major components involved in each of the dam projects are detailed in Appendix-K of the Supporting Report.

Main construction works of each dam project were estimated to take 4 years, and after then it would take more one year to fully impound the reservoir depending on the rainfall amount in the year. Besides, the following periods were estimated to be required before the commencement of the main construction works:

- two years for a prefeasibility study and feasibility study, or feasibility study
- two years for detailed design.

Construction costs are estimated on the basis of the preliminary design and work quantities at a study level of the master plan. Major unit prices are preliminarily estimated considering the local conditions, availability of construction materials and equipment and referring to the similar international projects.

The foreign and local currency portions of the project cost were estimated on the basis of US dollar. Assumptions and conditions applied for the cost estimate are as follows:

- Price level : Prices as of November 1993
- Exchange rate : US dollar 1.00 = T. Shs. 460 = J. Yen 108
- Construction works will be carried out by the contractor selected through an international tender.
- Construction costs are divided into direct construction cost and indirect construction cost.

The project cost comprises the following costs;

i) Cost for the preparatory works is estimated at 10 % of the sum of the remaining direct construction cost.

ii) Direct construction cost of civil works is estimated principally on the unit price basis, in which the unit price for each work item is multiplied by the corresponding work quantity to calculate the construction cost therefor. The unit prices include labor, material, equipment and overhead cost.

iii) Cost for metal works and generating equipment is estimated based on the recent international contract prices of similar works and considering the local conditions.

iv) Cost of land acquisition and compensation is estimated based on reservoir area and by applying the land value and house compensation cost.

v) Administration cost is estimated at 1 % of the direct construction cost and allocated to the local currency portion.

vi) Cost of engineering services for detailed design and construction supervision is estimated at 12 % of the sum of direct construction cost, sharing the foreign currency portion of 85 % and the local currency portion of 15 %. The costs for prefeasibility study and feasibility study are not included in the cost.

vii) The physical contingency cost is assumed to be 15 % of total cost for both local and foreign currency portions. While, the price contingency cost is not included in those project costs taking into account the unforeseen escalation rates of prices during the long time span of the implementation period.

The present-day construction costs for the three dam projects are shown in Tables 8.2 to 8.4 and summarized below:

Present-day Construction Costs of
Dam Project(s) by Development Scenario

Development Scenario -1		Development Scenario -2	
Name of Dam Project	Total Present-day Construction cost (Million US$)	Name of Dam Project	Total Present-day Construction Cost (Million US$)
(1z) Kidunda Dam Project	101.1	(1) Mgeta Dam Project	110.6
		(2) Ngerengere Dam Project	90.8
Total	101.1	Total	201.4

8.4.3 Construction time schedule

On the basis of the their development plans and in consideration of the required time for prefeasibility and feasibility studies, detailed design and the construction works, the general construction time schedules for the dam projects were established by the dam project as shown in Figs. 8.6 to 8.8.

8.5 Economic Appraisal for Water Resources Development in the Ruvu River Basin

8.5.1 Selection of priority development scenario for water resources development in the Ruvu River basin

Based on the detailed construction cost estimate for the selected three (3) dam projects which are described in Tables 8.3 to 8.5, the unit construction cost for water resources development is derived for each of the selected dam projects as follows:

No.	Description	Name of Dam Project: Development Scenario-1	Development Scenario-2	
		Kidunda	Mgeta	Ngerengere
(1)	Dam height (m)	26	45	36.0
(2)	Effective storage volume (Mill. m^3)	158.5	10.5	30.0
(3)	Yield of dependable discharge for water supply to DES/irrigation development (m^3/sec)	28.2	7.1	1.8
(4)	Hydropower development (kW)	3,900	2,300	400
(5)	Total present-day construction cost (Mill. US$)	101.1	110.6	90.8
Construction cost per dependable discharge (Mill. US$/$m^3$/sec): (5)/(3)		3.59	15.58	50.4

As seen in the table above, the Kidunda dam project exhibits the distinguished economic efficiency of the water resources development. Besides, the Kidunda dam will enable the large-scale irrigation development as compared with that in the development scenario-2.

From the above comparison, needless to say, the post-Study action should be taken towards the realization of the Kidunda dam project. This Study recommends to carry out the prefeasibily study on the Kidunda dam project forecasting on the environmental impact assessment in relation to the ecosystem of the Selous Game Reserve and the geological investigation at the Kidunda dam site.

8.5.2 Economic evaluation on Development Scenario-1: Kidunda dam project and the dam related irrigation projects

The results of the economic evaluation on the Development Scenario-1 are detailed in Appendix-L of the Supporting Report.

(1) General description

The economic evaluation was made on the water resource development plan in the Development Scenario-1 which comprise the following:

i) The Kidunda dam project including hydropower development
ii) The dam - related 5 irrigation projects including the flood control works therefor : Kidunda irrigation, Bagamoyo irrigation, low-lift pump irrigation, Ruvu national youth and Makurunge Irrigation projects

On the other hand, the cost and benefit for the three water conveyance projects were not included in those for the water resources development.

As explained in the other Appendices of this Supporting Report, the following benefits would be derived for the project life of the Kidunda dam through implementation of the Development Scenario-1:

- Increase of water supply to Dar Es Salaam in dry season,
- Increase of water for irrigation in dry season,
- Electricity generation making use of water to be released for regular water use in the lower reach.

The cash flow of benefit and cost was prepared for each of the following components of water resource development involved in the Development Scenario-1:

i) Municipal water supply shared by the Kidunda dam
ii) Dam related 5 irrigation projects
iii) Whole of the water resources development ((i) + (ii))

(2) Economic benefit accrued from the water resources development

Benefit of municipal water supply

Of the annual municipal water demand of NUWA's service area, that to be shared by the Kidunda dam was counted as benefit of the municipal water supply. The unit rates of the water to be exploited are valued in accordance with a criteria on the willingness to pay under the present condition as explained below:

(i) For 5 lpcd in the domestic sector
(at the survival level of people based on the current water price in the city): Tshs. 3, 150/m^3

(ii) For more than 5 lpcd in the domestic sector
(Corresponding to the actual O&M and capital costs) : Tshs. 88.7/m^3

(iii) For consumption in other sectors than the domestic one : Tshs. 105/m^3

Since the benefit of municipal water supply estimated by the above rates are considered to be achieved by the Kidunda dam and the 3 water conveyance projects, the total benefit of the municipal water supply was demarcated into the following tow portions in proportion to the present worth of their economic costs:

Benefit of hydropower generation
The benefit of hydropower generation is set at the value equivalent to the cost of the most competitive alternative thermal. The cost is divided into two categories, i.e., construction and O&M costs.

Benefit of irrigation development
Net incremental benefit of the project is defined as the difference between the net production value under "with project" condition and the production value under "without project" condition. Net production value is further defined as the difference between the gross production value and the crop production costs in both "with project" and "without project" conditions as explained in Appendix-G of the Supporting Report.

(3) Economic Costs

(i) The total financial cost for the water resources development consists of costs for construction of the Kidunda dam project and irrigation projects including the flood control works. To convert the financial cost into the economic cost, the transfer of payment was taken into account by kind of the construction works. In particular, a ratio of transfer of payment to the financial cost in the flood control works is considered to be considerably high, because the construction works are planned to be undertaken by the local contractor. In the present study stage, 90%, 80%, and 70% of the financial cost are assumed to be equivalent to the economic cost for the dam project, irrigation project and flood control works, respectively.

(ii) The annual O&M costs of the component structures are set at 0.5 percent of their construction costs.

The construction cost for the Kidunda dam project was allocated to two portions, cost for the municipal water supply and cost for new irrigation development.

(4) Estimated EIRR

The cash flows of economic benefit and cost for the aforesaid three cases are shown in Tables 8.6 to 8.8.

Table 8.6 shows the cash flow of economic cost and benefit for the municipal water supply which include those for hydropower development. Consequently, an economic internal rate of return (EIRR) for the municipal water supply is derived to be 14.3% and a ratio of benefit to cost (B/C) at about 2.3. While, an economic internal rate of return for the whole irrigation development is estimated to be as low as 4.2% as shown in Table 8.7. On the other hand, an EIRR for the whole water resources development comprising the municipal water supply, hydropower and irrigation development comes to about 10.2% as shown in Table 8.8. Therefore, the water resources development by the Kidunda dam project (Development Scenario-1) is judged to be economically sound.

8.5.3 Other uncountable benefits in water supply sector

Improvement of drinking water supply has two aspects, quantity and quality. The former is by far the dominant factor, as quality is always attained by the treatment of water.

Increase of water supply would give tremendous impact on the productivity in both industrial and commercial sectors, needless to say the encouragement in domestic users. Furthermore, within the domestic users, the increase would give benefits to both the rich and the poor across the community.

Increase of the water supply to the existing distribution system would reduce the area and time of suppressed use, which would enable factories to run closer to their capacity. Furthermore, the rich would reduce investment on installation of tanks with pumping sets, and it will result in reduction of a chance for the poor who will suffer from water-borne diseases like cholera, especially in the hot dry season when water shortage usually takes place.

Expansion of the water supply area with sewerage would result in the overall improvement of the marginal areas of the city economically and ecologically. This is the area where quality aspect of the drinking water would need keen attention. It would reduce the incidents of epidemics of water-borne diseases by enhancing the standard of hygiene. This would contribute to buildup of better human resources in the area. At the same time it would liberate many womenfolk and children from the labour of carrying water from sources some distance away.

8.5.4 Alternatives to water resources development in the Ruvu River basin

As the alternative plan to the water resources development in the Ruvu river basin for the purpose of the municipal water supply to Dar Es Salaam, the following may be conceived:

(i) Intake of water from the Rufiji River and its conveyance to Dar Es Salaam through installation of new pipeline

(ii) Installation of desalination plant at coastal line of the Indian Ocean near Dar Es Salaam

Concerning (i) above, a tremendously long pipeline of 150 to 200 km or more, depending on the location of the intake structure, would be required to be provided to convey water of the Rufiji to Dar Es Salaam. Furthermore, this would require a large scale river training works to stabilize the river bank where the intake structure is provided. Therefore, it is obvious that the alternative plan is considerably costly in comparison with the water resources development in the Ruvu River basin.

With regard to (ii) above, for the time being, the alternative seems to be very remote one taking into consideration the present situation in Tanzania where the water resources are abundant.

Therefore, it is recommended to promote the water resources development in the Ruvu River basin for the purpose of meeting the future water demand in Dar Es Salaam.

8.6 Preliminary Installation Plan of New Water Conveyance and Purification Facility for Municipal Water Supply to Dar Es Salaam

8.6.1 Necessity of expansion of capacity of existing water supply facility

The water conveyance project comprises mainly the intake structure on the downstream reach of the Ruvu River, treatment facilities for raw water, pumping facilities, transmission pipe main and reservoir to store water distributed to each consumer in the city.

There are two existing schemes on the Ruvu River, which are supplying the municipal water to Dar Es Salaam city and its surrounding area, namely the Lower and Upper Ruvu schemes. The design conveyance capacity of the treated water for the existing three (3) water supply schemes totals about 3.16 m3/sec as discussed in the foregoing Chapter IV.

Of the three schemes, the Lower Ruvu scheme is originally planned to allow the capacity to be expanded to 3.16 m^3/sec according to the Operation Manual for the scheme and the NUWA has a plan to expand the scheme although it has not been announced officially yet. On the assumption that rehabilitation of existing water supply schemes as well as expansion of the Lower Ruvu scheme are realized under the related projects, the total capacity of water conveyance for Dar Es Salaam comes to about 4.2 m3/sec. While, the gross water demand in the Dar Es Salaam water supply system is predicted to reach about 11.2 m^3/sec in average daily demand and 14.0 m^3/sec in the maximum daily demand in the year 2020.

Since the water conveyance facilities are required to be designed for the maximum daily demand, those facilities for conveying treated water of about 9.8 m^3/sec need to be newly constructed even in case the capacity of the Lower Ruvu scheme is expanded as aforesaid before implementation of the Kidunda dam project.

Herein assumed is that the three (3) water conveyance projects, each with a conveyance capacity of about 3.3 m^3/sec, are newly installed in accordance with the increase of the water demand. To cope with the municipal water demand in Dar Es Salaam, the following three (3) new water conveyance projects are proposed to be implemented:

No.	Name of New Water Conveyance Project	Water Conveyance Capacity (m^3/sec)
1.	New Lower Ruvu Scheme-1	3.27
2.	New Lower Ruvu Scheme-2	3.27
3.	New Upper Ruvu Scheme	3.28
	Total	9.82

The installation plan of these three water supply facilities is shown in Fig. 8.9.

8.6.2 Preliminary design of new water conveyance and purification facility

For the costing purpose, the major facilities involved in the aforementioned three (3) new water conveyance projects were preliminarily designed. The intake structure and transmission main for the New Lower Ruvu Scheme-1 are planned to be newly provided for a total capacity of the New Lower Ruvu Schemes-1 and -2. Therefore, main components of the New Lower Ruvu Scheme-2 comprises treatment plants and booster pumping stations only. A new intake weir is planned to be provided downstream of each of the existing Upper and Lower Ruvu schemes. The capacities of the intake facilities and low lift pumps for each of the water conveyance projects are determined in consideration of the maximum daily demand in the year 2020. The same type of water treatment facility as that of existing Lower Ruvu scheme was selected for each of the water conveyance projects.

The two lanes of new transmission mains, each for the New Lower Ruvu schemes-1 and -2 and the New Upper Ruvu scheme, are planned to be provided along the existing pipelines. In this stage, the prestressed concrete pipe was planned to be installed for the both projects. The velocity in the transmission mains is set at 2.2 m in order not to cause the harmful water hammer resulting from the long pipelines so that the diameters of the new transmission mains for the New Lower Ruvu Scheme and New Upper Ruvu Scheme were set to be 1.90 m and 1.35 m, respectively.

For each of the new water conveyance projects, the water conveyed to the treatment plant by the low water pumps is planned to be lifted to reservoir by the booster pumps in two steps taking into account the rather long pipeline thereto. Thus, the high lift pumping stations will be provided at two locations between the treatment plant and reservoir. The reservoir for the new projects is planned to have a capacity to keep volume equivalent to 10 hours for the conveyance discharge concerning each of the projects.

The general alignment of the new water conveyance projects is given in Fig. 8.10 and their major components are shown in Table 8.5. Their construction costs are shown in Tables 8.9 to 8.11.

8.7 Initial Environmental Examination

8.7.1 Objective

The Initial Environmental Examination (IEE) is preliminary environmental review carried out to assess whether or not the Environmental Impact Assessment (EIA) is necessary for the development plan in the next study stage. Major study components of IEE include identification of the project outline and environmental condition at the project site (Project Description and Site Description), preliminary assessment of negative environmental impacts to be caused by implementation of the plan, both during construction and after completion of the project, and evaluation on whether EIA is required in next study stage. In the Study on water resources development, the basic study works for the IEE were executed by entrusting to the Institute of Resources Assessment, University of Dar Es Salaam.

8.7.2 Environmental elements

The following elements were confirmed to be necessary for the IEE through the screening by the preparatory study carried out in October 1992:

i) Resettlement of inhabitants
ii) Public health and hygienic conditions
iii) Geographic and geological conditions
iv) Soil erosion
v) Surface water and water quality
vi) Ground water
vii) Animals and vegetation

8.7.3 Environmental impacts

The environmental impacts and influence on the confirmed environmental elements are summarized as follows:

(1) Resettlement of inhabitants

In the proposed project areas, no large-scale resettlement would take place, because in general less number of people are settled therein. However, in case of the Kidunda and Ngerengere dam projects, people are settled in the planned reservoir areas. With regard to the former, there exist the four villages in the Kidunda reservoir area, namely Bwila-Chini, Bwila-Juu, Kiganila and Magogoni, with a total population of about 6,000. Concerning the latter there is one village called Kwaba, whose population is about 900. These existing villages would be submerged by creation of the reservoirs.

In case the Mgeta and Kidunda dam projects, some parts of those project areas are consistent with the area of the Kisaki-Mvuha Buffer Zone Communal of the Wildlife Management Plan formulated under the on-going Selous Conservation Programme, a pilot programme with the objective of enhancing conservation by making local people participating in the management of exploitation of their wildlife resources.

The introduction of extensive irrigation farming as well as large-scale water supply projects would take away more land from the local people. This may have significant negative implication on their social and economic life unless proper resettlement and compensation is considered.

The irrigation development would result in movement of immigrants from outside into the basin so as to take advantage of employment opportunities in the irrigation farming. This would have significant impact on the environment and ecological balance of the basin since more resources would have to be utilized for their life. In implementing the intended development, care must be taken to ensure that the movement of outsiders into the basin does not significantly affect the current settlement patterns and nor does lead to social and environmental problems.

Accordingly, the detailed investigations in the project area and its surrounding areas, especially for the dam projects, must be carried out in the next study stage with respect to settlement pattern and area, village population and family number, land allocation pattern and the holding size, land tenure and land ownership registration, household income and sources, etc.

(2) Public health and hygienic conditions

Infectious water-related diseases are highly prevalent in the Ruvu River basin. Keeping the existing situation in mind, care should be taken in the water resources development plan in order not to create the conditions which will facilitate introduction of new diseases or increase of incidence and prevalence of existing ones. The most common water-related diseases which usually come with development of dam and irrigation projects are discussed in Appendix-F of the Supporting Report.

(3) Geographic and geological conditions

A large quantity of materials such as rock, stone and soil will be necessary for dam construction and flood protection works. These materials will be supplied from the neighborhood of the project sites. Some range of change of land form may occur depending upon the scale of dam and flood dike design. Therefore, an influence on the environment should be kept in mind in designing the projects.

(4) Soil erosion

The higher erosion risk results from various factors such as topography, geology, improper land use practices, etc. As in general the naturally steep slopes are more susceptible to soil erosion, the Uluguru Mountains area would face to the higher erosion risks imposed by topography. Also in other areas, it is important that, in order to ensure the sustainable farming with irrigation, the management practices must incorporate appropriate soil conservation measures. If not, the soil erosion may have significant impact on the environment. With regard to the soil erosion, the land use practices need to be examined in the next environmental study of the respective water resources development projects.

(5) Surface water and water quality

To maintain the environmental conditions of river, it is always necessary to discharge down the minimum river flow to the downstream reach and river mouth, in particular to safeguard the fauna and flora living and to sustain the water quality in the downstream areas. The dam project would have significant impact on the environment of the downstream surface water unless the minimum river maintenance flow is secured.

The contamination of water quality caused by river dredging and construction of river structures on the river would lead to temporary increase of turbidity in the river water. This high turbid water may affect some kinds of aquatic weeds in the downstream reach and may damage the habitat conditions of fish, and also may disturb the water supply system.

Due to the use of agrochemicals by the improvement of agriculture with irrigation development, the water drained from the cultivated lands would be contaminated with fertilizers and pesticides which can have negative effects on aquatic organisms. Besides, the eutrophication of river water might be caused by the agrochemical content or the water stagnation by the dam construction.

(6) Ground water

The ground water potential is rather poor in the Ruvu River basin in view of the water quality except for limited areas. Therefore, the ground water resources are scarcely used as a source of drinking water. Presently, there is no health hazards in relation to the contamination of the ground water resources. The water resources development plan in the Ruvu River basin involves no ground water development project. Accordingly, it is considered that the environmental impact on ground water would be insignificant.

(7) Animals and vegetation

Except for the wetlands as well as the areas bordering the Mikumi National Park and the Selous Game Reserve, *wildlife in the Ruvu River basin is dominated mainly by vermin species which* include baboons, monkeys, wild pigs and birds. Other wildlife species are restricted to specific zones. For example, hippopotamus, bushbuck and crocodile are confined to the river valleys. In particular, the wetlands are rich in varieties and numbers of birds. Since most of the floodplain is not utilized for cultivation, it forms a very important refuge for these animals and birds. Most of these animals and birds would be affected more or less, should the ecology of the floodplain change. Therefore, it is recommended to clarify the potential and biological values of wildlife in the area concerned with the water resource project in the next environmental study of the respective water resource development projects if the project may have a significant influence on the wetland.

Damming of the Ruvu, Mgeta and Ngerengere Rivers may lead to river bed degradation and subsequently drain of water in the existing swamps and wetlands, e.g. that in the Dutumi - Magogoni area. Depending on the magnitude of the changes in the flooding pattern and soil moisture regime, vegetation changes would take place and affect the animal habitats and animal population in various respects. In general, the ecology of the downstream areas would change and in particular the species such as the giraffe, wildebeest and zebra could be affected by the hydrological and ecological changes in the area. At present, these animals inhabit in very small and limited patches in the area. The proposed projects may limit these patches further and affect these animal species negatively.

A part of the reservoir area of the Mgeta dam would be probably located in the Mikumi National Park. This area is covered by the Miombo woodland, a home of some animals. On the other hand, the Kidunda dam would submerge a land of some 140 km^2 which include riverine forest of about 1,600 ha along the Ruvu and Mgeta Rivers, occupying a part of the Mikulazi Forest Reserve on the left bank of the Ruvu River. Its reservoir area would occupy a very small part of the Selous Game Reserve along the right bank of the Mgeta River and a part of the Mkulazi Forest Reserve on the left bank of the Ruvu River. This area is covered by woodland with thicket on termite mounds as well as taller and dense vegetation. Buffalo, elephant, hippopotamus and crocodiles are observed therein. Therefore, it is recommended that the environmental studies to be carried out in the next prefeasibility study on the Kidunda Dam project clarify the biological values in the planned reservoir area.

For the time being, the knowledge on ecology of animals and vegetation in the Ruvu River basin is scanty or lacking. This is because detailed scientific studies on the ecology have not been conducted yet. Therefore, the detailed ecological investigations must be carried out on the fields of fauna and flora for each of the project areas, especially for the dam project areas in the future study stage.

It is generally accepted that the river runoff yielded in the dry period is attributable to rainfall amount during the period as well as water conservation capacity of forest area in the basin. Thus, it would be essential to conserve the existing forest area to a maximum extent so as to ensure the sufficient runoff. Although it is too hard to quantify the yield in the specific forest area existing in the Ruvu River basin in the present master plan stage, on the other hand, it is considered necessary to conserve at least the forest area in the Uluguru Mountain area to secure the stable river runoff in the lower reach as it is the largest source of the Ruvu River from the geographical and meteo-hydrological viewpoint.

8.7.4 Recommendation on further environmental study

The present shortage of water and electricity supply in the Dar Es Salaam city area as well as the supply of unhygienic and unreliable water to the people in the Ruvu River basin could be much improved through realization of the comprehensive water resource development plan. Concerning the environmental impacts caused by the implementation of the proposed projects of the water resources development plan, it is considered that the environment of the Ruvu River basin would be affected as aforesaid. When implementing the plan, the possible impacts on the project areas need to be taken into account, together with the natural conditions and socio-economic environment of the surrounding areas of the proposed projects. As a result of the environmental screening shown in Table 8.12, a more detailed environmental investigation, namely the Environmental Impact Assessment (EIA), is necessary for the following projects:

- i) Kidunda dam project
- ii) Mgeta dam project
- iii) Ngerengere dam project
- iv) Kidunda Irrigation Project

In the next study stage, it is necessary to assess the possible effects on the environment to be caused by the implementation of the plan as in detail as possible and to find possible countermeasures.

CHAPTER IX

ORGANIZATION AND INSTITUTIONAL CONSIDERATION

9.1 General

The government of a country has been controlling water use within its territory by a set of laws. So has been Tanzania. The water use including drinking, irrigation, hydroelectric power generation and industry in Tanzania is wholly administered by the MWEM. The Ministry of Land, the Ministry of Agriculture and Livestock Development, the Ministry of Health, the Ministry of Tourism, Natural Resources and Environment, and the Ministry of Industry are responsible for the affairs of their respective jurisdictions, i.e., land use, agro-pastoral activities, sanitation, conservation and industrial effluence.

The Ruvu River basin extends over the two regions administratively, i.e., the Morogoro and Coast Regions. In case of water supply to Dar Es Salaam and its vicinity along the main pipelines from the intakes on the Ruvu, the National Urban Water Supply Agency (NUWA) was granted the water right under the water utilization act (WUA) No. 42 of 1974 for control and regulation of the water supply.

9.2 History of Legislation on Water Use in Tanzania

The water works ordinance Cap. No. 410 of 1959 was the legislation for control and regulation of the water supply in the country before it was repealed by the WUA. (There had been Cap. 130 and Cap. 257 before Cap. 410.) The act has been amended since then. In 1981, the urban water supply act (UWSA) No. 7 was introduced and the WUA was amended (Act No. 10). The purpose of revision was to include the provisions for control of water pollution. The nine national water basins were also defined under it. The second amendment was made in 1989 (Act No. 17). The revision aimed at raising the fines under section 33 of WUA, No. 42 of 1974. In the same year, nine national water basins were gazetted. Now, the Pangani Basin Water Office (PBWO) functions since July 1991, and opening of the Rufiji Basin Water Office was effected in September 1993.

At present, a draft of the new WUA is under preparation to revise existing one. Its major features are as follows:

i) Increase the water right application fee.

ii) Grant the water rights within the certain period, and they shall be renewed periodically with certain reporting of water abstraction.

iii) Introduce the water users fee (WUF) for the efficient operation of water management, i.e., the levy would be used for recurrent expenditures of the basin water office concerned including the maintenance or installation of control gates at the abstraction points for small users for irrigation and other uses.

The rates contemplated at the moment were:

- TShs. 15/1,000 m^3 for irrigation
- TShs. 30/1,000 m^3 for big industries
- TShs. 50/MWh for hydropower generation

With these rates, the Pangani Basin Water Office would expect to have some 25 million shillings per year.

iv) Extend general power of the WUA to the water advisory boards for the strong control of water abstraction and pollution.

9.3 RUBADA and PBWO

Tanzania has a river authority. The Rufiji Basin Development Authority (RUBADA) was established by Act No. 5 of 1975. The Rufiji is the biggest river basin in Tanzania, in which so far the two biggest hydropower stations, i.e., Kidatsu (204 MW) and Mtera (80 MW), are provided. In addition thereto, the Kihansi hydropower station (180 MW) is going to be built in the near future. There are several big irrigation projects in Usangu flats, and the Selous Game Reserve, the biggest one in Africa, is located in the middle reaches of the Rufiji River.

As shown in the Fig. 5.1, the organization has no executing authority with only the planning directorate.

The Pangani Basin Water Office (PBWO) was established at Hale in the Kologwe District of the Tanga Region in 1991. Its organizational setting is given in Fig. 5.2. It has improved a lot in its basin management, having its own source for its own recurrent expenditure. It has to take a supervising role in its coordinating activities with other interested administrative organizations in future for better performance.

9.4 Proposed Organization

9.4.1 General

As a result of examination of the precedence of river authorities such as RUBADA in this country, it is considered that the organization responsible for the purpose should be smaller as far as possible in view of the practical functioning. Although as a matter of course the management of a water basin encompasses all the aspects of human activities within it and their influences on the nature's carrying capacity, it deems that the task of the organization should also be directed to the coordination works with the other concerned organization within the established administrative framework.

There are two opposite types in terms of size of the organization. Both of them require the authority and resources such as manpower and fund. The big one requires much, while the small one does less. The big one would intend to supersede the existing boundaries of ministerial jurisdiction in order to take up all the responsibilities directly into its hand.

An example is the TVA. it was established to produce necessary energy to cope with the economic situation and at the same time to raise a regional economy and welfare of the residents in a remote and marginal area of the country. It required tough management to satisfy both needs which are apt to contradict each other. One superb example is the comparison of social gains by reducing malaria infection incidents with the production loss of aluminum. It weighed the gains more, and the reason persuaded the president.

The RUBADA was established in line with the inherited principle bestowed on it. Unfortunately it lacked manpower and fund for operation. No income from electricity generation by hydropower plants in the basin has been allocated to run it.

The smaller alternative would be formed within the sectoral framework. This setup would have more chances of surviving against constraint of fund and administrative boundaries. Four key points for its efficient functioning beyond its survival level, besides budget allocation issues, are:

i) Authority to issue a license for use of key resources, to control them, and if possible to punish the violators.

ii) Capability of collecting and analyzing accurate and updated information on the subject matters and affairs.

iii) Coordinating skill builtup in the inter-ministry supervisory system, in which no superseding of existing jurisdiction would take place.

iv) Quick responses to address the problems.

9.4.2 MWEM

The MWEM has the authority in managing water resources of the country. It controls the volume of water use by approving or disapproving (fully or partially) the water rights application, controls water quality, and is broadening its power to prosecute the quantitative or qualitative violators of water use. The management work has been carried out under the principal water officer's (PWO's) supervision.

The MWEM has been collecting and processing the hydrological data in the country, and keeps its data base and makes them update. The activity is undertaken by its hydrology subsection.

The MWEM has a capability of doing the job of managing the river basins of the country by itself. Furthermore its efficiency and effectiveness would surely increase with the introduction of amendment to the WUA mentioned above.

9.4.3 Project component and their probable effects

(1) Construction of the multi-purpose Kidunda dam project

The condition of the Kidunda dam would cause;

a. Change in ecosystem of the area, and

b. Creation of a new type of buffer zone for Selous Game Reserve.

The construction of the Kidunda dam would positively contribute to:

a. Increase of water supply to Dar Es Salaam,
b. Increase of water for irrigation,
c. Generation of electricity
d. Flood control, and
e. Improvement of life of people in the villages located near the dam site, including access road improvement, electrification, increase of income sources, better public institutions like schools and dispensaries.

On the other hand, the construction of dam would cause resettlement of several thousand people living in Selembara ward.

(2) Increase of irrigated farms in the basin around the Uluguru Mountains and lower reaches.

(3) Improvement of rural trunk roads around the Uluguru Mountains

9.4.4 Proposed organization

A simplified organization for management of the Ruvu River basin is proposed as given in Fig. 9.3. While Fig. 9.3 (a) and (b) exhibits the existing structures, Fig. 9.3 (c) illustrates the proposed set-up of the RUVU/WAMI BWAB. It does not require any new formation within or outside the existing organizational structures. Its central public figure would be the Ruvu/Wami Basins Water Officer (R/W BWO), whose appointment would surely take place in the next study stage, as the basin was defined by the WUA. The office of R/W BWO would keep on looking after the projects in the Ruvu River basin from the next planning stage to the O&M stage.

Interested parties are represented in the CWAB at the national level and in the R/W BWAB at the basin level. All the problems caused from competing interests of interested parties would be discussed and solved among the board members.

The activities of R/W BWO defined by the WUA with future amendment, which would be the nuclei of institutional changes to normalize the water use management, would *affect directly or indirectly the planned project components except the works on* improvement of rural trunk roads around the Uluguru Mountains.

The BWO originally had the power of apportionment of water. Even land use planning could be controlled by means of issuing the license for the water right. Its jurisdiction is clear, since classification of national rivers and regional rivers, which was somehow vague so far, is now amalgamated into basins.

The level of his counter-balanced responsibility to the welfare of people in the basin as well as nature as a whole should be maintained by getting accurate and updated information from the concerned organization as well as his own site survey.

Sequentially the relationship between the R/W BWO and the project would start when the BWO will assess the water rights concerning the proposed dam. Collection and analysis of hydrological data should be continued by the hydrological subsection. The BWO should participate in the hydrological works. The more accurate forecasting becomes, the better for all water users in the basin.

Before issuing the license, the situation of existing water right including riparian rights should be checked requesting concerned district water engineers (DWEs) and district agriculture officers (DAOs) to conduct an extensive survey.

The construction of the projects would be handled by the MWEM. The BWO would go on getting in touch with the site engineer so as to protect the water users in the lower reaches of the basin in terms of quality and quantity of the water during the period of dam construction. This will be the beginning of the monitoring activity.

Monitoring of water uses and further prosecution in case of violation of the conditions of water rights would be carried out by the DWEs, DAOs, district industry officers, etc.

Finally, we propose the establishment of the basin water users' association. Existing examples are found in Mbeya and Kilombero. One unit would consist of the users at the intake on the river where the intake volume is measured. The water use within the channel would be discussed among the unit members. The association may send its representative to the BWAB to express its opinion.

CHAPTER X

RECOMMENDED POST-STUDY ACTION PLAN

10.1 Prefeasibility Study on the Kidunda Dam Project

The Kidunda dam project (Development Scenario-1) is selected as the most economical one among the three dam projects for the purpose of meeting the water demand in the Dar Es Salaam by 2020 as discussed in the foregoing Chapter XIII. Moreover, the implementation of the Kidunda dam project would enable to realize a lot of irrigation projects as aforesaid and to encourage the rural development through the improvement of the local communication system now aggravated, since the Project includes the improvement works of existing 100 km long rural road, connecting the dam site and the Morogoro road.

On the other hand, the Kidunda dam project may have the following issues, which have to be clarified in next study stage;

- Geological issue : Existence of limestone at the downstream dam site and existence of clayey layer at the upstream dam site.
- Environmental issue : Adverse effect on the existing Selous Game Reserve with respect to its ecosystem.

From the above, it is strongly recommended that the prefeasibility study on the Kidunda Dam be carried out in the subsequent stage focusing on the geological investigations at the alternative dam sites and the environmental impact assessment (EIA) study. It is foreseen that the aggravated situation of water supply to Dar Es Salaam is accelerated from now on unless the water resources development project is to be proceeded at an earlier stage. In particular, the EIA study in the next study stage ought to carried out under a good coordination between the both Ministries concerned, namely the Ministry of Water, Energy and Minerals and the Ministry of Tourism, National Resources and Environment.

With regard to the environmental issue, it is envisaged that the following major environmental and social issues may take place after creation of the Kidunda dam and reservoir:

(i) Conflicts in relation to the resettlement of people living in the reservoir area (the reservoir area is resided by a population of about 6,000), and

(ii) Adverse effect on the present ecosystem, since the reservoir area constitutes an important migration routes of wildlife during the dry season according to the latest information.

Resettlement of people living in the reservoir area

Concerning the item (i) above, as explained in the foregoing Chapters V and VIII, the Kidunda dam project enables to irrigate about 14,000 ha of paddy fields in the downstream area of the dam site, while the inhabitants in the reservoir area cultivate an area of some 220 ha for paddy production utilizing traditional methods. Besides, around 98% of the inhabitants are engaged in the agricultural production. If they are allowed to migrate to the new irrigation development area of the Kidunda Irrigation Project under the Government's authorization, hence, the Kidunda dam project may encourage those local inhabitants from the economic viewpoint. Further, it has to be noted that there exist vast virgin areas downstream of the Kidunda dam site, which are usable for the new irrigation development.

Adverse effect on the present ecosystem

The Kidunda reservoir is to occupy an area of about 140 km^2 which is equivalent to only about 0.3% of the total area of the Selous Game Reserve (about 50,000 km^2). In addition, most of the reservoir area is located outside the Selous Game Reserve (SGR) area. Geographically speaking, thus, the creation of the reservoir would not have any direct influence on the SGR area itself. However, the ecosystem of the SGR may cover mostly the entire Ruvu River basin and the Kidunda reservoir area may be the important migration route for some species of the wildlife according to latest information obtained from the office of the Selous Conservation Programme (SCP).

It deems that this is quite complicated issue and subject to a number of unknown factors. Therefore, it is considered necessary to carry out the detailed environmental study (Initial Environmental Impact Assessment study) before proceeding with the regular feasibility study on the Kidunda dam project. Although the final judgement on the extent of the environmental impact needs to wait for the results of the study, on the other hand, the reservoir might form "a public drinking fountain" for the wildlife during the dry season.

For the time being, it is foreseen that the next Initial Environmental Assessment study would focus mainly on the following:

- Data collection on the SGR and their review
- Data collection on resettlement of people and communities in the reservoir area
- Identification of species of wildlife living and migrating into the reservoir area,
- Period of migration of those wildlife and their numbers (sampling survey), and
- Initial Environmental Impact Assessment in relation to the ecosystem of the SGR

10.2 Feasibility Study on the Mlali Irrigation and Uluguru Mountain West Projects

As the independent project of the dam development, it is recommended to proceed with a feasibility study on the Mlali irrigation and Uluguru Mountain West Projects in one package, both of which were selected as one of the high priority agricultural projects in the Study Area, since the other high priority irrigation projects will have to await the completion of the dam project.

Tables

Table 1.1 LIST OF MEMBERS OF JICA ADVISORY COMMITTEE

Designation	Name	Agency Belonging
Chairman / Water Resources Development	Mr. Osamu Yamaguchi	Ministry of Construction
River planning	Mr. Shigeharu Jikan	Water Resources Development Public Corporation
Irrigation	Mr. Toshio Hirodo	Ministry of Agriculture, Forestry and Fisheries
Agriculture	Mr. Akinari Kudo	Ministry of Agriculture, Forestry and Fisheries
JICA Coordinator	Miss Fumiko Tatebayashi	JICA
- do -	Mr. Kazuhiko Kikuchi	JICA

Table 1.2 LIST OF MEMBERS OF JICA STUDY TEAM

No.	Post	Name
1.	Team Leader	M. Tsuda
2.	Water Resource Engineer	T. Katayama
3.	Hydrologist	Y. Itakura
4.	River Planner	K. Matsumoto
5.	Design Engineer	Y. Samejima
6.	Geologist	K. Nakazato
7.	Surveyor	K. Takamatsu
8.	Environmentalist	Y. Nozaki
9.	Water Demand Analyst	S. Mochizuki
10.	Irrigation Engineer	M. Masaki
11.	Agronomist	K. Yamada
12.	Hydroelectric Planner	M. Kanda
13.	Construction Planner	T. Kozawa
14.	Socio-Economist	F. Onoda

Table 1.3 LIST OF COUNTERPART PERSONNEL

	Post	Name	Position
1.	Water Resource Engineer	Mr. M. Macha	Design Engineer of Ministry of Water, Energy and Minerals
2.	Hydrologist	Mr. Silvesta Salamba	Senior Hydrologist of Ministry of Water, Energy and Minerals
3.	Hydrologist	Mr. Emmanuel	- do -
4.	River Planner	Mr. Ngiloi	Construction Engineer of Ministry of Water, Energy and Minerals
5.	Design Engineer	Mr. B.S. Chayayi	Design Engineer of Ministry of Water, Energy and Minerals
6.	Geologist	Mrs. Chuwa	Geologist of Ministry of Water, Energy and Minerals
7.	Geologist	Mr. Msangazi	Geologist of Ministry of Water, Energy and Minerals
8.	Surveyor	Mr. David Edwin	Land Surveyor of Ministry of Water, Energy and Minerals
9.	Environmentalist	Mr. N. Steven	Environmentalist of Ministry of Tourism, Natural Resources and Environment
10.	Water Demand Analyst	Mr. Nyamajeje	Civil Engineer of National Urban Water Authority
11.	Water Quality Analyst	Mr. Kibakaya	Water Quality Analyst of Ministry of Water, Energy and Minerals
12.	Irrigation Engineer	Mr. R. L. Ishengoma	Irrigation Engineer of Ministry of Agriculture
13.	Agronomist	Mrs. E. M. Nnyiti	Soil Scientist of Ministry of Agriculture
14.	Hydroelectric Planner	Mr. Mathew Mbwambo	Senior Electric Engineer of Ministry of Water, Energy and Minerals
15.	Construction Planner	Mr. A. Masasi	Quantity Surveyor of Ministry of Water, Energy and Minerals
16.	Socio-Economist	Mr. J. Magingo	Ministry of Communication Development, Women Affairs and Children

Table 2.1 NATIONAL SOCIO-ECONOMIC DATA

*LAND

Total	Cropland	Pasture	Forest	Others	(Wilderness)
886,040	52,400	350,000	411,800	71,840	70,530
100.0 %	6.0 %	40.0 %	46.0 %	8.0 %	8.0 %
change:/78	2.2 %	0.0 %	-2.8 %	17.8 %	7.0 %

*Population mil.		*Safe Drinking Water		*Sanitation : 1988	
1990	1995	Urban	Rural	Urban	Rural
27.32	32.97	75.0 %	46.0 %	76.0 %	77.0 %

*BASIC ECONOMIC INDICATOR

GNP US$:1989		GDP Distribution : 1989		ODA : mil. US$: avr. annual	
Total	per capita	Agriculture	65.6 %	1982 - 84	1984 - 89
3,079 mil.	120	Industries	7.5 %	100	169
GNP net charge ; % pa		Services	26.9 %	ODA/GNP	
1969 - 79	1979 - 89			13.4 %	13.3 %
3.8 %	1.8 %	Total	100.0 %	p. capita ODA : '89 US$ 52	

External Debt US$: 1989		1989	Gov. Expenditure US$: 1981		Exchange rate
Total	per capita	/export	Total	per capita	Tshs/US$: '93
4,917 mil.	6.61	17.0 %	1,596 mil.	85	460

*AGRICULTURE

Agro Product Index : '80=100		Input			1988
'88-90 : Total	'88-90 : p.capt	Irrig. /Crop	Fertilizer	Pesticide	Tractor
122	88	3.0 %	9.0 kg/ha	5,733 ton	18,550

*WATER

Annual Renewable : 1990		Annual Withdrawal : 1970		Distribution : 1987	
Total	per capita	Total	per capita	Agriculture	74.0 %
76 km3	2,780 m3	0.48 km3	36 m3	Industries	5.0 %
				Domestic	21.0 %

*NATURAL AREAS

8 places	11,913 ha	12.6 % of land area

Source : World Resources 1992-93, WRI, Oxford Univ. Press.

Table 2.2 POPULATION OF MAIN LAND AND REGIONS

Region		Rate (%) '67 - 78	1978	Rate (%) '78 - 88	1988	1990	1991
Morogoro	Population	2.9	939,264	2.6	1,222,737	1,288,001	1,321,401
70,799 km2	Density/km2		13		17		
	H'hold size		4.7		5.3		
Coast	Population	1.7	516,586	2.1	638,015	665,382	678,402
32,407 km2	Density/km2		16		20		
	H'hold size		4.3		4.2		
Dar Es Salaam	Population	7.8	843,090	4.8	1,360,850	1,497,968	1,573,811
1,393 km2	Density/km2		605		977		
	H'hold size		4.1		4.3		
Mainland	Population	3.2	17,036,499	2.8	22,533,758	23,831,650	24,456,644
881,289 km2	Density/km2		19		26		
	H'hold size		4.9		5.3		

Sources : 1967,78,88 : Population Census 1988, Preliminary Report 1990
1990, 91 estimate : Economic Survey 1991, Planning Commission June 1992

Table 2.3 GDP OF MAIN LAND AND REGION

Year	GDP			Mil. TSh.	GDP per Capita			TSh.
	Morogoro	Coast	Dar Es Salaam	Mainland	Morogoro	Coast	Dar Es Salaam	Mainland
1980	1,944	463	9,462	37,454	1,983	889	9,072	2,072
1981	2,045	547	10,621	43,906	2,344	1,019	9,871	2,354
1982	2,441	690	11,718	52,546	2,769	1,252	10,453	2,729
1983	2,914	745	13,386	62,608	2,965	1,330	11,100	3,151
1984	2,383	860	16,754	78,143	3,185	1,511	12,927	3,811
1985	3,243	1,124	22,395	108,083	4,242	1,945	16,065	5,221
1986	4,224	1,408	28,228	140,866	4,874	2,336	21,953	6,715
1987	4,008	2,004	42,079	200,377	6,742	3,231	31,808	8,873
1988	5,703	2,852	68,436	285,152	9,326	4,469	50,284	12,919
1989	6,710	3,355	72,811	335,505	10,674	5,115	52,756	15,205
1990	12,022	4,007	84,151	400,719	15,502	5,943	58,508	16,837
1991	22,942	5,735	114,708	573,536	21,708	8,459	72,876	23,410

Source : National Accounts of Tanzania 1976 - 91, Bureau of Statistics

Table 2.4 GDP BY KIND OF ECONOMIC ACTIVITIES

(Unit : Mill. Tsh.)

Sector	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Agriculture	26,449	32,737	41,295	61,231	84,153	117,982	178,760	207,059	233,804	358,693
Mining	266	249	337	251	474	645	723	1,129	4,815	6,975
Manufacturing	4,361	4,869	5,932	6,665	8,551	14,792	15,187	15,197	18,301	20,680
Utilities	421	514	551	1,071	1,488	4,992	4,628	4,842	7,438	8,395
Construction	1,863	1,252	1,661	2,061	3,131	6,511	11,808	9,720	12,650	14,416
Commerce	6,814	8,148	10,447	14,195	19,476	25,963	41,591	50,392	56,638	83,325
Communicatic	3,395	3,507	4,789	7,021	7,797	11,584	14,259	23,854	36,242	47,017
Finance	4,891	5,252	6,028	6,659	8,127	11,061	14,132	19,187	24,123	28,757
Administraion	5,446	7,372	8,614	10,735	10,213	13,291	16,952	22,168	31,968	34,478
Bank Services	-1,360	-1,292	-1,511	-1,806	-2,544	-6,444	-12,888	-18,043	-25,260	-29,200
Total	52,546	62,608	78,143	108,083	140,866	200,377	285,152	335,505	400,719	573,536

Source : National Accounts of Tanzania 1976-91, Bureau of Statistics

Table 2.5 LAND USE AND AGRICULTURAL ACTIVITY IN THE PLANNED RESERVOIR AREA OF KIDUNDA DAM

		Name of Village				Total	Remark (Data Source)	
		Mggni	Kgnla	Bwila-J	Bwila-C			
Location (Bank side of the Ruvu River)		Right	Left	Left	Right/Left	-		
Population		929	979	806	1,962	4,676	CENSUS'88	
Population		na	1,016	na	2,700	na	WARD '93	
Population		na	2,128	881	2,961	5,970	SCP '91	+2.6pa
Population		1,420	1,170	1,104	1,014	4,708	DAO '92	
Workforce		696	573	541	497	2,307	DAO '92	
Household		237	195	184	169	785	DAO '92	
Household		na	266	220	370	856	SCP '91	
House No.		na	300	350	352	1,002	WARD '93	A.
(of burnt brick)			10	9	0	19	WARD '93	
Church+Pastor, School			5	1	0	6	WARD '93	
with gcs roof			na	20	45	65	WARD '93	
Housing Area (ha)		na	310	153	203	666	SCP '91	B.
Crop Land (ha)		na	837	310	641	1,788	SCP '91	C.
Maize	(max ha)	278	229	216	199	922	DAO '92	
	(act. ha)	252	179	196	159	786	DAO '92	
Paddy	(max ha)	40	115	24	38	217	DAO '92	
	(act. ha)	40	86	24	38	188	DAO '92	
Sorghum	(max ha)	278	229	128	199	834	DAO '92	
	(act. ha)	238	213	118	136	705	DAO '92	
Cotton	(max ha)	278	229	216	199	922	DAO '92	
	(act. ha)	78	89	65	39	271	DAO '92	
Total	(max ha)	874	802	584	635	2,895	DAO '92	
	(act. ha)	608	567	403	372	1,950	DAO '92	
Banana		na	900	1,050	1,056	3,006	WARD '93	Ax3
Coconut		na	450	525	528	1,503	WARD '93	Ax1.5
Mango		na	600	700	704	2,004	WARD '93	Ax2
Goat		256	420	135	150	961	DAO '92	
Poultry		3,680	4,027	2,116	2,312	12,135	DAO '92	
Duck		1,020	156	600	465	2,241	DAO '92	
Forest	(ha)		3,053	3,386	2,429	8,868	SCP '91	D.
Total	(ha)		4,200	3,849	3,273	11,322	SCP '91	B+C+D

SOURCE : WARD '93; from village chairmen
SCP '91; Selous Conservation Programme, DGTZ 1991
DAO '92; District Agriculture Office, 1992/93

NOTE : MGGNI=Magogoni, KGNLA=Kiganila, J=juu, C=chini
A big discrepancy in population of Bwila-chini is due to the fact if they count that of newly created Kiburma or not.

Table 2.6 METEOROLOGICAL RECORDS IN THE RUVU RIVER BASIN

Description	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Rainfall (mm)													
Upper Ruvu Basin	173	154	245	314	141	49	39	39	51	85	128	168	1,586
Mgeta Basin	135	116	208	280	137	28	11	14	17	31	77	95	1,149
Middle Ruvu Basin	120	93	146	242	72	22	8	18	24	76	90	107	1,018
Ngerengere Basin	101	90	153	205	103	25	14	16	28	50	90	104	979
Lower Ruvu Basin	86	71	140	191	119	26	16	15	32	65	108	105	976
Total Ruvu Basin	111	96	170	231	118	28	16	18	29	58	97	109	1,081
Temperature (C)													
Average Mean	26.9	27.4	27.5	25.7	25.4	23.5	23.0	23.3	24.7	25.9	26.9	27.0	25.6
Average Max.	32.0	32.0	31.8	29.9	29.4	28.1	27.6	28.3	30.2	31.3	31.9	31.3	30.3
Average Min.	22.1	23.0	22.2	21.2	20.8	18.1	17.0	16.9	18.4	19.3	21.1	21.7	20.1
Relative Humidity (%)	63.2	62.4	68.2	69.8	66.4	64.4	56.4	54.7	51.7	58.8	59.4	63.3	61.5
Wind Velocity (m/sec)	1.8	1.7	1.2	0.8	0.8	0.9	1.1	1.3	1.5	1.7	1.7	1.8	1.4
Sun Shine (hr/day)	7.1	8.7	6.6	5.4	5.8	6.7	6.6	6.6	7.0	7.9	8.0	7.3	7.0
Evaporation (mm/day)	5.09	5.94	5.29	4.04	3.69	4.00	3.65	4.20	5.24	5.94	5.98	6.59	4.97

Table 2.7 MAIN FEATURES OF EXISTING MINDU DAM

Catchment Area	303	km^2
Reservoir Area	3.8	km^2
Reservoir Storage (total)	13.0	Mill m^3
Reservoir Storage (effective)	11.3	Mill m^3
High Water Level	507.0	El.m
Low Water Level	501.5	El.m
Design Flood Discharge	710.0	m^3/s
Normal Discharge (initial)	57,500	m^3/day
Normal Discharge (after 20 years)	43,000	m^3/day *
Type of Dam	Earth fill with a concrete spillway	
Crest Level of Dam	501.1	El.m
Crest Length of Dam	1,600	m
Crest Width of Dam	8.0	m
Slopes of Dam (down stream)	1:2.25	
Slopes of Dam (up stream)	1:2.50	
Type of Spillway	Overflow	
Crest Level of Spillway	507.0	m
Length of Spillway Weir	100.0	m

Note

* : Estimated