sustainable growth including the maximization of positive impacts of development and the minimization of potential environmental hazards. The NWRMP including the need for an integrated environmental protection program and related strategies and countermeasures are suggested in some detail in the Chapters as mentioned above. In particular, the provision for fish ladders and other passage ways for fish movement up and down stream should be carefully examined during the stage of project identification and preparation, and when a negative conclusion is a given to the project economic viability as a whole, this project may be subject to suspension or cancellation.

For reference, a proposal on the technical cooperation program "EIA Study and Environmental Monitoring Program for Dam Projects" to be assisted by the external agencies which should be carried out during an early period of the National Water Master Action Plan by 2000 is compiled in Appendix 11-9 of Chapter 11.

4.5 NATIONAL WATER MASTER ACTION PLAN TOWARDS THE YEAR 2000

4.5.1 BMR Program for the Existing Dams

(1) Establishment of Integrated Water Management Rule in the North Region

The surface water of the Hadejia and Rima basins in the North region has been mostly developed by the existing dams. The outline of water resources development and service area under the existing dams is summarized as follows:

Item		Hadejia Basin	Sokoto-Rima
1. Potential surface water	(MCM)	1,700	2,500
2. Number of Existing Dams	(No)	14	8
3. Total Reservoir Water			
(1) Active Reservoir Capacity	(MCM)	3,010	1,660
(2) Available Reservoir Water	(MCM)	1,130	910
4. Public Irrigation			
(1) Potential Area	(10^3ha)	41	50
(2) Actual Irrigation Area	(10^3ha)	15	6
5. Private Irrigation			
(1) Potential Area	(10^3ha)	66	34
(2) Actual Irrigation Area	(10^3ha)	34	16
6. Water Supply by Surface Water			
(1) Actual Supply in 1991	(MCM)	71	68
(2) Water Demand in 2020	(MCM)	253	82

As is clear in the above table, the Hadejia and the Rima basin have large available reservoir water of 1,130 MCM and 910 MCM respectively under the large active reservoir capacity. The available reservoir water, however, has not been used effectively for irrigated agriculture due to inadequate irrigation system in the service area. The actual public irrigation area in both basins is 21,000 ha against the potential area of 91,000 ha. Although the domestic water demand towards the year 2020 will increase to 335 MCM a year in both basins, this could be satisfied by the available water of the existing dams. FMWRRD intends to implement the irrigation system at the undeveloped service area towards the year 2000 and the water supply agencies will implement the waterworks to respond to the increasing domestic water demand towards the year 2020. The water management in both basins for the effective use of reservoir water, however, is rather difficult as compared with that in the other basins of the Central and South regions due to the following reasons:

- Potential surface water decreases by Sahelian Drought.
- Active reservoir capacity in the dams of Tiga, Challawa and Goronyo is very large against their reservoir inflow.
- Some of the existing reservoir dams located in the upstream basin of the Challawa and Goronyo use the surface water preferentially for the service area, as a result the inflow of the Challawa and Goronyo will be decreased.
- Large Fadama area lying in the downstream of damsites requires the water to be released from the reservoir.
- Large seepage loss will take place along the rivers between damsite and Fadama area.

If the integrated water management rule is not set up by solving the above problems, the reservoir water will be released randomly, as a result the water management in the irrigation system and waterworks in the service area could not be made adequately.

With this background, the integrated water management rule in both basins shall be urgently set up as explained in 4.4.3. The water management study will be commenced firstly in the Hadejia basin with the following items:

(a) Data Collection Related to the Study by the Inventory Survey

(b) Installation of Gaging Stations

Site	Rainfall/Evaporation	Surface Water	Sub-Surface Groundwater
Damsite1	2	4	-
Along River	-	6	-
Wet Land	-	-	5
Total	2	10	5

(c) Topographical survey and discharge measurement at gaging stations.

(d) Hydrological analysis by the runoff model at the representative damsites.

(e) Water balance study at the wetlands.

(f) Water demand study for irrigation and water supply in the service area as well as for the wetlands.

(g) Integrated reservoir operation study for Tiga, Challawa, Watari and the other medium scale dams.

(h) Rehabilitation plan for the existing dams, irrigation system and waterworks.

(i) River improvement plan to minimize water loss.

(j) Preliminary design for the above rehabilitation and river improvement works.

(k) Formulation of the integrated water management rule and OM plan including OM organization.

(l) Environmental Impact

(m) Implementation program

The guideline for the integrated water management study is as shown in Appendix 4-1. Work schedule for the above study is as follows:

Item	1996	1997	1998	1999	2000
1. Hadejia Basin	←	—	→		
(1) Review & Analyse of Data	—				
(2) Data Collection	—				
(3) Site Survey	—				
(4) Installation of Gaging Stations	—				
(5) Water Management practice		—			
(6) Formulation of Management Plan			—		
2. Sokoto-Rima Basin			←	—	→

(2) Rehabilitation Works

(a) Ordinary Rehabilitation Works

The ordinary rehabilitation works will be composed of the items as mentioned in 4.4.2 (3). Dam and Reservoir Operation Department in FMWRRD has carried out the survey to identify the defects of the existing dams. Accordingly the rehabilitation program for the defects will be urgently set up in the following manner:

- Review of inventory survey result by site survey and identification of the size of rehabilitation works.
- Classification of the rehabilitation works from view point of size, urgency and execution method by RBDA force account or by the contractor on contract basis.
- Detailed design and construction plan for the rehabilitation works.
- Provision of construction equipment, if RBDA or OM office implement the works.
- Execution of the works.

(b) Particular Rehabilitation Works

As for the particular rehabilitation works in the Goronyo and Bakolori dams, the survey, analysis, detailed design, construction method, specifications for construction shall be either executed or prepared by recruiting the consultants.

The rehabilitation works will be executed by the contractor under the supervision of the consultants.

(c) Rehabilitation Work Schedule

The rehabilitation work schedule is set up as follows;

Item	1996	1997	1998	1999	2000
1. Ordinary Rehabilitation Works					
(1) Review of Inventory Survey Result	———				
(2) Detailed Design / Construction Plan	———				
(3) Procurement of Equipment	———	———			
(4) Execution of Works		———	———	———	
2. Particular Rehabilitation Works					
(1) Survey and Design	———	———			
(2) Execution of Works		———	———		

4. 5. 2 Preparation of the Medium and Small Package Program

(1) Preparation Method

The medium and small dam package program will be prepared by the year 2000 aiming to implement the program after the year 2000. One model river basin with priority to prepare the program will be firstly selected by each RBDA and FMWRRD, although JICA Team proposes tentatively the selection guideline and the proposed basin at each RBDA as described in 4.4.4 (6). The preparation work of the program after selection of the model basin will be carried out by recruiting the consultants.

(a) Master Plan or Pre-Feasibility Study

The basinwide master plan or the pre-feasibility study will be made prior to the feasibility study with the following purposes:

- Identification of a number of the proposed dams and summarization of their outline.
- Analysis of the potential surface water resources.
- Study of the water balance of the potential water resources and the available water to be developed by the proposed dams.
- Selection of the priority tributary basin and the representative dams for the feasibility study.
- Formulation of survey and study items for the feasibility study.

(b) Feasibility Study

The feasibility study will be performed in the above selected tributary basin and the representative dams. The representative dams will be composed of three to five medium and small dams with different size. The study will be made with the international feasibility study level including hydrological analysis, reservoir plan, preliminary design, cost estimation, environment impact, project evaluation, etc.

(c) Formulation of Package Program

In accordance with the feasibility study result, the package program is formulated in the following manner;

- Outline of all proposed dams identified in the master plan will be reviewed based on the data of the feasibility study for the representative dams.
- The proposed dams to be implemented with priority are selected based on the above reviewing result and taking into account the project and budget size, project economy, urgency of each sub project, etc.
- Package program will be classified into the sub-package program consisting of three to five proposed dams.

(2) Particular Attention for the Study

(a) Reservoir

- Active reservoir capacity will be planned with 60 to 70 percent of average annual inflow. The reservoir with large active capacity against average annual inflow will not be filled up to the full water level in dry year, as a result the reservoir operation will be difficult.
- Damsite to be able to obtain the large reservoir capacity by low dam height and short dam length will be selected with the priority for implementation.
- Dead water capacity in the reservoir will be carefully studied taking into consideration sediment transport based on the size of the catchment area. Small dams under the large catchment area shall not be selected.
- The service area shall be located near damsite.

(b) Dam Standard Section

The center core type fill dam as shown in the Database Drawings (24) will be applied for the proposed dams taking into account the prevention of seepage water through dam foundation and the stability of dam body.

(c) Spillway

Spillway will be planned with the non controlled weir without gate. The emergency spillway will be planned, if there should be a suitable site.

(d) Intake and Outlet

- Intake elevation shall be placed so as to carry out the gravity irrigation from the reservoir to the service area.
- Intake will be designed with drop inlet or inclined inlet instead of the intake tower in order to minimize the construction cost.
- Outlet conduit will be designed by reinforced concrete without steel pipes, because of the low reservoir water head of 15 to 25m (medium and small dams).

(e) Construction Period

The medium dams will be constructed in two years, while the small dams in one year.

(3) Work Schedule for the Study

Work schedule for the study of the package program will be as follows:

Item	1996	1997	1998	1999	2000
1. Model Basin with Priority					
(1) Master Plan Study					
Data Collection & Review					
Site Survey					
Analysis & Study					
(2) Feasibility Study					
Topo-Survey					
Geological Investigation					
Construction Material Survey					
Analysis and Study					
(3) Preparation of Implementation					
2. Additional Basin Study					

4. 5. 3 Guideline for Water Management, Dam Planning and OM Work

The integrated water management study in the North region, the rehabilitation works under OM office and dam planning study for the medium and small dam package program will be mainly implemented by the year 2000. In order to carry out the above study and works smoothly and properly, the guideline is prepared and given under Appendices 4-1, 4-2 and 4-3.

It is necessary that NWRI in Kaduna shall emphasize the study to formulate more detailed guideline for the planning and designing and to upgrade the dam engineering through staff training. It is also necessary to request the foreign technical aid to fulfill the above work in NWRI.

4.5.4 Implementation Program

The implementation program for the study and works by the year 2000 is summarized as follows:

Item	1996	1997	1998	1999	2000
1. Integrated Water Management in the north region					
(1) Hadejia Basin					
(2) Sokoto Rima Basin					
2. Rehabilitation Works					
(1) Ordinary Rehabilitation					
(2) Particular Rehabilitation					
3. Preparation of Medium and Small Dam Package Program					
(1) Model Package Program					
(2) Second Package Program					

4.5.5 Terms of Reference for Water Resources Management and Medium/Small Dam Package Program

Terms of Reference for the water resources management in the upper Hadejia and for the medium/small dams package program is prepared as shown in Appendices 4-4 and 4-5.

TABLE 4.2.1 NUMBER BY SIZE OF EXISTING DAMS

	I	II	III	IV	V	VI	VII	VIII	Total
1. Dam Height									
>50 m	1	1	0	0	0	0	0	0	2
30~50 m	1	6	4	0	0	2	0	3	16
15~30 m	7	12	8	4	0	4	1	9	45
<15 m	11	13	9	9	7	26	11	11	97
Total	20	32	21	13	7	32	12	23	160
2. Dam Length									
>3 km	4	2	1	0	0	0	0	8	15
3~2 km	1	2	0	0	0		0	7	10
1~2 km	0	8	5	1	0	3	0	3	20
0.5~1 km	6	7	4	4	0	10	0	1	32
<0.5 km	9	8	8	8	0	8	5	3	49
Total	20	27	18	13	0	21	5	22	126
3. Reservoir Capacity									
>1,000 MCM	1	2	1	0	0	0	0	2	6
500~1,000 MCM	1	0	1	0	0	0	0	1	3
100~500 MCM	3	3	0	0	0	2	0	3	11
10~100 MCM	3	14	9	1	0	5	1	11	44
5~10 MCM	2	3	0	2	0	1	0	3	11
<5 MCM	8	8	5	8	1	24	1	2	57
Total	18	30	16	11	1	32	2	22	132
4. Reservoir Area									
>100 km^2	3	3	2	1	0	0	0	3	12
50~100 km^2	1	0	0	0	0	1	0	0	2
10~50 km^2	3	4	1	0	0	2	0	8	18
5~10 km^2	2	6	3	0	0	1	0	4	16
<5 km^2	6	4	11	10	0	8	1	6	46
Total	15	17	17	11	0	12	1	21	94

TABLE 4.2.2 EXISTING NOTABLE DAMS

H.A	Dam	Active Capacity (MCM)	Dam Height (MCM)	Objective	Completed Year
1	Zibiya	121	21.5	Irri/W.S	1990
1	Zobe	170	18.9	Irri/W.S	1983
1	Bakolori	403	48.0	Irr/H.P	1982
1	Goronyo	833	20.0	Irri/W.S	1984
1	Kainji	11,500	65.5	H.P	1968
1	Kubli	62	23.0	Irri	1992
2	Kontagora	200	32.0	Irri	U.C
2	Asa	344	27.0	W.S	?
2	Kagara	39	31.0	W.S	U.C
2	Jebba	1,000	40.0	H.P	1983
2	Omi	220	43.0	Irri	U.C
2	Zaria	29.8	15.0	W.S	1974
2	Kangimi	59.3	19.2	W.S/Irri	1975
2	Shiroro	6,050	105.0	H.P	1989
2	Suleja	48.6	27.8	W.S	?
2	Ussuman	100	45.0	W.S	1984
3	Balanga	63	41.0	Irri	1987
3	Dadin Kowa	1,770	42.0	Irri/H.P	1988
3	Kiri	325	37.0	Irri	1982
4	Doma	28.5	15.7	Irri	1988
6	Ikere Gorge	565	47.5	Irri/W.S/H.P	U.C
6	Oyan	254	30.4	Irri/W.S/H.P	1983
8	Erinle	92.5	27.0	W.S	1989
8	Gari	203	22.0	Irri	1980
8	Challawa	900	38.0	Irri/W.S	1992
8	Watari	92.7	19.8	Irri	1980
8	Tiga	1,845	47.2	Irri/W.S	1975
8	Kafin Zaki	2,500	40.0	Irri	U.C
8	Tomas	56.6	13.7	Irri	1976
8	Jakar	54.5	14.3	Irri	1976
8	Alau	106	9.5	Irri/W.S	1992

Irri: Irrigation W.S: Water Supply H.P: Hydropower U.C: Under Construction

TABLE 4.2.3 DISTRIBUTION OF EXISTING DAMS ON SHA BASIS (1/2)

SHA		Irrigation Dam						Water Supply Dam					
		Large		Small		Total		Large		Small		Total	
		No	Ac	No	Ac	No	Ac	No	Ac	No	Ac	No	Ac
HA-1	101	1	121			1	121					-	-
	102	1	170			1	170					-	-
	103		403			-	-			1	25	1	25
	104	1	933			1	403	1	3	1	5	2	8
	105	1		1	20	2	953					-	-
	109					-	-	1	5			1	5
	110			1	1	1	1			3	6	3	6
	111			1	2	1	2			1	0	1	0
	113			1	0	1	0			1	0	1	0
	114	2	75			2	75					-	-
Sub-total		6	1,702	4	23	10	1,725	2	8	7	36	9	44
HA-2	203	1	200			1	200	1	16			1	16
	204					-	-	1	34	1	0	2	34
	205			1	0	1	0	1	19			1	19
	206					-	-	2	43	1	3	3	46
	207	1	18			1	18					-	-
	208	1	220	2	18	3	238			1	12	1	12
	209			1	3	1	3					-	-
	211			3	9	3	9	1	30	1	3	2	33
	212					-	-	1	59			1	59
	214			1	21	1	21	2	27			2	27
	216			1	0	1	0	5	195			5	195
Sub-total		3	438	9	51	12	489	14	324	4	18	13	441
HA-3	303	2	335			2	335					-	-
	304	2	1,785			2	1,785	6	116	7	12	13	128
	305	1	63	1	7	2	70					-	-
	310					-	-	1	4			1	4
Sub-total		5	2,183	1	7	6	2,190	7	120	7	12	14	132
HA-4	401			1	0	1	0	1	3	4	4	5	7
	403	1	2			1	2					-	-
	406			2	4	2	4				0	-	-
	407	1	29			1	29			1	0	1	0
	408					-	-			1	4	1	0
Sub-total		2	31	3	4	5	35	1	3	6		7	7
HA-5	501			1	0	1	0				0	-	-
	502			1	0	1	0			1	0	1	0
	504			3	0	3	0			1	0	1	0
Sub-total		0	0	5	0	5	0	0	0	2	0	2	0

Remarks : AC Active reservoir capacity (Unit MCM)

TABLE 4.2.3 DISTRIBUTION OF EXISTING DAMS ON SHA BASIS (2/2)

SHA		Irrigation Dam						Water Supply Dam					
		Large		Small		Total		Large		Small		Total	
		No	Ac	No	Ac	No	Ac	No	Ac	No	Ac	No	Ac
HA-6	602	3	824	7	9	10	833			3	11	3	11
	603			1	7	1	7					-	-
	604					-	-			1	3	1	6
	605					-	-	2	123	6	20	8	143
	607					-	-			1	9	1	9
	608					-	-	1	20	6	23	7	43
	610					-	-			1	1	1	1
Sub-total		3	824	8	16	11	840	3	143	18	70	21	213
HA-7	702					-	-	1	2			1	2
	703			2	0	2	0			4	0	4	0
	705			1	0	1	0					-	-
	706			2	0	2	0			1	0	1	0
Sub-total		0	0	5	0	5	0	1	2	5	0	6	2
HA-8	802	1	203	2	111	3	314			1	7	1	7
	803	4	1,032	1	6	5	1,038	1	15	2	13	3	33
	804	4	1,883			4	1,883					-	-
	805	1	2,500	1	20	2	2,520					-	-
	806					-	-			1	1	1	1
	807			2	24	2	24	1	25			1	25
	813			1	106	1	106					-	-
Sub-total		10	5,618	7	267	17	5,885	2	40	4	26	6	66
Total		29	10,796	42	368	71	11,164	30	739	53	166	83	905

Remarks: AC Active reservoir capacity (Unit MCM)

TABLE 4.2.4 DISTRIBUTION OF EXISTING DAMS BY REGION AND OBJECTIVE

	North West HA-1		North East HA-8		Central West HA-2		Central East HA-3, 4		South West HA-6		South East HA-5, 7		Total Nationwide	
	No	A.C	No	A.C	No	A.C	No	A.C	No	A.C	No	A.C	No	A.C
1. Large Dam														
Irrigation	6	1,702	10	5,618	3	438	7	2,214	3	824	0	0	29	10,796
Water Supply	2	8	2	40	14	423	8	123	3	143	1	2	30	739
Hydropower	1	11,500	0	0	2	7,050	3	49	0	0	0	0	6	18,599
Total	9	13,210	12	5,658	19	7,911	18	2,386	6	967	1	2	65	30,134
2. Small														
Irrigation	4	23	7	267	9	51	4	11	8	16	10	0	42	368
Water supply	7	36	4	26	4	18	13	16	18	70	7	0	53	166
Hydro power	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	11	59	11	293	13	69	17	27	26	86	17	0	95	534
3. Dam, Total														
Irrigation	10	1,725	17	5,885	12	489	11	2,225	11	840	10	0	71	11,164
Water supply	9	44	6	66	18	441	21	139	21	213	8	2	83	905
Hydro power	1	11,500	0	0	2	7,050	3	49	0	0	0	0	6	18,599
Total	20	13,269	23	5,951	32	7,980	35	2,413	32	1,053	18	2	160	30668

Remark, Large dam > Height of 15m, Small dam < Height of 15m
A.C; Active reservoir capacity (Unit MCM)

TABLE 4.3.1 COMPARISON OF RESERVOIR INFLOW AND ACTIVE RESERVOIR CAPACITY IN EXISTING LARGE IRRIGATION DAMS

HA	Dam	Reservoir Inflow (MCM)	Active Capacity (MCM)	Rate of Inflow / capacity	Remarks
HA-1	Jibiya	260	121	2.1	◎
HA-1	Zobe	240	170	1.4	○
HA-1	Bakolori	760	403	1.9	◎
HA-1	Goronyo	660	933	0.7	×
HA-1	Kubli	160	62	2.5	◎
HA-2	Kontagora	270	200	1.4	○
HA-2	Omi	260	220	1.2	○
HA-3	Balanga	86	63	1.4	○
HA-3	Waya	29	15	1.9	◎
HA-4	Doma	21	28.5	0.7	×
HA-6	Ikere Gorge	1,020	565	1.8	◎
HA-6	Oyan	2,250	254	8.8	◎
HA-8	Gari	120	203	0.6	×
HA-8	Challawa	420	900	0.5	×
HA-8	Guzuguzu	22	21.5	1.0	△
HA-8	Magaga	24	17.2	1.4	○
HA-8	Watari	65	92.7	0.7	×
HA-8	Tudun Wada	18	16.6	1.1	△
HA-8	Tiga	830	1,845	0.4	×
HA-8	Bagauda	41	20.9	2.0	◎
HA-8	Kafin Zaki	1,060	2,500	0.4	×
HA-8	Kafin Chiri	35	24.6	1.4	○
HA-8	Tomas	59	56.6	1.0	△
HA-8	Jakara	56	54.5	1.0	△
HA-8	Garara	46	20	2.3	◎
HA-8	Alau	164	106	1.5	○

Remarks Mark ◎ Abundant inflow ○ Moderate inflow
△ Poor inflow × Insufficient inflow

TABLE 4.3.2 EVALUATION OF EVAPORATION LOSS FROM RESERVOIR AREA (1/2)

HA	Dam	Reservoir Inflow (MCM) ①	Active Capacity (MCM) ①	Reservoir Area (km^2) ②	Pan-Evapo Value (mm) ③	Evapo-Loss in Dry Season (MCM) ④=②×③×0.4	Evapo-Loss Rate (%) ⑤=④÷①	Remarks
HA-1	Jibiya	260	121	26	3,500	36.4	30	O
	Zobe	240	170	45	3,500	63	37	O
	Bakolori	760	403	80	3,000	96	24	
	Goronyo	* 660	933	200	3,500	280	42	O
	Kubli	160	62	9.4	2,500	9.4	15	
	Bubo	41	25.1	11.5	2,800	12.9	51	O
	Mairuwa	24	5.3	1.6	2,800	1.8	34	O
HA-2	Kontagora (2)	270	200	39	2,500	39	20	
	Kagara	40	38	5.8	2,800	7.3	19	
	Omi	260	220	25.7	2,500	25.7	12	
	Zaria	450	29.8	8	2,800	9	30	O
	Kangimi	1,800	59.3	6.6	2,500	6.6	11	
	Tagwai	33	26.5	5.5	2,500	5.5	21	
	Iku	42	36.2	4.3	2,500	4.3	12	
	Suleja	42	48.5	7.4	2,500	7.4	15	
	Usuma	260	100	8	2,500	8	8	
	Tungan Kawo	34	21	4	2,500	4	19	
HA-3	Liberty	33	15	1.1	2,800	1.2	8	
	Balanga	86	63	11	2,800	12.3	20	
	Y.Gowon	30	24	5	2,500	5	21	
	Dadin Kowa	3,100	1,770	300	2,800	336	19	
	Gubi	45	35	5.9	2,800	6.6	19	
	Waya	29	17	4.5	2,800	5	29	
	Kiri	4,480	325	110	2,500	110	34	O
	Lantang	31	3.5	0.6	2,500	0.6	17	
	Tenti	22	9.8	4	2,500	4	41	O
	Cham	20	6.5	1.8	2,500	1.8	28	
HA-4	Pankshin	42	2.8	0.5	2,500	0.5	18	
	Doma	* 21	30	2.2	2,500	2.2	9	
HA-6	Ikere Gorge	1,020	565	53	2,000	42.4	8	
	Oyan	2,250	254	40	2,000	32	13	
	Asejire	1,860	30.5	5.3	2,000	4.2	14	
	Erinle	360	75	16.4	2,000	13.1	17	
	Awon	88	8.4	2	2,000	1.6	19	
	Eleyele	17	5.5	1.6	2,000	1.3	24	

TABLE 4.3.2 EVALUATION OF EVAPORATION LOSS FROM RESERVOIR AREA (2/2)

HA	Dam	Reservoir Inflow (MCM) ①	Active Capacity (MCM) ①	Reservoir Area (km^2) ②	Pan-Evapo Value (mm) ③	Evapo-Loss in Dry Season (MCM) ④=2×③×0.4	Evapo-Loss Rate (%) ⑤=④÷①	Remarks
HA-8	Tundan Wada	18	16.6	3.5	3,500	4.9	30	○
	Gari	* 120	203	33.2	3,500	46.5	39	○
	Challawa	* 420	900	100	3,500	140	33	○
	Guzuguzu	22	21.5	6.4	3,500	9	42	○
	Magara	24	17.2	3.7	3,500	5.2	30	○
	Watari	65	92.7	19.6	3,500	27.4	30	○
	Tiga	* 830	1,845	178	3,500	249	30	○
	Kafin Zaki	* 1,060	2,500	235	3,500	329	31	○
	Kafin Chiri	35	24.6	8.4	3,500	11.8	48	○
	Tomas	59	56.6	15	3,500	21	37	○
	Jakara	56	54.5	16.6	3,500	23.2	43	○
	Galala	46	20	1.1	3,500	1.5	8	
	Alau	164	106	50	3,500	70	66	○

Remark (1) Evaporation loss in dry season is estimated by the following assumption

(a)	Average reservoir area during operation;	Reservoir area × 0.8
(b)	Evaporation from large surface area;	Annual Pan-Evapo. Value × 0.7
(c)	Evaporation during dry season	Annual Pan-Evapo. Value × 0.7 (Wet season, 0.3)
(d)	Rate: $0.8 \times 0.7 \times 0.7 \doteq 0.4$	
(e)	Evaporation loss in dry season;	Area × Pan - Evapo. Value × 0.4

(2) Evapo-Loss rate is estimated as follows:
Evapo-Loss in dry season ÷ Active capacity (Reservoir inflow)
In case, reservoir inflow value is smaller than active capacity value, reservoir inflow value is adopted for available reservoir capacity, because active capacity is not filled by reservir inflow.

(3) Mark ○ shows presenting high evaporation losses.

TABLE 4.3.3 SUMMARY OF EVALUATION FOR AVAILABLE RESERVOIR WATER IN EXISTING DAMS

Items	Unit	Hydrological Area (HA)								Total
		1	2	3	4	5	6	7	8	
1. Reservoir Inflow (RI)	MCM	3,850	4,320	7,880	200	-	14,270	-	3,280	33,800
2. Active Capacity (A.C)	MCM	1,750	940	2,280	60	20	1,030	30	5,940	12,050
3. Evapo-Losses (E.L.)	MCM	620	140	490	0	0	90	0	1,060	2,400
4. Total Available Water (AW)	MCM	980	790	1,570	50	20	890	40	2,120	6,460
5. Downstream Water (D.W.)	MCM	270	80	260	0	0	50	0	730	1,390
6. Irrigation Water (IW)	MCM	580	380	1,140	20	10	490	20	1,120	3,760
7. Water supply Water (W.S.W.)	MCM	130	330	170	30	10	350	20	270	1,310
Rate of Reservoir Water Use										
(1) A.C/R.I 2÷1	%	45	22	29	30	-	7	-	181	36
(2) E.L/R.I 3÷1	%	16	3	6	0	-	1	-	32	7
(3) E.L/A.C 3÷2	%	35	15	21	0	0	9	-	18	20
(4) A.W/R.I 4÷1	%	25	18	20	25	-	6	-	65	19
(5) A.W/A.C 4÷2	%	56	84	69	83	100	86	130	36	54
(6) D.W/A.C 5÷2	%	15	9	11	0	-	5	0	12	11

Remark: (1) Reservoir inflow is not available at many existing dams in HA 5 and 7.

(2) In case reservoir inflow is less than active reservoir capacity, the inflow value is used for evaluation of available reservoir water.

TABLE 4.3.4 EVALUATION OF AVAILABLE WATER IN EXISTING DAMS (UNIT MCM) (1/3)

HA	Dam	Objective		Reservoir Inflow	Active Capacity	Evapo-Loss	Carry Over Capacity		Available Reservoir Water ④=①-②-③	Reservoir Water Use in Dry Season				
										Downstream Water		Irrigation/Water Supply		
		I	W.S.	①	①	②	Rate (%)	Capacity ③=①×%		Rate (%)	Water ⑤=④×%	Total ⑥=①-⑤	Irrigation	Water Supply
HA-1														
1010	Jibiya	●	○	260	121	36	15	18	67	20	13	54	37	17
1020	Zobe	●	●	265	170	76	-	-	104	-	22	82	48	34
1030	Tubo	○	●	41	25	13	15	4	8	0	0	8	3	5
1040	Gusau	○	●	410	3	0	0	0	40	0	0	40	10	30
1040	Bakalori	●	-	799	403	139	-	-	326	-	104	222	222	0
1040	Mairuwa	○	●	24	5	0	0	0	3	0	0	3	1	2
1050	Goronyo	●	○	* 710	933	342	-	-	344	-	128	216	203	13
1050	Wurno	●	-	750	20	6	0	0	14	0	0	14	14	0
1090	Zuru	-	●	420	5	0	0	0	10	0	0	10	0	10
1100	4 Small Dams	-	●	-	-	-	-	-	5	-	-	5	0	5
1110	Bin Yauri	●	-	-	2	0	0	0	5	0	0	5	0	5
1110	Nasko	●	○	13	2	0	0	0	3	0	0	3	2	1
1130	2 Small Dams	○	●	-	4	0	0	0	5	0	0	5	2	3
1140	Kubli	●	-	160	62	9	10	6	47	10	5	42	42	0
	Subtotal			3,852	1,755	621		28	981		272	709	584	125
HA-2														
2030	Kontagora (1)	-	●	36	16	4	10	2	10	10	1	9	0	9
2030	Kontagora (2)	●	-	298	200	36	-	-	189	-	11	178	178	0
2040	Asa	-	●	184	34	7	10	3	24	0	0	24	0	24
2040	Offa	-	●	27	-	-	-	-	3	0	0	3	0	3
2050	Ero	○	●	140	19	4	10	2	13	0	0	13	6	7
2050	Oshin	●	-	-	-	-	-	-	5	0	0	5	5	0
2060	Kagara	-	●	40	38	7	20	8	23	20	5	18	0	18
2060	Bagoma	○	●	150	5	0	0	0	15	0	0	15	6	9
2060	Birnin Gwari	○	●	150	3	0	0	0	15	0	0	15	5	10
2070	Guzan	●	○	-	18	4	20	1	13	0	0	13	10	3
2080	Omi	●	○	260	220	26	20	44	150	20	30	120	100	20
2080	Ikole	-	●	22	12	2	20	2	8	0	0	8	0	8
2080	Kpada	●	-	-	14	3	20	3	8	0	0	8	8	0
2080	Apariko	●	○	8	4	0	0	0	4	0	0	4	3	1
2090	Kerawa	●	-	-	3	0	0	0	3	0	0	3	3	0
2110	Zaria	-	●	450	30	9	0	0	21	0	0	21	0	21
2110	Kargi	●	-	-	3	0	0	0	5	0	0	5	5	0
2110	Ikara	○	●	32	3	0	0	0	3	0	0	3	1	2
2110	Matari	●	-	220	8	2	0	0	6	0	0	6	6	0
2110	Baki	●	-	-	3	0	0	0	5	0	0	5	5	0
2120	Kangimi	○	●	1,800	59	7	0	0	52	10	5	47	22	25
2140	Tagwai	-	●	33	27	6	20	5	16	10	2	14	0	14
2140	Tungan Kawo	●	-	37	21	4	-	-	18	-	1	17	17	0
2160	Jabi	-	●	86	5	0	0	0	10	0	0	10	0	10
2160	Iku	-	●	42	36	4	20	7	25	10	3	22	0	22
2160	Suleja	-	●	* 42	49	7	20	10	32	10	3	29	-	29
2160	Pedan	-	●	-	5	0	0	0	10	0	0	10	-	10
2160	Ussuman	-	●	260	100	8	0	0	100	20	20	80	0	80
	Subtotal			4,317	935	140		111	786		81	705	380	325

Remarks, Mark * shows dams having less inflow than active reservoir capacity.

TABLE 4.3.4 EVALUATION OF AVAILABLE WATER IN EXISTING DAMS (UNIT MCM) (2/3)

HA	Dam	Objective		Reservoir Inflow	Active Capacity	Evapo-Loss	Carry Over Capacity		Available Reservoir Water ④=①-②-③	Reservoir Water Use in Dry Season				
										Downstream Water		Irrigation/Water Supply		
		I	W.S.	①	①	②	Rate (%)	Capacity ③=①×%		Rate (%)	Water ⑤=④×%	Total ⑤=④-⑤	Irrigation	Water Supply
HA-3														
3030	Biu	●	○	-	10	3	20	2	5	0	0	5	4	1
3030	Kiri	●	-	4,480	325	110	10	33	182	0	0	182	182	0
3040	Liberty	-	●	33	15	1	20	3	11	0	0	11	0	11
3040	Y. Gowon	-	●	30	24	5	20	3	16	10	2	14	0	14
3040	Gubi	-	●	45	35	7	20	7	23	10	2	21	0	21
3040	Waya	●	○	29	17	5	10	2	10	0	0	10	8	2
3040	Dadin Kowa	●	○	3,100	1,770	336	10	177	1,257	20	251	1,006	900	106
3040	Tenti	-	●	22	10	4	10	1	5	0	0	5	0	5
3040	6 Small Dams	-	●	-	-	-	-	-	10	0	0	10	0	10
3050	Balanga	●	-	86	63	12	20	13	38	0	0	38	38	0
3050	Cham	●	○	20	7	2	0	0	5	0	0	5	4	1
3100	Lantang	-	●	31	4	0	0	0	3	0	0	3	0	3
	Subtotal			7,876	2,280	485		726	1,565		255	1,310	1,136	174
HA-4														
4010	Panksin	-	●	42	3	0	0	0	5	0	0	5	0	5
4010	5 Small Dams	-	●	-	15	0	0	0	15	0	0	15	-	15
4030	Bokkos	●	○	16	2	0	0	0	3	0	0	3	2	1
4060	Naka	●	○	4	2	0	0	0	4	0	0	4	3	1
4060	Umogidi	●	○	12	3	0	0	0	3	0	0	3	2	1
4070	Doma	●	○	* 21	30	2	20	4	15	0	0	15	12	3
4070	Lafia	-	●	44	-	-	-	-	5	0	0	5	0	5
4080	Nasarawa	-	●	64	1	0	0	0	5	0	0	5	0	5
	Subtotal			203	56	2		4	55		0	55	19	36
HA-5														
5010	2 Small Dams	○	●	-	6	0	0	0	5	0	0	5	2	3
5020	1 Small Dams	●	○	-	2	0	0	0	3	0	0	3	2	1
5040	4 Small Dams	●	○	-	8	0	0	0	10	0	0	10	6	4
	Subtotal			-	16	0		0	18		0	18	10	8
HA-6														
6020	Igbojaiye	●	○	38	5	0	0	0	5	0	0	5	3	2
6020	Ikere Gorge	●	○	1,020	565	42	10	57	466	10	46	420	300	120
6020	Oyan	●	○	2,250	254	32	0	0	222	0	0	222	170	52
6020	Ofiki (1)	●	○	200	1	0	0	0	1	0	0	1	1	0
6020	Ofiki (2)	●	○	190	1	0	0	0	1	0	0	1	1	0
6020	Fawfaw	-	●	16	1	0	0	0	1	0	0	1	0	1
6020	Igbohr	●	○	20	1	0	0	0	1	0	0	1	1	0
6020	Sepeteri (A)	●	○	57	2	0	0	0	2	0	0	2	2	0
6020	Sepeteri (B)	●	○	54	1	0	0	0	1	0	0	1	1	0
6020	Awon	-	●	88	8	0	0	0	8	0	0	8	0	8
6020	Lekan Are	●	○	14	1	0	0	0	1	0	0	1	1	0
6020	Opeki	-	●	180	2	0	0	0	2	0	0	2	0	2
6020	Mokoloki Div.	●	○	6,150	0	0	0	0	0	0	0	2	2	0
6030	Oke Odan	●	○	15	7	0	0	0	7	0	0	7	5	2
6040	Eleyele	-	●	17	6	0	0	0	6	0	0	6	0	6
6050	Asejire	-	●	1,860	31	0	0	0	31	0	0	31	0	31

Remarks, Mark * shows dams having less inflow than active reservoir capacity.

TABLE 4.3.4 EVALUATION OF AVAILABLE WATER IN EXISTING DAMS (UNIT MCM) (3/3)

HA	Dam	Objective		Reservoir Inflow	Active Capacity	Evapo-Loss	Carry Over Capacity		Available Reservoir Water ④=①/②-③	Reservoir Water Use in Dry Season				
										Downstream Water		Irrigation/Water Supply		
		I	W.S.	①	①	②	Rate (%)	Capacity ③=①×%		Rate (%)	Water ⑤=④×%	Total ⑥=④-⑤	Irrigation	Water Supply
6050	Elinle (1)	-	O	360	75	8	0	0	67	0	0	67	0	67
6050	Otin	-	O	310	5	0	0	0	5	0	0	5	0	5
6050	Eko-Ende	-	O	310	5	0	0	0	5	0	0	5	0	5
6050	Ayiba	-	O	14	2	0	0	0	2	0	0	2	0	2
6050	Elinle (2)	-	O	670	4	0	0	0	4	0	0	4	0	4
6050	Oba	-	O	45	4	0	0	0	4	0	0	4	0	4
6050	Esa-Odo	O	O	355	-	-	-	-	-	0	0	0	0	0
6070	Owena	O	O	43	9	2	0	0	7	0	0	7	2	5
6080	Egbe	-	O	670	20	2	0	0	18	0	0	18	0	18
6080	Owo	-	O	9	-	-	-	-	2	0	0	2	0	2
6080	Ado-Ekite	-	O	9	9	2	20	2	5	0	0	5	0	5
6080	Ojirami	-	O	10	4	1	0	0	3	0	0	3	0	3
6080	Ayede	-	O	20	-	-	-	-	3	0	0	3	0	3
6080	Ikare	-	O	9	8	2	20	2	4	0	0	4	0	4
6100	Ikpoba	-	O	260	-	-	-	-	5	0	0	5	0	5
	Subtotal			14,268	1,033	91		61	891		46	845	489	356
HA-7														
7020	Obudu	O	O	15	2	0	0	0	3	0	0	3	1	2
7030	6 Small Dams	O	O	-	18	0	0	0	20	0	0	20	8	12
7050	Umopara	O	-	-	3	0	0	0	5	0	0	5	3	2
7060	3 Small Dams	O	O	-	9	1	0	0	8	0	0	8	5	3
	Subtotal			15	32	1		0	36		0	36	17	19
HA-8														
8020	Gari	O	O	* 120	203	47	20	24	49	0	0	49	40	9
8020	Ibrahim Adamu	O	O	-	7	4	0	0	3	0	0	3	1	2
8020	Tomas	O	-	65	57	25	-	-	25	-	6	19	19	0
8020	Jakara	O	-	65	55	26	-	-	24	-	3	21	21	0
8030	Karaye	-	O	16	15	3	20	3	9	0	0	9	-	9
8030	Challawa	O	O	460	900	130	-	-	330	-	130	200	130	70
8030	Guzuguzu	O	-	22	22	9	20	4	9	0	0	9	9	0
8030	Magara	O	O	24	17	5	20	3	9	0	0	9	7	2
8030	Watari	O	O	* 75	93	32	-	-	20	-	3	17	17	0
8030	Marashi	O	-	9	6	3	20	1	2	0	0	2	2	0
8030	Pada	O	O	13	11	5	20	2	4	0	0	4	2	2
8030	Kango	O	O	9	8	4	20	2	2	0	0	2	1	1
8040	Tudun Wada	O	-	18	17	5	20	3	9	0	0	9	9	0
8040	Tiga	O	O	* 910	1,845	270	-	-	700	-	270	430	280	150
8040	Bagauda	O	O	41	21	5	10	2	14	0	0	14	4	10
8050	Kafin Zaki	O	-	* 1,170	2,500	400	-	-	860	-	310	550	550	0
8050	Galala	O	-	46	20	2	10	2	16	10	2	14	14	0
8070	Kafin Chiri	O	O	35	25	12	20	5	8	0	0	8	3	5
8070	Warwade	O	O	21	10	5	10	1	4	0	0	4	3	1
8130	Alau	O	O	164	106	70	10	11	25	10	3	22	12	10
	Subtotal			3,283	5,938	1,062		63	2,122		727	1,395	1,124	271
	Total			33,814	12,045	2,405		993	6,454		1,381	5,073	3,759	1,314

Remarks: (1) Mark * shows dams having less inflow than active reservoir capacity.
(2) Evaluation value of DAM, described by bold letter in the table is estimated by the reservoir operation study result of the JICA Team.

TABLE 4.3.5 EVALUATION OF DEAD RESERVOIR CAPACITY & SPILLWAY FLOOD CAPACITY BASED ON CATCHMENT AREA (1/2)

HA	Dam	Catchment Area (km^2)	Reservoir Area (km^2)	Active Capacity (MCM)	Dead Reservoir Capacity			Spillway Flood Capacity		
					Design (MCM)	Specific Yield (m^3/km^2)	Remark	Design (m^3/sec)	Specific Yield (m^3/sec/km^2)	Remark
HA-1	Jibiya	3,700	26	121	21	110		2,200	0.6	
	Zobe	2,309	45	170	7	60	●	1,087	0.5	
	Bakolori	4,857	80	403	47	190		3,750	0.8	
	Goronyo	21,445	200	933	9	10	●	1,540	0.1	●
	Zuru	3,170	23.5	5	1	10	●	432	0.1	●
	Kubli	791	9.4	62	13	330		522	0.7	
	Bubo	171	11.5	25.1	10.4	1,220	○	220	1.3	
	Mairuwa	120	1.6	5.3	0.2	30	●	43	0.4	
	Nasko	52	0.6	2.0	0.6	230		40	0.8	
HA-2	Kontagora (2)	2,000	39	200	140	1,450	○	240	0.1	●
	Asa	918	-	34.4	8.6	190		-	-	
	Ero	610	-	18.5	1.5	50	●	-		
	Kagara	158	5.8	38	5	630	○	197	1.2	
	Omi	1,640	25.7	220	14	170		3,550	2.2	
	Zaria	3,200	8	29.8	16	100		-	-	
	Kangimi	14,946	6.6	59.3	14.8	20		-	-	
	Tagwai	110	5.5	26.5	1.8	330		-	-	
	Iku	144	4.3	36.2	6.5	900	○	-	-	
	Suleja	144	7.4	48.5	3.5	490	○	-	-	
	Ussuman	1,315	8.0	100	20	300		-	-	
	Birnin Gwari	594	2.0	3.2	0.8	30	●	56	0.1	●
	Apariko	21	-	4.0	0.7	670	○	134	6.4	○
	Ikara	108	-	3.0	0.4	70	●	400	3.7	
	Matari	1,090	36	8.2	4.4	80	●	1,800	1.7	
	Tungan Kawo	166	4	21.0	1.0	120		85	0.5	
HA-3	Liberty	113	1.1	15	5	890	○	96	0.8	
	Balanga	385	11	63	10	520	○	2,500	6.5	○
	Y. Gowon	100	5	24	6	1,200	○	248	2.5	
	Dadin Kowa	32,700	300	1,770	1,085	660	○	1,110	0.03	●
	Gubi	179	5.9	35	3	340		-	-	
	Waya	106	4.5	17	4	750	○	-	-	
	Kiri	52,700	110	325	290	110		4,000	0.1	●
	Langtang	104	0.6	3.6	1.1	210		79	0.8	
	Tenti	90	4	9.8	4.2	930	○	171	1.9	
	Cham	66	1.8	6.6	1.6	45	●	30	0.5	

TABLE 4.3.5 EVALUATION OF DEAD RESERVOIR CAPACITY & SPILLWAY FLOOD CAPACITY BASED ON CATCHMENT AREA (2/2)

HA	Dam	Catchment Area (km^2)	Reservoir Area (km^2)	Active Capacity (MCM)	Dead Reservoir Capacity			Spillway Flood Capacity		
					Design (MCM)	Specific Yield (m^3/km^2)	Remark	Design (m^3/sec)	Specific Yield (m^3/sec/km^2)	Remark
HA-4	Pankshin	156	0.5	2.8	1.2	150		165	1.1	
	Dp,a	60	2.2	30	7.5	2,500	○	63	1.1	
	Naka	11	1.5	2	0.6	910	○	6	0.5	
	Imogidi	40	1.0	1.8	0.7	350		100	2.5	
	Lafia	146	0.1	0.1	0.1	10	●	170	1.2	
HA-6	Ikere Gorge	4,620	53	565	125	541	○	6,850	1.5	
	Oyan	9,000	40	254	16	36	●	3,440	0.4	●
	Asejire	7,424	5.3	30.5	2.4	6	●	5,130	0.7	
	Elinle	1,200	16.4	75	19	25	●	1,520	1.3	
	Egbe	2,389	-	20.3	2.7	23	●	453	0.2	●
	Awon	250	2.0	8.4	1.6	130		255	1.0	
	Eleyele	42	1.6	5.5	1.5	710	○	368	8.8	○
	Eko-Ende	883	4.9	4.5	1.0	20	●	877	1.0	
HA-8	Gari	1,155	33.2	203	11	190		-	-	
	Challawa	3,859	100	900	30	155		3,850	1.0	
	Guzuguzu	106	6.4	21.5	3.1	585	○	-	-	
	Magaga	119	3.7	17.2	2.5	420	○	-	-	
	Watari	653	19.6	92.7	11.8	361		-	-	
	Tiga	6,641	178	1,845	123	370		3,257	-	
	Kafin Zaki	5,300	235	2,500	200	755	○	1,460	0.3	●
	Kafin Chiri	225	8.4	24.6	6.5	678	○	-	-	
	Tomas	585	15	56.6	3.7	126		-	-	
	Jakara	559	16.6	54.5	10.9	390		-	-	
	Galala	462	1.1	20	3	130		-	-	
	Alau	4,105	50	106	6.4	31	●	251	0.1	●

Remarks (1) Specific Yield of Sediment transport = Design dead Capacity ÷ (Catchment area × 50 years)

(2) Specific Yield of Spillway Flood = Design flood capacity ÷ Catchment area

(3) Mark ○ ; Large design capacity

(4) Mark ● ; Small design capacity

TABLE 4.3.6 DEFECTIVE ITEMS IN THE EXISTING DAMS

Dam	Content
Zobe (HA-1)	(1) A little seepage through dam foundation and deteriorated concrete at outlet conduit.
Bakolori (HA-1)	(1) Large seepage through inlet chamber of minihydro power plant (suspension of plant operation).
Goronyo (HA-1)	(1) Large seepage through dam foundation (urgent need of remedial works from viewpoint of dam safety).
Kubli (HA-1)	(1) Scouring at the downstream of spillway. (2) In complete gate installation at the outlet (sluice gate can't be closed).
Birnin Gwari (HA-2)	(1) Dam Collapse by flood over topping at dam due to small spillway flood capacity.
Kiri (HA-3)	(1) A little seepage through deteriorated concrete at outlet conduit.
Langtang (HA-3)	(1) No Reservoir storage due to leakage through reservoir area and dam foundation.
Doma (HA-4)	(1) Broken pumping equipment to lift up the reservoir water. Upgrading works of gravity system instead of lifting water by pump.
Ikere Gorge (HA-6)	(1) Seepage through concrete joint of intake tower due to poor concrete placing method.
Kafin Chiri (HA-8)	(1) Seepage water through dam foundation. (2) Large vegetation and gully erosion on dam slope. (3) Large sediment deposit at approach canal of spillway.
Birnin Kudu (HA-8)	(1) Seepage water through foundation. (2) Large vegetation and gulley erosion on dam slope. (3) Broken bridge connecting to intake tower. (4) Deteriorated booster pump for water supply.
Galala (HA-8)	(1) Scouring at the downstream of spillway (2) Increasing of dam height due to insufficient reservoir capacity against much reservoir inflow.
Bagauda	(1) Treatment of meandering channel at the downstream of spillway to release flood smoothly. (2) Backfill at the borrow area located at the downstream toe of left dam embankment.
Other Small Dams	(1) Many sediment deposit at the reservoir upstream and at approach channel of spillway. (2) Some seepage water through foundation. (3) Large vegetation and gully erosion on dam slope. (4) Large aquatic weed covering reservoir surface water. (5) Sweeping off of riprap material by reservoir surface water. (6) Defect of gate and valve to be repaired.

TABLE 4.3.7 SUMMARY OF EVALUATION FOR DAM CONSTRUCTION COST (10^3 US$)

Items	Challawa Gorge Dam	Kafin Zaki Dam	Kwali Dam	Rafin Jatau Dam	Kontagora Dam	Kagara Dam
1. Dam Construction Cost						
Dam Excavation	5,580	22,530	2,240	5,150	5,020	7,270
Grouting	1,970	29,440	4,540	-	780	5,470
Dam Embankment	22,860	156,030	21,740	15,970	22,080	12,300
Outlet / Spillway	13,370	18,320	14,560	4,410	10,590	630
Irrigation Canal / Road	-	-	-	-	9,670	-
Others	5,570	19,550	6,690	2,330	4,480	9,030
Contingency	2,470	31,910	6,540	-	2,350	4,590
Total	51,820	277,780	56,310	27,860	54,970	39,290
2. Rate of Major Works	(%)					
Dam Excavation / Embankment	65	79	56	83	70	76
Grouting	5	13	11	0	2	21
Outlet / Spillway	30	8	33	17	28	3
3. Average Cost / Embankment						
Embank, Volume (10^3)	5,000	19,070	1,470	1,230	1,900	980
Cost / m^3 ($/ m^3)	10.4	14.6	38.3	22.7	28.9	40.0

Remark (1) Construction cost of Kawali dam / cu.m is a little high as 38.3$/$m^3$, because the dam is diversion dam which requires high cost for concrete and gate against overflow weir.

(2) Construction cost for Kagara also show a little high cost of 40$/$m^3$ caused by high other cost which includes resettlement cost and restroration cost for temporary suspension.

TABLE 4.3.8 EVALUATION OF DAM CONSTRUCTION COST (1/2)

Description of works	Unit	Challawa Gorge Dam				Kafin Zaki under Contract						Kawali Diversion Dam under Contract						
		Q'ty	Const. cost LC	Convert to US$	Unit Rate	Q'ty	Const. Cost		Convert to US$			Unit Rate US$	Q'ty	Const. Cost		Convert to US$			Unit Rate US$
							L.C	FC	L.C	FC	Total			L.C	FC	L.C	FC	Total	
			10^3N	10^3	US$		N 10^3	DM 10^3	10^3	10^3	10^3			N 10^3	DM 10^3	10^3	10^3	10^3	
1. General & Preliminary Item	L.S	-	24,000	1,600	-	L.S	72,700	10,200	3,640	6,370	10,010		L.S	39,520	6,550	1,980	4,090	6,070	-
2. Site Clearance	ha	3.4	170	10	3.0	152	2,080	1,000	100	620	720	4.7	22.6	310	150	20	90	110	4,870
3. Dam Excavation, Earth	10^3m^3	2,740	65,490	4,370	1.6	940	10,330	4,830	520	3,020	3,540	3.8	93	1,260	580	60	360	420	4.6
4. Dam Excavation, Rock	10^3m^3	69	9,160	610	8.8	1,370	47,900	21,320	2,400	13,330	15,730	8.4	118	3,400	1,510	170	940	1,110	9.4
5. Foundation Treatment	10^3m^2	L.S	8,790	590	-	1,750	12,520	3,060	630	1,910	2,540	1.5	231	2,850	740	140	460	600	2.6
6. Exploratory Drilling	10^3m	-	-	-	-	14.6	18,630	5,940	930	3,710	4,640	318	2.3	4,090	1,310	210	820	1,030	448
7. Drilling for Grout Hole	10^3m	36.7	17,100	1,140	31.0	72.8	31,540	10,050	1,580	6,280	7,860	108	14.8	3,500	1,130	180	710	890	60
8. Grounting works	10^3no	1.2	12,390	830	690	36.0	23,400	8,350	1,170	5,220	6,390	175	9.0	9,680	3,430	480	2,140	2,620	291
9. Slurry Trench	10^3m^2	-	-	-	-	60.0	38,320	13,810	1,920	8,630	10,550	176	41.5	30,520	10,600	1,530	6,630	8,160	197
10. Dam Embankment Earth	10^3m^3	4,450	132,220	8,810	2.0	14,470	238,000	114,900	11,900	71,830	83,730	5.6	983	16,760	8,060	840	5,040	5,880	6
11. Dam Embankment Filter	10^3m^3	-	-	-	-	3,290	73,220	28,770	3,660	17,940	21,600	6.6	292	6,600	2,530	330	1,580	1,910	6.5
12. Dam Slope Riprap	10^3m^3	545	181,220	12,080	22.2	1,310	159,730	68,330	7,990	42,710	50,700	39	196	18,220	7,810	910	4,880	5,790	30
13. Intake / Outlet, Concrete work	10^3m^3	63.1	157,420	10,490	166	17.5	22,670	8,990	1,130	5,620	6,750	385	23.5	26,030	9,900	1,300	6,190	7,490	318
14. Intake / Outlet, Mechanical Parts	L.S	-	43,200	2,880	-	L.S	38,410	23,080	1,920	14,430	16,350	-	L.S	16,710	9,970	840	6,230	7,070	-
15. Investigation Study	L.S	-	19,500	1,300	-	L.S	5,890	2,680	290	1,680	1,970	-	L.S	1,820	850	90	530	620	-
16. Miscellaneous	L.S	-	69,580	4,540	-	L.S	9,800	3,680	490	2,300	2,790	-	-	-	-	-	-	-	-
17. Contingency	L.S		37,010	2,470		L.S	139,530	39,890	6,980	24,930	31,910	-	L.S	30,630	8,010	1,530	5,010	6,540	-
Total			777,250	51,820			944,740	368,880	47,250	230,530	277,780			211,900	73,130	10,610	45,700	56,310	

Remarks : (1) Challawa Gorge dam construction cost is summarized based on the Final Bill of Quantity in Contract variation.
Conversion rate of Nira to US$ is 15Nira / $ taking into account average rate during construction period.

(2) Kafin Zaki and Kawali dam construction costs are summerized based on the Bill of Quantity just contracted in 1992
Conversion rate; US$ = 20Nira and 1.6DM.

(3) L.C. Local currency (N) F.C. Foreign Currency. (DM or US$)

TABLE 4.3.8 EVALUATION OF DAM CONSTRUCTION COST (2/2)

Description of works	Unit	Rafin Jatau Dam				Kontagora Dam							Kagara Dam						
		Q'ty	Const. cost LC	Convert to US$	Unit Rate	Q'ty	Const. Cost		Convert to US$			Unit Rate US$	Q'ty	Const. Cost		Convert to US$			Unit Rate US$
							L.C	FC	L.C	FC	Total			L.C	FC	L.C	FC	Total	
			10^3N	10^3	US$		N 10^3	DM 10^3	10^3	10^3	10^3			N 10^3	DM 10^3	10^3	10^3	10^3	
1. General & Preliminary Item	L.S	L.S	45,450	2270	-	L.S	3,960	1,140	200	1,140	1,340	-	L.S	24,410	6,620	1,220	4,140	5,360	-
2. Site Clearance	10^3ha	1.2	57,450	2870	2.4	0.2	1,680	450	80	450	530	2,650	0.65	2,780	1,090	140	680	820	13
3. Dam Excavation, Earth	10^3m^3	500	44,270	2210	4.4	359	6,900	1,990	350	1,990	2,340	6.5	1,500	8,820	3,560	440	2,230	2,670	1.8
4. Dam Excavation, Rock	10^3m^3	15	1,420	70	4.7	65	6,390	1,830	320	1,830	2,150	33	40.5	1,920	840	100	520	620	15.3
5. Foundation Treatment	10^3m^2	-	-	-	-	-	-	-	-	-	-	-	26.5	18,560	3,570	930	2,230	3,160	119
6. Drilling for Grout Hole	10^3m	-	-	-	-	2.9	800	230	40	230	270	93	15.6	4,120	1,700	210	1,060	1,270	81
7. Grounting works	10^3no	-	-	-	-	0.48	1,520	430	80	430	510	1,060	1.7	12,780	5,690	640	3,560	4,200	2,470
8. Dam Embankment, Earth	10^3m^3	1,090	210,490	10,520	9.7	1,650	43,950	12,610	2,200	12,610	14,810	9	755	26,060	11,050	1,300	6,910	8,210	11
9. Dam Embankment, Rock	10^3m^3	40	22,310	1,120	28	154	7,300	2,100	370	2,100	2,470	16	68.6	4,340	1,860	220	1,160	1,380	20
10. Dam, Slope Riprap	10^3m^3	100	86,540	4,330	43	95	14,240	4,090	710	4,090	4,800		155.7	10,820	3,470	540	2,170	2,710	17
11. Intake / Outlet, Concrete	10^3m^3	6.5	80,210	4,010	617	20	30,850	8,850	1,540	8,850	10,390		0.74	2,360	810	120	510	630	850
12. Intake / Outlet, Mechanical Parts	L.S	L.S	7,910	400	-	L.S	600	170	30	170	200		-	-	-	-	-	-	-
13. River Diversion Works	L.S	-	-	-	-	L.S	6,710	1,920	340	1,920	2,260		L.S	800	340	40	210	250	-
14. Canal / Road Construction	10^3m^3	-	-	-	-	1,170	28,700	8,230	1,440	8,230	9,670		-	-	-	-	-	-	-
15. Investigation Work	L.S	-	-	-	-	-	-	-	-	-	-		L.S	1,900	960	100	600	700	
16. Miscellaneous	L.S	L.S	1,100	60	60	L.S	2,570	770	130	770	900		L.S	9,660	3,590	480	2,240	2,720	
17. Contingency	L.S	-	-	-	-	L.S	6,970	2,000	350	2,000	2,350		L.S	22,930	5,510	1,150	3,440	4,590	
Total			557,150	27,860			163,140	46,810	8,160	46,810	54,970			152,260	50,660	7,630	31,660	39,290	

Remarks: (1) Rafin Jatau dam construction cost is summerized based on Bill of Quantity of Tender Evaluation in 1993.
Conversion Rate; US$ = 20N

(2) Kontagora dam and Kagara construction costs are summerized based on Bill of Quantity under construction
Conversion Rate; US$ = 20N and 1.6D.M

(3) L.C, Local currency (N) F.C, Foreign Currency (D.M or US$)

TABLE 4.3.9 REMARKABLE INCREASE OF CONSTRUCTION QUANTITY IN CONTRACT VARIATION

Description	Unit	Kontagora Dam			Challawa Gorge Dam		
		Original Quantity	Variation Quantity	Increase Rate	Original Quantity	Variation Quantity	Increase Rate
Dam Excavation, Earth	m^3	276,700	359,000	1.3	1,579,000	2,740,000	1.7
Dam Excavation, Rock	m^3	2,100	65,000	31	6,400	69,000	10.8
Drilling for Grout Hold	m	2,400	2,900	1.2	0	36,700	-
Grouting	no	400	480	1.2	0	1,200	-
Dam Embankment	m^3	1,657,000	1,899,000	1.1	4,973,000	5,000,000	-
Outlet / Spillway Concrete	m^3	6,100	20,000	3.3	14,000	63,100	4.5

Remark: (1) Increase of excavation volume in both dams is caused by unconsolidated and permeable dam foundation, which is not surveyed during detailed design stage.

(2) Drilling and grouting works at Challawa dam were estimated at *N*5,579,000by provisional sum in original contract but increase to *N*38,280,000 due to permeable foundation.

(3) Outlet & spillway was not designed properly in detailed design stage, so that its cost also increases remarkably.

(4) Construction cost of both dams is considerably increased by contract variation as follows;

Dam	Original Contract	Variation Contract
Kontagora	*N*4,070,000 + US$29,900,000	*N*163,140,000 + US$46,810,000
Challawa	*N*328,280,000	*N*777,222,000

TABLE 4.4.1 RESERVOIR OPERATIONS STUDY AT EXISTING DAMS

Dam	Tiga	Challawa	Kafin Zaki	Watari	Jakara	Tomas	Zobe	Goronyo	Bakalori	Konta-gora	Tungen-Kawa
1. River Basin	Chad	Chad	Chad	Chad	Chad	Chad	Rima	Rima	Sokoto	Niger	Niger
2. Major Dimensions											
Reservoir Area (km²)	178	100	235	20	17	15	45	200	80	39	4
Dam Height (m)	47	38	40	20	14	14	19	20	48	32	12
Active Reservoir Capacity (MCM)	1,845	900	2,500	92	55	57	170	933	403	195	21
3. Reservoir Input (MCM p.a.)	79	36									
Annual Runoff (MCM)	831	422	1,058	66	59	59	245	656	757	277	34
Rainfall on Reservoir (MCM)	79	36	116	9	6	6	20	57	42	21	3
Total	910	458	1,174	75	65	65	265	713	799	298	37
4. Present Irrigation											
Originally Planned (ha)	22,000	40,000	125,000	1,700	2,000	1,100	8,200	69,000	23,000	11,200	800
Actually Serviced (ha)	14,000	0	0	1,350	820	200	100	800	4,200	0	400
5. Reservoir Output (MCM p.a.)											
Potential Irrigation (ha)	26,000	12,500	50,000	1,500	2,000	1,800	5,000	17,000	23,000	11,200	1,200
5.1 Irrigation Demand (MCM)	278	132	546	16	21	19	48	203	222	178	17
5.2 Water Supply Demand (MCM)	146	72	-	-	-	-	34	13	-	-	-
5.3 Release to Downstream (MCM)	276	124	312	3	3	6	22	128	104	11	1
5.4 Reservoir Loss (MCM)	272	126	401	32	26	25	76	342	139	36	4
Total (5.1 to 5.4) (MCM)	972	455	1,259	51	50	50	180	686	465	225	22
6. Water Balance (3. - 5.)	-62	3	-85	-24	15	15	85	27	334	73	15
7. Active Reservoir Capacity / Reservoir Input (%)	200	200	210	120	85	88	64	120	50	65	60

TABLE 4.4.2 EXISTING DAM AND IRRIGATION AREA IN THE HADEJIA RIVER BASIN

	Objective		Reservoir Inflow (MCM)	Active Reservoir Capacity (MCM)	Evapo-Loss (MCM)	Available Water in Dry Season (MCM)	Potential Irrigation		Actual Irrigation Area (ha)	Rate Actual / Potential
	Irri.	WS					Area (ha)	Water Demand (MCM)		
1. Challawa Dam	◎	○	460	900	130	330	12,500	120	500	4
2. Tiga Dam	◎	○	910	1,845	270	700	22,000	211	14,000	64
3. Watari Dam	◎	-	75	92	30	20	1,900	18	70	4
4. Tudun Wada	◎	-	18	16.6	5	9	360	4	0	0
5. Bagauda	◎	○	41	20.9	5	14	610	6	300	49
6. Marashi	◎	-	9	5.8	3	2	-	-	-	-
7. Pada	-	◎	13	10.5	5	4	-	-	-	-
8. Magara	◎	○	24	17.2	5	9	600	6	100	17
9. Karaye	-	◎	16	14.7	3	9	-	-	-	-
10. Guzuguzu	◎	-	22	21.5	9	9	530	5	0	0
11. Kafin Chiri	○	◎	35	35	12	8	660	6	0	0
12. Warwada	◎	○	21	10	5	4	200	2	40	20
13. Birnin Kudu	◎	-	9	0.9			-	-	-	-
14. Galala	◎	-	46	20	2	16	1,500	14	0	0
Total			1,699	3,010.1	484	1,134	40,860	-	15,010	37

TABLE 4.4.6 OUTLINE OF PRIORITY RIVER BASIN FOR THE PROPOSED MEDIUM AND SMALL DAM PACKAGE PROGRAM (1/2)

	HA-1		HA-2				HA-3				HA-4			
	whole Basin	Danzaki SHA 110	whole Basin	Awun SHA 204	Galma/ Karami SHA 211	Cboko SHA 214	whole Basin	Kilange SHA 301	Hawal SHA 303	Belwa SHA 307	whole Basin	Ankwe SHA 403	Katsina-Ala SHA 4052 ~53	Mada SHA 407
1. Basin Feature														
(1) Catchment Area (km²)	131,600	813	158,100	7,150	11,630	7,670	158,900	9,450	16,140	7,560	73,000	11,550	8,550	8,730
(2) Agricultural Land (10³ ha)	6,952	425	6,702	413	686	653	4,628	368	552	191	3,929	447	698	272
(3) Population in 2020 (10³)	14,147	746	21,867	1,466	3,761	1,257	15,152	1,183	1,349	1,974	17,602	2,713	1,678	1,260
(4) Population Density (No / km²)	108	91	138	205	323	164	95	125	84	261	159	235	196	144
(5) Agricultural Area / Population (ha)	0.49	0.57	0.31	0.28	0.18	0.52	0.31	0.31	0.41	0.1	0.34	0.16	0.42	0.22
(6) Potential Surface Water (MCM)	22,400	1,100	32,600	1,070	2,930	1,680	49,200	1,430	2,150	2,120	27,400	1,390	12,800	1,010
(7) Potential Surface Water / Population (m³)	1,580	1,480	1,490	730	780	1,340	3,250	1,210	1,590	1,070	2,360	510	7,630	800
2. Existing dam Project														
(1) Number (No)	14	4	28	2	5	2	12	0	0	0	8	0	0	2
(2) Active Capacity (MCM)	1,755	7	935	34	47	48	2,280	0	0	0	56	0	0	30
(3) Available Reservoir Water (MCM)	981	5	786	27	40	34	1,565	0	0	0	55	0	0	20
3. Proposed Dam Project														
(1) Number (No)	64 (50)	14 (7)	304 (230)	29 (17)	23 (17)	24 (0)	140(110)	27 (18)	27 (7)	24 (18)	213(160)	32 (24)	37 (24)	41 (34)
(2) Active Capacity (MCM)	950(250)	204 (35)	4,090(1,150)	527 (85)	540 (85)	778 (0)	2,640(550)	300 (90)	315 (35)	447 (90)	2,050(800)	288(120)	351(120)	310(170)
(3) Available Water (MCM)	630(156)	134 (21)	3,060 (920)	380 (64)	378 (64)	590 (0)	1,900(440)	234 (67)	242 (27)	378 (67)	1,530(640)	213 (90)	240 (90)	231(130)
4. Total Available Water (MCM)	1,611	139	3,846	407	418	624	3,456	234	242	378	1,585	213	240	251
5. Irrigation Project														
(1) Existing Area (10³ ha)	60	1	55	0	1	10	25	0	1	0	15	3	4	2
(2) Proposed area (10³ ha)	55	11	234	30	29	43	125	16	16	25	125	17	19	18
(3) Total (10³ ha)	115	12	289	30	30	53	150	16	17	25	140	20	23	20
(4) Water Demand (MCM)	1,104	115	3,295	340	340	604	2,010	214	228	335	1,624	232	267	232
6. Water Supply Project														
(1) Water Supply Capacity in 1991 (MCM)	103	3	203	25.4	22.6	15.2	44	1.5	1.4	5.2	28	2.7	1.4	2.1
(2) Water Demand in 2020 (MCM)	166	10	642	118	110	52	138	6	7	23	183	11	17	17
(3) Increase Rate of W.S (%)	1.6	3.3	3.2	4.6	4.9	3.4	3.1	3.7	5.3	4.4	6.5	4.1	12.1	8.1
7. Total Water Demande (MCM) {5 (4) + 4(2)}	1,270	125	3,937	458	450	656	2,148	220	235	358	1,807	243	284	249
8. Surface Water Withdrawal Rate (%) {7 ÷ 1 (6)}	6	11	12	43	15	39	4	15	11	17	7	17	2	25

Remarks, ( ) in the above figure shows the value of small dams

TABLE 4.4.6 OUTLINE OF PRIORITY RIVER BASIN FOR THE PROPOSED MEDIUM AND SMALL DAM PACKAGE PROGRAM (2/2)

	HA-5		HA-6				HA-7			
	whole Basin	Mamu SHA 5041	whole Basin	Upper Ogun SHA 6021 ~23	Oshun SHA 605	Osse SHA 608	whole Basin	Aloma SHA 701	Aya SHA 702	Abo Ine SHA 703
1. Basin Feature										
(1) Catchment Area (km^2)	53,900	4,270	100,500	20,140	10,130	13,730	59,800	7,490	8,660	9,490
(2) Agricultural Land (10^3 ha)	1,427	153	4,105	1,290	410	463	3,865	517	711	532
(3) Population in 2020 (10^3)	24,772	5,863	44,355	2,541	5,270	4,003	26,887	2,099	1,999	6,193
(4) Population Density (No / km^2)	460	1,370	441	126	520	292	450	280	231	653
(5) Agricultural Area / Population (ha)	0.06	0.03	0.09	0.51	0.08	0.12	0.14	0.25	0.36	0.09
(6) Potential Surface Water (MCM)	20,000	4,270	35,400	6,600	4,000	4,800	65,700	4,180	4,820	9,240
(7) Potential Surface Water / Population (m^3)	810	730	800	2,600	760	1,200	2,440	1,990	2,410	1,490
2. Existing dam Project										
(1) Number (No)	3	4	31	13	7	5	12	0	2	1
(2) Active Capacity (MCM)	16	8	1,033	844	126	21	104	0	74	18
(3) Available Reservoir Water (MCM)	18	10	1,145	905	152	17	87	0	54	20
3. Proposed Dam Project										
(1) Number (No)	49 (35)	23 (17)	141(100)	36 (18)	27 (18)	22 (18)	144(115)	33 (22)	37 (26)	27 (22)
(2) Active Capacity (MCM)	515(175)	172 (85)	1,410(500)	500 (90)	279 (90)	196 (90)	1,205(575)	278(110)	345(130)	301(110)
(3) Available Water (MCM)	490(160)	161 (76)	1,280(450)	456 (81)	245 (81)	172 (81)	1,110(520)	267(102)	317(117)	280(102)
4. Total Available Water (MCM)	508	171	3,207	1,361	397	189	1,197	267	371	300
5. Irrigation Project										
(1) Existing Area (10^3 ha)	20	2	45	36	1	0	10	0	2	0
(2) Proposed area (10^3 ha)	25	8	60	19	11	9	65	16	16	16
(3) Total (10^3 ha)	45	41	105	55	12	9	75	16	18	16
(4) Water Demand (MCM)	621	138	1,533	803	175	131	990	211	238	211
6. Water Supply Project										
(1) Water Supply Capacity in 1991 (MCM)	16	6	277	4	26	13.9	76	0.6	1.6	0.6
(2) Water Demand in 2020 (MCM)	131	50	1,683	50	86	89	275	9	11	5
(3) Increase Rate of W.S (%)	8.2	8.3	6.1	12.5	3.3	6.4	3.6	14.7	6.9	8.3
7. Total Water Demande (MCM) {5 (4) + 4 (2)}	752	188	3,216	853	261	220	1,265	220	249	216
8. Surface Water Withdrawal Rate (%) {7 ÷ 1 (6)}	4	4	9	13	6	5	2	11	10	14

Remarks, ( ) in the above figure shows the value of small dams

TABLE 4.4.7 EVALUATION OF HIGH PRIORITY RIVER BASIN

Items	Danzaki SHA 110	Awun SHA 204	Gbako SHA 2141	Kilange SHA 301	Mada SHA 407	Mamu SHA 504	Upper Ogun SHA 6021~23	Osse SHA 608	Aya SHA 702
1. Potential Surface Water	○ Mo	○ Mo	◎ H	○ Mo	○ Mo	◎ H	◎ H	◎ H	◎ H
2. Existing Project	◎ F	◎ F	◎ F	◎ Mo	◎ F	○ F	△ Mo	○ F	○ F
3. Proposed Dam	○ Ma	◎ Ma	◎ Ma	◎ Ma	◎ Ma	◎ Ma	◎ Ma	◎ Ma	◎ Ma
4. Population Density	○ Mo	◎ H	○ Mo	◎ H	○ Mo	◎ H	○ Mo	◎ H	◎ H
5. Per Capita farm Land	○ Mo	○ Mo	◎ L	○ Mo	△ S	△ S	◎ L	△ S	◎ H
6. Proposed Irrigation Area	○ Mo	◎ H	◎ H	○ Mo	○ Mo	△ S	○ Mo	△ S	○ Mo
7. Increase Rate of W.S.	○ Mo	○ Mo	○ Mo	○ Mo	◎ H	◎ H	◎ H	◎ H	◎ H
8. Water Withdraw Rate	○ Mo	○ Mo	◎ H	○ Mo	◎ H	△ L	○ Mo	△ L	○ Mo
9. Management	○ Mo	○ Mo	◎ G	◎ G	◎ G	◎ G	◎ G	○ Mo	◎ G
10. Access to site	○ E	△ D	◎ E	◎ E	◎ E	◎ E	○ E	△ D	◎ E
11. Map Availability	○ -	○ -	○	○	○	○	○	△	○
12. Basin Area Size	◎ Mo	◎ Mo	◎ Mo	◎ Mo	◎ Mo	◎ Mo	△ L	△ L	◎ Mo

Remark Mo ; Moderate, F, Few, Ma, Many, H, High L, Large S, Small G, Good E, Easy, D, A little difficult
◎ Best Condition ○ Good Condition △ Poor Condition

The above evaluation is made based on comparison of the condition between whole basin (HA) and the high priority basin.

TABLE 4.4.8 EVALUATION OF RESERVOIR OPERATION FOR KATSINA-ALA HYDROPOWER DAM

(unit MCM)

Month	Reservoir Inflow ①	Reservoir Storage ②	Out flow from Inflow ③=①−②	Out flow from storage ④	Total out flow ⑤=③+④
6	1,570	0	1,570	0	1,570
7	3,060	0	3,060	0	3,060
8	3,710	450	3,260	0	3,260
9	4,450	1,000	3,450	0	3,450
10	4,400	1,000	3,400	0	3,400
11	1,820	0	1,820	0	1,820
12	700	0	700	75	775
1	260	0	260	515	775
2	130	0	130	645	775
3	170	0	170	605	775
4	240	0	240	535	775
5	700	0	700	75	775
Total	21,210	2,450	3,260	2,450	21,210

Remarks; (1) Average monthly runoff in 1980s is adopted for the reservoir inflow.

(2) Reservoir with the capacity of 2,450MCM is filled with the rich inflow from August to October.

(3) The reservoir water storaged in the above three months is used for the power outflow together with the reservoir inflow during dry season from December to May in order to increase the power outflow in dry season.

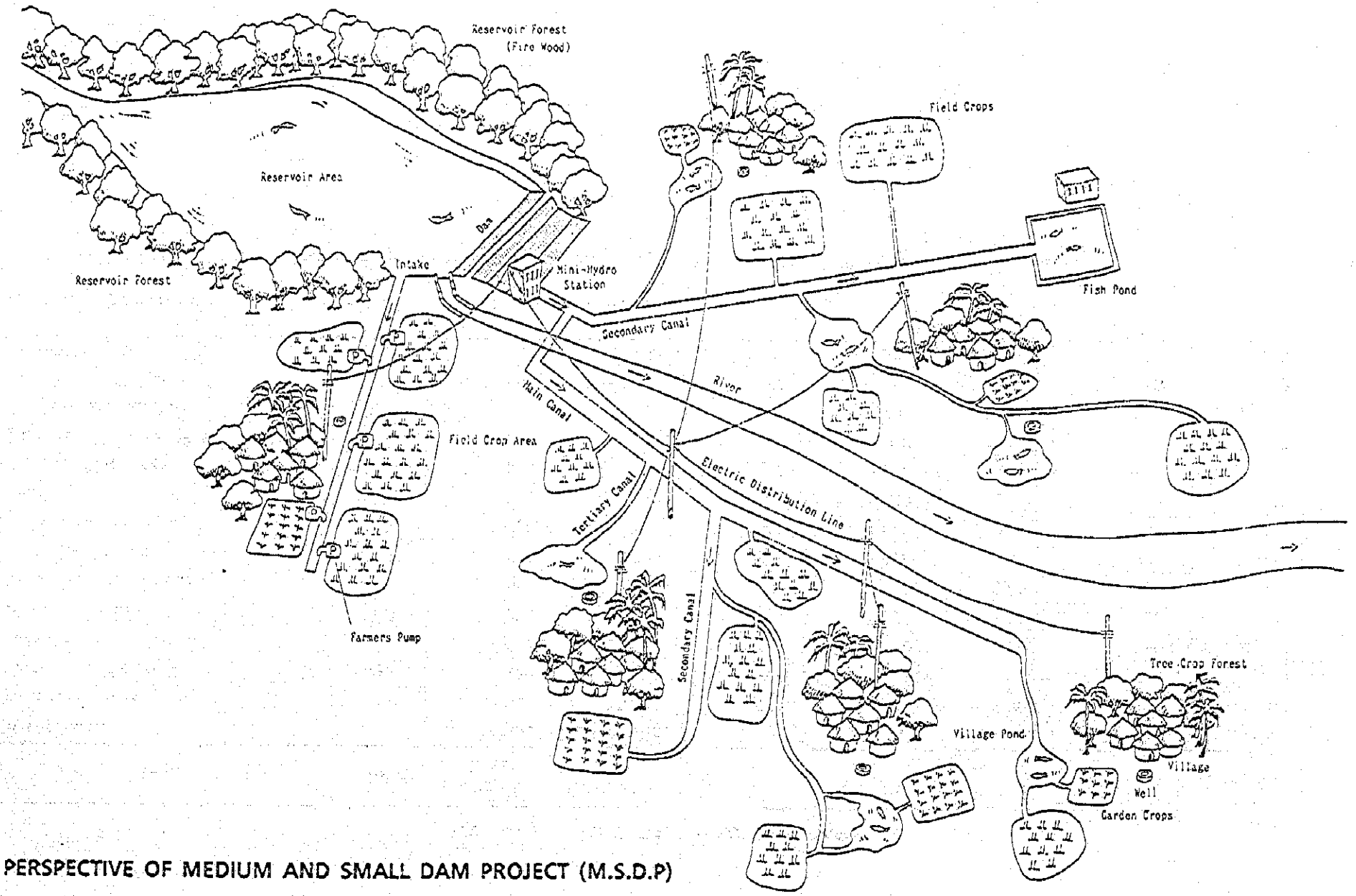
(4) The power outflow in dry season decreases to 25 percent of that in wet season due to small reservoir capacity.

TABLE 4.4.9 POTENTIAL HYDROPOWER DAM

Items	Unit	Zungeru Dam	Katsina-Ala Dam	Suntai Dam	Karamti Dam	Mayo Yim Dam	Su Dam	Kam Dam
River Basin		Kaduna	Katsina-Ala	Donga	Taraba	Taraba	Taraba	Taraba
Catchment Area	km^2	44,400	15,430	1,700	4,800	2,300	1,900	2,600
Runoff specific Yield	mm	230	1,500	800	800	700	700	700
Average Annual Runoff	MCM	10,000	23,000	1,360	3,840	1,600	1,330	1,820
Reservoir Area	km^2	974		30	170	120	60	100
Total Reservoir Capacity	MCM	29,500	2,040	1,700	4,500	2,000	1,800	2,500
Active Capacity	MCM	24,500	1,900	1,400	3,500	1,500	1,300	1,800
Dead Capacity	MCM	5,000	140	300	1,000	500	500	700
Dam Height	m	113	43	60	70	60	50	50
Average Discharge	m^3 / sec	300	730	43	122	51	42	58
Effective Discharge (80%)	m^3 / sec	240	580	34	98	41	34	46
Outflow for Peak Power	m^3 / sec	-		102	294	123	102	138
Power Plant Capacity	MW	950	440	55	190	65	45	60
Annual Production	GWH	6,000	1,900	160	550	190	130	175

Remarks; The above dimension of Zungeru and Katsina-Ala is based on NEPA data.

The dimensions of the other hydropower dam is studied preliminary on the map of 1 to 50,000 scale.



A PERSPECTIVE OF MEDIUM AND SMALL DAM PROJECT (M.S.D.P)

APPENDIX 4-1. GUIDELINE FOR THE INTEGRATED WATER MANAGEMENT STUDY IN THE NORTH REGION

The integrated water management study is to be carried out with the following guideline:

1. Preparatory Work

(1) Data to be Collected and Surveyed

(a) Map of 1 to 50,000 scale

(b) Aerial photograph in the river basin, if available

(c) Hydrological data in the basin on daily basis such as rainfall, evaporation, river runoff.

(d) Outline of the existing dams such as location, reservoir area, reservoir capacity, H-A and H-Q curve, dam dimension, spillway flood capacity.

(e) Outline of the existing irrigation projects such as location, planned area, actual irrigated area, cropping pattern, irrigation schedule, irrigation water demand.

(f) Outline of the existing water supply projects such as location, projected service population and water demand, supply capacity and dimension of the existing waterworks, actual water supply volume under the existing waterworks, etc.

(g) Outline of the wet land condition along the downstream river of the damsite such as the river slope and width, branched off tributaries, agricultural area, present water use, water right, etc.

If the above data are not available, the inventory survey including the site survey shall be carried out to collect data.

(2) Review and Analysis based on the Collected data

(a) Runoff analysis by formulation of the runoff model at each damsite and the control points along the river.

(b) Review of the water demand for irrigation and water supply.

(c) Analysis of the evaporation and seepage loss from the reservoir.

(d) Analysis of the water loss along the downstream river.

(e) Alternative water allocation to the downstream area.

(f) Review of the outlet discharge capacity based on the reservoir water head and the opening degree of gate or valve at the outlet.

(3) Site Survey

(a) Selection of location for the gaging stations to be installed at the upstream river of the reservoir for the inflow observation, in the reservoir to monitor the reservoir water level, and along the downstream river of the damsite to monitor the released water from the reservoir. In addition, selection of location along the river to install the monitoring well to monitor the water level for the sub-surface ground water in Fadama Area.

(b) Identification of the deteriorated and defective facility and structure to be rehabilitated in the existing dams.

(c) Survey for the sediment accumulation condition at the upstream and surrounding area of the reservoir.

(d) Survey for the downstream river condition at the river reaches which take place the large seepage loss and have many branched off channels.

(e) Survey for the present water use condition for the irrigation and water supply in the service area.

2. Installation of Gaging Stations and Monitoring Wells and Hydrological Observation

(1) Installation

(a) Provision of the hydrological equipment.

(b) Design and construction of gaging stations and monitoring wells.

(2) Discharge Measurement and Rating Curve

(a) Discharge measurement at gaging station.

(b) Review of the existing rating curve and preparation of new rating curve based on discharge measurement at the stations.

(3) Water Level Monitoring at Wells

Monitoring of the sub-surface water level at the wells in wet and dry season.

3. Reservoir Operation Study

(1) Operation Study

The alternative reservoir operation study based on the different water demands.

(2) Optimum Reservoir Operation Rule

Formulation of the optimum reservoir operation rule based on the above operation study.

4. Water Management Practice

(1) Reservoir Operation Practice

(a) Reservoir inflow observation.

(b) Outflow practice based on the proposed optimum reservoir operation rule taking into account the reservoir inflow.

(c) Monitoring of the reservoir water level fluctuation based on the above outflow practice.

(d) Data complication based on the above practice and monitoring result.

(2) Monitoring Practice for Released Water from Reservoir

(a) Simultaneous monitoring of the water level fluctuation at the representative gaging station along the river based on the different released water from the reservoir such as 10 m^3/sec, 30 m^3/sec, 50 m^3/sec, etc.

(b) Simultaneous monitoring of the fluctuation of the sub-surface water level at the wells based on the above discharge.

(c) Monitoring period of six months under the continuous outflow from the reservoir.

5. Establishment of Water Management Plan

(1) Analysis of the Water Management Practice

(a) The reservoir water level fluctuation comparing the reservoir operation rule previously set up.

(b) Analysis of the water loss along the river based on the monitoring result at the gaging stations and wells.

(c) Review of the reservoir operation rule taking into account the analyzed water loss along the river.

(2) Preparation of the Optimum Water Management Plan

(a) Formulation of the optimum water allocation plan, taking into account the water loss.

(b) Formulation of the standard outflow guideline in wet and dry season on 10 days basis.

(c) Preparation of the reservoir operation rule curve.

(d) Preparation of the guideline for the outflow in the abnormal dry season with less reservoir inflow.

(e) Formulation of the rehabilitation and upgrading plan for the existing dams.

(f) Formulation of the river improvement plan to minimize the water loss.

(g) Preparation of the operation and maintenance manual for each dam.

(h) Preparation of data compiling form for the water management.

APPENDIX 4-2. GUIDELINE FOR PLANNING OF MEDIUM AND SMALL DAM PACKAGE PROGRAM

1. Master Plan or Pre-Feasibility Study

The master plan or the pre-feasibility study shall be performed at the model river basin with the priority at each RBDA.

(1) Data to be Collected

(a) Aerial Photograph and the map of 1 to 50,000 scale.

(b) Hydrological data in the basin or the adjacent basin.

(c) Socio-economic data at LGA in the basin.

(d) General geological map in the basin.

(e) Existing water resources projects including location and outline.

(f) Other necessary data.

(2) Preparatory Work for the Study in the Office

(a) Division of the basin into the several tributary basins with the catchment area of 1,000 to 2,000 km^2 on the map of 1 to 50,000 scale and measurement of their catchment area.

(b) Study for the basin salient feature such as the basin topography and geology, tributary system, land use, socio-economy, etc.

(c) Study for hydrological condition such as aerial rainfall and evaporation, annual average runoff, sediment transport, peak flood discharge, etc. Preparation of the guideline for the specific yield of annual average runoff (mm), peak flood discharge (m^3/see/km^2) and sediment transport (m^3/km^2) in order to estimate approximate reservoir inflow and reservoi.· capacity.

(d) Study for water demand in service area and reservoir water use under the existing dams.

(e) Finding of the proposed dams and service area on the map of 1 to 50,000 map.

(f) Measurement of catchment area, reservoir area, dam height and dam length at the finding damsite on the map of 1 to 50,000 scale.

(g) Approximate estimation for the reservoir inflow based on the catchment area and the specific runoff yield.

(h) Approximate estimation for the reservoir active capacity based on the reservoir area and effective reservoir depth.
Preparation of the guideline for the effective reservoir depth taking into account the reservoir dead water depth, spillway overflow depth, and dam free board.

(i) Classification of the finding dams by the reservoir and dam size.

(j) Drawings the location, catchment area, reservoir area, damsite, etc. for the existing and proposed dams on the map of 1 to 50,000.

(3) Site Survey Work

The site survey work is to be carried out with the expert of dam, hydrologist, geologist, soil mechanist, agriculture, irrigation, socio-economist and topo-surveyor under the team leader with capability of the water resources development plan.

(a) Topographical and geological condition at damsite and reservoir area, especially rock outcrop, gully erosion, vegetation, etc.

(b) Overburden depth at damsite by providing test pit or hand auger.

(c) Water level and runoff fluctuation at rivers by observation and interview to local people.

(d) Longitudinal survey along the proposed dam axis.

(e) Longitudinal and cross section survey in the reservoir area to estimate the reservoir capacity. (Longitudinal length of 5km along the river and cross section interval of 250 to 300m)

(f) Selection of gaging station site for the surface water observation.

(g) Agricultural and socio-economic condition survey at the service area by questionnaire.

(h) Beneficial intention survey for the proposed dams.

(i) Environment survey in the reservoir and service area.

(4) Analysis and Study in the Office Work based on Site Survey

(a) Hydrological analysis for monthly rainfall, evaporation and runoff and design flood capacity for spillway.

(b) Study of the reservoir dimension and preparation of H-A and H-Q curve.

(c) Water demand study in the service area.

(d) Simple reservoir operation study and available reservoir water for the service area.

(e) Water balance study in tributary basin based on the potential surface water and available reservoir water use.

(f) Dam standard section and dam embankment volume.

(g) Potential irrigation area and domestic water supply quantity by the proposed dam.

(h) Environment impact at the project area.

(i) Approximate dam construction cost based on the dam embankment volume.

(5) Selection of the Representative Dams for the Feasibility Study

In accordance with the above study, four to five representative dams will be selected for the feasibility study with the following conditions;

- Dams consisting of the medium and small dams with the representative size.
- Dams with priority from viewpoint of the project economy.
- Dams without environment problem.
- Dams with easy condition for the survey and study such as accessibility to damsite.

2. Feasibility Study

The feasibility study shall be performed for the above selected representative dams based on the international standard. The particular attention shall be paid for the following items.

(1) Survey and Investigation Works

(a) Preparation of aerial photo map of 1 to 10,000 scale covering the reservoir area, damsite and service area. (Average area of 50km^2/ each representative dam)

(b) Installation of bench marks at damsite and topo-survey at the damsite (Plain map scale of 1 to 2,000)

(c) Installation of rainfall and water gage and continuous observation at stations.

(d) Geological survey at the damsite by seismic prospecting, core drilling and test pits.

(e) Soil sampling at the borrow area and its mechanical test in laboratory for construction materials.

(2) Hydrological Analysis

(a) Runoff analysis on daily basis by preparation of the runoff model.

(b) Design flood capacity analysis for spillway based on the unit hydrograph.

(3) Reservoir Plan Study

(a) Preparation of accurate reservoir H-A and H-Q curve.

(b) Reservoir operation study on 10 days basis.

(c) Formulation of the reservoir operation rule.

(d) Estimation of available reservoir water in wet and dry season and also in wet and dry year.

(4) Preliminary Design of Dam and Appurtenant Structures

(a) Dam Body

- Dam foundation treatment method based on the geological investigation result.
- Available embankment material at reservoir area and borrow area from viewpoint of quantity and quality.
- Analysis for flow net and equipotential line and dam stability based on the standard dam section.

(b) Outlet and Spillway

- Hydraulic and structural analysis.
- Application of simple structure for intake such as drop inlet or inclined inlet.
- Application of outlet conduit by reinforced concrete without steel pipes, taking into account the low water head in the medium and small dam.
- Application of Ogee type weir without gate.

(5) Construction Plan and Cost Estimate

- Construction method and schedule on the contractor basis or force account basis of RBDA.
- Cost estimation preparing the bill of quantity.

(6) OM Plan

OM organization, equipment, facility and OM cost.

(7) Environment Impact

(a) Resettlement problem in the reservoir area.
(b) Water pollution problem during construction.
(c) Variation of the river flow at the downstream after completion of dam.
(d) Other ecological problem by dam construction.

(8) Project Evaluation

(a) Water cost to be developed by dam.
(b) Economical and financial analysis for the project cost.
(c) Evaluation of farmer income generation and job creation.

3. Guideline of the Other Project Facility

The following project facility will be studied in the service area under the medium and small dam.

(1) Irrigation Canal System

- Main canal with the design discharge capacity of 0.5 to 3 m^3 / sec by concrete lining or stone pitching
- Secondary and tertiary canal with earth canal.

(2) Village Ponds

- Five to ten village ponds for fish culture and garden irrigation at each village in the service area.
- Ponds to be constructed with the surface area of 1,000m^2, the depth of 2 to 3^m and the capacity of 2,000 to 3,000m^3.

(3) L.G.A. Supporting Facility

- Hatchery center to feed fry for fish culture.
- Sapling center for reforestation.
- Agricultural extension service center.

(4) R.B.D.A. Construction Center

- Construction equipment workshop.
- Construction and OM office.

APPENDIX 4 - 3. GUIDELINE OF OPERATION AND MAINTENANCE FOR DAM

1. Technical Materials to be Provided at OM office

(1) Report of feasibility study, detailed design, etc.

(2) Map and Drawings:

- 1/50,000 map showing catchment area of dam.
- General plan map at damsite.
- Location map of gaging station for rainfall, evaporation. surface water, etc.
- Dam longitudinal section drawings along dam axis showing geological condition.
- Dam standard section and cross section drawings.
- Drawing showing location and structure dimension of dam instruments and relief wells.
- Structural drawings of intake, outlet and spillway.
- Structural drawings of gates, values, mini-hydropower plants .
- Drawings showing reservoir H-A and H-Q curve.
- Drawings showing outflow discharge based on reservoir water head and opening degree of gates and values.
- Drawing showing reservoir operation rule curve.

(3) Basic Data:

- Hydrological data at damsite including rainfall, evaporation, reservoir inflow, peak flood discharge, water quality, etc.
- Reservoir dimension such as catchment area, reservoir surface area, reservoir capacity, water level, etc.
- Dam dimension such as dam height and length, spillway design flood capacity and overflow depth, outlet discharge capacity.
- Gate and valve dimension such as units, width, length, motor capacity, etc.

- Service area outline such as irrigation area and water requirement, population and water demand for domestic supply, water right of downstream area, etc.

(4) Operation manual of gates and valves prepared by manufacturers.

(5) List of O/M equipment and facility including operating condition.

2. Reservoir Water Operation

2.1 Hydrological Observation Management

(1) Installation of Gaging Station:

- Several rainfall gaging stations will be installed at the damsite with large catchment area taking into account proper distribution.
- Automatic water level gaging station is to be installed at the reservoir and the upstream river of reservoir in large dam with height of more than 30m or reservoir capacity of more than 50 MCM.
- Staff gage is to be installed at the river and reservoir of other dams.
- Particular attention shall be paid in selecting gaging station site, as cross section and river bed at the upstream river of reservoir changes by backwater of reservoir and sediment deposit.
- Original gaging station installed prior to dam construction shall be checked from the above viewpoint. The station will be replaced, if river condition is not suitable for observation.
- When two to three large rivers flow into the reservoir, gaging station at each river is to be required.

(2) Observation and Data Compilation:

- Continuous observation shall be carried out at stations.
- Old rating curve for discharge estimation shall be checked and amended by discharge measurement.
- Accurate water level observation and discharge measurement in wet season from July to September shall be carried out, since potential

reservoir inflow is defined by wet season runoff and reservoir operation rule is to be set up based on wet season runoff.

- Periodical measurement of water quality in the reservoir and sediment transport at the upstream river of reservoir shall be carried out.

2.3 Reservoir Operation Study and Rule Curve

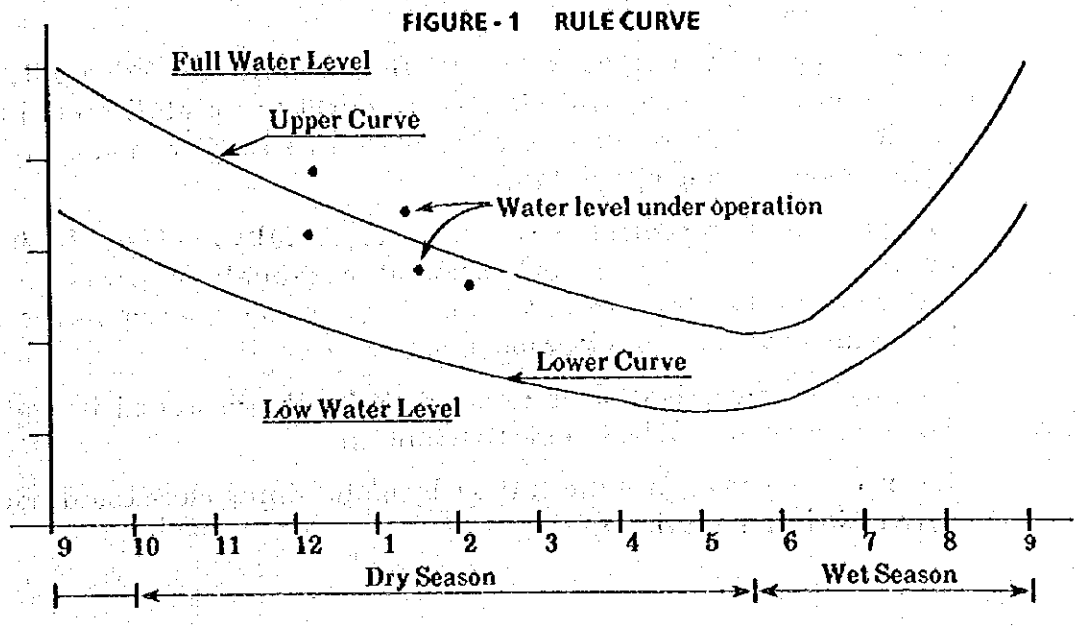
(1) Reservoir Operation Study

Reservoir operation study shall be carried out based on reservoir inflow, rainfall on reservoir area in wet season, evaporation from reservoir area, downstream water release, water demand in service area, etc. Computer program for reservoir operation study is prepared by the JICA Team and submitted to Data Bank of FMWRRD.

(2) Reservoir Operation Rule Curve

Reservoir operation rule curve as shown in Figure-1 is to be prepared based on the operation study result.
The rule curve is consisting of the upper curve for ordinary year and the lower curve for dry year.

FIGURE - 1 RULE CURVE



(3) Reservoir Water Level Monitoring and Evaluation:

- Fluctuation of reservoir water level during operation shall be measured at least on weekly basis and plotted on the reservoir rule curve.
- Remained storage capacity at the end of week, month and year shall be estimated based on the above water level and reservoir H-Q curve.
- When the plotted curve as mentioned above will be at the lower position than the reservoir rule curve, it is judged that the reservoir inflow is less and taking the dry year pattern or larger outflow than designed one.
- When reservoir water level is placed at the full water level or designed operation water level, the proposed service area could be sufficiently irrigated.
- When reservoir water level is not recovered at the end of wet season, the proposed service area at next season will be reduced based on the remained storage capacity in the reservoir and as a consequence, the reservoir operation is to be made by the lower rule curve.

2.4 Outflow Control

- Outflow from reservoir is to be controlled by gate and valve operation in accordance with the water demand, water head of reservoir and opening degree of gate and valve. Outflow shall be measured on daily basis and summarized on monthly and its value is evaluated as compared with designed water demand.
- When supplement irrigation for wet season crops is carried out, the irrigation requirement will change by effective rainfall amount in service area. For example, service area will require none, or less irrigation water during rainfall.

  Therefore, outflow control in wet season is carefully made by obtaining information for changing water demand by rainfall, otherwise excess water is released from reservoir and it is not only water losses but brings about water logging problem in service area.

  The dry season irrigation is to be made by the designed irrigation demand, as there will be no effective rainfall.

  It is necessary to control the outflow by maintaining close coordination with OM staff in service area.

2. 5 Flood Discharge Management at Spillway

- In Ogee type spillway (non controlled spillway), overflow depth during flood spilling period shall be measured and its flood discharge shall be estimated with hydraulic formula. ($C \cdot L \cdot H^{3/2}$)

  In gate controlled spillway, flood discharge shall be estimated by gate opening degree and reservoir water head.

  In gate spillway, particular attention shall be paid to gate control to prevent abnormal flood release to the downstream which may cause flood damage.

- When large flood appears at spillway, flood alarm shall be given to the downstream area.

3. Monitoring work in Dam Maintenance

(1) Settlement of Dam Embankment

Settlement of dam embankment is measured by installing bench marks on dam crest and slope. In addition, appearance of crack on dam crest and slope, and surface slip on dam slope shall be checked.

(2) Seepage Water

- Seepage water level and quantity shall be measured by dam instruments and relief wells. Fluctuation of seepage water line depending on reservoir water level is to be drawn up on dam cross section drawings.

  Seepage water quantity is measured by weir installed at the end of drainage ditches to collect and guide seepage water.

- When the reservoir water level draws down, the upstream slope condition such as phenomenon of surface slip, abnormal depression, crack, settlement, etc. shall be checked.

(3) Others

- After spilling flood through spillway, sediment and log accumulation at approach channel infront of spillway, and scouring at stilling basin and downstream river shall be checked.
- Scouring condition at the downstream of outlet shall be checked periodically.
- Sediment deposit condition at the reservoir upstream area and river reaches influenced by reservoir backwater shall be measured.

  For this purpose, bench marks shall be installed at both banks of reservoir area and river. Measurement of sediment deposit is made by measuring the elevation of deposit with top-survey, when the reservoir water level reaches the low water level in the end of dry season.
- Seepage water through construction joint, souring and fissure of concrete surface, settlement of structure, etc. at concrete structure shall be checked at the outlet, and spillway.
- Mechanical parts such as gates and valves shall be periodically inspected and repaired. Periodical painting and oiling works for equipment shall be carried out.

(4) Report and Data Analysis

The above monitoring result is summarized on report and drawings and submitted to agencies in charge of dams such as headquarter of RBDA, SID and SWA.

The following items to be analyzed, repaired and rehabilitated urgently shall be immediately reported to agencies concerned.

- High seepage water or rapid increased seepage line at dam instrument and seepage drainage ditch. Particular attention shall be paid for appearance of turbid seepage water.
- Phenomeon of boiling, spring and water level increasing at the dam down stream area and swamp area.
- Large erosion and gulley phenomenon on dam slope and abutment as well as reservoir area.
- Large scouring at the downstream of spillway and outlet.

- Large sediment deposit at intake mouth and approach channel of spillway.
- Defect of concrete structure to be urgently repaired.
- Large aquatic weed accumulation at intake mouth and spillway approach channel.
- Damage of mechanical parts.
- Others from viewpoint of dam safety.

4. Rehabilitation Works in Dam Maintenance

(1) Counter-measures for seepage water through Dam Foundation:

- Swamps and stagnant water area being found at the downstream area of dams shall be filled with soil materials, otherwise mosquito and pest will be generated in those area. Seepage water through dam foundation shall be guided by drainage ditches to the river.
- Large depression and excavated borrow area at the downstream of dam shall be backfilled with soil material, otherwise water head between reservoir water level and elevation of those area becomes larger and accelerate the piping phenomenon.
- When dams show relatively high seepage water which could endanger dam structure safety, counter weight berm installing filter drain will be required at the downstream dam toe.
- When dams present high seepage water with some piping pressure, grouting or slurry trench method will be applied for rehabilitation. Those works shall be made at the lower water level of reservoir in order to minimize the influence of reservoir water head to the hole and trench.

(2) Protection Work on Dam Slope:

- Developed sheet and gulley erosion on dam slope shall be shaved and refilled with compacted earth material. In the easy eroded area by rainfall, catch drain of rain runoff shall be provided on dam crest and berm on dam slope. Catch drain is to be protected with riprap or dry stone pitching.

- Dense vegetation covering on dam crest and slope shall be removed.
- Where riprap material on the upstream slope of dam is sweeped away by wave of reservoir water, rehabilitation of the protection work with large size riprap material shall be carried out.

(3) Protection of Scouring Place:

Scouring place at the downstream of spillway and outlet is rehabilitated or upgraded with wire sausage, gabion, wet mansory or concrete structure taking into account souring energy of spilling flood and outlet discharge.

Stilling basin to dissipate scouring energy will be constructed, when scouring energy is large.

(4) Removal of Sediment Deposit:

If sediment deposit is found at the approach channel of spillway and downstream of outlet, the deposit shall be quickly removed, otherwise the flood and discharge could not be released smoothly to the downstream.

(5) Remedial works of concrete Structure:

Deteriorated, defected and broken concrete structure due to scouring energy, foundation settlement, etc. shall be reconstructed.

(6) Repair or replace of Mechanical Items:

Mechanical items, such as gate and valve with defect or broken part shall be repaired or replaced.

Emergency stand-by diesel generator shall be provided for smooth operation, as electric current often goes out during operation of gate, valve and pumps.

(7) Others:

- Access road, lighting system, control house, OM Office, etc. are in poor condition, so that remedial works for those facilities will be required.
- OM equipment such as vehicles, motor cycle, survey equipment, hydrological equipment, construction equipment is not sufficiently provided in OM office. Those equipment shall be strengthened in order to carry out the smooth OM works.
- Alarm system for flood to the downstream area will be required in large dam, especially in dam to control flood by gate.

5. Improvement of O/M Organization for Dam:

OM organization for dam shall be improved taking into consideration of the following items:

- Strength of OM staff consisting of hydrologist, topo-surveyor, water controller, mechanics electrician, etc. in large dam.
- Strength of National Water Resource Institute in Kaduna in order to analyze, evaluate and respond to the rising problems of dam brought from OM Office.
- Strength of coordination between dam OM office and other agencies managing water demand in service area.
- Allocation of sufficient funds to OM work.

APPENDIX 4-4 WATER RESOURCES MANAGEMENT PROGRAM IN THE UPPER HADEJIA

1. Background

The Lake Chad Basin extends over the Sahel and Sudan Savannah zones and is broadly divided into two: (1) the Hadejia / Jama'are-Komadugu / Yobe sub-basin and (2) the Yedseram-Chad sub-basin, both discharging into the fresh water Lake Chad. There would be presently many problems and several constraints for adequate water resources management due to the recent downward trend of Basin rainfall under severe Sahelian drought and also to the alarming prospect of drying up of the Lake Chad. In particular, there are an extensive Hadejia-Yobe wetlands along the middle part of this Basin which are composed of swamp, grassland and woodland created by the passage of the Hadejia and Jama'are Rivers. The area floods annually to an extent determined by river discharge, and this has supported the diverse socio-economic activities.

In view of the inherent geological structure and less rainfall availability prevailing in this Basin, the surface runoff yield in the upper Hadejia / Jama'are is rather high, and large-scale water abstraction schemes in the Upper Hadejia Basin that were based upon an international advice in the 1960s due to the need of expanding irrigated agriculture at rapid population growth rate have constructed 14 large and medium-scale dams with a total active reservoir capacity of 3×10^9 cu.m which is about twice as much as the inflow. It appears that at present a large proportion of the surface water resources are trapped in these reservoirs, and many of them are always maintained at a full water level with the fear of less incoming flow resulting in a fact that the reservoir water to be released for downstream is evaporating. This evaporation from 14 reservoirs amounts to 500×10^6 cu.m that is equivalent to about 30 percent of the potential surface water resources. In particular, the construction of two large dams at Tiga and Challawa Gorge has restricted the extent of flooding and groundwater recharge for these wetlands, and this fact remains that the water management over these wetlands has become an increasingly complex, technical, economic and political issues. This unfavorable way at existing reservoirs would have been caused mainly by the lack of inflow monitorings and proper reservoir operations rules and partly by

less water demand for the underdevelopment in downstream public irrigation projects. In addition, less emphasis has been placed upon artificial flooding over the downstream wetlands. The IUCN-funded Hadejia-Nguru Wetland Conservation Project as initiated in 1985 is taking a central role in encouraging the open debate on the present and future water management issues that are critical to the effective conservation of existing biodiversity.

2. Outline of the Proposed Program

During the course of the National Water Resources Master Plan Study conducted by the Japan International Cooperation Agency, the unfavorable performance of larger public irrigation schemes has been highlighted. Undoubtedly, the most successful would be the Kano River Irrigation Project, but while the farmers' skills have increased over time, newly perceivable problems of a low rate of return and an increasing level of operating costs due to the poor level of OM over the past ten years may ultimately render a significant portion of the scheme inoperable. With the implementation of Tiga and Challawa Gorge Dams, the total area flooded over their downstream wetlands has been greatly reduced, while the existence of these dams has led to an overall reduction in the variability in the extent of flooding, and this has significantly reduced the level of risk for the wetland farmers. However, this appears to have had serious impacts on the agricultural production and water-related environment as a whole because the large-scale flooding formerly distributed the available water over the large wetlands and thereby effected the vital shallow-groundwater recharge.

In accordance with the recent progress of appropriate, small-scale and local-level fadama development in a form of the private irrigation scheme as supported by the World Bank and the EC, a focus has been given to the rehabilitation and improvement of Hadejia-Yobe wetlands in view of the immediate local human needs and food security. At present, part of these countermeasures has been taken by the Hadejia-Jama'are RBDA under the political pressures to release the limited flow from upstream water storages during wheat-growing season. It is highly recommended that in view of a surplus reservoir capacity in the Upper Hadejia Basin, the flooding over the wetlands to be made possible by artificial flood releases from those dams in the wet season should be maintained to make possible the production of rice, dry

season agriculture, fish, grazing, wildlife as well as biodiversity and shallow-groundwater recharge in connection with the establishment of an appropriate surface water and shallow-groundwater monitoring system.

Because of a complex nature in estimating the water demand over the Hadejia-Yobe wetlands, a series of test releases from the upstream Tiga and Challawa Gorge storages in a trial-and-error manner may be one of the most feasible options to identify the volume and timing of artificial flooding through the examination of an interrelationship between surface and shallow-groundwater on the basis of simultaneous hydrological observation work throughout the area. To this end, a flow depletion and conveyance study would be made possible to quantify an appropriate level of the artificial flood releases from the dams. In view of the urgent importance of this matter, the National Water Resources Master Plan has called for appropriate implementation of the Study on the Water Resources Management Program in the Upper Hadejia to be carried out under a framework of the technical cooperation program from external multinational or bilateral agencies. It may be noted that this Study should be a model for the recovery of wetlands functions, a result of which could be applied to other cases including those of the Sokoto-Rima.

3. Terms of Reference

3.1 Objectives

General objective for the Technical Assistance on the Water Resources Management Program in the Upper Hadejia Basin is to prepare a feasible plan on the artificial flood releases from Tiga and Challawa Gorge dams for the Hadejia-Yobe wetlands. More particularly, the following specific objectives may be involved:

- Test releases from upstream dams for simultaneous hydrological and hydrogeological observations after installation of the related gages and preparation of the topographical maps.
- Selection of the most feasible options to identify a scope of artificial flooding through a series of the related studies.

- Formulation of an integrated water management program including the rehabilitation and improvement for existing facilities and the river improvement proposal.
- Preparation of a feasibility report including possible implementation program.
- Transfer of the planning skills and technologies to Nigerian personnel in Nigeria and donor country.

3.2 Agencies

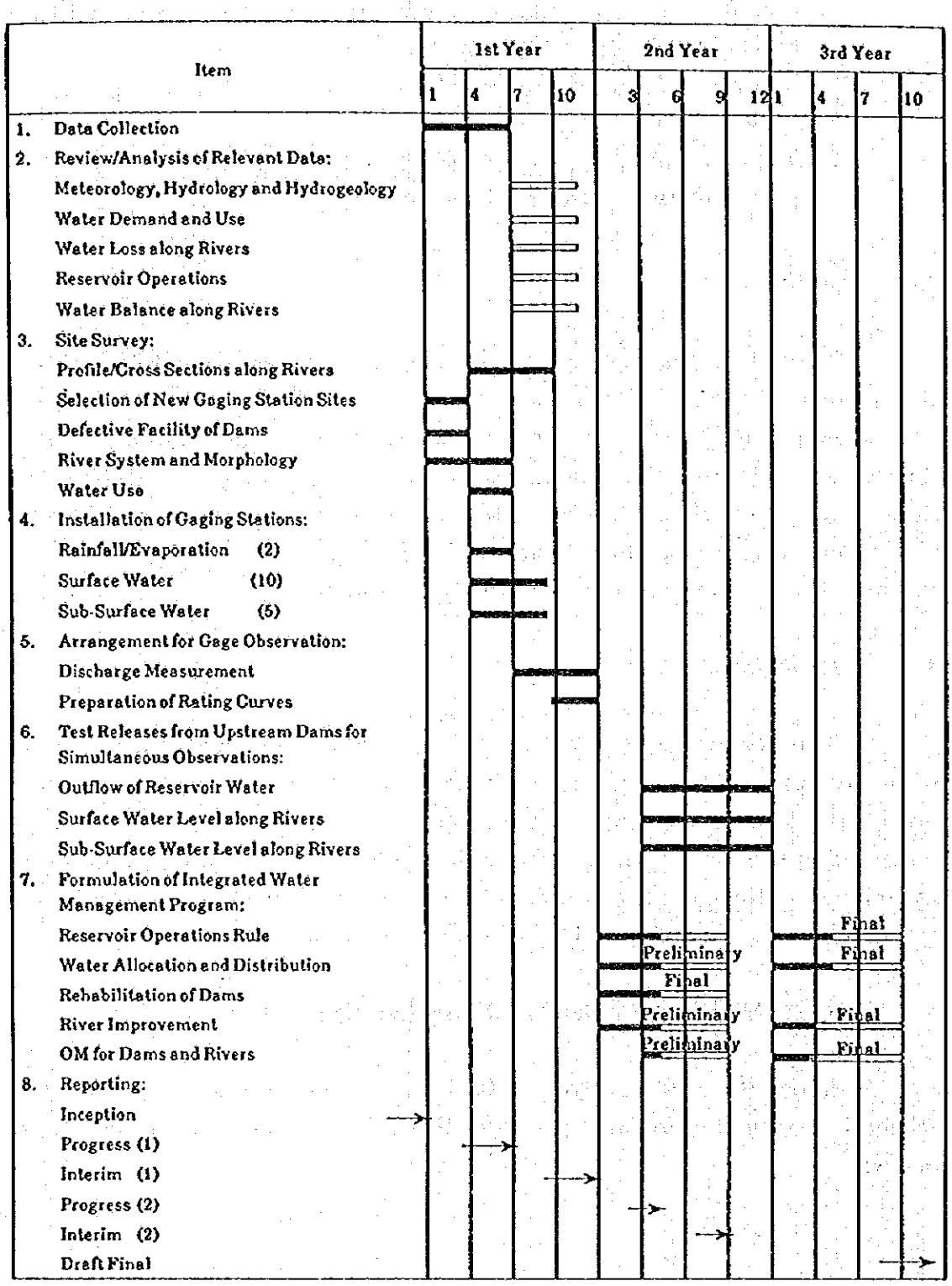
The executing agency will be the Hadejia-Jama'are River Basin Development Authority, Kano to be led by the Federal Ministry of Water Resources and Rural Development in cooperation with the National Water Resources Institute, the Federal Ministry of Agriculture and Natural Resources and the State Governments concerned. This Program will also be carried out in close consultation with the National Water Resources Manpower Training Program to be introduced in a separate manner.

3.3 External Inputs

The external agency will dispatch a survey and study team of experts with the provision of equipment and materials to support proper implementation of the Technical Assistance Program. The team may be composed of the experts in the field of leadership, water resources planning, hydrology, hydrogeology, river, dam and reservoir, irrigation and drainage, socio-economy, agriculture and fisheries, and environment.

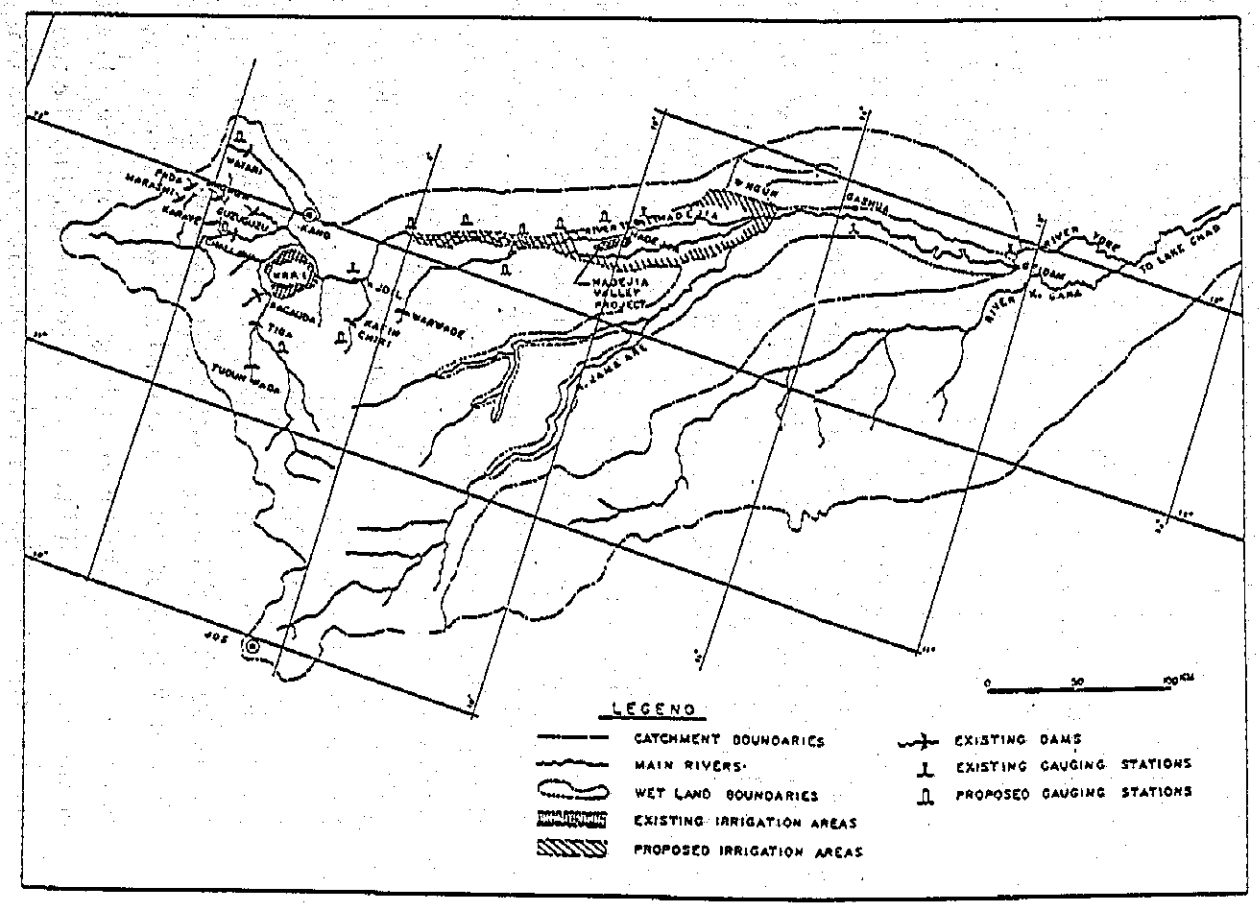
3.4 Scope of Work and Implementation Schedule Proposed

Major items to be involved in the Study and related implementing schedule during the proposed period of three years from 1996 are described below:


Item
1st Year
2nd Year
3rd Year
1
4
7
10
3
6
9
12
1
4
7
10
1. Data Collection
2. Review/Analysis of Relevant Data:
Meteorology, Hydrology and Hydrogeology
Water Demand and Use
Water Loss along Rivers
Reservoir Operations
Water Balance along Rivers
3. Site Survey:
Profile/Cross Sections along Rivers
Selection of New Gaging Station Sites
Defective Facility of Dams
River System and Morphology
Water Use
4. Installation of Gaging Stations:
Rainfall/Evaporation (2)
Surface Water (10)
Sub-Surface Water (5)
5. Arrangement for Gage Observation:
Discharge Measurement
Preparation of Rating Curves
6. Test Releases from Upstream Dams for Simultaneous Observations:
Outflow of Reservoir Water
Surface Water Level along Rivers
Sub-Surface Water Level along Rivers
7. Formulation of Integrated Water Management Program:
Reservoir Operations Rule
Water Allocation and Distribution
Rehabilitation of Dams
River Improvement
OM for Dams and Rivers
Preliminary
Final
Preliminary
Final
Preliminary
Preliminary
Final
Final
Final
8. Reporting:
Inception
Progress (1)
Interim (1)
Progress (2)
Interim (2)
Draft Final

Project	SHA	Catchment Area (km²)	Storage (MCM) Active	Storage (MCM) Total	Dam (m) Height	Dam (m) Length	Irrigation Area (ha)	Water Supply
Karaye	8032	80	14.7	17.2	15.2	1,586	-	0
Challawa	8032	3,869	900.0	930.0	38.0	7,804	12,500	0
Gusugusu	8032	106	21.5	24.5	17.4	2,090	630	-
Magaga	8032	119	17.2	19.7	19.4	2,550	600	0
Watari	8033	663	92.7	104.5	19.8	3,668	1,600	0
Marashi	8031	43	5.8	6.8	11.5	540	n.a.	-
Pada	8031	62	10.6	12.0	14.2	2,160	200	0
Tudun Wada	8041	85	16.6	20.8	21.0	2,478	360	-
Tiga	8041	8,641	1,845.0	1,968.0	47.2	5,791	26,000	0
Bagauda	8042	207	20.9	22.1	20.7	2,134	610	0
Kafin Chiri	8071	225	24.6	31.1	15.0	5,405	660	0
Warwade	8072	106	9.7	12.3	10.0	2,780	240	0

WATER MANAGEMENT PROJECT OF THE UPPER HADEJIA



THE FEDERAL REPUBLIC OF NIGERIA
FEDERAL MINISTRY OF AGRICULTURE, WATER RESOURCES AND RURAL DEVELOPMENT (FMAWRD)

THE STUDY ON
THE NATIONAL WATER RESOURCES MASTER PLAN (NWRMP)

SWAMP PRIORITY BASINS
HADEJIA-JAMA'ARE (SA-08)

JAPAN INTERNATIONAL COOPERATION AGENCY

MAP No.
3.3-1/8

APPENDIX 4 - 5 PREPARATION OF MEDIUM / SMALL DAMS PACKAGE PROGRAM

1. Background

The JICA-assisted Study of the National Water Resources Master Plan (NWRMP) has reviewed that the Federal Government of Nigeria has placed the primary focus on large-scale water resources exploitation facilitated by the oil boom for food production; however, actual status is that the building of irrigation systems and related practices under large dams mostly in dry North has proceeded more slowly due to serious shortages of skilled and experienced manpower. With a view to mobilizing the water resources as called for by the National Perspective Plan, the NWRMP has been directed, apart from a comprehensive rehabilitation and improvement works for existing water storages, to implement a series of the proposed medium and small-scale multipurpose water resources development projects to meet water demand anticipated in various sectors concerned in such manner as (1) self-reliance, (2) human-centred approach and (3) focus on household production unit in informal sector on the basis of maintenance of environmental protection as well as the improvement in implementing capability of the Government agencies and the strengthening of institutions to facilitate more effective cooperation and greater participation of the local people concerned.

It may be noted that the history of irrigation in Nigeria has been that smaller-scale and decentralized schemes have been more successful from the cost-benefit and environmental standpoints than larger schemes. In line with the specific strategies involved, the NWRMP has been established to provide medium to small-size water storages at 1,084 sites located over the tributary basins in response to the demand predicted mainly for irrigation and water supply and partly for mini-hydro and aquaculture, on the premise that the priority area should be shifted to the Middle Zone with emphasis on irrigation and to the Southern Zone on water supply. These sites have been examined on the 1 : 50,000 FSN maps with short visits over some tributary basins with an area of 2 to 5 $\times$ 10^3 sq.km where a sufficient coverage of immediate downstream wetlands is seen for gravity irrigation. These multipurpose dams commonly of earth-fill type will be constructed by the River Basin Development Authorities (RBDAs) on force account basis for small and on domestic

contracting for medium, and relevant joint costs will be allocated among the responsible agencies concerned.

The NWRMP has given a preliminary guideline on the size of medium and small dams to cope with the above-mentioned functions:

	Medium Dam	Small Dam
Dam Height	15 to 25 m	below 15 m
Average Active Capacity	35 MCM	5 MCM
Maximum Active Capacity	50 MCM	7 MCM

While the proposed 264 medium dams with the catchment area of 50 to 500 sq.km have been confirmed on the 1 : 50,000 maps, it would be difficult to identify the small dams on these maps in view of the contour interval of 15 m; thus, only the number of small dams has been distributed in potential river basins on the basis of its catchment area (10 to 30 sq.km) as well as the location of farmland and village as are observed on the 1 : 50,000 maps. Basinwide dimensions of the medium and small dams as identified for implementation of the NWRMP are shown below:

Items	HA								Total
	1	2	3	4	5	6	7	8	
1. Medium Dam									
(1) Number	14	74	39	53	14	41	29	0	264
(2) Active Capacity (MCM)	700	2,940	2,090	1,250	340	910	630	0	8,860
(3) Available Water (MCM)	480	2,140	1,460	890	330	830	590	0	6,720
For Irrigation (MCM)	430	1,930	1,310	800	200	500	470	0	5,640
For Water Supply (MCM)	50	210	150	90	130	330	120	0	1,080
2. Small Dam									
(1) Number	50	230	110	160	35	100	115	20	820
(2) Active Capacity (MCM)	250	1,150	550	800	175	500	575	100	4,100
(3) Available Water (MCM)	159	920	440	640	160	450	520	60	3,340
For Irrigation (MCM)	135	830	395	575	140	405	465	55	3,000
For Water Supply (MCM)	15	90	45	66	20	45	55	5	340
3. Total									
(1) Number	64	304	149	213	49	141	144	20	1,084
(2) Active Capacity (MCM)	950	4,090	2,640	2,050	515	1,410	1,205	100	12,960
(3) Available Water (MCM)	630	3,060	1,900	1,530	490	1,280	1,110	60	10,060
For Irrigation (MCM)	565	2,760	1,705	1,375	340	905	935	55	8,640
For Water Supply (MCM)	65	300	195	155	150	375	175	5	1,420

Notes: (1) Rate of irrigation water for the total available water for the medium dams is given taking into account the large water demand for the water supply in the South region.
HA-1, 2, 3 and 4 · · · 90%, HA-5 and 6 · · · 60%, HA-7 · · · 80%.

(2) Active capacity and available water for the small dams are estimated:

- Average active capacity..... 5 MCM/unit
- Average available water..... 3 MCM for HA-1 and 8
  4 MCM for HA-2, 3, and 4
  4.5 MCM for HA-5, 6, and 7
- Irrigation water..... 90% for the above available water

Prior to adequate implementation of the proposed small and medium-sized dam projects, a series of the sub-basin wide pre-feasibility and feasibility study should be a prerequisite to examine the possible site location and relevant water input-output for each dam and formulate a package program of the dams to be implemented with a high priority from the technical, social, economic and environmental point of view.

2. Outline of the Proposed Program

The NWRMP has identified 264 potential sites for medium-sized dams and 820 sites for small dams to be built along the tributaries throughout Nigeria during the NWRMP period through office work on the 1 : 50,000 FSN topographical maps along with short field visits to some potential sites; therefore, subsequent pre-feasibility study for site identification and full-scale feasibility study for preparation will be required for orderly implementation. When executing a series of these procedures, a sub-basinwide approach is a pre-requisite to prepare an appropriate medium and small dams package program in order to verify well-balanced allocation of the water resources in a particular basin with the priority sub-project rating.

The first step to be taken for this long-range implementation program during the NWRMP period is to carry out a pilot study and preparation of the medium and small dams package programs for some basins where the fundamental technology for selection and planning of potential sub-projects should be developed as model. To select these model basins, the following criteria have been provided:

- Potential water resources : High in amount
- Existing water resources development : Few in number
- Potential medium and small dams proposed : Many in number
- Population density : High
- Per capita farmland : High
- Irrigable area proposed : High in scope

- Increase of demand for water supply : High rate at 2020/1991
- Surface water withdrawal rate in 2020 : High
- Convenience for the management by RBDA and the demonstration effect for other basins in similar nature from locational point of view : Favorable
- Access to the site : Easy
- 1 : 50,000 FSN Maps : Available
- Basin area size for the Study : Moderate

First, 17 sub-basins were screened out, and with a principle of one basin per RBDA, the following nine model basins which are designated at "Priority Basins" have been identified:

No.	SHA	Basin	RBDA	Basin Area (10^3 sq.km)	Population 2020(10^6)	Surface Water (10^9 cu.m)	No of Proposed Dams	Proposed Irrigable Area (10^3 ha)	Water Supply Demand in 2020 (10^3 cu.m)
P.1	110	Dansoki	Sokoto-Rima	0.81	0.75	1.01	14	11	11
P.2	214	Gbako	Upper Niger	7.67	1.25	1.68	24	43	52
P.3	204	Awun	Lower Niger	7.15	1.45	1.07	29	30	118
P.4	301	Kilange	Upper Benue	9.45	1.18	1.43	27	16	6
P.5	4052 to 3	Lower Katsina-Ala	Lower Benue	8.55	1.68	12.80	37	19	17
P.6	504	Mamu	Amambra-Imo	4.27	5.56	0.73	23	8	50
P.7	6023 to 3	Upper Ogun	Ogu-Oshun	20.14	2.54	2.60	36	19	50
P.8	608	Osse	Benin-Owena	13.73	4.00	1.20	22	9	89
P.9	702	Aya	Cross	8.66	2.00	2.41	37	16	11

It is scheduled that all of the studies for nine Priority Basins will be carried out by the FMWRRD during the National Water Master Action Plan period by 2000 with the positive participation of State Water Agencies (SWAs) for domestic water supply, the National Electric Power Plc. (NEPA) and State Rural Electricity Boards for mini-hydro, the Federal Department of Fisheries and State agencies concerned for fisheries, and others. In principle, all of these activities will be supported under the proposed Water Resources Manpower Training Program to be assisted by the external agencies; however, in view of the work load under this Program, the study and preparation for three Priority Basins of P.3 (Awun), P.4 (Kilange) and P.9 (Aya) which are most representative from the locational point of view would be duly requested possibly to three external agencies for more elaboration. It is also

recommended that in view of the past neglect in the environmental factors, a special technical assistance program by an external agency that is called at "EIA Study and Environmental Monitoring Program for Dam Projects" is carried out in a separate way to support the preparation of medium and small dams package programs.

For more clear understanding on the scope of work to prepare a series of the medium and small dams package programs, the general guidelines and criteria have been presented being apart from the procedures for the EIA:

Pre-Feasibility Study:

- Installation of hydrological gaging stations and their reliable observation over the basin.
- Study for potential surface water over the basin dividing into those for tributary basins with the area of 1,000 to 2,000 sq.km.
- Identification of potential sub-projects to be developed by proposed dams on the 1 : 50,000 maps and site reconnaissance survey.
- Preparation of approximate outline of identified sub-rpojects including potential surface water, number of sub-projects, dimension of dam and reservoir, irrigable area size, water demand, socio-economic condition, capital cost, etc.
- Water balance and allocation study at each sub-project and tributary basins as a whole based on potential surface water and water demand.
- Screening of most likely feasible sub-project and tributary basins for subsequent feasibility study.

Feasibility Study:

- Preparation of topographical maps for tributary basin, damsite and service area.
- Geological investigation at damsite, soil survey over service area, socio-economic survey, EIA, etc. for the proposed sub-project areas.
- Feasibility study at international level including plan formulation, preliminary design for project facility, project cost estimates and evaluation, etc.

Preparation of Package Program for Implementation:

- Package program for two to four sub-projects to be developed by medium dams which will be implemented by domestic contractor.
- Package program for five to ten sub-projects to be developed by small dams which will be implemented on the RBDA force account basis.

In order to conduct the above-mentioned study smoothly and rationally, the FMWRRD will be directed to prepare the guidelines to be applied for the following items prior to the pre-feasibility study.

- Hydrological analysis.
- Reservoir planning.
- Geological and soil survey.
- Dam standard section and appurtenant structure.
- Irrigation water demand and per capita demand for water supply.
- Irrigation canal system.
- Cost estimate including the cost allocation procedures for multipurpose joint facilities.
- Environmental Impact Assessment (EIA).

In addition, particular attention will be paid to the feasibility study of service components under the proposed multipurpose medium and small water storages:

- Socio-economic and land tenure conditions in service area, especially problem and constraint to be solved for achievement of successful irrigated agriculture.
- Local people participation for project planning and implementation.
- Definitive area for irrigation based on available irrigation water in water storage and irrigation water demand in service area.
- Irrigation facilities to be managed easily and effectively by WUA.
- Multipurpose use of water for irrigated agriculture, domestic water supply, fish culture, mini-hydro, reforestation, etc.
- Adequate project implementation program including proper project cost estimate and implementation schedule.

- Project evaluation including economic evaluation.
- Institutional building of RBDA, State agencies, and beneficiaries to implement the project and manage irrigated agriculture and other activities.

3. Terms of Reference

3.1 Objective

General objective for the Technical Assistance Program on the Preparation of Medium / Small Dams Package Programs to be carried out by three Study Teams of the external agencies is to prepare the medium / small dams package programs for three Priority Basins of P.3 (AWUN), P.4 (Kilange) and P.9 (Aya) for immediate implementation. Major profiles on these basins as demarcated in the NWRMP are given below:

		HA-2	HA-3	HA-4
		Awun SHA 204	Kilange SHA 301	Aya SHA 702
1. Basin Features				
(1) Catchment Area	(km^2)	7,150	9,450	8,660
(2) Agriculture Land	(10^3 ha)	413	368	711
(3) Population in 2020	(10^3)	1,466	1,183	1,999
(4) Population Density	(km^2)	205	125	231
(5) Agricultural Area / Population	(ha)	0.28	0.31	0.36
(6) Potential Surface Water	(MCM)	1,070	1,430	4,820
(7) Potential Surface Water / Population	(m^3)	730	1,210	2,410
2. Existing Dam Projects				
(1) Number		2	0	2
(2) Active Capacity	(MCM)	34	0	74
(3) Available Reservoir Water	(MCM)	27	0	54
3. Proposed Dam Projects				
(1) Number		29 (17)	27 (18)	37 (26)
(2) Active Capacity	(MCM)	527 (85)	300 (90)	345 (130)
(3) Available Water	(MCM)	380 (64)	234 (67)	317 (117)
4. Total Available Water	(MCM)	407	234	371
5. Irrigation Component				
(1) Existing Area	(10^3 ha)	0	0	2
(2) Proposed Area	(10^3 ha)	30	16	16
(3) Total Area	(10^3 ha)	30	16	18
(4) Water Demand	(MCM)	340	214	238
6. Water Supply Component				
(1) Water Supply Capacity in 1991	(MCM)	25.4	1.5	1.6
(2) Water Demand in 2020	(MCM)	118	6	11
(3) Increase Rate of Water Supply	(%)	4.6	3.7	6.9
7. Total Water Demand	(MCM)			
{5 (4) + 4 (2)}		458	220	249
8. Surface Water Withdrawal Rate	(%)			
{7 ÷ 1 (6)}		43	16	10

Note: ( ) in the above figures shows the those of small dams

More particularly, the following specific objectives may be involved;

- Pre-feasibility study for identification of possible sites covering the Priority Basins of P.3 (Awun), P.4 (Kilange) and P.9 (Aya) as representatives.
- Feasibility study for five core multipurpose dam sub-projects and related service components including two for medium and three for small covering each of the Priority Basins.
- Preparation of a feasibility report for each Priority Basins compiling the guidelines and criteria for selection and planning in similar-natured projects and possible implementation program for sector financing.
- Transfer of the planning skills and technologies to Nigerian personnel in Nigeria and donor countries.

3.2 Agencies

The executing agencies will be each of the Lower Niger, Upper Benue and Cross River Basin Development Authorities to be coordinated by te Federal Ministry of Water Resources and Rural Development in cooperation with the National Water Resources Institute, Federal Ministry of Agriculture and Natural Resources, National Electric Power Plc., and State Governments concerned. This Study will also be carried out in close consultation with the National Water Resources Manpower Training Program and the EIA Study and Environmental Monitoring Program for Dam Projects both to be introduced under the technical assistance in a separate way.

3.3 External Inputs

Each of three external agencies will dispatch a survey and Study Team of required experts with the provision of equipment and materials to support proper implementation of the technical assistance program. Each team may be composed of the experts in the field of leadership, water resources planning, hydrology, dam and reservoir, engineering geology, soil mechanics, river, agriculture, irrigation and drainage, fisheries, mini-hydro, socio-economy, environment and project economy.

3. 4 Scope of Work and Implementation Schedule Proposed

i) Pre-Feasibility Study

The pre-feasibility study shall be performed at the model river basin with the priority under each RBDA:

(a) Data to be Collected

(i) Aerial Photograph and the 1 to 50,000 scale map.
(ii) Hydrological data in the basin and adjacent basin.
(iii) Socio-economic data at LGA level in the basin.
(iv) General geological map in the basin.
(v) Existing water resources projects including location and outline.
(vi) Other necessary data.

(2) Preparatory Work for the Study in the Office

(i) Division of the basin into the several tributary basins with the catchment area of 1,000 to 2,000 km^2 on the 1 to 50,000 scale map of and measurement of their catchment area.

(ii) Study for the basin salient features such as topography and geology, tributary system, land use, socio-economy, etc.

(iii) Study for hydrological condition such as aerial rainfall and evaporation, annual average runoff, sediment transport, peak flood discharge, etc. Preparation of the guideline for the specific yield of annual average runoff (mm), peak flood discharge ($m^3/sec/km^2$) and sediment transport (m^3/km^2) in order to estimate approximate resevoir inflow and reservoir capacity.

(iv) Study for water demand in service area and reservoir water use under the existing dams.

(v) Location of the proposed dams and serice area on the 1 to 50,000 map.

(vi) Measurement of catchment area, reservoir area, dam height and dam length at the proposed damsites on the 1 to 50,000 scale map.

(vii) Approximate estimation for the reservoir inflow based on the catchment area and the specific runoff yield.

(viii) Approximate estimation for the reservoir active capacity based on the reservoir area and effective reservoir depth.

Preparation of the guideline for the effective reservoir depth taking into account the reservoir dead water depth, spillway overflow depth, and dam free board.

(ix) Classification of the proposed dams by the reservoir and dam size.

(x) Drawings of the location, catchment area, reservoir area, damsite, etc. for the existing and proposed dams on the 1 to 50,000 map.

(c) Site Survey Works

(i) Topographical and geological condition at damsite and reservoir area, especially rock outcrop, gully erosion, vegetation, etc.

(ii) Overburden depth at damsite by providing test pit or hand auger.

(iii) Water level and runoff fluctuation at rivers by observation and interview to local people.

(iv) Longitudinal survey along the proposed dam axis.

(v) Longitudinal and cross-section survey in the reservoir area to estimate the reservoir capacity. (Longitudinal length of 5 km along the river and cross section interval of 250 to 300 m)

(vi) Selection of gaging station site for the surface water observation.

(vii) Agricultural and socio-economic condition survey at the service area by questionnaire.

(viii) Beneficial intention survey for the proposed dams.

(ix) Environment survey in the reservoir and service area.

(d) Analysis and Study in the Office Work based on Site Survey

(i) Hydrological analysis for monthly rainfall, evaporation and runoff and design flood capacity for spillway.

(ii) Study of the reservoir dimension and preparation of H-A and H-Q curve.

(iii) Water demand study in the service area.

(iv) Simple reservoir operation study and available reservoir water for the service area.

(v) Water balance study in tributary basin based on the potential surface water and available reservoir water use.

(vi) Dam standard section and dam embankment volume.

(viii) Potential irrigation area and domestic water supply quantity by the proposed dam.

(viii) Environment impact at the project area.

(ix) Approximate dam construction cost based on the dam embankment volume.

(e) Selection of the Representative Dam for the Feasibility Study

In accordance with the above study, five representative core dams will be selected for the feasibility study with the following conditions:

- Dams consisting of the medium and small dams with the representative size.
- Dams with priority from viewpoint of the project economy.
- Dams without environment problems.
- Dams with easy condition for the survey and study such as accessibility to damsite.

ii) Feasibility Study

The feasibility study shall be performed for the above selected representative dams based on the international standard. The particular attention shall be paid for the following items:

(a) Survey and Investigation Work

(i) Preparation of aerial photo map of 1 to 10,000 scale covering the reservoir area, damsite and service area. (Average area of 50 km^2/each representative dam)

(ii) Installation of bench marks at damsite and topo-survey at the damsite (plain map scale of 1 to 2,000)

(iii) Installation of rainfall and water gages and continuous observation at stations.

(iv) Geological survey at the damsite by seismic prospecting, core drilling and test pits.

(v) Soil sampling at the borrow area and its mechanical test in laboratory for construction materials.

(b) Hydrological Analysis

(i) Runoff analysis on daily basis by preparation of the runoff model.

(ii) Design flood capacity analysis for spillway based on the unit hydrography.

(c) Reservoir Plan Study

(i) Preparation of accurate reservoir H-A and H-Q curve.

(ii) Reservoir operations study on 10 days basis.

(iii) Formulation of the reservoir operation rule.

(iv) Estimation of available reservoir water in wet and dry season and also in wet and dry year.

(d) Preliminary Design of Dam and Appurtenant Structures

(i) Dam Body

- Dam foundation treatment method based on the geological investigation.
- Available embankment material at reservoir area and borrow area from viewpoint of quantity and quality.
- Analysis for flow net and equipotential line and dam stability based on the standard dam section.

(ii) Outlet and Spillway

- Hydraulic and structural analysis.
- Application of simple structure for intake such as drop inlet or inclined inlet.
- Application of outlet conduit by reinforced concrete without steel pipes, taking into account the low water head in the medium and small dam.

- Application of Ogee type weir without gate.

(e) Construction Plan and Cost Estimate

- Construction method and schedule on the contractor basis or force account basis of RBDA.
- Cost estimation preparing the bill of quantity.

(f) OM Plan

OM organization, equipment, facility and OM cost.

(g) Environmental Impact

(i) Resettlement problem in the reservoir area.
(ii) Water pollution problem during construction.
(iii) Variation of the river flow at the downstream after completion of dam.
(iv) Other ecological problem by dam construction.
(v) Preparation of the environmental impact statement.

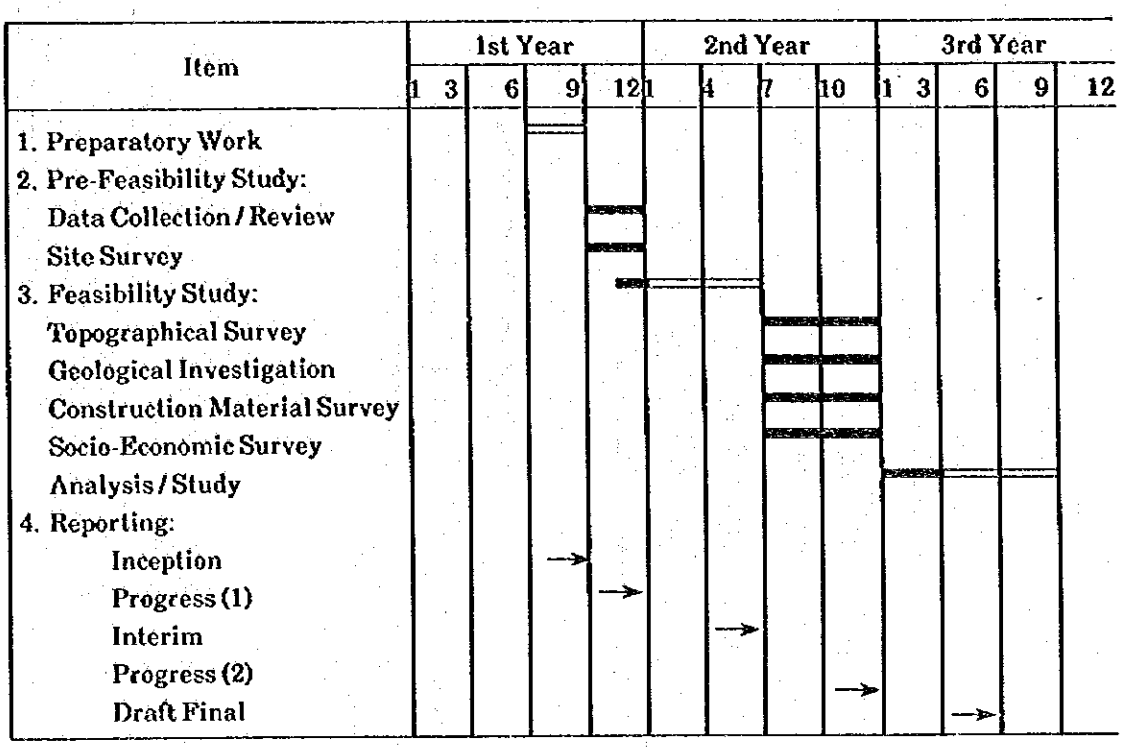
(h) Project Evaluation

(i) Water cost to be developed by dam.
(ii) Economical and financial analysis for the project cost.
(iii) Evaluation of farmer income generation and job creation.

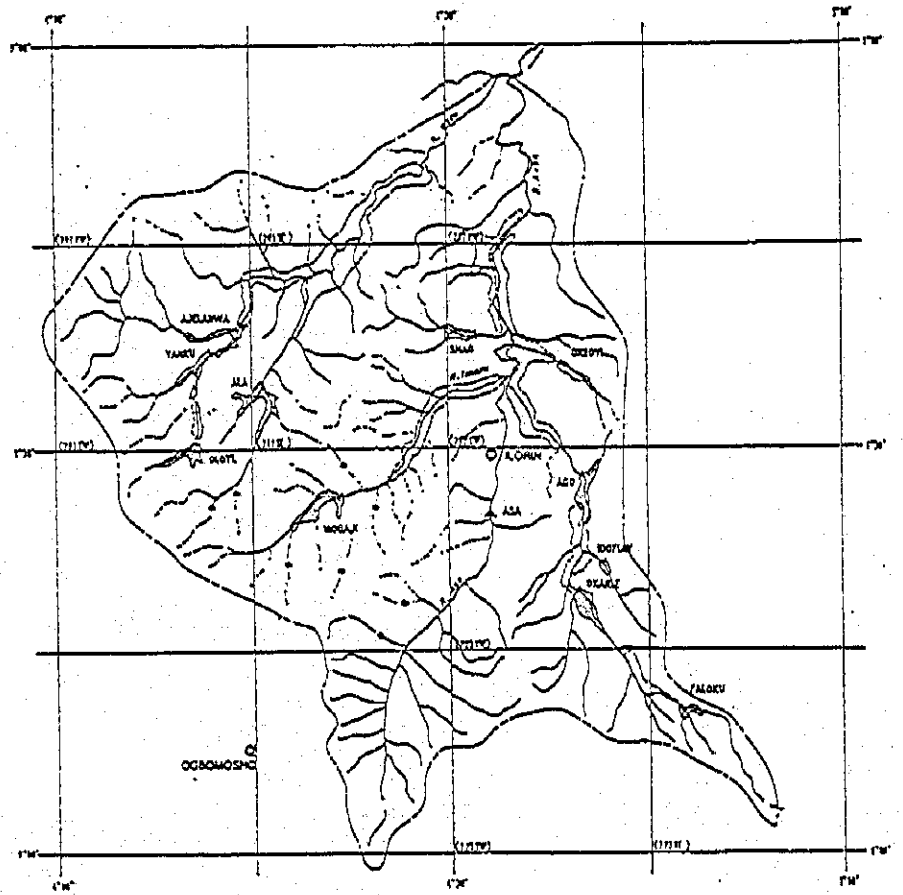
(i) Preparation of the Guideline and Criteria for Selection and Planning in Similar-Natured Projects

(j) Preparation of Possible Implementing Program for Sector Financing.

The implementing schedule proposed for each of three priority sub-basins is given below.


Item
1st Year
2nd Year
3rd Year
1 3 6 9 12 1 4 7 10 1 3 6 9 12
1. Preparatory Work
2. Pre-Feasibility Study:
Data Collection / Review
Site Survey
3. Feasibility Study:
Topographical Survey
Geological Investigation
Construction Material Survey
Socio-Economic Survey
Analysis / Study
4. Reporting:
Inception
Progress (1)
Interim
Progress (2)
Draft Final

AWUN BASIN (SHA NO.204)



GENERAL LEGEND

- Basin Boundary (Basin Area, 1,630 sq.km)
- Major River
- Major Town

SPECIFIC LEGEND

- Proposed Large / Medium Dam
- Proposed Small Dam and Diversion Dam
- Existing Large Dam
- Proposed Irrigation Area

Note: 1) Following Maps of 1:50,000 are not available ;

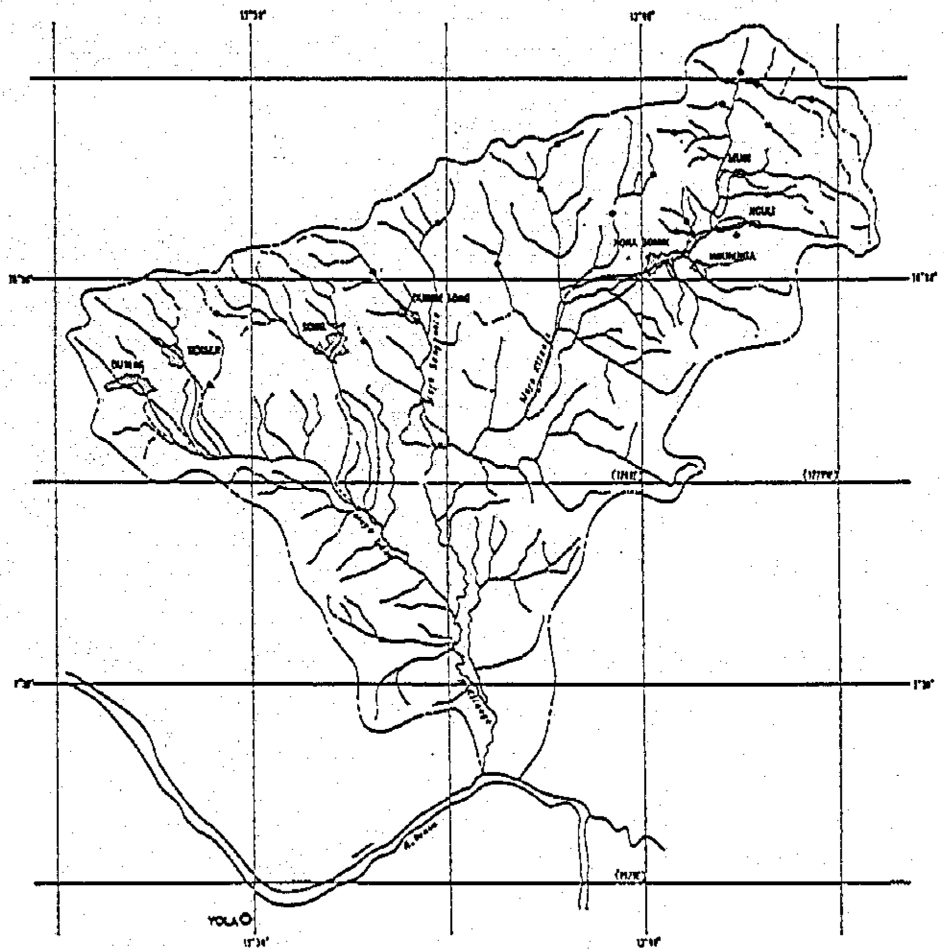
(201:NW,NE,SW,SE), (202:NW,SW), (223:NW,SW,SE)

2) Proposed Dams are planned with multipurpose for irrigation and Water Supply.

0 5 10 15 20Km

THE FEDERAL REPUBLIC OF NIGERIA FEDERAL MINISTRY OF ENVIRONMENT, WATER RESOURCES AND RURAL DEVELOPMENT (FMEWR&RD)
THE STUDY ON THE NATIONAL WATER RESOURCES MASTER PLAN (NWRMP)
NWRMP PRIORITY BASINS 2. AWUN (BA-2)
JAPAN INTERNATIONAL COOPERATION AGENCY NIPPON KOEI CO.

KILANGE BASIN (SHA NO.301)



GENERAL LEGEND

- Basin Boundary (Basin Area, 5,540 sq.km)
- Major River
- Major Town

SPECIFIC LEGEND

- Proposed Large / Medium Dam
- Proposed Small Dam and Diversion Dam
- Existing Large Dam
- Proposed Irrigation Area

Note: 1) Following Maps of 1:50,000 are not available ;

(176NE), (177NW), (177NE)

2) Proposed Dams are planned with multipurpose for irrigation and Water Supply.

0 5 10 15 20 km

CHAPTER 5. IRRIGATION AND DRAINAGE

CHAPTER 5: IRRIGATION AND DRAINAGE

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CHAPTER 5. IRRIGATION AND DRAINAGE

5.1. GENERAL BACKGROUND

5.1.1 Historical Perspectives

Some simple forms of dry season irrigation on individual basis in the wetlands have probably been practiced in the North Region from time immemorial, particularly near large cities such as Kano and Sokoto. The farmers practiced lift irrigation through lifting devices such as shadouf and calabash to increase crop production. By the second decade of this century, the increasing population pressure and the knowledge that rainfall and river flow were trending downward under the frequent severe droughts had caused the then colonial administration to construct small dams and diversions in some areas of the North, especially to improve the Fadama water regime. Most of these works, however, were carried out in an ad hoc manner, and while some of the farmers have benefited, others have suffered from their lands being flooded for water storage. Moreover, wet-season rainfall washed away many of the infrastructures. Under this situation, most of those activities had been abandoned by the middle of 1920's.

A fresh start was made in 1949 when an irrigation division was set up in the then Northern Provinces Agricultural Department and an irrigation training school was established in Sokoto. This new division initiated a village irrigation scheme, and by 1960 the area irrigated totaled 3,400 ha, of which 400 ha are in the arid zone and the remaining 3,000 ha in the Fadama areas of the Niger Valley. It is believed that this scheme failed more for social reasons than technical problems. In the South Region irrigation began much later. In the South-East Region the first irrigation engineer was appointed in 1960 and he began to promote rice growing mostly with wet season supplementary irrigation in the inland swamps, while in the South-West Region there was virtually no irrigation development except for the few attempts made to promote wet season supplementary irrigation in Fadama areas prior to the establishment of RBDAs in 1976.

Following the end of the civil war in 1970, various foreign-assisted studies and related pre-activities conducted in the 1960s had convinced FGN to

initiate more irrigation programs especially for rehabilitation of irrigation facilities and provision of more food after the war hazards ended and in association with rapid growth of the national economy resulting from rise in oil exports and more importantly, rise in the real price of oil. In the North Region, large-scale irrigation was initiated as a solution to the constraints caused by the poor response of basic crops (sorghum and millet) to modern inputs, increasing population pressure, and continued decline of rainfall. Between the years 1970 to 1974, the Kano State Government constructed the Tiga dam and the 17.6 km long main canal. In the humid South-East Region, population pressure was the major concern, and increase in rice production through irrigation was recognized as one of the ways where the problem of ensuring family food security from relatively small land holdings could be overcomed. In the 1970s, public sector irrigation investments rose sharply and remained very high until the end of the oil boom.

The balance of payments crisis in 1978/79 was met by government budget cutbacks and import restrictions. At the same time, the problems of rapid population growth in urban areas and the relative decline in rural areas became apparent; thus, the Fourth Plan (1981-85) tackled these problems to achieve the targets, in which the highest priority was given to "hastening the development of rural areas and agriculture", as compared with the relatively neglected budget for agriculture in the Third Plan. In mid-1986, FGN launched the Structural Adjustment Program (SAP) with the introduction of a market-determined exchange rate and elimination of import licensing system, which so far have resulted in significant increase in incentives for the agriculture sector. Under this situation, one of the successful initiatives of the World Bank-funded State ADPs, under the coordination of DOA, is the small-scale, low-cost, farmer-managed irrigation in wetlands, which is in contrast with the large-scale irrigation schemes promoted by RBDAs. These large-scale schemes, involving high capital costs and long gestation period, have been completed with a few exceptions and the remaining are either reduced to pilot activities or frozen at various stages of implementation.

5.1.2 Necessity of Irrigated Agriculture

Recently, increase in food production has become necessary to cope with the rapid population growth. Since increase in food production through