hydrological information has been included in Vol. Three "Water Resources Inventory Survey". In addition, a database map entitled "NEPA Power Grid System" has been compiled as Map No.22 in Vol. Four "Water Resources Database Maps" indicating the sites of potential hydros preliminarily identified on the FSN Maps (1 : 50,000) by the JICA Team during the course of the NWRMP Study on the basis of the "Map of Nigeria Showing NEPA Grid System Up to December 1995" (prepared by NEPA in November 1990).

8.2 PRESENT SITUATIONS

8.2.1 Power Supply and Distribution Facilities

(1) General

Until the advent of Kainji power, no unified grid existed and power generated was distributed on isolated basis. As of today, over 3,700 km of 330 KV line and about 40,000 km of 132 KV lines have been constructed to link all the major power plants and the (25 in No.) intermediary 330/132 KV and (70 in No.) 132/330 KV grid substations located at different parts of the country. It will be seen from the Database Map No.22 "NEPA Power Grid System" that nearly all the State capitals including the Federal Capital of Abuja are linked to the grid at either 132 KV or 330 KV. Apart from current efforts being made to link the remaining three State capitals (Dutse, Jalingo and Damaturu) to the grid at 132 KV, it is the intention to ensure that power is provided to all state capitals at 330 KV by 1995.

(2) Generation

The NEPA's total installed generating capacity within 21 years of its establishment in 1972 increased tremendously from a significant figure of 500 MW to about 6,000 MW in 1990 representing an increase of 91.6 percent over the period, or an annual growth rate of 5.4 percent. Table 8-1 compiles the installed capacities of power plants in 1993. As is shown in Table 8-2: Installed Capacities of Power Plants by Type, the power generating mix during the period of 1974 to 1988 was dominated mainly by gas and hydro-based plants. In 1988 prior to the commissioning of the Shiroro hydro plant, the gas accounted for 26 percent and the hydro for 28.5 percent, while the steam plants which

derived its fuel resources mainly from gas and oil derivates contributed 45.5 percent to the generating mix.

TABLE 8 - 1 INSTALLED CAPACITIES OF POWER PLANTS IN 1993

Item	Type	Plant	Year Installed or Commissioned	Installed Capacity (MW)
1	Hydro	Kainji	1968/78	760
		Jebba	1983/84	578
		Shiroro	1989/90	600
	Sub-Total			1,938
2	Steam	Sapele	1978/80	720
		Egbin	1986/87	1,320
		Oji River	1956	20
	Sub-Total			2,060
3	Gas	Sapele	1981	300
		Afam 1-4	1963/82	611
		Delta 1-3	1966/78	312
		Delta 4	1990	600
		Ijora	1966/78	67
		Ajaokuta	1989	110
	Sub-Total			2,000
	Total			5,998

A survey carried out in recent years (1989 - 1991) indicated that suppressed demand has increased to an unassuming scale amounting to about 2,500 MW or roughly 41.6 percent of NEPA's total installed capacity. This confirmed that apart from the plants tied to the national grid, there is a significant installed capacity of generating plants being operated by the private firms and individuals to off set the no power hours when public supply failed. It would appear that NEPA was no longer in a position to cope with demand judging by the incessant power failures and the frequency of interruptions.

As would be seen from Table 8-3, the NEPA generation increased by 9.5 percent from 7,142 GWH in 1980 to 7,823 GWH in 1981. Consumption of energy increased by 21 percent from 4,654 GWH to 5,627 GWH in the same period. In 1990 out of 6,000 MW installed capacity, barely 2,500 MW was available indicating that the availability factor was 0.416 showing that only 41 percent of the plant capacities were available.

TABLE 8-2 INSTALLED GENERATING CAPACITIES BY PLANT TYPE

(unit: MW)

Year	Hydro	Gas	Steam	Coal	Diesel	Total
1974	320	164	85	30	85	684
1975	420	328	85	30	28	891
1976	520	378	85	30	54	1,067
1977	520	378	85	30	58	1,071
1978	760	658	163	30	34	1,645
1979	760	658	720	30	38	2,008
1980	760	658	720	30	33	2,201
1981	760	960	720	30	43	2,513
1982	760	1,272	696	30	44	2,802
1983	850	1,262	696	30	49	2,887
1984	1,210	1,222	696	30	50	3,206
1985	1,210	1,250	1,136	10	44	3,650
1986	1,300	1,186	1,576	10	39	4,111
1987	1,300	1,186	2,016	10	47	4,559
1988	1,300	1,186	2,016	10	47	4,559

Source: NEPA Statistics, 1973 - 1989.

TABLE 8-3 POWER GENERATION

Year	Installed Capacity (MW)	Energy Generated (GWH)	Maximum Demand (MW)	Energy Sales (GWH)	No of Consumers (MW)	Peak Demand (MW)
1973	500	3,607	390	1,752	338	385
1974	684	2,819	457	2,038	390	457
1975	891	3,273	579	2,343	431	579
1976	1,057	3,902	703	2,715	503	703
1977	1,071	4,674	767	3,243	597	767
1978	1,645	4,648	887	3,627	708	887
1979	2,003	6,205	1,095	4,163	829	1,095
1980	2,201	7,142	1,181	4,654	1,071	1,181
1981	2,513	7,822	1,323	5,627	1,222	1,323
1982	2,802	8,566	1,448	5,916	1,381	1,448
1983	2,887	8,713	1,434	6,107	1,537	1,434
1984	3,206	9,035	1,532	5,459	1,674	1,532
1985	3,650	10,431	1,720	6,149	1,841	1,720
1986	4,111	10,765	1,730	7,375	1,957	1,730
1987	4,632	11,265	1,855	7,471	2,025	1,855
1988	4,632	11,654	1,952	7,202	2,061	1,952
1989	4,632	11,700	2,003	8,556	2,113	2,005
1990	6,000	13,365	2,219	7,870	2,185	2,219

Source: NEPA statistics on Reports on its expansion programs in the 1970s and 1980s. IEA Energy statistics and Balances in Non-OECD countries 1988 - 1989 and CBN A annual Report 1991.

(3) Transmission

The NEPA's main transmission network at 330 KV would almost covers the entire country. It consists of about 4,700 km circuit of overhead lines mostly twin "Bisbon" 381 mm 2 ACSR conductors and twenty-two (22) 330 / 132 KV substations. Most of the 330 KV systems were constructed within the last 20 years. Although extensions are underway to link most parts of the north-east to the grid, construction of a line to link power plants of the oil producing areas of the south with the centres of population of the north-east has been on the drawing board for some time. Construction of a 330 KV to link Enugu with Makurdi and Jos will enhance the economy of the middle belt areas of the country. As of today, there are about 5,000 km circuits of 132 KV lines criss-crossing the country. However, much is still to be done to improve the method of load dispatch at the National Control Center (NCC) at Oshogbo which should be fully equipped for the work and assignment it is to carry.

(4) Distribution

What happens in the distribution section of the NEPA is not much different from that of the transmission; more lines at 33 KV have to be constructed. However, in urban areas where the load density is high, there is the need to regularly assess the load growth by periodic readings to ascertain when to up-rate distribution transformers, and to create more substations in an endeavour to obviate low voltages. This is the only way to avoid the current incidence of breakdowns and outages plaguing many areas. It is observed, however, that in spite of these difficulties, there are some increases in the load growth and consumer population over the years as is shown in Table 8-3.

In spite of the NEPA's difficulties in matching supply with demand, consumers population continue to grow indicating mounting demand in the face of unreliability of the NEPA supply. For example, consumers population grew by 6 percent from 2,060,605 in 1989 to 2,184,924 in 1990 and by 3.0 percent from 2,184,924 in 1990 to 2,251,035 in 1991 according to the Skoup's inventory survey.

(5) Special Remarks

The current status of three hydro plants is briefed below through the information of the Federal Ministry of Mines and Power:

Plant	Installed Capacity (MW)	Available Capacity (MW)	Current Status
KAINJI (8 units)	760	500	- 5 units are functional. - 3 units are down. - All units are due for overhaul. - N5 billion required for major overhaul. - Fund constraint.
JEBBA (8 units)	540	540	- Spare parts required for routine maintenance. - Over N1 billion required for spares.
SHIRORO (4 units)	600	450	- 1 unit under-going repairs. - N50 million for repairs and materials.

In 1990, the annual power generated was 13,365 GWH of which 8,413 GWH came from the thermal and 4,952 GWH from the hydro under the NEPA prudent management of the hydro resources vis-a-vis the thermal plant availability. For instance, once water is available, at Kainji, the power output from Jebba could be assured even in the event of breakdown at Kainji, while much depend upon the preparedness of the thermals which may be called upon for relief. Following table provides noteworthy figures;

Year	Energy Generated			
	Kainji (hydro)		Sapele (steam)	
	GWH	%	GWH	%
1988	1,563	100	992	100
1989	1,696	108	837	84
1990	1,151	74	500	50
1991	1,753	120	11	1

It could be inferred from the above that there are major breakdowns in plant machinery and equipment at two stations which probably have not been repaired either due to the non-availability of fund to procure much needed spare parts or delay in negotiating with contractors who are to carry out the job. This again brings to focus the recurring question of repairs and maintenance of the installed facilities. There is no doubt that if the idle generators and turbines have been repaired and put back into operation, power production

would have increased tremendously. With an installed capacity of 6,000 MW, it would be possible to involve 4,000 MW i.e., 66.6 percent of the installed capacity in power production.

8. 2. 2 Problems and Needs

(1) NEPA Power Grid System as a Whole

During a recent survey on some of the NEPA's installations, it was observed that a number of machinery of all types of the hydro, gas, and steam plants have brokendown and are in the state of disrepair over long period; the cost of overhauling these equipments has been put at about N300 $\times$ 10^9 by the 1991 estimate. This state of affairs actually calls for an aggressive maintenance action to salvage the power industry from collapse. Unless the machinery are repaired and quickly brought back into operations, the hydropower may not be able to play its role to cope with the peak load.

For instance, out of the eight units installed at Kainji hydro, four were already listed for scheduled maintenance in 1994 alone. These include:

- IG6 - scheduled for repair in the period of June 13 to July 27.
- IG7 - scheduled for maintenance in the period of October 24 to December 2.
- IG9 - scheduled for maintenance from January 31 to March 11.
- IG12 - scheduled for repair in the period of April 11 to May 20.

This is the picture or state of affairs throughout all of the NEPA's major power plants, and one wonders whether there would be any major activities with the power production this year if this state of affairs is allowed to continue. Another factor militating against the repairs and over-hauling of these machines is the long lead-time people have to wait for Government's approval for fund and clearance before such machines are committed for maintenance. A report recently prepared by London Economics shows that majority of the damages suffered were due to electrical faults which were not properly cleared due to incorrect operations of the protective devices on the transmission lines. Most of the present NEPA distribution networks are

virtually overloaded resulting in frequent breakdowns and outages. Even if the long-term damage effects to units arising principally from electrical units is excluded, the forced outage rate suffered in Nigeria is too high and cannot be defended. Thus, in the mid-1991, about 2,153 MW of the plants were out of service being sent either for repairs or awaiting repairs.

A team from London Economics and L. E. Energy remarked, inter alia, that: Some generating units have suffered major damages and are unlikely to be operable until substantial refurbishment works have been carried out. The majority of the damages which were attributable to electrical faults were not properly cleared due to incorrect operations of the protective devices on the transmission system. To improve the NEPA's system, a utility twinning arrangement has been entered into with the BEI with the aim of training and improving the capabilities of some of the Corporation's operating personnel.

It was also in their report that of the 3,428 MW average available, 1,265 MW was out of service either on planned or unplanned outages. Based on their planning assumption, the JICA Team is not favourably disposed to building new plants until the broken down plants are completely over-hauled, except in the case of the 950 MW Zungeru which is estimated to cost US$ $1,045 \times 10^9$ at the rate of US$ 1,100/KW. The others are the 3×20 MW standby gas turbines intended to serve as reserve to Abuja and the 3×100 MW gas plant for Geregu.

By examining the constraints to bring the idle plants to operation, the following measures are considered as possible solutions to be studied;

(i) Adequate provision of the essential maintenance spare parts as part of the contractual agreement.

(ii) Training of the requisite maintenance manpower on new installations should be made mandatory by entrenching such identified requests in the contractual agreements.

(iii) Provision of the inducement allowance for those who could work under difficulties and in inclement weather.

(iv) Improve the security of transmission and major distribution lines by providing the duplicate feeders and inter-tie lines.

(v) Establishment of a basic manufacturing plant to back up the electricity supply industry. This should be possible in the nearest

future when Ajaokuta starts producing. This will enable a substantial part of equipment to be available and the lead time from award to construction would be significantly reduced.

(2) Output Decrease of Kainji and Jebba Hydros

(a) Decrease of the Inflow into the Reservoirs

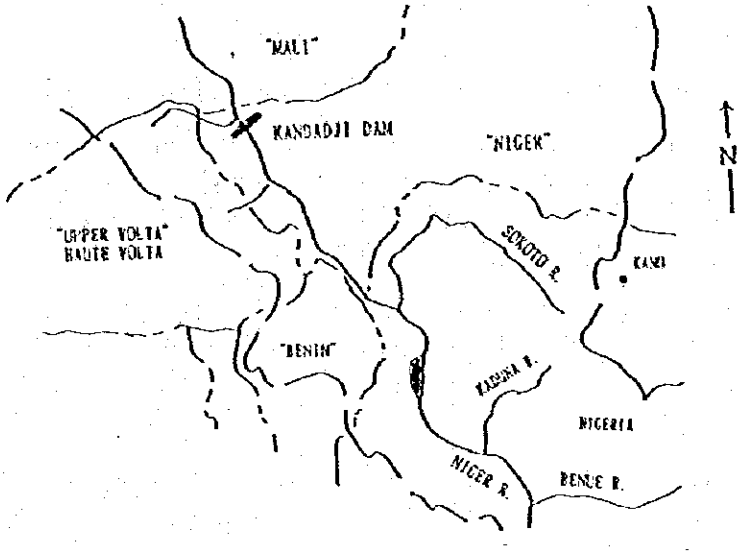
The runoff information at Jebba damsite on historical basis which have been examined previously are summarized below:

	Annual Runoff at Jebba Site (Catchment: 629,400 sq.km)		
	MCM	%	
1910s	46,700	70	
1920s	46,800	70	
1930s	-		
1940s	46,000	69	
1950s	67,000	100	
1960s	-		
1970s	-		%
1980s	24,200	36	(100)
← From Niger Republic, (Catchment = 461,600 sq.km)	18,300		(59)
← From Sokoto-Rima, (Catchment = 88,300 sq.km)	6,000		(19)
← From Other Rivers, (Catchment = 79,500 sq.km)	6,920		(22)

If the water of the Sokoto-Rima Basin and surrounding rivers is diverted or used excessively for other purpose, their contributory role in terms of water into Kainji lake may become low in which case water into Kainji will be solely dependent on the Black Flood from the upper catchment of the Niger in the Republic of Niger and Mali.

With imminent construction of the proposed Kandanji Dam by the Republic of Niger and the anticipated uses of the Niger water by other member countries of Niger Basin Commission, coupled with the vagaries of climate in

the Sahelian region, the continued operation's of Kainji hydro may be jeopardised at least in the foreseeable future.



Therefore, attempts have to be made to ensure that:

(i) The RBDAs concerned with the Kainji lake and in particular those within the Sokoto-Rima Basin regulate the use of water from their various dams and irrigation systems and release certain pre-agreed quantities into the Kainji Lake regularly.

(ii) International agreement should be struck between the countries of the Niger Basin Commission so as to assure a regular release of an agreed predetermined volume of water into the Kainji lake all the year round.

(b) Water Hyacinth Menace

The Nigerian newspapers reported this problem in the beginning of January 1994 in accordance with the press interview made by Dr. Titilola Farri, the Secretary of the National Committee on Water Hyacinth Control and the Chairperson of the National Expert Committee on Water Hyacinth, stating that the water hyacinth is threatening the Kainji hydro turbines as well as reducing the water level in the Kainji reservoir with a particular emphasis upon the reservoir evaporation rate with water hyacinth that is six times

higher than the present 100 cu.m per second. Currently, the NEPA is employing the fishermen for physical clearing of the weeds in the Kainji lake.

To solve this problem, the following measures are suggested:

(i) Release of the weevils already imported to the Kainji lake.

(ii) Practical application of the machine manufactured by the Nigerian Institute for Oceanography and Marine Research to rid the lagoons and rivers of weeds with a view to utilizing it to combat the growth of the water hyacinth.

(iii) When clearing, the water hyacinth is applied as silage for cattle and sheep and soil conditioner and for paper and stationary industry as well as for the production of chemical by-products, materials and energy.

(iv) Nigeria should seek the cooperation and support of neighboring countries on the water hyacinth problem to coordinate the effort in combating the growth of the water hyacinth.

8.3 NWRMP TOWARDS THE YEAR 2020

8.3.1 Power Demand - Supply Projections

The NEPA - projected generation expansion program has been influenced by the forecast of the World Bank Mission (Nigeria: Issues and Options in the Energy Sector, 1983) and the 25-Year NEPA Power System Development Study (by Oladipo Ilumoka & Associates, Lagos and Tractebel Engineering International, Belgium in 1988). The nationwide load projections are compiled in conjunction with the NEPA actual records which are given in Table 8-4.

Before making any prediction for the future expansion program (generation and consumption demands) of NEPA, it should be borne in mind that there can be no special method to be applied to project the energy supply and demand into the future on long-term basis; any attempt made would have to be regarded as mere guestimation but should be acceptable provided it is based on historical trends and past experience.

(a) Assuming 5 percent for spinning reserves, 10 percent for breakdown and repairs, 5 percent for transmission and distribution losses and another 5 percent for unforeseen circumstances e.g: force majeure etc., it is clear that at least 25 percent of installed capacity is not put into productive usage. While it is realized that bottlenecks on the distribution network might be impeding the flow of current to pick up the huge suppressed demand estimated recently by the team of London Economics at about 25 percent (2,500 MW) of NEPA's present installed capacity, the need to repair idle plants is imperative.

(b) Nigeria is fortunate to own abundant, low-cost energy resources suitable for use in power generation, the most important of which are associated and non-associated natural gas, hydro, coal, lignite and crude oil derivatives, such as, diesel and fuel oils. Nigeria is one of the leading oil exporting countries of the world, and oil exports provide the revenues for most of its current and development expenditures; however, because of uncertainties about future oil revenues and the fact that the present export level would not be sustained in future if domestic use continues to accelerate, the FGN has attached high priority in diversifying its economy both to lessen the country's dependence on oil and generate a broader resource base.

It is said that the natural gas reserves (approx. 150 TSCF) as large enough to support the projected power demand from the year 2000 for another 100 years. A survey reflecting on the wastefulness of energy resources commented that 21 percent of the gas produced in 1990 was utilized while 79 percent flared, and in 1991, 78 percent of the gas produced was flared with others consumed by NEPA, NAFCON and others with the NEPA share of consumption declined by 9.5 percent. Indicated coal and lignite resources are large making a potentially substantial contribution to power sector; however, the coal-based generation would be more costly than natural gas and, perhaps, hydro. Petroleum products should only be used for power production when the practical alternatives such as isolated generating sites or standby equipment cannot be developed.

TABLE 8-4 POWER DEMAND - SUPPLY PROJECTIONS

	1980		1990		1995		2000		2005		2010	
	MW	GWH	MW	GWH	MW	GWH	MW	GWH	MW	GWH	MW	GWH
NEPA Recorded												
Capacity	2,201		6,000									
Peak Demand	1,181		2,219									
Energy Generated		7,142		13,365								
World Bank Forecast, 1983												
Capacity	1,922		5,615		8,174		12,749					
Energy Generated		7,142		23,609		37,298		57,702				
25-Near NEPA Power System Development Study, 1988												
Capacity			3,802		4,976		6,116		8,366		10,856	
Peak D emand			2,346		3,516		4,868		6,532		8,586	
Energy Generated				13,513		19,712		27,292		36,621		48,136

(a) Development of the Thermal Generating System

- In Nigeria, it appears that the natural gas would be the best fuel for the future, and it is cheaper to locate new generating units near the gas fields than to transport the gas to the load centres.
- For future power units, it is recommended that the combined cycle sets be selected instead of the conventional steam units for baseload generation purpose. The size of 500 MW (two 250 MW sets) for each power plant appears to be well-adapted to the NEPA system each comprising two 90 MW gas turbines together with an associated 70 MW steam unit.
- The gas-fired conventional steam units are far less attractive from the viewpoint of cost and stability of power supply.
- The gas turbines are mainly used to supply the peak loads. Their number in the plant mix may be determined on the basis of 120 MW unit, but smaller units would also be suitable.

(b) Development of the Hydro Generating System

- It is extremely difficult for hydro sites in Nigeria to become competitive as baseload units against the cheaper gas fueled combined cycles. At present cost, no hydro site has been selected as part of the optimal generation mix. As far as the existing hydro units are concerned, they should be operated as peaking units which was not foreseen in most of the feasibility studies previously carried out for hydro sites in Nigeria.
- No new hydro plant is selected within the optimum generation mix until the year 2010. However, the sites proposed for Zungeru, Mambilla, Ikom, Makurdi and Lokoja require attention, although not economically justified at present for power generation alone.

(c) Reserve Margin and Quality of Service

- In the very short term, the NEPA generating systems will face severe shortages when the power plants under construction are not made fully available and the existing units are not reconditioned. Taking into account the actually available units, the real reserve margin is presently smaller than 20 percent. Quick rehabilitation for the power units is, therefore, highly desirable.
- While the program for commissioning of new units and the rehabilitation of old power plants in the medium term, combined with

a predictable reduction of the demand growth will lead to a high reserve ratio in the system until 1996 or later, the strict application of the reliability criteria in the long term may lead to reserve margins in the range of 17 to 26 percent. These figures might seem rather low, but they may correspond to two characteristics of the NEPA system:

- a growing economic value is to be allocated to the unsupplied energy in accordance with the increasing industrialization of the country.
- the generation mix is made up of numerous small size units instead of huge base units calling for more reserve capacity.

(d) Operating Conditions, System's Management Rules

- During the next few years, proper operation of the generating system will be difficult, because of the high share of hydro capacity, and the lack of reliable thermal stations. The risk of failure will depend largely on the operating policy. Too much dependence on hydro generation to compensate the failure of thermal generation should be alerted, considering the risk of shortage of reservoir inflow in dry years.
- It is recommended that the operation should not be optimized on a day by day basis but on a longer term basis in order to maximize the benefits from the hydro generation, by taking into account all the parameters involved in the generating system such as the load behavior, the units available either on the thermal side or on the hydro side of the generation system, the expected inflows foreseen in the short, medium and long term into the hydro reservoirs and the other constraints of the power generation system.

8. 3. 2 Hydro Potential Identified

(1) Major Hydro Projects Proposed by NEPA

Nigeria has a substantial hydro potential; most of it is located in the Niger river drainage basin including the Benue river and their major tributaries. Other hydro sources include the Cross river and other several short rivers directly discharged into the Gulf of Guinea. The hydro projects in operation, apart from mini - hydros on the Jos Plateau by NESCO since 1929, are the 760MW Kainji (Niger, 1969), the 540 MW Jebba (Niger, 1984) and the 600MW Sgiroro (Kaduna, 1990). A hydro potential of 6,530 MW at 50 percent capacity factor and 30,690 GWH in an average year as given below is considered technically feasible. In addition, the potential of mini-hydro sites is estimated at 400MW and 1,580 GWH with an average capacity factor of 44 percent according to the description in the World Bank report "Nigeria : Issues and Options in the Energy Sector (1983)".

INSTALLED CAPACITIES OF POTENTIAL HYDRO DEVELOPMENTS

Site	River	Nameplate Capability*(MW)	Average Annual Energy (GWH)
Lokoja	Niger	1,950	8,540
Onitsha	Niger	760	3,280
Makurdi	Benue	600	4,750
Zungeru I	Kaduna	500	2,190
Zungeru II	Kaduna	450	1,970
Ikom	Cross	400	1,750
Yola	Benue	350	1,530
Katsuna - Ala	Katsina - Ala	260	1,140
Beli	Taraba	240	1,050
Afikpo	Cross	180	790
Atan	Cross	180	790
Garin Dali	Taraba	135	590
Gembu	Donga	130	570
Sarkin Danko	Suntai	45	200
Gudi	Mada	40	180
Kiri	Gongola	40	150
Richa I	Mosari	35	150
Kombo	Gongola	35	150
Gwaram	Jama'are	30	130
Kasimbila	Katsina - Ala	30	130
Ifon	Osse	30	130
Richa II	Daffo	25	110
Kurra II	Sanga	25	110
Mistakuku	Kurra	20	90
Zurubu	Kaduna	20	90
Kurra I	Sanga	15	70
Isom	Gurara	10	40
Kafanchan	Kongum	5	20
Total	(28)	6,530	30,690

* At plant factor of 0.5
Source : Motor - Columbus et al, Energy Study for Fourth National Development Plan, 1980 - 85, March 1980.

Major hydro projects studied include the 1,950MW Lokoja (confluence on Niger and Benue), the 600-1,100MW Makurdi (Benue), the 800-2,000MW Onitsha (Niger), the 400 MW Ikom (Cross), the 500 MW Zungeru I (Kaduna), the 450 MW Zungeru II (Kaduna), the 350MW Yola (Benue) and others to allow a proper ranking of potential hydro projects and a comparison of those with alternative natural gas based . It may be mentioned that the Lokoja, Makurdi, Zungeru I and Zungeru II appear to be attractive on a strict cost basis, but the resettlement requirements for them are formidable, and also the reservoirs for these hydro projects would be required to provide major water storages for multipurpose use in view of the limited water resource in the country as well as of the substantial reduction of power cost. On the other hand, the 25-Year NEPA Power System Development Study (1988) has made special attention on major hydro at Zungeru and Mambilla.

The JICA Team's comments on major hydro development are summarized below :

(a) Zungeru (950MW) designed to utilize the spillage from existing Shiroro hydro and being currently at tendering stage by the NEPA. It is considered that a huge amount of the resettlement requirements will take a long lead-time for solution before its construction work, and the Zungeru hydro may be commissioned into the NEPA generation system after the year 2010 as is suggested by the 1988 NEPA Study.

HA 2102, Catchment : 44,400 sq.km
Annual inflow $= 10.0 \times 10^9$cn·m, Active storage $= 24.5 \times 10^9$cn·m

(b) Mambilla (2,600MW) is a very ambitious project which can produce 5,720 GWH of energy annually by directing the headwater of the Donga river on the Plateau through some chains of reservoirs and interconnecting tunnels to turn the turbines at the foot of the Abong escarpment. The execution of the Mambilla hydro calls for the construction of long access roads to the project sites and also most importantly for the prior agreement with Cameroon under a probable situation that it is not unlikely that Cameroon may request the study of a scheme including the works on the Donga river as an alternative. In addition, more detailed geological investigation are required due

to the complex geotectonic structure to confirm the engineering feasibility and related cost. The Mambilla scheme in its present configuration calls for an initial investment of US$2.1 $\times$ 10^9 before any energy can be produced, and there is no possibility of spreading expenses. This cost, almost double that of the Zungeru hydro, will doubtlessly create the increased difficulty in setting up its funding.

The Mambilla hydro will have the peak load duty mainly when the site is fully equipped. The 1988 NEPA Study shows that the site equipped with 3,960MW is definitely interesting, and also that an over equipment up to 5,700MW still remains very attractive. Although the equipment of the site in stages would allow the capacity to keep in step with load growth, the choice of Mambilla would withstand to significant variations of the main parameters such as investment cost, fuel cost, load growth and etc.

It may be noted that the Mambilla project so far proposed is judged optimistic because this depends on various actions being taken of which the timing cannot be predicted with any degree of certainty at this stage. Consequently, there would be no room to incorporate this scheme into NWRMP towards the year 2020.

HA 3140, Catchment: 2,100 sq·km
Annual inflow : 2.5 $\times$ 10^9 cu.m, Active storage: 2.9 $\times$ 10^9 cu.m

(c) Katsina-Ala (440MW) on the Katsina - Ala river. In its upstream, there is the Lake Nyos in Cameroon which is considered as a serious threat to Nigeria from the view point of gas burst or other seismic activity in the area and more seriously from the likely failure of the weak natural dam at the lake outlet. This site has been under the NEPA investigation . Its plan indicates that the Katsina-Ala hydro appears to be useful as a base load unit with a storage in small regulating capacity as compared with a large amount of the inflow. This means that it is very difficult for this site to become competitive as the base load unit against the cheap gas fueled combined cycle, and then this hydro cannot be considered in the NEPA power generation system unless a Katsina-Ala reservoir dam plan is established so a multi purpose project with the downstream irrigation so that a

substantial part of its investment cost is allocated to the irrigation sector. Considering the large-scale downstream irrigation plan, this Katsina-Ala scheme cannot be identified attractive in the NWRMP.

HA 4051, Catchment : 15,430 sq·km
Annual inflow : 2.3 × 10^9 cu.m, Active storage : 1.9 × 10^9 cu.m

(d) Ikom with the original capacity of 400MW is also on a long-term planning. For the scheme to be realized, the NEPA has to, first of all, solve the problem of Manfe (Republic of the Cameroon) which may be flooded if the scope is not reduced.

(2) Major Hydro Schemes Proposed by the JICA Team

Apart form the evaluation on the NEPA major hydro projects as described hereinbefore, the JICA Team has devoted to identify the potential sites of medium and small-scaled dam projects on the FSN topographical maps with short field visits which are incorporated into a main stream in the NWRMP. During the course of this work, five potential multipurpose dam projects in the basins of Taraba and Donga, the left side of the Benue River have been preliminarily screened out where main purpose being hydro power which would be extremely useful as peaking units for 6-hour generation a day, and the provision of regulating reservoirs in their downstream would enable a large-scale irrigation covering the wetlands as far developed along the downstream of these major tributaries. These include :

Site	Suntai	Karamti	Mayo Yim	Su	Kam
River Basin	Donga	Taraba	Taraba	Taraba	Taraba
Location : Latitude	7°33'	7°41'	7°52'	7°55'	8°17'
: Longitude	10°34'	11°29'	11°38'	11°33'	11°10'
Catchment Area (sq.km)	1,700	4,800	2,300	1,900	2,600
Annual Inflow (10^9 cu.m)	1.36	3.84	1.60	1.33	1.82
Active Storage (10^9 cu.m)	1.40	3.50	1.50	1.30	1.80
Dam Height (m)	60	70	60	50	50
Outflow for Peak Power (cu.m/s)	102	294	123	102	138
Power Plant Capacity (MW)	55	200	65	45	60
Annual Power Production (GWH)	160	550	190	130	175

The location of these hydro sites are specified on the Database Map No. 24, and some of the detailed description is made in Chapter 4 of this Sector Report.

Since the irrigation components to be involved in these large-scale dam projects are also large in size and nature, these dam projects would not be qualified in a series of the medium and small dam projects as recommended for NWRMP towards the year 2020. As far as the power sector is concerned, these major hydro schemes are concentrated in the Taraba State where the NEPA transmission system is not available at this stage and the major power load centers are situated at distant places; therefore, it is difficult for these hydro sites to be selected as part of the NEPA optimal generation mix even after the year 2010. It is suggested that a pre-feasibility study on the five potential dam projects be included in the later stage of NWRMP by a joint undertaking of the FMWRRD and the NEPA for the identification of their technical and economic feasibleness for multipurpose implementation.

(3) Mini Hydro Schemes Proposed for Isolated Rural Electrification

It may be noted that the NWRMP is giving a high priority to promote the implementation of a series of the medium and small dam projects with the basic objectives of irrigation water supply, inland fisheries and electrification in particular rural areas where the potential mini-hydro schemes would be organized appropriately.

Prior to the the description on the potential of the mini-hydros in the NWRMP, some of the relevant background are explained :

- In 1971, a group of African scientists meeting under the auspices of the Scientific, Technical and Research Arm of the OAU at Addis Ababa, advocated the need for African countries which are endowed with the hydraulic resources to embark on the construction on mini-hydros as a means of stimulating rural economy. It was argued that while the major hydro plants were often designed and constructed to generate and transmit bulk supply of power over extra-high voltage transmission lines to feed industries and urban centers of population, the rural area were often neglected.
- The fact is that the rural loads are small and scattered; hence, the authorities and companies in charge of the power supply in bulk are neither induced nor attracted to connect them to their systems. In case that the power needs for village households and related cottage industries are not away from the potential mini-hydro sites with the hydraulic head of 5 to 20m, the economic

returns on the mini-hydro cost may be justified taking into account the huge cost for new transmission line from existing power network to meet this isolated power demand. Dr. S. B. Elegba, Centre for Energy Research and Training and Dr. U. O. Aliyu, ABU summarized the distribution of small hydropower potential at State level in their publication "Prospect for small Hydropower Development of Rural Applications in Nigeria" (1981), from which a list of the proposed and half-completed mini hydro potentials is quoted below for reference :

State **	River Basin *	Total Sites	Developed (MW)	Undeveloped (MW)	Total Capacity (MW)
Sokoto	Sokoto - Rima	22	8.0	22.6	30.6
Katshina	Sokoto - Rima	11	-	8.0	8.0
Niger +	Niger	30	-	117.6	117.6
Kaduna	Niger	19	-	59.2	59.2
Kwara +	Niger	12	-	38.8	38.8
Kano	Hadeija - Jamaare	28	6.0	40.2	46.2
Borno	Chad	28	-	20.8	20.8
Bauchi	Upper Benue	20	-	42.6	42.6
Gongola +	Upper Benue	38	-	162.7	162.7
Plateau	Lower Benue	32	18.0	92.4	110.4
Benue +	Lower Benue	19	-	69.2	69.2
Cross River +	Cross River	18	-	28.1	258.1
Total		277	-	702.2	734.2

Note : * Largest overlapping River Basin only
** Information Available for only 12 states
+ States with either developed or technically exploitable, intermediate medium and lage hydro schemes.

While this publication was not readily available to the JICA Team, some of the mini hydro potentials to be attached to the proposed medium and small dam projects have been confirmed in a qualitative manner during the course of identification work on the FSN topographical maps. It is to be noted that the contour interval of 15m in the FSN 1 : 50,000 maps could not give any of the technical dimension of these mini hydro potentials.

It is recommended that when a pre-feasibility study of the medium and small-scale dam projects in a multipurpose nature is carried out for the sectors of irrigation, water supply, mini-hydro, fisheries and so forth, the State Rural Electrification Boards should be involved to identify the need of isolated rural electrification and examine the technical capability of power generation and its distribution in cooperation with other executing agencies. When

identified, the feasibility study from the technical, economic and financial point of view is fully discussed under the technical assistance of the Federal Ministry of Power and Steel and its parastatal " NEPA ".

8. 3. 3 Amalgamation of RBDA Hydro Sites into NEPA Grid System

To date, four RBDA dams have been built with the hydro components in accordance with the River Basin Development Authorities Decree, No.35 of 1987 for undertaking a comprehensive development of surface water resources for multipurpose use. These include the hydro (3MW, existing) at Bakolori dam under S-R RBDA, 9MW (installed in 1993) at Oyan dam under 0-0 RBDA, 6MW (to be installed in near future) under 0-0 RBDA and 34MW (not yet install) at Dadin Kowa dam under UB RBDA.

Of these, the Bakolori hydro is not operated due to the defect of relevant penstocks, and the Dadin Kowa hydro is already equipped with the intake, penstocks and other works to house the power outfits except the installation of turbines and generators due to the financial constraints partly in relation to the implementation of the RBDA-partial commercialization policy.

Virtually, these hydros have been planned and developed by individual RBDA without any cooperation of the NEPA. Because of the limited manpower resources available in the RBDAs, there should be operational problems for satisfactory OM of each RBDA hydro plant. In addition, there is a problem on distribution and sales of the power generated. It is regretted that in most of the RBDA hydros, the work has been left uncompleted even at this stage. In order to enable these multipurpose dams hare their full compliment of functions, the following measures should be taken :

- Funds must be provided for completion of all multipurpose dams that were originally designed to produce power as part of their designed functions.
- Officials of NEPA be included in all committees where such dams are being constructed ab-initio i.e. from conception to award and construction.

- Upon completion, the NEPA should be directed to take over such power facilities and link the generated power to the NEPA power grid system. As is shown in the Database Map No.22, all of these RBDA hydros are located close to the NEPA power grid system. At the same time, the cost incurred for these hydro facilities and part of the cost for multipurpose dam to be allocated with appropriate procedures should be cleared by NEPA.
- A national committee on multipurpose dams be set up to work out all modalities of operation of multipurpose functions.

The JICA Team's observation on the Dadin Kowa hydro scheme for urgent action program is introduced below:

- This dam was commissioned in 1988 with the main objective of irrigation; however, no action taken to date to develop the irrigation system in its downstream. The JICA Team has examined this item and the conclusion is that there is virtually no wetland suitable for gravity irrigation to a large extent between the Kiri reservoir except for the upland in high elevation where substantial pumping is needed.
- It may be considered that main objective of the existing Dadin Kowa dam be changed to the hydropower generation as peaking units for quick recovery of the previous huge investment from the national economic point of view. Immediate benefit will be derived with the installation of electro-mechanical turbines and generators (34 MW) and subsequent connection of this plant to the national power grid (some 10 km in distance) by the NEPA.
- To realize this plan, the administrative procedures required for the transfer of the RBDA's properties to NEPA, the payment of the cost allocated to the hydro sector both for initial construction and subsequent OM to RBDA or the transfer of water right in monetary term to NEPA should be discussed and concluded between RBDA and NEPA under the positive arrangement of the FGN.
- A preliminary cost estimate to install the electro-mechanical equipment for the above-specified urgent scheme may be given at around N 600×106. With this investment, the Dadin Kowa dam and appurtenant structures which are completely idle for years will be converted to productive infrastructure.

8.3.4 Plan Implementation Program

In line with the findings so far obtained in the previous sub-chapters mainly with reference to the 25-Year NEPA Power System Development Study (1988), the following plan implementation program should be recommended:

1. In not a distant future, the NEPA system could experience severe power generation shortage as a consequence of various problems because the real reserve margin is currently less than 20 percent taking into account the actual available units. Quick rehabilitation including the reconditioning and refurbishment is, therefore, highly desirable.

2. The NEPA generating system will be difficult to operate during the next few years due to high share of the hydro capacity and lack of the reliable thermal plants. The actual operations will run the hydro powers when the thermal power is failing, however, the risk of decrease in inflow to the Kainji and Jebba lakes should be taken into account. Reference is also made to para 8.3.1 (2) (d) of this Chapter.

3. The NEPA study (1988) has taken a peak demand of 9,000MW for the year 2010 where no hydro site is selected as part of the optimal generating mix, because it is extremely difficult for hydro sites to become competitive as base load units against the cheap gas fueled combined cycles. This concept is supported by the JICA Team, but the high degree of uncertainty concerning the power demand-supply projection both in Nigeria and throughout the world requires the development plan to be updated more frequently. The down turn of the power demand growth due to the economic and political changes currently experienced by the FGN may prolong the availability of the NEPA 2010 plan with a peak demand of 9,000MW to the year 2020.

4. The NWRMP study has identified the current position of major hydro sites including Zungeru,, Mambilla, Katsina-Ala, Suntai, Karamti, Mayo Yim, Su and Kam which should be operated as peaking units, as are described in para, 8.3.2. Among them, the sites at Zungeru and Mambilla appear as most attractive and interesting, and further study

on both the sites are needed particularly for Zungeru on the environmental impacts and cost reduction by a multipurpose use of the reservoir and for Mambilla on more clear presentation of the engineering feasibility. As far as other six sites are concerned, it is suggested that a pre-feasibility study will be carried out as a multi purpose water resources development during the second half of the NWRMP period for the project preparation. As a matter of fact, the irrigation components to be involved in each of the six hydro schemes are large-scaled and, if feasible, would likely to be implemented after the year 2020.

5. Apart from the major hydro sites for the NEPA generation system, priority should be given to the provision of mini-hydro powers for isolated rural electrification in accordance with the implementation of medium and small-scale dam projects for multipurpose water use with the main objective of irrigation. It is recommended that pre-feasibility study of those projects will be commenced immediately after the completion of the NWRMP study so that the potential sites for mini-hydro will be identified involving the participation of the State Rural Electrification Boards, and the construction of the identified mini-hydro works will be positively promoted during the period after the year 2000.

6. In compliance with the FMWRRD policy on multipurpose water resources development projects, the RBDAs have constructed four dams at Bakolori, Oyan, Ikere Gorge and Dadin Kowa with the attachment of hydropower facilities being independent from the NEPA. As a matter of fact, the RBDAs are not capable of handling all of these hydro facilities including the generation, transmission and distribution in terms of the management personnel and the funds required for operations. It is recommended that the hydro works already equipped at the former three sites be amalgamated into the NEPA power grid at the earliest possible after urgent settlement of the official procedures as required.

The 34MW electro-mechanical facilities for the Dadin Kowa dam as commissioned in 1988 have not been installed to date, and its reservoir water has not been used at all due to non-identification of the major

irrigation service area. It is strongly recommended that the political and official arrangement on the conversion of main objective from irrigation to hydro power should be made as soon as possible to enable the NEPA to install the turbines and generators for urgent power generation. With an additional investment at around N 600×10^6, quick recovery of the initial investment for construction of the Dadin Kowa dam will be made possible, and this will surely contribute towards the practical gain of benefits from the national economic point of view.

7. For proper implementation of the NEPA study (1988), supplementing the recommendations related with its investment framework, some immediate countermeasures for taking into account the human and organizational factors with influence on OM of the power systems and on their reliability that include training, spare parts management and the Oshogbo National Control Centre's reinforcement should be considered.

The above-recommended programs are presented in time-scheduling in Figure 8-1" NWRMP : Hydropower Sector Program".

8.3.5 Project and Program for Consideration by External Agency(s)

During the course of the NWRMP Study, the needs and categories to be assisted by the external agencies have been examined; to this end, two projects have been preliminarily delineated viz. (1) "Technical Cooperation: Preparation on Medium/Small Dam Package Program" which may be related to the hydropower sector and (2) "Economic Cooperation: Hydropower Development Project at Dadin Kowa". Provisional terms of reference for the former program is compiled in Appendix 4-4 of the Sector Report Chapter 4 "Water Source Works" for ready reference.

An implementing arrangement proposed for Hydropower Development Project at Dadin Kowa is given below:

(1) Background

To date, four dams managed under the River Basin Development Authorities (RBDA) have been built with hydro component in accordance with the policy of the Federal Ministry of Water Resources on multipurpose development of the surface water; however, these hydro units have been planned and developed by individual RBDA without any contact and cooperation of the National Electric Power Plc. (NEPA). Because of the power distribution and OM problems under the scarce manpower available in RBDAs, it is highly recommended that all of the hydro units be amalgamated into the NEPA system operations as quickly as possible after proper settlement of the official procedures as required. These hydro units include Bakolori (3MW, existing), Oyan (9 MW, installed in 1993), Ikere Goge (6 MW, scheduled) and Dadin Kowa (34 MW, not scheduled).

In addition, a critical review on the function of the Dadin Kowa Dam as completed in 1988 has been made. In the Gongola River basin, a large tributary of the Benue River, 11 reservoirs for irrigation have been constructed, in which two major storages at Dadin Kowa (1.77×10^9 cu.m) and Kiri (325×10^6 cu.m) along the Gongola main channel are specified while others belong to the medium- and small-scale ones with less than 15×10^6 cu.m each in its tributaries. The original plan of Dadin Kowa Project indicates the development of 34 MW power and 38×10^3 ha irrigation; however, there is no potential of the land suitable for irrigation along its downstream course with the exception of 4×10^3 ha on the right side upland, and the hydro generation facilities have not yet been equipped although the penstocks and power house / foundation were constructed simultaneously with dam body. In view of obtaining quick return for the huge investment made by 1988 and two advantages of most favorable inflow conditions (2.5×10^9 cu.m) and the Kiri Dam as a regulating reservoir, necessary action to change the objective of Dadin Kowa Project to the hydropower should be sought.

In line with these findings, the National Water Resources Master Plan has recommended that the Dadin Kowa Dam could be mainly mobilized for hydropower purpose for quick recovery of the previous huge investment in line with many salient advantages. Annual power output of 200 GWH would be generated under 34 MW plant, and its annual income would reach 400×10^6 Naira at an assumed rate of 2 Naira per KWH. It is also considered that there

should be a great potential as peaking units with the downstream regulating pond at Kiri into the NEPA national grid system and/or as complement to the output reduction at Kainji and Jebba in dry season due to the decrease of Black Flood inflow. To realize this plan, the administrative procedures required for the transfer of the RBDA's properties to NEPA, the payment of the cost allocated to the hydro sector both for initial construction and subsequent OM to RBDA or the transfer of water right in monetary term to NEPA should be discussed and concluded between RBDA and NEPA under the positive arrangement of the Federal Government of Nigeria (FGN).

From the technical point of view, it may be suggested that immediate benefit will be derived with the installation of electro-mechanical turbines and generators (34 MW) and subsequent connection of this plant to the national power grid (some 10 km in distance) by the NEPA. A preliminary cost estimate to install the electro-mechanical equipment for the above-specified urgent scheme may be given at around ₦600 × 10^6. With this investment, the Dadin Kowa Dam and appurtenant structures which are completely idle for years will be converted to productive infrastructure.

(2) Preliminary Terms of Reference

As mentioned previously, the 34 MW electro-mechanical facilities for the Dadin Kowa Dam as commissioned in 1988 have not been installed to date, and its reservoir water has not been used at all due to non-identification of the major irrigation service area. It is strongly recommended that the political and official arrangement on the conversion of main objective from irrigation to hydro power should be made as soon as possible to enable the NEPA to install the turbines and generators for urgent power generation. With an additional investment at around ₦600 × 10^6, quick recovery of the initial investment for construction of the Dadin Kowa Dam will be made possible, and this will surely contribute towards the practical gain of benefits from the national economic point of view.

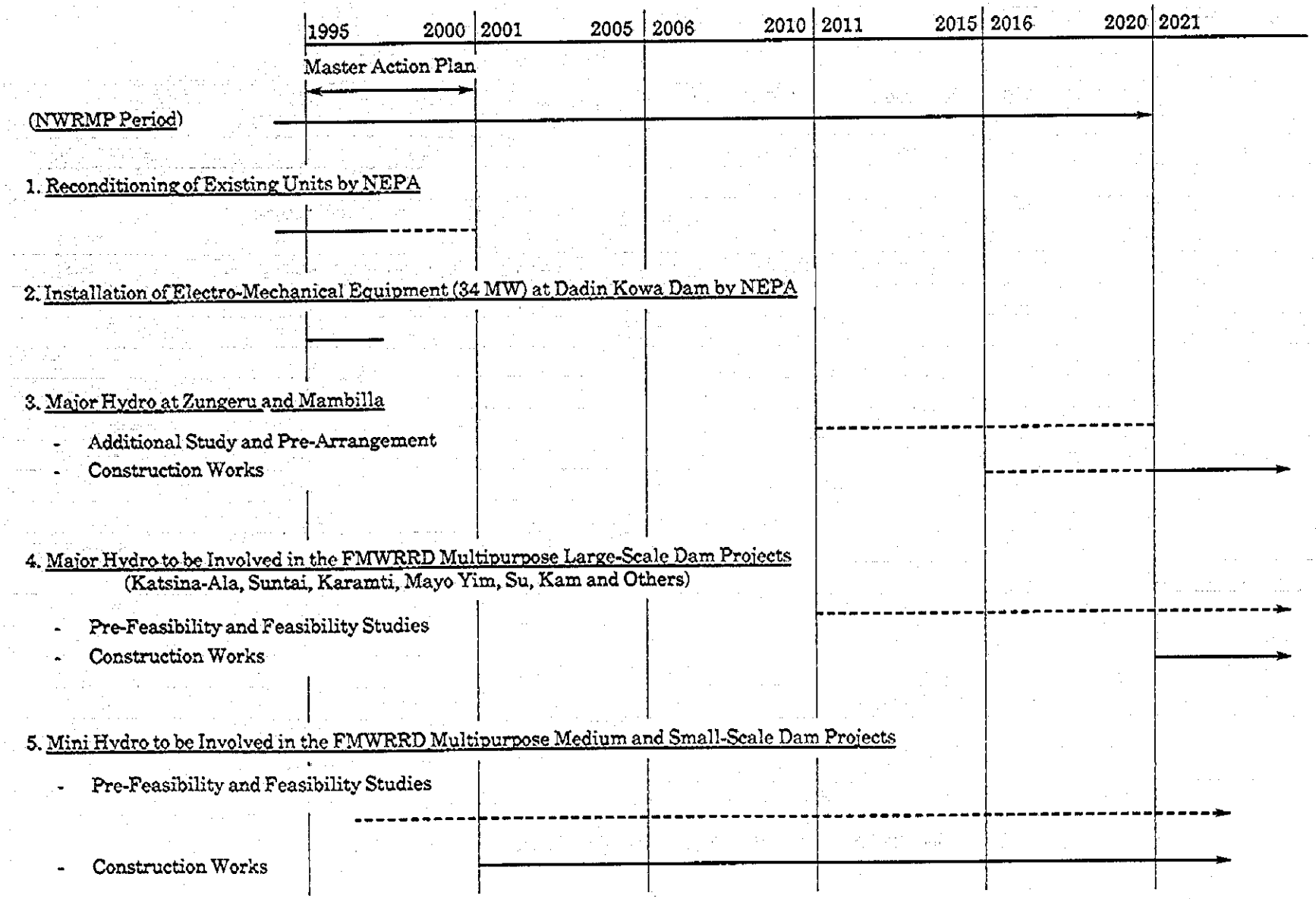
When a financial assistance for implementation of the hydropower development project at Dadin Kowa Dam by external financial agency is sought, preliminary terms of reference for its realization may be given below:

- Objective:

- Preparation of a project implementation program for installation of electro-mechanical turbines and generators (34 MW in total) and subsequent connection of this plant to the NEPA national power grid system including the technical assistance study on operating conditions.
- Installation of the equipment with the approximate cost of 600 $\times$ 10^6 Naira mostly in foreign currency be external financing.

- Agencies: NEPA in cooperation with FMWRRD
- Implementing Schedule: Three years after completion of the administrative procedures required for transfer of RBDA properties to NEPA.

FIGURE 8 - 1 NWRMP : HYDROPOWER SECTOR PROGRAM



APPENDIX 8-1 NESCO MINI-HYDRO DAMS CHARACTERISTICS

ITEMS	PROJECTS								
	Ource	Kwall	N'gell	Tenti	Ankwil I	Ankwil II	Kurra	Jekko I	Jekko II
(1) General									
Code No.	N-LDCP...MS	IV-MDCP...MS	IV-MDCP...MS	IV-MDCP...MS	IV-LDCP...MS	IV-MDCP...MS	IV-LDCP...MS	IV-MDCP...MS	IV-SDCP...MS
State	Plateau	Plateau	Plateau	Plateau	Plateau	Plateau	Plateau	Plateau	Plateau
River	Ouree	Ouree	N'gell	Tenti	Tenti	Tenti	Tenti	Sanga	Sanga
SHA No.	IV	IV	IV	IV	IV	IV	IV	IV	IV
Agency	NESCO	NESCO	NESCO	NESCO	NESCO	NESCO	NESCO	NESCO	NESCO
(2) Reservoir									
Area (sq km)	0.126	0.140	0.042	3.96	5.10	0.23	4.80	0.4	0.02
Capacity(MCM 10^6)	6.68	0.63	0.025	14.0	31.0	1.16	17.0	1.4	1.4
Discharge (m^3/sec)	257	271	108	171	228	343	571	685	685
(3) Dam									
Height(m)	21	9	9	14	27	9	19	9.75	6
Crest Length(m)	860	274	38	854	708	203	1,067	128	23
Volume (MCM)	114,000	90,500	1,250	238,000	521,240	46,578	348,654	6,000	700
Altitude(ASL)	1,158	1,068	1,319	1,315	1,274	1,274	1,172	870	674
Type	Earthfill	Earthfill	Concrete	Earthfill	Earthfill	Earthfill	Earthfill	Concrete	Concrete
Spillway	Broad Crested weir	Ogee	Broad Crested weir	Broad Crested weir	Underflow	Underflow	Broad Crested weir	Ogee	Ogee
(4) Power Plant									
Output(KW)		2000			1000	2000	8000	4000	4000
(5) Stage	Completed 1936	Completed 1923	Completed 1923	Completed 1943	Completed 1964	Completed 1963	Completed 1929	Completed 1937	Completed 1950

Source : Nigerian Electricity Supply Corporation Ltd., Bukuru, Jos.

CHAPTER 9. INLAND NAVIGATION

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9.1 Background and Present Situations

9.1.1 Historical Perspectives

In 1954, the World Bank recommended that a Government department be established to collect detailed information about the behavior of Nigerian rivers and to hold this information ready for the studies of flood control, irrigation and reclamation projects as well as for navigation and hydropower schemes. And, in 1956, the FGN established the Federal Inland Waterways Department (FIWD) which is in charge of the river conservancy after the then Nigeria Marine had for a long time been the only Government department on inland and coastal rivers, with the principal duties as summarized below:

- the operation and maintenance of Government craft;
- maintenance and improvement of channels; control of navigation;
- wrecks, lights, buoys and piers, licenses, examinations and surveys of craft;
- hydrological and hydrographic surveys including map production; and
- hydraulic engineering.

Nigeria has over 3,000 km of the navigable waterways made up of the Niger and Benue river systems, the Niger delta creeks and the intercoastal waterways and lagoons which run from Badagry in the extreme west to Calabar in the east of the country. The FIWD had in the past provided the main communication routes and access from the coast to the hinterland where the expatriate trading firms made an extensive use of these navigable waterways to transport the agricultural products. During those early days and up to the early 1960s, the river transport was very prominent and accounted for over 30 percent of the product transport in the country. Because the seasonal patterns of navigability of these waterways coincided with the seasonal changes of agricultural export products, there was no compelling need for

serious investment to extend the period of navigability of the inland waterways system until 1956 when the FIWD was created.

The studies on potential movement of the production materials by water in Nigeria and experience from other countries with developed water transport systems strongly suggested that the inland waterways continue to be prime and critical mover of the bulk materials for industry and agriculture. The coming up of some development activities such as the Ajaokuta steel industry, the new Federal Capital development in Abuja, etc, generated massive transportation needs which brought the inland waterways into focus.

As far as the NWRMP Study is concerned, attention has been paid to the dredging and navigation improvement works:

- Some of the key objectives of the FIWD include the development of infrastructural facilities for a national inland waterways network. This network would connect the creeks, the rivers, the river ports serving as inter-modal exchanges, with the economic centres. Others include the provision of minimum requirements for year round navigation by increasing the water carrying capacity and safety for bulk cargo transport by barges.
- Due to financial constraints, the scope of more extensive development in the inland waterways was reduced to the barest necessities. From 1985 to date, the works executed include the dredging of Lekki flats which improved navigation between Lagos and Warri ports thereby linking Lagos port complex with the hinterland of Nigeria. The approach channel to Warri dockyard slipway was also dredged. The buoyage of Niger and Benue rivers, installation and maintenance of river gauges, collection of hydrological data were carried out.
- To aid the planning of water-based projects the hydrological year books covering the period of 1914-1959 were published . The FIWD further conducted hydrographic survey and charter for new ferry routes in Lagos metropolis. To enhance the planning of river works, the FIWD carried out survey of the Niger river from Baro to Warri and Port Harcourt which established the permanent survey beacons tied to the national grid.

9.1.2 JICA-NWRIS

(1) TOR

Form N-5.1

Historical and present situations of the inland navigational activities including:

- Name of river, river reaches, river length, width and depth to use for navigation.
- Number of ship and cargo volume on each river basis.
- Navigation period (month) in accordance with river depth.
- Cargo loading and unloading ports.
- River dredging activity including the following items:
  * Dredging volume (m^3/day and m^3/year)
  * River reaches under dredging.

Form N-5.2

Current conditions of the river morphology for navigational course including:

- River cross-section and slope.
- River bed fluctuation by sediment accumulation.
- Meandering condition of river.
- Plugging condition of river mouth.

Reference Forms :

Form N-5.2(1): Present River Morphology for Navigational course

Form N-5.2(2): Existing Navigation Improvement Projects

Form N-5.3

Development plan for the inland navigation activity for the years of 2000 and 2020:

- General cargo handling plan:

(2) Summary of the Outputs

The outputs of the Skoup survey are compiled in the Final Report dated January 29, 1993 with the Base Maps, several copies of which were submitted by the JICA Team to the FMWRRD for future reference. Major outputs are summarized below:

Form N-5.1

A part from the navigational river conditions, the data to be incorporated in the JICA Forms were not available due to weak statistical base in the FIWD. The following information together with a figure indicating the navigational periods of the principal rivers were compiled:

- River cargo traffic is operated by private companies using the barges with pusher tug boats. They operate mainly during the wet season. There are, however, many small operators using locally built boats. It is estimated that their aggregate volume of cargo is over 1 million ton, although it is said that there would be a potential traffic flow of over 2.5 million ton of river cargo transport per annum.

Historical and Present Situation of Cargo Traffic

(Unit : ton)

Year	The Niger and the Benue	
	Upstream	Downstream
1980	234	315,000
1981	4,000	446,000
1982	70,000	500,000
1983	75,000	510,000
1984	100,000	670,000
1985	-	880,000
1986	-	953,565
1987	-	1,053,500
1988	4,000	1,224,994
1989	-	1,201,000
1990	4,125	1,162,500
1991	6,500	1,207,909
1992	8,575	1,102,846

- There are 27 passenger boats of the capacity to ferry 125 to 800 passengers each. The FIWD provides ferry services for passengers and goods at the following routes:

Historical and Present Situation OF Passenger Traffic

Route		1980	1985	1990
Lagos - Apapa	(Lagos Lagon)	890,897	159,665	861,343
Lokoja - Shintaku	(Lower Niger)	137,209	66,898	79,721
Ida - Agenebode	(Lower Niger)	25,561	11,660	-
Calabar - Oron	(Cross River)	221,357	525,632	102,509
Calabar - Greek Town	(Cross River)	-	131,466	-
Port Harcourt - Abonnema/Buguma	(Niger Estuary)	-	10,851	17,564
Ibi - Sarkin Kudu	(Benna River)	62,487	55,142	-
Donga - Nassarawa	(Donga River)	-	8,775	-
Yauri - Dolekaina in Kebbi State	(Upper Niger)	-	18,296	2,398

A map showing the navigable sections and periods of the year of the inland waterways is enclosed as Figure 9-1.

Form N-5.2

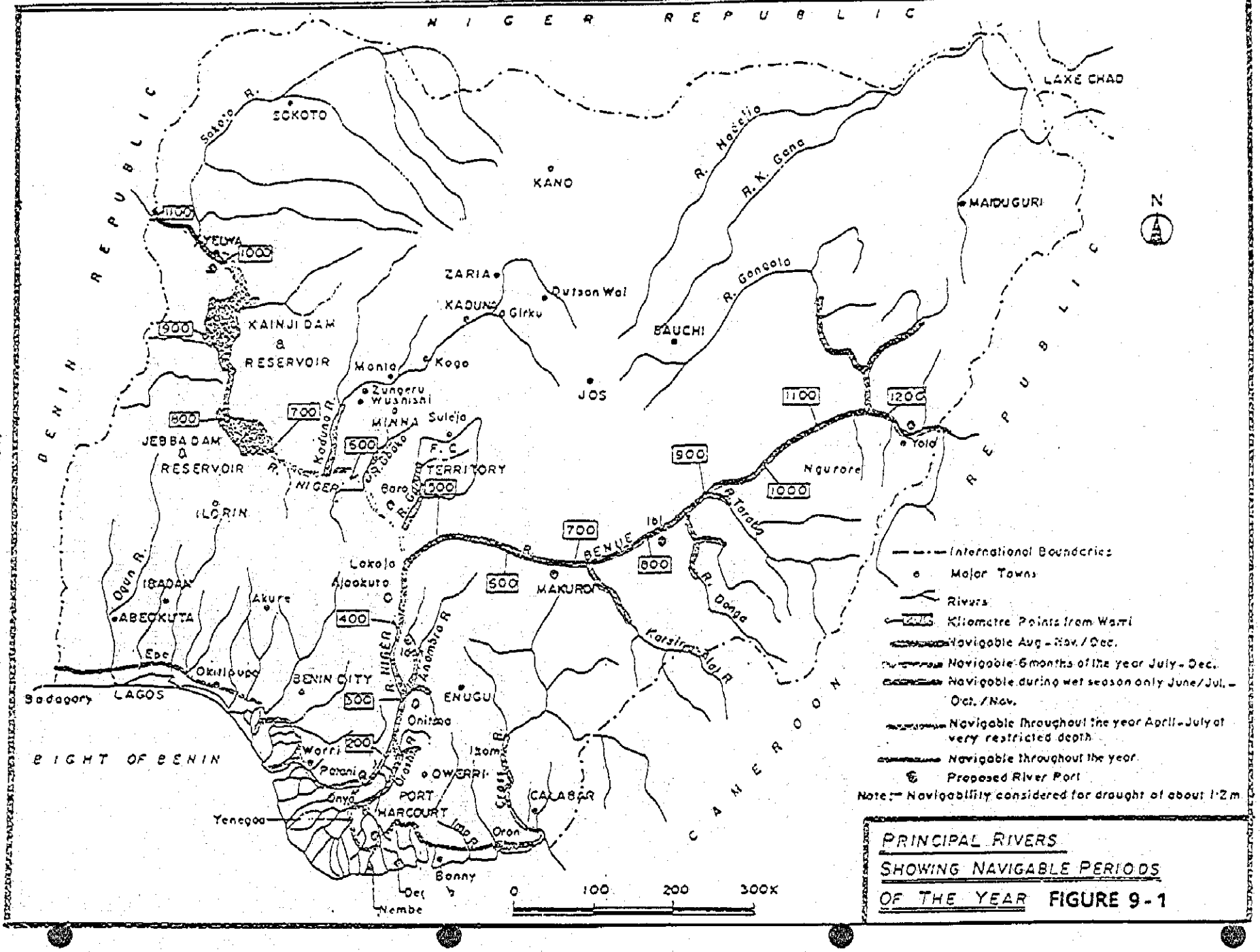
The information given to the river morphology are examined in river related paragraph of Chapter 3 (Sector Report). Existing navigation improvement projects that are undertaken by the FIWD are summarized in Table 9-1.

Form N-5.3

This Form dealing with the development plan proposed for the years 2000 and 2010 has not been filled, because the information available are only descriptive and could not be put into the given Form being similar to the Form N-5.1.

- Short-Term Plan to the Year 2000

  This may be summarized as,
  - manpower development;
  - improved data collection, including installation of recording gauges to minimize human errors;
  - maintenance of the navigation channel by dredging;
  - installation of night navigation aids to allow for 24-hour navigation during the flood season;
  - buoyage and river patrols; and
  - daily broadcast of navigation bulletins.



PRINCIPAL RIVERS SHOWING NAVIGABLE PERIODS OF THE YEAR **FIGURE 9-1**

TABLE 9-1 EXISTING NAVIGATION IMPROVEMENT PROJECTS

River Niger

		Niger	Niger	Niger	Forcados	Num
1.	River condition to be Improved	Shallow draughts at crossings during dry seasons	Shallow draughts at crossings during dry seasons. Also rock outcrops.	Shallow draughts at crossings. Braided channel.	Sharp bends requiring bend cutting.	Sharp bends requiring bend cutting
	River Reaches (km)	Baro to Lokoja (116 km)	Lokoja to Onitsha (211 km)	Onitsha to Bifurcation (129 km)	Bifurcation to Warri (84 km)	Bifurcation to Port Harcourt (285 km)
	River Depth (m)	5.0 to 6.0	6.0 to 10.0	7.0 to 13.0	8.0 to 16.0	7.0 to 15.0
	Discharge in Wet Season (m^3/sec)	6,000	8,000	15,000	N. A	N. A
	Sediment Problem Reaches (km)	1,300	1,500	1,100	N. A	N. A
	River Mouth Plug Area (ha)	3.2	15.0	3.1	3.9	3.0
2.	Project Component	Dredging, Rock blasting, river training and Navigation aids			Dredging and cutting of sharp bends	
	Dredging Volume (m^3)	225,000 sand	917,000 sand, 6,800 rock. Bottom panels have been installed near Lokoja.	133,000 and	9,000 sand	126,000 sand
	Project Cost	About ₦ 200 million per annum during the first four years				

River Benue

1.	River condition to be Improved	Navigable for only 3 months during wet season. Numerous sad banks and rock outcrops during dry season	
	River Reaches	Lokoja to Ibi (252 km)	Ibi to Yola (274 km)
	River Depth (m)	5.0 to 8.0	3.0 to 5.0
	Discharge in Wet Season (m^3/sec)	11,000 to 16,500	2,500 to 11,000
	Discharge in Dry Season (m^3/sec)	200 to 1,000	50 to 200
	Sediment Problems (km)	Sand banks and islands line to entire length of the river	
	River Mouth Plug Area (ha)	There are shifting sand banks at the confluence with river Niger	
2.	Project Component	1. River Patrols. 2. Installation of navigation aids.	
	Dredging Volume along River	No dredging has been done.	
	Project Cost	About ₦ 1,000 per annum.	

- Long-Term Measures up to the Year 2010

While the short-term plan (2000) is designed to maximize the use of the waterways during the flood season with the minimal artificial intervention, the long-term measures aim at achieving year-round navigability of the waterways for the reach of the Niger river from Baro to Warri and Port Harcourt sea ports. Baro is considered an ideal terminal point because its river port provides a rare inter-nodal linkage between water, rail and road systems. Goods shipped to Baro can be trans-shipped by rail or road to North-Eastern or North-Western Regions of Nigeria as well as to the fast growing Federal Capital Territory, Abuja.

To realize this, major permanent structural measures should be introduced to improve and sustain the economic navigable depths for at least ten months of the year. In the "Baro to Bifurcation" reach where the annual water level fluctuation is up to 9 m, there are shallow channels linking the deep concave bends at 59 crossings. Implementation of the proposed long-term plan may be associated with the substantial financial implications of permanent structural works as well as the time and technical capability needed to design, install and monitor the performance of these measures.

It may be noted that the report by NEDECO on engineering studies and dredging of the Niger from Lokoja to Warri and Port Harcourt in 1977-80 identified the following crossing as particularly difficult:

Atani-Goma	381 km from Warri
Oyedega	360 km from Warri
Illah	310 km from Warri
Anam	283 km from Warri
Azagba	231 km from Warri
Epidiama	151 km from Warri
Aruke	134 km from Warri

There is a range of permanent structural measures which can be applied to correct the navigation problems. The selection of type of structure is based on site requirements and investigations which can include the laboratory modeling of flow patterns. However, the basic aim in this reach would be to increase the flow depth either by:

- concentrating flow in one channel of a braided reach (most reaches are braided);
- inducing degradation of the navigation channel bottom and aggradation of the bank;
- diversion of sediments from the navigation channel to the banks; and
- water level regulation.

In the downstream of the Bifurcation along the Forcados river to Warri and the Nun river to Port Harcourt, the problems are largely the same:

- meanders with comparatively short lengths and high amplitudes, consequently sharp bends;
- narrow channels; and
- overhanging trees, floating debris and sudds.

The channels are generally deep enough for navigation by barges and push tugs. A program of carefully selected bend cutting will greatly improve navigation by:

- reducing travel time; and
- increasing fleet capacity by allowing for safe navigation of barge convoys of 100m in length or more.

A typical example of such difficult and dangerous bend is near the village of Siama about 64km from Warri on the Forcados river.

9.1.3 Problems and Needs

(1) Position of the Inland Navigation in the Transport Sector

Very few countries are fortunate enough to have within their borders a river system with such potential for development as the Niger / Benue river system; however, the river transport in Nigeria is very much underdeveloped. It may be mentioned that in relation to the cargo flows to and from the main

seaports, the market shares of both river and rail transports are declining in favor of road transport.

The Civil War of 1967 to 70 caused a complete change in the nature and direction of river traffic in Nigeria. Prior to the war, the river transport for agricultural product was engaged in its export from the north to the mainline delta ports at Burutu and Warri; however, in the post-war years changes in the marketing system and lower agricultural production have delayed the resumption of this transport mode. The economic study carried out by the NEDECO indicates that the rail and river transport are best suited for the long distance carriage of bulk materials. A number of the factors would make and outlook for river transport versus other rail / road positive. With the rising cost of fuel, the inland navigation would become one of the most attractive way to transport large quantities of goods to and from the Nigerian hinterland through the Niger and Benue river and their tributaries where the density of road / rail network is smaller.

This suggestion may be referred to "the Policies and Objectives of Inland Waterways as compiled in the First National Rolling Plan (1991 to 93); however, the lack of funds for huge cost and the technical capability for difficult tasks to improve the large-scale rivers would have eliminated the implementation of potential development works. It may be overviewed that from an environmental standpoint, the logical solution to the lack of existing suitable conditions indicates that large commercial inland navigation schemes should be de-emphasized. Existing flow patterns and conditions on major rivers would require significant modification, and construction costs and annual maintenance requirements would be very high. In Nigeria, most major population centers are not located on the Niger or Benue Rivers. The country can be served more cost-effectively by rail and truck from existing port facilities at Lagos, Port Harcourt, and Calabar. It appears that existing flow conditions are adequate to support local coastal passenger and commerce traffic.

* .... The inland water transport mode has been identified by the FGN as requiring greater investment in order to exploit the cheapness of this mode to full advantage. The FIWD will be given adequate support in its dredging activities to ensure greater improvement in the navigability of the rivers all the year-round particularly the Rivers Niger and Benue as this will facilitate bulk-transportation in support of industry and agriculture as well as mass transit program.

(2) Water Hyacinth Menace

It is reported that the tremendous progress has been made by the FGN to control the perennial problems of water hyacinth in the coastal water, and in addition to the procurement of necessary equipment for the exercise, the FGN has also erected barriers at selected locations to control the spread of the weeds. It has been observed, however, that while the FIWD has the responsibility to keep the waterways free of floating vegetation and debris that impede navigation, this problem is more pronounced in the delta sections of the waterways. Virtually, the water hyacinth, that is a fast growing aquatic plant has invaded the FIWD waterways and so complicated the weed problems. The FIWD has plans to procure more weed clearing machines to facilitate fast removal of the weeds from the waterways. The water hyacinth menace to decrease the power to be generated by existing major hydro sites at Kainji and Jebba has been explained in para. (2) of 8.2.2 of Chapter 8 where the measures to solve this problem is suggested for reference.

(3) Discussion on the Proposed Barrages

The 1984 report "Niger River Channel Development Program" prepared by LCHF (France) for FIWD compiles a proposal to provide a series of the barrages in the Niger below Lokoja. Its intention is to raise the surface water level during the dry season by closing gates and to make the river flow almost normally during the flood season by opening gates. This proposal to improve navigability in the Lower Niger has a plan to build the barrages (or estuary dams) at Eroko, Otngbo, Illushi, Onitsha, Odoguri and Bifurcation with a navigation lock, a barrage with radial gates and an earth dike per each site.

With a view to mitigate harmful environmental damages anticipated by future decrease of the Niger and Benue river discharges due to the upstream diversions and subsequent saltwater intrusion into more upstream, it may be worthwhile to examine this proposal within the context of the NWRMP. It may be noted that this was preliminarily discussed with the FIWD, Lokoja December 1992 with the FIWD's concern at Otugba and Illushi.

When discussing this proposal in the coming stage, the following will be carefully examined:

- Works would have to be designed to withstand the seasonal changes in flows in these major rivers, a change in volume of 30 : 1 between wet and dry seasons.
- Specific to the proposal for a barrage, the environmental effects would include downstream erosion, lowering of the groundwater table, changes in flora and fauna assemblages, and loss of critical fish nursery areas.
- Upstream of the dam, sedimentation problems are likely, and the logistics of handling large water volumes during seasonal flooding periods must be addressed.

9. 2 NWRMP Towards the Year 2020

9. 2. 1 Capital and Maintenance Dredging

Reference has been made to the annual sediment transport along the rivers of Niger and Benue in the NEDECO report (1959), from which Table 9-2 has been prepared. Higher concentrations as are seen along the Benue river mean severe erosion of parts of the drainage areas, and the loss of great quantities of soil might give rise to the activities on local soil conservation. As is seen in Table 9-2, between three groups of transport viz. bed-load, suspended load and wash-load, greater differences exist; differences in origin and mechanism as well as in effect on the river and the river-bed.

Generally speaking, the bed-load is the determinant for the behavior of channels in an alluvial river, and the quantity of bed-load always equals the transporting capacity. Extra supply of sand means the deposition and increase of river-slope; reduced supply may, on the contrary, cause the scour and decrease of slope. Notwithstanding its importance, the bed-load forms only a very small function of the total transport, the great bulk of sediment being wash-load.

TABLE 9-2 ANNUAL SEDIMENT TRANSPORT ALONG THE NIGER AND THE BENUE

Location	Year	Bed-Load		Suspended Load		Wash-Load		Total	
		10^6cu·m	%	10^6cu·m	%	10^6cu·m	%	10^6cu·m	%
Upper Niger									
• Baro	1956	0.29	8	0.29	8	3	84	3.6	100
	1957	0.44	7	0.82	13	5	80	6.3	100
	Average								
(C.A. =730,300 sq·km)	1915-57	0.31	6.5	0.55	11	4	82.5	4.9	100
	(cu.m/sq·km)	(0.42)		(0.75)		(5.48)		(6.65)	
Benue									
• Yola	1956	0.20	6	0.17	5	3.0	89	3.3	100
	1957	0.28	6	0.24	5	4.2	89	4.7	100
	Average								
(C.A. =108,400 sq·km)	1934-57	0.20	6	0.17	5	3.0	89	3.3	100
	(cu.m/sq·km)	(1.84)		(1.57)		(27.68)		(31.69)	
• Makurdi	1956	0.57	5	0.87	8	9.5	87	11	100
	1957	0.86	5.5	1.3	9	13	85.5	15	100
	Average								
(C.A. =305,500 sq·km)	1932-57	0.61	5	0.95	8	10	87	12	100
	(cu.m/sq·km)	(2.00)		(3.11)		(32.73)		(37.84)	
Lower Niger									
• Shintaku	1956	0.72	5	1.0	7	13	88	15	100
	1957	1.2	5.5	1.8	9	18	85.5	21	100
	Average								
(C.A. =1,089,500 sq·km)	1915-57	0.88	5	1.3	8	15	87	17	100
	(cu.m/sq·km)	(0.81)		(1.19)		(13.77)		(15.77)	
• Onisha	1956	0.76	5	1.2	8	14	87	16	100
	1957	1.3	6	2.2	10	19	84	22	100
	Average								
(C.A. =1,100,800 sq·km)	1925-57	1.0	5.5	1.7	9	16	85.2	19	100
	(cu.m/sq·km)	(0.91)		(5.00)		(14.53)		(20.44)	

Source: River Studies and Recommendations on Improvement of Niger and Benue (NEDECO, 1959)

The FIWD is currently undertaking a scheme of the capital and maintenance dredging for the Niger river and its creek routes to link the sea ports with the hinterland through the inland waterways which has been a priority project of the Department. More particularly, efforts will be made to provide at least available depth of 2m in the waterways from Baro to Warri and Port Harcourt at a minimum discharge of 1,750 cu.m per sec at Shintaku, as one of the FIWD long-term plans.

When the transport tonnages along these waterways are increased substantially as compared with the present volume as is compiled in para (2) of 9.1.2, the dredging of the Niger river will warrant its heavy expenditures. Taking into account the present favorable road transport and the deteriorated

situation of Baro virtually with no railway service as is seen at this stage and may be kept in the foreseeable future, it is observed that there would be no room to implement the large-scale capital and maintenance dredging scheme to be positively promoted by the FIWD.

It is, therefore, suggested that the programs and projects currently being undertaken by the FIWD would be continued without any expansion within the foreseeable future. It may be suggested that the improvement of the Niger navigability be carried out in four steps, viz. (1) river management for the navigation including hydrological and morphological observation and study, (2) dredging for local critical parts, (3) bed-regulation by means of groynes, training-walls and bank stabilization of difficult crossings and flats and (4) discharge regulation by the Jebba and Shiroro hydro reservoirs. For the Benue river, the improved navigability will be done in two steps, viz. (1) river management and (2) discharge regulation, if possible.

It may be noted that these steps as mentioned above are supplementary to one another, and their respective improvements could be added together. In addition, each separate step in itself may be subdivided into a number of phases which may overlap in time with phases of other steps, and each step will generally increase the efficiency of the previous one. In this way, a flexible improvement program for the waterways is obtained so that at any time the rivers may be developed to a stage that meets the demand of inland navigation in particular or of the national economy in general.

9.2.2 Barrages in the Lower Niger River

A proposal to provide the barrage(s) in the Niger river below Lokoja has been discussed in para. (3) of 9. 1. 3 in this Chapter. In principle, these barrages may take an opportunity for implementation if a relevant plan is established as a multipurpose project with the sectors of irrigation and water supply so that a substantial part of its investment cost is allocated to these sectors. It has been intended that the NWRMP towards the year 2020 for the irrigation and water supply sectors should be established in line with the implementation of a series of medium and small-scaled water resources development projects along minor tributaries of many rivers; in addition, a

large-scale irrigation project is excluded from the NWRMP because of technical and management difficulties involved in the executing agencies concerned.

Under this situation, it has been difficult to establish a multipurpose project(s) with a focus upon the proposed barrage(s). It is, however, suggested that a pre-feasibility study on this multipurpose projects, to identify the nature and extent of each component to be assigned and also to evaluate preliminarily the probable environmental impacts to be given, would be carried out during the later stage of the NWRMP period for consideration as the post-NWRMP action program.

9.2.3 Transfer of the FIWD Hydrological Gages to the FMWRRD

From the historical point of view, the FIWD has initiated the hydrological observation work over the rivers of Niger and Benue as major input into the river management for inland navigation purpose. This system is still being maintained by the FGN even after establishment of the FMWRRD who should be in charge of the river management as a whole for public use and benefit.

To remedy this and have the FMWRRD accelerate an intensive effort on the hydrological observation and subsequent data processing and analysis nationwide, the JICA Team appealed to the FIWD in March 1993 for the transfer of the FIWD-managed hydrological stations to the FMWRRD for full operations. In the National Workshop on Preparation of the NWRMP held in December 1993, a representative of the FIWD implied a possible transfer due to the lack of OM cost for the FIWD hydrological gages under the critical budgetary situation, the inadequate fund allocations are being made for the undertakings of the current on-going projects and programs under the FIWD.

In accordance with a series of these discussions, the JICA Team proposes that major hydrological stations which are qualified as the reference control points required for future nationwide coordinated management of the surface water resources to be intensively carried out by the FMWRRD shall be transferred to the Water Administration Department of the FMWRRD with a full responsibility after completing the administrative and official arrangement required. Keeping this concept in mind, the major gaging

stations to be transferred include those at Jiddere Bode, Baro, Lokoja, Onitsha and Aboh along the Niger river and at Wuro Boki, Yola, Nnman, Lau, Agwan Taru, Ibi, Makurdi and Umaisha along the Benue river, with a total of 13 stations in number. It is considered that minor gages other than the above mentioned which are essential for the hydrological and morphological observations for the purpose of the FIWD benefit on day-by-day navigations will be managed by the FIWD.

CHAPTER 10. INLAND FISHERIES

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CHAPTER 10. INLAND FISHERIES

10.1 Present Situations

10.1.1 General Background

The importance of the fisheries sector in the Nigerian economy would be recognized from various perspectives, one of which is its contribution to the balanced diet of the population. Nigeria is believed to be the largest consumer of fish and its products in Africa in terms of its population size, economic status and dietary habits. While the exact level of the current fish consumption is unknown, there is an evidence that the per capita annual consumption of fish was 15 kg in 1981 before dropping to the low level of 4 kg in 1985 which is lower than the average of Africa (9.3kg) and the minimum animal protein requirement of 11.5 kg as recommended by FAO. The fisheries sector is also important in providing employment opportunities.

Data on the supply sources and consumption of fish as shown below indicate an increasing reliance on fish import in the form of frozen whole fish and processed fish, while domestic production has proportionately decreased. The implication of this on the country's foreign exchange should be noted, and its disincentive effects on domestic fish production could not be ignored.

Fish Supply and Consumption

Selected Years	Artisanal Fishery				Aquaculture or Fish Farming		Industrial Fishery		Import		Total Supply		Per Capita Consumption
	Coastal & Brackish		Inland & Lake										
	10^3ton	%	10^3ton	%	10^3ton	%	10^3ton	%	10^3ton	%	10^3ton	%	kg/Annum
1972	218.8	42	215.0	41	–		4.2	1	83.2	16	526.2	100	7.7
1975	229.9	33	226.2	33	–		10.1	2	221.2	32	687.5	100	9.2
1977	247.9	31	240.2	30	–		16.0	2	306.2	38	810.2	100	10.3
78	255.4	28	246.0	27	–		17.2	–	404.7	43	923.2	100	11.5
79	264.5	27	259.6	26	–		11.3	1	426.7	43	998.1	100	12.1
1980	274.2	33	187.2	23	–		18.2	2	348.1	42	827.7	100	9.8
81	323.9	24	157.9	12	–		14.4	1	855.8	63	1,352.0	100	15.6
82	377.7	30	119.5	10	–		18.6	2	714.8	57	1,260.6	100	14.1
83	377.0	32	146.3	13	20.5	3	17.3	2	607.1	52	1,163.1	100	12.8
84	246.8	36	112.2	16	22.0	3	24.7	4	216.6	32	682.3	100	7.3
1985	140.9	33	60.5	14	15.0	4	25.3	6	132.2	31	423.8	100	4.4
86	160.2	33	107.0	22	14.9	3	24.0	5	144.2	29	490.3	100	6.0

Source: A Perspective Plan for Agricultural Development in Nigeria (Revised Draft), FMAWRRD, May 1992

Domestic Fish Production, 1985 - 1992

Year	Coastal & Brackish		Lakes & Rivers		Aquaculture		Total	
	10^3 ton	%	10^3 ton	%	10^3 ton	%	10^3 ton	%
1985	166.1	69	60.5	25	15.0	6	241.6	100
1986	141.3	54	104.3	40	17.5	6	263.1	100
1988	220.8	63	112.4	32	15.8	5	349.0	100
1990	170.5	59	113.0	39	7.3	2	290.8	100
1991	168.2	55	122.2	40	15.9	5	306.3	100
1992	184.4	61	97.2	32	19.8	7	301.4	100

Source: C.A. Okafor, Federal Department of Fisheries, January 1994

Since 1988, the FGN formulated and is implementing an Agricultural Policy whose ultimate goal is to attain the self-sufficiency and growth in all the agricultural sub-sectors as well as the realization of structural transformation necessary for the socio-economic development in rural areas. Fish is also one of the major commodities for which the national self-sufficiency at the increasing level of demand was to be achieved by 1992; however, this target in fish production has remained as a dream in attainment.

Available data show that the Nigeria's potential marine and freshwater fishery resources at the maximum sustainable yield can only provide 1.2×10^6 ton against the current national demand of fish which stands at 1.5×10^6 ton. The current fish production is grossly inadequate, and it appears that the desire for self-sufficiency in fish production may only be realized through development of the aquaculture.

Estimate of Potential Yields in Marine and Inland Fishery Resources in Nigeria

Source	Potential Yields	
	10^3 ton	%
1. Rivers and Flood Plains	226.6	19.3
2. Lake Chad	24.5	2.1
3. Kainji Lake	8.5	0.7
4. Natural Lakes and Reservoirs	35.0	3.0
5. Coastal and Brackish Water	190.0	16.2
6. Marine	32.8	2.7
- Inshore Waters (5 - 50 m)	16.6	
- Offshore Waters (50 - 200 m)	16.2	
7. Aquaculture	656.8	56.0
Total	1,174.2	100.0

Source: J. G. Tobor, Nigerian Institute of Oceanography and Marine Research (NIOMR), 1990

Further to the need to ensure the proper management and regulation of the nationwide fisheries resource potential in both marine and inland waters, the FGN has promulgated and signed the Inland Fisheries Decree to regulate and monitor the activities of inland fisheries. This complements the Sea Fisheries Decree. Section 10 (1) of the Inland Fisheries Decree delegates the Federal Department of Fisheries (DOF) with appropriate authority to regulate and control the construction of dams, weirs or other permanent barriers which may hinder the free circulation of fish movement.

The DOF, FMANR is charged with the mandate of developing the nationwide fisheries for the achievement of sustainable self-sufficiency in fish production without sacrificing the overriding consideration for fisheries resources conservation. In line with the Government Policy, DOF does not embark upon direct fish production but executes the projects and programs which are aimed at accelerating the private sector participation in fish production, utilization and conservation. The strategies adopted by DOF in relation with the inland fisheries, among others, could be summarized as follows:

- Provision of appropriate infrastructure to enhance the fish production and utilization by the private sector, and sourcing and provision of credit to fishermen through the collaboration with appropriate credit institutions and State Fisheries Divisions.
- Transfer of appropriate and modern fisheries technology to fishermen and extensionists in linkage with relevant State extension agencies, and monitoring of the control and surveillance of the country's valuable freshwater and marine fisheries resources in collaboration with relevant research institutes.
- Restocking of lakes and lagoons to enhance fishermen productivity and for fisheries resources conservation on long and short-term basis.
- Conducting of fish quality inspection and quarantine services for the achievement of quality assurance, resources conservation and enhanced values added, and also provision of short-term training program for extensionists, fish farmers, and boat builders.
- Collection, collation, analysis and dissemination of landing socio-economic data on fisheries for planning and development purposes.

10. 1. 2 Fish Production Systems

The Nigerian domestic fishing industry is generally divided into following three major components:

(a) Artisanal Fishery

This is small-scale, labor-intensive fishing operated with the investment of up to ₦ 30×10^3.

i) Coastal canoe industry
ii) Brackish water canoe fishery in the creeks and lagoons near the coast
iii) Riverine and lake canoe fishery
iv) Flood pond fishery in the wetlands following the seasonal flooding of major river systems

(b) Aquiculture or Fish Farming

This includes the cultivation of fish in a controlled environment, also being combined with crop farming and irrigation schemes.

(c) Industrial Fishery (coastal)

This is capital-intensive in the use of highly sophisticated vessels and equipment for the ease of accessibility to the continental shelf and more distant resources outside the territorial waters.

The paragraph 10. 1. 1 explains that the varying rates of growth in fish production from different components are reflected in changes in the share of total output derived from artisanal and industrial ones. By 1982, the share from artisanal (coastal and brackish water) fishery had increased drastically while that from the inland artisanal fishery consequently declined. The share from industrial fishery, though stir modest, had more than trebled to 4 percent of aggregate production.

The freshwater production systems which are the subject of discussion in the NWRMP are summarized below:

i) Freshwater Rivers and Flood Pond Fisheries

These involve fishing in the river systems of Niger and Benue and the freshwater portions of other rivers into the Gulf of Guinea. Although the information on these fisheries are scattered, the rivers in many places are extensively fished mostly for local consumption in the nearby densely populated areas as well as in the form of seasonal part-time job by the local residents. In general, various parts of the rivers have the varying resource potentials which are related to the area topography. It is said that three-major rivers of Niger, Benue and Cross harbour well over 750×10^3 of both full and part-time fishermen. The smaller canoes are used as the fishing craft with the outboard motors sometimes in open water. Major fish species are Tilapia Spp., Clarias Spp., Alestes Spp., Eynodontis Spp., Mormyrus Spp., etc.

In the NWRMP, attention has been paid to the fisheries in wetlands which are low-lying, flood-prone and slow-draining. These wetlands are not only important to terrestrial plants and animals, but also are used by many riverine fish species for spawning via lateral migrations from the braided river channels into the temporarily-inundated depressions. Fish that are trapped in the wetlands as flooding recedes are easily harvested by local fishermen and become an important income sources for communities within or adjacent to wetlands.

Because of the human doings such as the dam construction as well as the iron and steel industries, paper and chemical industries, and the use of farm chemicals with their effluents into rivers, the fish yields in the rivers and lakes vary in the range of 100 kg to 2.5 ton per canoe per annum in some places. With the present trend as is shown in the table given hereinbefore, the rivers and wetlands cannot be expected to make a high contribution to the total fish output in Nigeria, and the maximum potential is estimated to be about 230×10^3 ton per annum.

ii) Lake Chad Fishery

The Lake Chad, an international water body with the Nigerian share of about 25 percent constitutes the single largest freshwater fishery resources. This lake is remarkably shallow with an average depth in normal times of less than 6 m and the recorded maximum of under 11 m, while its surface area

ranges between 25×10^3 to less than 6×10^3 sq.km. The recent Sahelian drought that has changed the lake ecology may lead to complete drying up of the lake in near future. Direct consequence of this lake area shrinkage is that the aquatic weeds proliferate, the papyrus islands develop and the large coastline area is exposed as water recedes; thus, the islands become fishing camps while the drawdown areas are cultivated after the rainy season. The highest water level in the lake occurs in December, while the lowest in July corresponding with the rainy season and the time of higher fish catches. The fishery, however, is constrained by the difficult access due to weeds and poor road condition.

There are two types of the Lake Chad fishery:

- Alestes Fishery: Prior to the time when the resources of lake open waters were exploited, this fishery had been established on the flood plains and deltas of the river Yobe and El-Beid utilizing the resources of flood streams and pools left behind by stream drying in the deltaic regions. Thus, this seasonal fishery is composed of a few species of migratory fish.
- Main Fishery: Available data on the lake fishery are conflicting due to the large fluctuations of water regime which have caused drastic changes in the resource levels. What is certain is that the lake is considered to be very productive averaging about 100 kg per ha.

Reference is made to a Master Plan for the Development and Environmentally Sound Management of the Natural Resources of the Lake Chad Conventional Basin which was presented in June 1992 by the LCBC with the assistance and cooperation of UNEP, UNSO and FAO. The recommended action plan includes 36 projects for implementation comprising the aspects of fisheries sector. The Master Plan depicts that the symptoms of fisheries degradation include loss of prized species, drying up of nursery and fishing areas, increased exploitation by displaced farmers and nomads, juvenile catch, and collapse of traditional management practices. The plan follows that high priorities include fishing cooperatives with the legalization of managed fishing areas and mesh sizes; technical interventions to reduce spoilage, incorporation of flood depth, duration and area into all hydrological models and resurrection of the monitoring program. It is expected that the findings to be obtained

through implementation of this Master Plan will be much appreciated for the revitalization of Lake Chad fishery.

iii) Kainji Lake Fishery

The Kainji Lake, the largest man-made reservoir in Nigeria which was filled up in 1968 may be treated separately because of its importance to the national economy and also as the subject of extensive studies on fishery. The FAO/UNDF-assisted Kainji Lake Research Project was launched to carry out the research on lake fishery, and this was led to establish the Kainji Lake Research Institute (KLRI) in 1976. This fishery is essentially of a gillnet canoe, and various assistance to the lake fishermen have been given including the fishing nets, outboard motors and cold storage facilities at subsidized rates or as credit in kind.

The KLRI study revealed that with the reservoir area of 1,243 to 680 sq.km, the total fish production on the lake which rose from 17 $\times$ 10^3 ton in 1969 to 28.5 $\times$ 10^3 ton in 1970, dropped to 4.5 $\times$ 10^3 ton in 1978. Citharinus Spp. which constituted 90 percent by weight of the total commercial landings in 1970/71 dropped to 34 percent in 1972, and the resources are currently dominated by Tilapia Spp. The current situation on the Kainji lake fishery indicates overfishing, and it is estimated that when the regulatory measures to conserve the resources are taken, the Kainji fish yield may be increased from the current 5 $\times$ 10^3 to 10 $\times$ 10^3 ton.

vi) Natural Lakes and Reservoirs Fishery

The construction of dams across the rivers affects the fish resources of such rivers. The studies conducted for Kainji Lake and Lake Chad basins show that while the fishery potentials of the upstream areas of major impoundments are enhanced, there is a considerable loss of the fishery resources in the downstream areas as a result of the dam construction.

Although very little study has been made on the fishery potentials of the Nigerian reservoirs, the researches in Kainji Lake, IITA reservoir, Asejire and Tiga dams and so on suggest that the fish yields of 35 to 500 kg per ha per annum are possible, depending upon the size and depth of reservoir as well as

the intensity of management and the fertility of water, and that a national average of 200 kg per ha is generally accepted.

v) Aquaculture or Fish Farming

Aquaculture practices in Nigeria can be classified into two systems : extensive and intensive. The extensive system is commonly practiced in local coastal and brackish waters and wetlands of the major rivers, involving only the construction of water or fish retention weirs across the streams and wetlands. The fish not usually fed, thus, depend upon the nature for food and water supply, and the fish yield is consequently low. The intensive system, on the other hand, involves the construction of well-designed artificial pond as laid out in such way that the pond is easily drained and the surface or groundwater is properly supplied. The pond is constructed with the earth or concrete embankment and dike across or adjacent to streams, springs or rainwater. The fish are selected, stocked, fed and harvested at appropriate time, resulting in higher yields than the extensive system, if well managed. Very recently, a more intensive and mechanized close-circuit system has been introduced where fish are cultivated in concrete troughs containing re-circulated water from borehole or reservoir.

Aquaculture development was started in Nigeria in 1951 at a small station at Onikan, Lagos. By 1970, both the Federal and State agencies embarked the idea of fish farm production resulting in the operation of some 2,000 rural ponds under the private sector throughout the country. This, however, witnessed a low performance and was reactivated in the late 1980 with the provision of the DOF-managed African Regional Aquaculture Centre (ARAC) at Alau near Port Harcourt. The ARAC aimed at the operations of four Fish Seed Multiplication and Training Centres, the restructuring of fisheries and aquacultural research, the introduction of aquaculture courses in some universities and agricultural schools as well as the involvement of some State corporations in operations. Since then, the pattern of aquacultural production has remained being dominated by small-scale operators, while there has been a surge of interest in large-scale commercial farms owned and operated by wealthy Nigerians.

It is reported that the quality of aquaculture system management in Nigeria is inadequate, and very little or no attention is paid to such practices as

water level, fertility, stocking, feeding, maintenance and record-keeping. An estimate of all fish ponds gives a total area of over 5,000 ha with an output level of 20×10^3 ton per annum. The main fish species cultured are the local species of catfishes (Clarias, Heterobronchus, Crysichthys, Cyprinus Carpo, Lates Niliticus) and the Tilapias, most of which are common being hardy, surviving in any forms of conditions. The culture practices are generally semi-intensive with the annual production of one ton per ha in rural ponds and 3 ton from commercial farms.

While the total area under aquaculture is still small, the resources potentials are considerable with vast water areas, such as creeks, lagoons, rivers, ponds, lakes and borrow pits (for civil works) which can be put into use by developing them. Various studies have revealed that there are more than 5.6×10^6 ha of the land available for aquacultural practices in Nigeria with the breakdown of aquatic glassland (1.14×10^6 ha), forest mosaic (0.37×10^6 ha), farmland swamp (1.23×10^6 ha), mangrove (0.97×10^6 ha) and forest swamp (1.91×10^6 ha). Assuming that only 25 percent of these sites or 1.41×10^6 ha are developed, the total output of aquaculture system will be 2.8×10^6 ton which will be more than the projected fish demand in the year 2005.

10.1.3 NWRIS

The Regional Technical Inventory Survey in the JICA-NWRIS as entrusted to five domestic consultant firms included the inland fisheries sector as is explained in Appendix 1-1 of Chapter 1: NWRIS and SIA. The TOR specified two items for data collection: (1) current condition of the inland fisheries with the Forms R-7.1 (1) and (2), and (2) proposed inland fisheries development plan with the Form R-7.2. The data filed in these formats are compiled in each of five Final Reports submitted on regional basis by the respective consultants, which are being kept by the FMWRRD.

The data collected are usually incomplete with the lack of many important information which makes them inadequate for any meaningful use, and a high percentage of them are inconsistent and unreliable, although the data filed in the formats provide the general information on current inland fisheries and locational distribution of the relevant projects. It has been apparent that the government agencies concerned would be unable to function

for data collection. It is also mentioned that one of major problems in planning for the inland fisheries sector is the dearth of basic data on fisheries resources and their response to increased exploitation.

Nigeria is generally endowed with very large bodies of the natural water as contained in the wetlands, rivers and lakes. In recent years, the FGN has, through the Water Resources Sector, established a large number of the man-made reservoirs. It has been observed that in the effort towards the water resources development nationwide, the FGN has virtually paid little or no attention at all to the important living aquatic resources. To date, many of the large and medium rivers have been dammed up without regard to such resources in both up - and downstream. Virtually, there is no fish ladders at the existing hydraulic structures across the rivers, and there has been no pre-impoundment study to protect the ecology of a newly inundated reservoir bottom.

10. 1. 4 Problems and Needs

(1) Constraints

With the abundant fishery resources in Nigeria, the fisheries sector should be expected to contribute more significantly to the national economy than at present. There are, however, a number of interrelated constraints to the fishery development.

(a) Policy Implementation

The main policy to achieve the self-sufficiency in fish production is very clear; however, the major problems would be the unstable and conflicting approach to its policy implementation including (1) low level of the priority given and the resources allocated to fisheries development relative to other sectors and (2) high level of the attention often devoted to fish importation against domestic production.

(b) River and Wetland Artisanal Fisheries

In Nigeria, both freshwater and brackish water wetlands are found inland and along the coast respectively. Inland extensive seasonal floodings in the river floodplains, inland valleys and swamps occur during the rainy period when fish migrate to spawn in the inundated plains. The delta coastline consists mainly of lowlying sand beaches running along a narrow strip of land with interconnecting lagoons and estuaries. From the coastline, inland is characterized by sand beaches, brackishwater mudflats and arhomboid shape of freshwater swamps and floodplains where some 600×10^3 artisanal fishermen operate on local canoes and motorized boats. The discharge from many rivers converging in the delta areas is variable. This and other environmental factors are important factors which determine the abundance of shrimp and some fish species such as Ethmalosa fimibriata; however, it appears that the land and water use patterns are already affecting the water quality in the delta areas.

Three major rivers of Niger, Benue and Cross command an enourmous volume of freshwater all the year round, and together they also provide the chief inland waterways extended over 7,000 km. They also harbour nearly 750×10^3 full and part-time fishermen. The fisheries resources of these river systems put together represent well over 98 fish species with a potential fish yield of some 200 ton per year.

Major problem of these fisheries centres on the varying degrees of resource endowment along different sections of the rivers which are attributable to varying hydrography and topography of particular areas as well as the varying impact of such natural phenomena as drought and flood. Strengthening of this system would be made in such discriminated way that only the rich endowed areas are equipped with motorized crafts and large-size advanced fishing gear.

(c) Lake Chad Fishery

The drastic ecological changes have left considerable technological gap particularly in the areas related to fish catching and processing. Being largely inaccessible by water and road during the rainy season, the fishing activities and related extension services are restricted.

(d) Reservoir Fishery

Large-scale investment in the fishery of Nigerian large reservoirs may not be foreseen until various problems militating against the realization of full potentials of these waters are solved. Those problems may include those of the inadequate resource assessment and the lack of effective reservoir management system.

Over the time, both the Federal and State governments have established a large number of the dams and reservoirs nationwide. It is, however, regrettable to note that the way and manner these dams were constructed do not take any cognizance of the water use for fish production. There has been no pre-impoundment study, and the lake bottoms have not been stumped to enhance the productive fishing operations. There has been no provision of fish ladders and other passage ways for fish movement up and down the streams. In addition, there is no fishery institution except for the NEPA Kainji Lake to manage the fishery resources in such water bodies leading to enhance the fish production at the artisanal level through restocking and also prevent overfishing practiced through all sorts of obnoxious catching methods.

(e) Aquaculture

The prospects for aquaculture are good, but the realization of this potential may depend upon the solution to the following problems:

- Difficult processes involved in the land acquisition and the high cost of land development.
- Scarcity of the local expertise to construct and manage the fish ponds.
- Inadequate supply of the qualified water and the improved breeds of fish fry and fingerling.
- High cost of the fish feed under intensive fish cultivation.

Currently in the private sector, there are the estimated 2,000 rural ponds, 3,000 homestead ponds and over 50 commercial fish farms throughout the country. In the public sector, however, there are more than 30 fish seed

production units and hatcheries, a large pool of trained manpowers as well as the training and research facilities for artisanal fisheries and aquaculture. Most of these public sector institutions are operating below full capacity due to the following main factors:

- Inadequate and unrealizable releases of funds to the DOF.
- Shortage of input supplies.
- Management problems in the operations of public institutions and facilities mainly due to the insufficient motivation of relevant staff.

On the other hand, progress in the private sector is hampered by inadequate supply of the high quality fast growing fish seeds and feeds, low performing extension services and long and painful procedures to have access to suitable land and institutional credit for its development.

(2) Demand and Market Forecast

The DOF reports that given an estimated 3 percent annual population growth rate, the projected growth rate in per capita income and the income elasticity of demand for fish and its products, the annual demand growth rate in Nigeria may be taken at 5.7 percent. At this rate, the quantity of fish required on the basis of fish demand of 1.05×10^6 ton in 1988 to satisfy the domestic demand will increase to 3.5×10^6 ton in 2010 and 6.2×10^6 ton in 2020, respectively.

With the domestic fish production as estimated at 350×10^3 ton in 1988, the domestic output of fish in Nigeria will have to increase at the rate of about 10 percent per annum if the supply and demand is to be balanced in the target years of 2010 and 2020. What is evident from this high growth rate in domestic fish production is that the wide gap between supply and demand will persist for some years to come; as a result, the fish prices are likely to continue at higher rate so that this will probably make investment in fish production increasingly profitable.

(3) Potential Resources for Fish Production

It may be noted that the Nigeria's potential resources for fisheries development are adequate to sustain the projected target rate of increase in fish output through the increased exploitation of these potential resources. Several factors, however, are required for the effective exploitation of the natural fisheries resources, including the availability of funds for development, the accessibility of private investors to land and water and the availability of experienced manpower to implement various fisheries programs and projects. The poor infrastructural facilities particularly in fishing communities have constituted serious obstacles to efficient fish production, processing, storage and marketing. Furthermore, the fisheries development requires some consistency and continuity in policies which were lacking.

10. 2 NWRMP Towards the Year 2020

10. 2. 1 General Strategies and Priority

This Sub-Chapter aims to highlight the optimization of benefits derivable from the water resources management through inland fisheries which, placing emphasis on its economic benefits as important as they are, can only attain meaningful achievements, through integration with the aquaculture in general and other interests in particular to be properly associated with future operations of the water resources management in its Master Plan.

In the NWRMP to be coordinated and managed by the FMWRRD, the sector of inland fisheries is situated as one of the service components including irrigation, water supply, hydropower and other water-related, all of which are properly associated with the water resources development and management. It is stressed that the main framework of the NWRMP already established is to undertake the BMR works for existing water storages and the additional development of on-going water resources projects, and to promote the implementation of some 1,080 medium and small-scale multipurpose projects to meet the FGN goals as provisionally described in "A Pre-Plan Vision Document towards A Perspective Development Plan (by 2010)" as circulated by the NPC

in December 1992. Aside from the general strategies and priority for inland fisheries-component that are described in this section, the basic principles and general strategies involved in the sectors of water source works and public irrigation and drainage that are examined in other Chapters should be taken into account for appropriate development of the fisheries component. In addition, attention is paid to a proposed TA "Water Resources Management Program in Upper Hadejia" to be assisted by external agency to study the artificial flood releases from Tiga and Challawa Gorge dams for Hadejia-Yobe wetlands.

10.2.2 Fisheries in Wetlands

Inland and coastal water is both linked in many ways. As the rivers bring into the coastal water the materials being particulated and dissolved, the coastal water is fertile in its environment which serves as important nursery grounds for many freshwater and marine organisms. Furthermore, the wetlands in the inland and coastal water are important ecosystem complexes for fisheries and aquaculture development, the importance of various types of ecosystems as sources of food fish varies greatly, and it would not be easy to identify and evaluate.

The complexity of riverine ecosystems has been brought about by incessant human activities on the environment, mainly exhibited in land degradation. The erosion of top soil over their catchments has caused heavy and constant siltation of small streams which were the breeding grounds of the most abundant fish species. Owing to the construction of dams on the upstream river systems, various riverine ecosystems have been altered so extensively that wildlife habitat has basically disappeared, fisheries have severely been reduced and the social conflicts have become more intense with serious implications for indigenous people and existing small-scale and informal economic activity.

In this NWRMP, a plan to implement a series of the small to medium-scale multipurpose dam projects in the tributary drainage basins has been contemplated for positive rural development as indicated in Chapter 4 "Water Source Works". Virtually, these sub-projects should be situated immediately upstream of the inland valleys to irrigate the wetland areas as a main objective.

In this occasion, the FMWRRD should pay special attention to release the minimum maintenance flow during the dry season in order to mitigate adverse impacts to be generated in its downstream riverine ecosystems. When necessary, provisions for fish ladders and other passage ways for fish movement up and down the stream should be made to the dam body. All of these items should be carefully examined during the course of a sub-project preparation stage. To this end, when a negative conclusion is given to the project viability, this sub-project should be subject to suspension or cancellation.

10. 2. 3 Fisheries in Existing Reservoirs

This proposal recognizes the urgent need to put into the most productive use the nation's aquatic environment such as reservoirs, lakes, lagoons and rivers. While the ecological aspects of these water systems are identified with a view to assessing their suitability for development of their fishery resources, these reservoirs may be in general stocked with a density of 10,000 stocking population per ha of water surface area for selected suitable fast-growing fish fry and fingerlings, such as i) Hetero-brunchus bidorsalia, ii) Gymnarchus niloticus, iii) Clarias gariepinus, iv) Heterotis niloticus, v) Cyprinus carpio and vi) Tilapia Spp. This may lead to the fish yield of 0.5 ton per ha to be expected under extensive management practice. This program is yet another consideration towards the improvement of the nutritional status of the Nigerian people through a positive domestic production of high quality protein-rich fish. One of the areas of a common interest in reservoir fisheries includes the cage and pen culture methods, which can play an important fish production roles in the shallow reservoirs including other areas of irrigation canal, sheltered lagoon and estuary.

It is a known fact that the number of fish species inhabiting the inland water bodies is a function of size with the larger river basins having several more fish species than small basins. Once the level of siltation is higher in the reservoirs, the water body becomes unproductive because of less biochemical activities within the mud. If left unattended, the numerous large reservoirs as well as the rivers and wetlands which currently harbour and produce fish as human food will become fish-less. The solution of this problem lies in:

- Massive recreation of the major river courses all over the country's river systems.
- Repopulation of the major reservoirs and others with fish fingerlings.
- Monitoring, control and surveillance of the stocked reservoirs and other water bodies.

In connection with the development of reservoir fisheries, the DOF has outlined the proposed activities to achieve this which may be a reference in planning the water resources projects:

Phase I

1.1 Reconnaissance survey of the type, size and biological status of the major man-made and natural lakes.

1.2 Fishery stock assessment of the water bodies.

1.3 Survey of the major river systems and the type of fishery practiced.

1.4 Appraisal of the data in 1.1 - 1.3. above, and production of an interim report.

Phase II

2.1 Development of the inventory of the economically important fish resources in these river, lake and lagoon systems.

2.2 Study of the various production parameters which encourage or hinder fish production in the water bodies.

2.3 To study and control the management of watershed regimes and to make a comprehensive and practicable recommendations on measures to remove bottlenecks.

2.4 Collation and analysis of data and recommendation of fishery best suited to each ecological zone.

2.5 Presentation of report on activities carried out from 2.1 to 2.4.

Phase III

3.1 Establishment of fish feed complexes.

3.2 Establishment of fish hatcheries and support infrastructure e.g nursery ponds etc.

3.3 Establishment of trial/model fish farms.

3.4 Production of breedstock.

3.5 Production of fish fry and fingerlings.

Phase IV

4.1 Cage rearing and feeding to stocking size followed by stocking of the major lakes, rivers and lagoons, with high quality fast growing fish fry and fingerlings.

4.2 Monitoring, surveillance and control of fishing operations and tagging by State and LGA staff.

4.3 Appraisal and stock assessment of the stocked water bodies.

4.4 Preparation and recommendation of fishing gear and fishing inputs.

Phase V

5.1 Preparation of a training manual for the management of the water bodies in such a way as to avoid overfishing.

5.2 A periodic (quarterly) training program, and extension manual preparation.

5.3 Preparation of a final report, distribution to all program participating agencies (State and LGs) and a phased training workshop in lake, river and lagoon fishery management practices.

10.2.4 Aquaculture in the Water Resources Projects

There is currently an ever-increasing awareness in Nigeria of the need to develop the vast aquaculture potentials of the country to bridge the national fish demand - supply gap. Both the public and private sectors of the national economy are responding to this opportunity by planning for and embarking upon the aquaculture projects. These interests can only be sustained if the ventures are found to be profitable. As a matter of fact, there would be many problems to be overcome and serious bottlenecks to be solved as pointed out in the previous Sub-Chapter 10. 1 "Present Situations". These include the problems of limited manpower in this industry, the non-availability of

fingerlings in right quantity, and the limited information on pond construction and management techniques.

In connection with the urgently increased food production and water supply program, the NWRMP has compiled a water resources development program to construct a series of the dams and reservoirs with major emphasis on small and medium type to be distributed to the tributary basins nationwide as main objective of the wetland irrigation. It is intended that this program will take a multipurpose function to upgrade the rural infrastructure for future development in conformity with a National Perspective Plan including the objectives to achieve the rural water supply, mini-hydropower and fisheries. In the fisheries component, this is a good opportunity to expand the aquaculture industry in the remote rural areas for local demand.

More particularly, this aquaculture activity will include, among others, the fish pond operations by a farmers cooperative or a private company within the irrigation service area or outside the area with a specific channel for water conveyance, as well as the small integrated vegetables, animal rearing and fish farm to be operated by individual farmers within the irrigation service area. Although preliminary location of the proposed dams has been identified at a master plan level, it is suggested that almost all of the dams and reservoirs to be built would contain more or less this aquaculture component depending upon the local conditions.

The DOF, on the other hand, has disclosed the idea in writing to the JICA Team with the following summary:

- There would always be the land not suitable for conventional irrigation in the water service area under the dam because of shape slopes, undulating landscape, salinity with high alkalinity and so forth. This land is considered suitable for aquaculture. In many man-made reservoirs established so far, no such consideration has been provided for in these areas.
- It is intended that both crops and fish are produced using same land, same space, same water volume and same human attention.

  This is a perfect example of the economy of time, land and space, and, by extension, of labor cost saving. In this proposal, the irrigation water from the canal outlet passes successively through farm pond(s) and generally returns to the irrigation network.

Therefore, water used for the operations of fish ponds is non-consumptive taking a distinct additional advantage for the water resources project as a whole; in other words, the aquaculture easily lends itself to integrated agriculture in the area of rice-cum-fish production.

The integrated aquaculture as defined above involves a combination of vegetable cultivation and/or animal rearing with fish culture. A Perspective Plan for Agricultural Development in Nigeria (FMAWRRD, 1992) shows that some fish farms are integrated with poultry, cattle and vegetable enterprises with the wastes from one enterprise serving as inputs for others; that is to say, the poultry droppings and cow dung could fertilize the pond and enhance its fish production while fertilizer applied to vegetables also enriches the pond for fish production. It may be noted that this kind of the integrated aquaculture operated by an individual farmer and/or a small group of some farmers can be observed in a scattered form within the irrigation service area in many of the Asian countries.

In order to promote the fisheries component to be included in the proposed dam projects, the DOF experts in the field of rural aquaculture should be assigned to all stages in their project cycles from the pre-feasibility and site identification study to be conducted by FMWRRD, where the DOF should confirm a possible inclusion of the aquaculture with an acceptable combination of other water users. In parallel with this project activity, model fish farms basically being extension-oriented should be planned, constructed and operated in line with the concept of the multipurpose dam projects at strategic locations to test the realization of possible benefits from integrating the aquaculture with the water resources projects and also to afford local farmers or their cooperative(s) and private sector easy access during the project cycle. In addition, some of the model fish farms may be designated as seed production centres from where the high-quality fish seeds are supplied to local farmers and also may be provided for bringing local farmers and extension agents together for short-term training in fish breeding, water management and fish pond construction and management techniques.

More particularly, the selected locations for pilot demonstration fish farms will have adequate water supply, suitable soil and a topography that allows for total drainage in any time. The ponds will be designed for several

modes of the management but on a modest scale. The dikes will also be appropriately constructed, compacted and grassed to create ideal pond conditions. The DOF may propose the pilot fish farms of 80 ha each as follows:

- 50 ha to be used for production, 8 ha for service ponds inclusive of hatchery nursery, segregation and storage ponds, and 22 ha of the production ponds to be sub-divided into several areas to demonstrate the modern techniques which can increase the annual fish yield to 4.5 to 5 ton per ha.
- For integrated aquaculture operations, some 2 ha fish farm units in different modes will be organized in each of the pilot fish farms for the demonstration to local farmers.

Aside from the integrated aquaculture ponds which may be scattered within the irrigation service area and be operated by the individual able farmers on their own initiative, it is suggested that the fish pond operated by a farmers cooperative which is a main focus in the fisheries component would be provided as "Village or Community Pond" being located close to the community hamlets within a distance of 1 km, and these fish ponds would be a possible magnification of the night storage necessary for the daytime irrigation for dry season field crops. This Community Pond may be mobilized for multiple use of the villages' fishery, domestic / livestock water supply and other water needs which should be positively situated as a core of the villagers' strong cooperation and also be a firm foundation for successful implementation of the proposed water resources project as a whole. For instance, the village farmers will enjoy their conversations on their interested topics in gathering around the Community Pond surrounded by the planted trees every evening after their heavy work, and this will surely contribute towards strengthening their bonds of unity.

Needless to say, the DOF is recommended to realize the above-mentioned benefits through possible implementation of the proposed dam projects that the quick action program to overcome the current problems including (1) the need of more adaptive research being composed of the improvement of broodstock, fish seeds and feeding rates, fish diseases, stocking densities and fish biology, and water quality, (2) inappropriate supply of improved and certified varieties of fish fry and fingering, and (3) development

of fisheries manpower for optimum performance in aquaculture development and related production activities, should be launched.

10. 2. 5 Plan Implementation Program

Implementing arrangement proposed for the inland fisheries development in the NWRMP as is previously described would be subject to those of the NWRMP's main stream including the sectors of water source works and public irrigation and drainage. As are detailed in other Chapters, the National Water Master Action Plan towards 2000 to be implemented during the five-year period of 1996 to 2000 includes (1) the accomplishment of proper operations and management of existing and on-going water resources projects and facilities, and (2) the preparation of medium and small water resources projects over nine priority basins to establish a solid foundation for successful implementation from 2001.

The NWRMP has introduced the concept of a basinwide approach for the preparation of medium and small water resources development package program where the well-balanced use of water resources and mitigation of environmental impacts in a particular basin are properly verified, and the priority sub-project rating is included. As the first step, the NWRMP has selected nine priority basins as are depicted in a frontispiece Map for pilot and model study where the fundamental technology for selection and planning of the potential sub-projects should be developed. For each of the priority basins, a series of the studies including the pre-feasibility for sub-project identification and the full-scale feasibility for preparation of a package program will be conducted by the FMWRRD with the participation of representatives for service components where the DOF and State Fisheries division are included in such manner as is examined in the previous paragraph. In addition, the NWRMP has proposed that a TA "EIA Study and Environmental Monitoring Program for Dam Projects" to be assisted by external agency for the preparation of guidelines for the EIA study and environmental management plan in line with the EIA and monitoring of related parameters for five existing and five proposed is implemented within a framework of the National Water Master Action Plan for future reference and application.

It is scheduled that a full implementation of the medium and small water resources development package program for the components of multipurpose dam and public irrigation and drainage in the priority basins would be initiated by the RBDAs concerned in the beginning of the 2000s. In this occasion where the inland fisheries sector is included, the cost required for such joint facilities as multipurpose dam and conveyance canal will be allocated among the participants in line with the appropriate procedures to be determined by the FMWRRD. In parallel with this, the preparation of medium and small water resources development package programs for other basins will be done by the FMWRRD for subsequent implementation.

CHAPTER 11. ENVIRONMENTAL MANAGEMENT

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11.1 GENERAL

Sustainable development is defined as projects and policies which promote per capita economic growth without jeopardizing the integrity of the physical stock of renewable and environmental resources (JICA, 1992a). Nigeria's "National Policy on the Environment" (FGN, 1989) recognizes that sustainable development to meet the needs of present and future generations must be based on proper management of environmental resources (LCBC, 1992). Lack of environmental management results in the degradation of natural resources, thereby forfeiting the benefits that are derived from them. Environmental degradation precludes the achievement of sustainable development, and/or reduces the level of sustainable development possible (FEPA, 1991). "Development is the process by which man mobilizes the resources of nature to provide for human welfare. Thus, both human survival and sustainable economic development depend on proper maintenance of the natural resource base" (FMAWRRD and NCF, 1986).

The importance of environmental protection and conservation measures has been increasingly recognized during the past decades, and it is internationally accepted that the environmental protection will not take place without development, and the development cannot be sustainable without environmental protection; thus, both of environment and development are two sides of the same coin. As a matter of fact, much agricultural land is currently deteriorating due to inappropriate soil and water management. Soil erosion, nutrient depletion, salinization and waterlogging all reduce the productivity and jeopardize the long-term sustainability while the indiscriminate agricultural expansion has often encompassed the marginal land in many parts of Nigeria. It is stressed that the attention presently being given to environmental issues is a relatively new feature in water resources development in Nigeria, and the present interest has largely resulted from international/external agencies and conservation NGOs demanding that the mistakes made in developed countries are not repeated in the developing world. A typical early sub-basin plan which barely addressed the environmental matters is the Hadejia River Basin Study (Schultz Report, 1976) covering the basins of Hadejia and Jama'are that are the two main tributaries of the Yobe

River, confirming the then ongoing policy of building major water storages to irrigate upland areas at the expense of existing vast wetland (fadama) in such manner that the effect on downstream users is apparently given no regard.

Wise management of the environment requires an ability to forecast, monitor, measure and analyze the environmental trends and assess the capabilities of land and water at different levels ranging from a small irrigated plot to a watershed. Adopting the environmental impact assessments should enable Nigeria to plan water and land use without irreversible environmental damage and allow the sustainable resource use. Environmental impact assessments should be followed by monitoring and implanting necessary actions. In particular, an appropriate action is needed in the upper catchment areas, not only to conserve them but also to ensure the available water downstream, groundwater recharge, water quality protection and overall sustainability of water development projects, therefore, a number of environmental protection measures need to be implemented throughout watersheds in order to preserve their environmental quality, maximize the positive impacts of development and minimize the potential environmental hazards.

Generally speaking, the environmental protection and conservation of natural resources should be made as an integral part of development, and objective environmental impact assessments should be considered as pre-requisites for approval of development plans and projects from the beginning of any project cycle. And, the integrated environmental monitoring, evaluation and feedback are essential to ensure the sustainable development. The necessary actions are generally as follows:

- For water-related projects and programs, Nigeria should:

  - carry out the objective environmental impact assessments in order to ensure the sustainability and environmental acceptability;
  - take appropriate measures and actions to maximize positive environmental impacts and minimize adverse environmental impacts;
  - ensure the amelioration measures as recommended to reduce environmental problems are implemented; and