FEDERAL REPUBLIC OF NIGERIA
FEDERAL MINISTRY OF WATER RESOURCES (FMWR)

THE PROJECT FOR REVIEW AND UPDATE OF NIGERIA NATIONAL WATER RESOURCES MASTER PLAN

VOLUME 4

NATIONAL WATER RESOURCES MASTER PLAN 2013

JANUARY 2014

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

YACHIYO ENGINEERING CO., LTD.
CTI ENGINEERING INTERNATIONAL CO., LTD.
SANYU CONSULTANTS INC.

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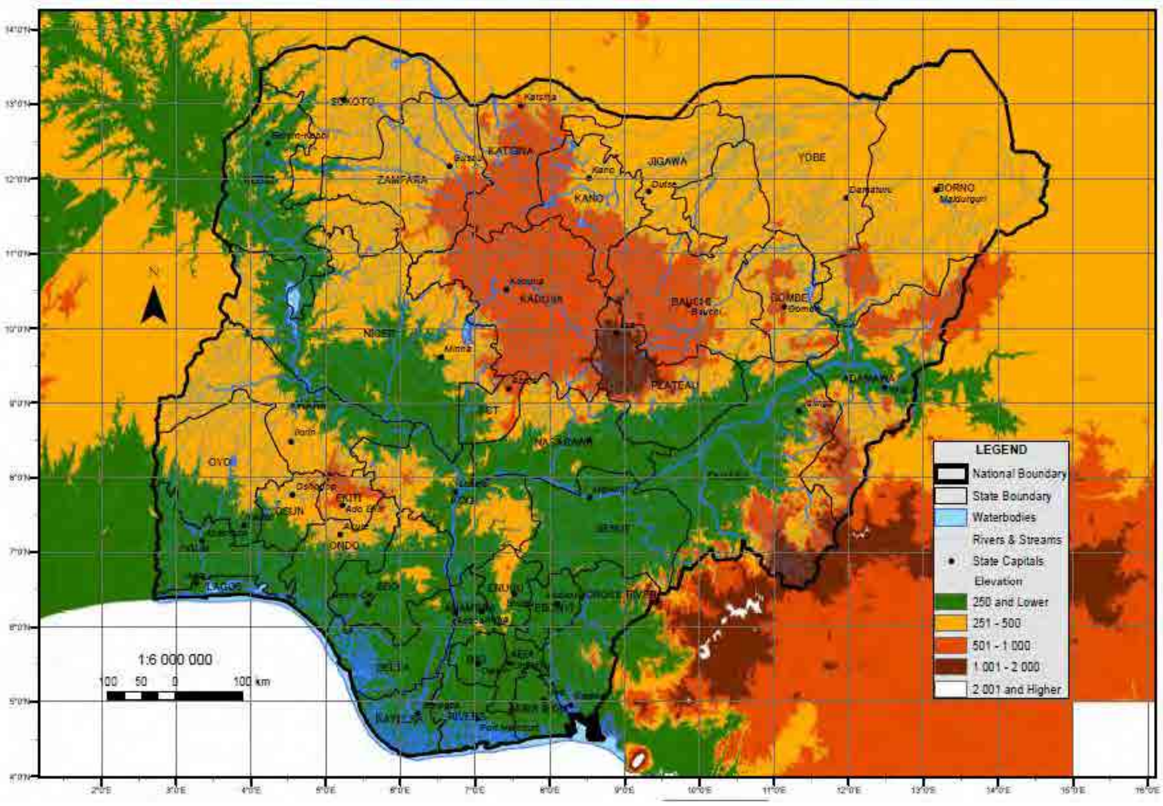
Foreign Exchange Rate

USD1.00 = NGN155.27 = JPY86.5

(31st Dec. 2012)

Location of the Federal Republic of Nigeria



Map of Project Area

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List of Abbreviations

Abbreviation & Acronym	Explanation
ACGSF	Agricultural Credit Guarantee Scheme Fund
ADP	Agricultural Development Project
AEPB	Abuja Environmental Protection Board
AfDB	African Development Bank
BADC	British Atmospheric Data Centre
BCM	Billion Cubicmeter
BOD	Biochemical Oxygen Demand
BOT	Build-Operate-Transfer
CCU	Climate Change Unit
CD	Capacity Development
CITES	Convention on International Trade in Endangered Species
CMCC	Catchment Management Coordinating Committee
CMO	Catchment Management Office
CMP	Catchment Management Plan
CPI	Consumer Price Index
CWIQS	Core Welfare Indicators Questionnaire Survey
DDRO	Department of Dam and Reservoir Operations
DEM	Digital Elevation Model
DFID	Department for International Development in UK (UKAID)
DID	Department of Irrigation and Drainage
DO	Disolved Oxygen
DPRS	Department of Planning and Research and Statistics
DRBOI	Department of River Basin Operation and Inspectorate
DWQ&S	Department of Water Quality Control and Sanitation
DWS	Department of Water Supply
EA	Environmental Assessment
EC	European Commission
ECN	Energy Commission of Nigeria
EIA	Environment Impact Assessment
EL	Elevation
EMSS	Environmental Management Support System
ERICA	European Rivers and Catchment
ET	Evapotranspiration
EU	European Union
FAO	Food and Agriculture Organization
FCA	Fadama Association Committee
FCT	Federal Capital Territory
FEPA	Federal Environmental Protection Agency
FEWS	Flood Early Warning System
FGN	Federal Government of Nigeria
FIWD	Federal Inland Waterways Department
FMANR	Federal Ministry of Agriculture and Natural Resources
FMARD	Federal Ministry of Agriculture and Rural Development
FME(d)	Federal Ministry of Education
FME(n)	Federal Ministry of Environment
FMH	Federal Ministry of Health
FMP	Federal Ministry of Power
FMT	Federal Ministry of Transport
FMWA	Federal Ministry of Women’s Affairs
FMWR	Federal Ministry of Water Resources
FMWRRD	Federal Ministry of Water Resources and Rural Development
GCM	Global Climate Models
GDMA	Gurara Dam Management Authority

Abbreviation & Acronym	Explanation
GDP	Gross Domestic Product
GIS	Geographical Information System
GWMA	Gurara Water Management Authority
HA	Hydrological Area
HYCOS	Hydrological Cycle Observation System
ICT	Information and Communication Technology
IEE	Initial Environmental Evaluation
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resources Management
JAXA	Japan Aerospace Exploration Agency
JICA	Japan International Cooperation Agency
JMP	Joint Monitoring Programme
kW	Kilowatt
kWh	Kilowatt-Hour
LCBC	Lake Chad Basin Commission
LGA	Local Government Authority
M&E	Monitoring and Evaluation
M/P	Master Plan
MANR	Ministry of Agriculture and Natural Resources
MCM	Million Cubicmeter
MDG	Millennium Development Goals
MICS	Multiple Indicator Cluster Survey
MLIT	Ministry of Land, Infrastructure and Transport of Japan
MW	Megawatt
MWh	Megawatt-Hour
NACRDB	Nigeria Agricultural Cooperative and Rural Development Bank
NAFDAC	Nigeria Food Drag Administration and Control
NAFSS	National Agriculture and Food Security Strategy
NASRADA	Nigeria Space Research and Development Agency
NBA	Niger Basin Authority
NBN	National Bank of Nigeria
NBS	National Bureau of Statistics
NCC	Nigeria Cameroon Commission
NCWR	National Council on Water Resources
NDHS	National Demographic and Health Survey
NEED	National Economic Empowerment and Development Strategy
NEMA	National Emergency Management Agency
NERA	National Emergency Relief Agency
NESREA	National Environmental Standards and Regulations Enforcement Agency
NEWMAP	Nigerian Erosion and Watershed Management Project
NFDP	National Fadama Development Project
NFSSP	National Food Security Support Project
NGO	Non Governmental Organization
NGSA	Nigeria Geological Survey Agency
NIHSA	Nigeria Hydrological Services Agency
NIMET	Nigerian Meteorological Agency
NIS	Nigerian Industrial Standard
NIWA	National Inland Waterways Authority
NIWRMC	Nigeria Integrated Water Resources Management Commission
NNJC	Niger-Nigeria Joint Commission
NPC	National Population Commission
NPC	Nigeria Planning Commission
NRDS	National Rice Development Strategy
NRW	Non Revenue Water
NTN	National Training Network

Abbreviation & Acronym	Explanation
NWRI	National Water Resources Institute
NWSSBS	National Water Supply and Sanitation Baseline Survey
OORBDA	Ogun-Osun River Basin Development Authority
PET	Potential Evapotranspiration
PHCH	Power Holding Company of Nigeria
PPP	Public-Private Partnership
PSP	Private Sector Participation
RBDA	River Basin Development Authority
RBMC	River Bain Management Commission
RCM	Regional Climate Models
ROPSIN	Review of the Public Irrigation Sector of Nigeria
RUWASSA	Rural Water Supply and Sanitation Agency
SEA	Strategic Environmental Assessment
SHA	Sub Hydrological Area
SON	Standards Organisation of Nigeria
SRRBDA	Sokoto-Rima River Basin Development Authority
SRTM	Shuttle Radar Topography Mission
SSHA	Small Sub Hydrological Area
STWSS	Small Town Water Supply and Sanitation
STWSSA	Small Town Water Supply and Sanitation Project
STWSSP	Small Town Water Supply and Sanitation Agency
SWA	State Water Agencies
TOR	Terms of Reference
UAC	Users Association Committee
UFW	Unaccounted for Water
UNDP	United Nations Development Programme
UNEP	UN Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
UNISDR	United Nations International Strategy for Disaster Reduction
VAB	Visual Basic Application
WASHCOM	Water, Sanitation and Hygiene Committee
WATSAN	Water and Sanitation
WB	World Bank
WCA	Water Consumers Association
WHO	World Health Organization
WRDP	Water Resources Development Plan
WRMP	Water Resources Management Plan
WRUP	Water Resources Utilization Plan
WSSSRP	Water Supply Sanitation Sector Reform Programme
WTP or WTW	Water Treatment Plant or Works
WUA	Water Users Association

CHAPTER 1 CURRENT SITUATION OF PROJECT AREA

Nigeria is located on longitude N3° - N14°and latitude E 3° - E15°, with area of 923,768km^2. The territory faces Guinea bay in the south and is bounded by Benin in the west, Niger in the north, Cameroon in the east, and Chad in the north-east.

1.1 Socio-economy

1.1.1 Administrative Units of Nigeria

Nigeria, officially the Federal Republic of Nigeria (FRN), is located in West Africa and shares land borders with the Republic of Benin in the west, Chad and Cameroon in the east, and Niger in the north. Its coast in the south lies on the Gulf of Guinea on the Atlantic Ocean. The FRN is headed by the President.

(1) State Administration

The governance system of the FRN is based on the separation of legislative, executive, and judicial powers.

a. Legislative Branch
   The National Assembly is a legislative branch which consists of two chambers: the House of Representatives that has 360 members elected for a 4-year term, and the Senate that has 109 members elected also for a 4-year term in 108 seats to 36 states and 1 seat to Abuja, its Federal Capital Territory (FCT).

b. Executive Branch
   The executive branch consists of the President and the Federal Ministries. The President is elected for a 4-year term directly by the people. The ministries are headed by ministers nominated by the President and currently 27 in number as shown in Table 1-1.

c. Judicial Branch
   The judicial branch consists of the Supreme Court, the Court of Appeal, the High Courts and other trial courts.

Table 1-1 Executive Branches of the Federal Government of Nigeria

I. Federal Ministries (27)			
1	Agriculture and Rural Development	15	Land and Housing
2	Aviation	16	Mines and Steel Development
3	Communication and Technology	17	Niger Delta
4	Defense	18	Petroleum Resources
5	Education	19	Power
6	Environment	20	Science and Technology
7	Federal Capital Territory	21	Tourism, Culture and National Orientation
8	Finance	22	Trade and Investment
9	Foreign Affairs	23	Transport
10	Health	24	Water Resources
11	Information	25	Women Affairs
12	Interior	26	Works
13	Justice	27	Youth Development
14	Labour and Productivity		
II. Commissions (11)			
1	Federal Character	7	National Population
2	Federal Civil Service	8	National Sports
3	Fiscal Responsibility	9	Police Service Commission
4	Infrastructural Concession Regulatory	10	Revenue Mobilization Allocation & Fiscal
5	National Human Right	11	Public Complaints
6	National Planning		

Source: Web-site of FGN and Budget Office of the Federation

(2) State and Local Government

The Local Government consists of two administrative layers such as the States and the Local Government Areas (LGAs).

a. The FRN is divided into 36 states and Abuja, FCT as presented in Table 1-2, which have increased from 31 to 37 after jurisdiction boundary split in 1996. Each state is administered by a state government headed by a governor, elected for a 4-year term.

b. Each state is further divided into LGAs. There are 775 LGAs in the FRN at present. Each LGA is administered by a local government council headed by a chairman and other councilors. The chairman is the chief executive of the LGA.

1.1.2 Population

(1) Census Population of Year 1991 and 2006

The comprehensive population census was carried out in 1991 and 2006. The result of the census revealed that the total population of Nigeria in1991 and 2006 was respectively 88.9 million and 140 million as shown in Table 1-2. The population growth between the above 2 census was 3.18 % annually.

(2) Estimated Population of Year 2010

No official population estimate exists for the years after the census 2006. Interviews conducted at NPC revealed that it has been working on the future population projection based on the 2006 census but it is not completed yet.

Meanwhile, “The World Population Progress: the 2010 Revision” by the United Nations estimated the year 2010 population of Nigeria at 158.4 million. Accordingly, this estimated population is considered as a base data for the Project as set out in Table 1-2.

Table 1-2 State-wise Land Area and Population of Nigeria

Name of State		Area (km^2)	Number of LGA	Population (.000)				
				1991 Census	2006 Census	Growth (%)	Person/ km^2	2010 Estimate
1	Abia	4,900	17	1,914	2,845	2.77	581	3,157
2	Adamawa	38,700	21	2,102	3,179	2.89	82	3,543
3	Akwa Ibom	6,900	31	2,410	3,902	3.36	566	4,427
4	Anambra	4,865	21	2,796	4,178	2.80	859	4,642
5	Bauchi [1)]	49,119	20	2,862	4,653	3.39	95	5,284
6	Bayelsa	9,059	8	1,122	1,705	2.92	188	1,902
7	Benue	30,800	23	2,753	4,254	3.04	138	4,767
8	Borno	72,609	27	2,536	4,171	3.47	57	4,751
9	Cross River	21,787	18	1,911	2,893	2.89	133	3,225
10	Delta	17,108	25	2,590	4,112	3.22	240	4,641
11	Ebonyi	6,400	13	1,454	2,177	2.82	340	2,420
12	Edo	19,187	18	2,172	3,233	2.78	169	3,589
13	Ekiti	5,435	16	1,536	2,399	3.11	441	2,696
14	Enugu [1)]	7,534	17	2,125	3,268	3.00	434	3,658
15	Gombe	17,100	11	1,489	2,365	3.23	138	2,670
16	Imo	5,288	27	2,486	3,928	3.19	743	4,427
17	Jigawa	23,287	27	2,876	4,361	2.91	187	4,864
18	Kaduna	42,481	23	3,936	6,114	3.07	144	6,861
19	Kano	20,280	44	5,810	9,401	3.36	464	10,663
20	Katsina	23,561	34	3,753	5,802	3.04	246	6,503
21	Kebbi	36,985	21	2,068	3,257	3.17	88	3,668
22	Kogi	27,747	21	2,148	3,314	3.03	119	3,713
23	Kwara	35,705	16	1,548	2,365	2.96	66	2,643
24	Lagos	3,671	20	5,725	9,114	3.24	2,483	10,293
25	Nassarawa	28,735	13	1,208	1,869	3.05	65	2,096
26	Niger	68,925	25	2,422	3,955	3.42	57	4,496
27	Ogun	16,400	20	2,334	3,751	3.31	229	4,247
28	Ondo [1)]	15,820	18	2,250	3,461	3.01	219	3,875
29	Osun	9,026	30	2,158	3,417	3.21	379	3,854
30	Oyo	26,500	33	3,453	5,581	3.35	211	6,328
31	Plateau [1)]	27,147	17	2,105	3,207	2.94	118	3,581
32	Rivers [1)]	10,575	23	3,188	5,199	3.41	492	5,908
33	Sokoto [1)]	27,825	23	2,397	3,703	3.03	133	4,150
34	Taraba	56,282	17	1,512	2,295	2.91	41	2,560
35	Yobe	46,609	17	1,400	2,321	3.53	50	2,650
36	Zamfara	37,931	14	2,073	3,279	3.20	86	3,697
37	FCT (Abuja)	7,607	6	372	1,406	9.28	185	1,974
Nigeria		909,890	775	88,992	140,432	3.18	154	158,423

Note: 1) 1991 Population of these 6 states, Bauchi, Enugu, Ondo, Plateau, Rivers and Sokoto was divided by NPC to consist with that of present states split in 1996. 2) Nigeria population of 2010 estimated by the United Nations is distributed to the states by JICA Project Team based on the state-wise growth rate between two censuses.

Source: Annual Abstract of Statistics 2009 by NBS, data provided by NPC, and "The World Population Progress - the 2010 Revision" by the United Nations.

1.1.3 Economic Profile

(1) Gross Domestic Product (GDP)

Nominal GDP of Nigeria was 37.4 Trillion Naira in 2011 that is equivalent to 240 Billion US dollars as shown in Table 1-3. GDP per capita of Nigeria was US$1,470 in 2011.

Table 1-3 Nominal GDP (Naira in Billion)

Sectors	Particulars		2007	2008	2009	2010	2011
Primary	Crops		6,024	7,115	8,201	9,160	10,323
	Livestock		434	513	584	662	756
	Fishing		216	255	291	328	374
	Forestry		84	99	111	124	140
	Total		6,758	7,981	9,187	10,274	11,593
Secondary	Mining & Quarrying	Crude Oil & Natural Gas	7,533	9,098	7,418	9,747	15,285
		Others	31	36	41	46	52
		Total	7,564	9,134	7,459	9,793	15,337
	Manufacturing		521	586	612	647	695
	Building & Construction		266	307	348	394	456
	Public Utility		46	53	62	71	81
	Total		8,397	10,080	8,481	10,905	16,569
Tertiary	Wholesales & Retails		3,045	3,502	4,082	4,668	5,386
	Others		2,457	2,732	3,044	3,359	3,862
	Total		5,502	6,234	7,126	8,027	9,248
Total of GDP			20,657	24,295	24,794	29,206	37,410
GDP per Capita		In Naira	142,900	163,300	162,000	185,400	230,200
		In US$	1,230	1,250	1,100	1,250	1,470

Note: GDP per Capita was estimated applying national population of Table 1-2 and Table 4-4, and exchange rate of Table 1-9.
Source: Annual Abstract of Statistics 2009 and Website of NBS

The real GDP growth rate of 2011 was 7.5% as presented in Table 1-4. The tertiary sector has been helping the growth constantly.

Table 1-4 Real GDP Growth (%) at 1990 Price

Sectors	Particulars		2007	2008	2009	2010	2011
Primary	Crops		7.2	6.2	5.8	5.6	5.8
	Livestock		6.9	6.8	6.5	6.4	6.1
	Fishing		6.1	6.1	5.9	5.8	5.8
	Forestry		6.6	6.6	6.2	6.0	4.5
	Total		7.2	6.3	5.9	5.6	5.8
Secondary	Mining and Quarrying	Crude Oil & Natural Gas	-4.5	-6.2	0.5	5.0	0.4
		Others	12.7	12.8	12.1	12.3	13.1
		Total	-4.3	-5.9	0.7	5.1	0.6
	Manufacturing		9.6	8.9	7.9	7.6	7.2
	Building & Construction		13.0	13.1	12.0	12.1	11.7
	Public Utility		4.9	3.7	3.2	3.3	3.2
	Total		-0.6	-1.6	2.9	5.8	7.0
Tertiary	Wholesales & Retails		16.7	14.0	11.5	11.2	11.4
	Others		11.4	12.2	12.8	13.9	15.3
	Total		14.3	13.2	12.0	12.4	13.1
Total of GDP			6.7	6.0	7.0	7.9	7.5

Source: NBS - Annual Abstract of Statistics 2009 and Website

The largest contributors to GDP of Nigeria were the primary and secondary sector as a whole as illustrated in Table 1-5. Among all, such industries as crops and crude oil & natural gas were prominently large contributors for Nigerian economy.

Table 1-5 Contribution to GDP (%) by Economic Sector

Sectors	Particulars		2007	2008	2009	2010	2011
Primary	Crops		29.2	29.3	33.1	31.4	27.6
	Livestock		2.1	2.1	2.4	2.3	2.0
	Fishing		1.0	1.0	1.2	1.1	1.0
	Forestry		0.4	0.4	0.4	0.4	0.4
	Total		32.7	32.8	37.1	35.2	31.0
Secondary	Mining and Quarrying	Crude Oil & Natural Gas	36.5	37.4	29.9	33.4	40.9
		Others	0.1	0.2	0.2	0.1	0.1
		Total	36.6	37.6	30.1	33.5	41.0
	Manufacturing		2.5	2.4	2.5	2.2	1.9
	Building & Construction		1.3	1.3	1.4	1.3	1.2
	Public Utility		0.2	0.2	0.3	0.2	0.2
	Total		40.6	41.5	34.3	37.2	44.3
Tertiary	Wholesales & Retails		14.7	14.4	16.5	16.0	14.4
	Others		12.0	11.3	12.1	11.6	10.3
	Total		26.7	25.7	28.6	27.6	24.7
Total of GDP			100.0	100.0	100.0	100.0	100.0

Source: NBS - Annual Abstract of Statistics 2009 and Website

(2) External Trade

The summary of external trade is presented in Table 1-6. The table clearly shows that mineral for export and machinery & transport equipment of import are the prominently major materials for Nigerian external trade. As to the agro-products, Nigeria has been importing more than exporting in terms of Naira.

Table 1-6 Summary of Foreign Trade (Naira in Billion)

Trade	Particulars	2007	2008	2009	2010	2011
Export	Mineral	6,531	8,805	6,720	11,416	-
	Agro-products	49	48	80	182	
	Others	975	716	635	1,412	
	Total	7,555	9,569	7,435	13,010	10,665
Import	Machinery & Transport Equip	1,427	1,525	2,437	3,285	-
	Manufactured Goods	942	791	950	1,412	
	Chemical Products	685	401	680	709	
	Agro-products	777	289	561	605	
	Others	297	293	421	638	
	Total	4,128	3,299	5,048	6,649	9,318
Balance		+3,427	+6,270	+2,387	+6,361	+1,348

Source: NBS

(3) Labor Force and Employment

Table 1-7 presents the labor market in Nigeria in the last 6 years. The labor force totaled 67.3 Million in 2011, an increase of 17% over the 6 years. Meanwhile, the employed persons numbered in 51.2 Million, an increase of 2% only over the same period. Thus, the number of unemployed persons soared by 127% in 6 years and numbered 16.1 million in 2011 This equals to 23.9% in the unemployment rate in the Nigerian labor force.

Table 1-7 Labor Market (Million)

Social Status	2006	2007	2008	2009	2010	2011	6 Years' Change
Economically Active	78.9	81.4	84.0	86.7	89.5	92.4	17%
Labor Force	57.5	59.3	61.2	63.1	65.1	67.3	17%
Employed	50.4	51.8	52.1	50.7	51.2	51.2	2%
Unemployed	7.1	7.5	9.1	12.4	13.9	16.1	127%
(%)	12.3	12.6	14.9	20.0	21.4	23.9	-

Source: 2011 Annual Socio-economic Report, NBS

Table 1-8 presents the sector-wise number of working population in Nigeria during 5 years. The working population amounted to 54.0 million in 2007. Among all, an extremely large number of the population engages in the agriculture/forestry/fishery industry sector that was around 60% in 2007. The agriculture/forestry/fishery industries absorb a major percentage of workers in Nigeria.

Table 1-8 Working Population by Occupation (Million)

Industrial Sector	2003	2004	2005	2006	2007
Agriculture, Forestry and Fishery	27.8	28.4	29.0	30.7	31.3
Manufacturing	0.8	0.8	0.9	0.9	0.8
Electricity and Water	0.4	0.4	0.4	0.4	0.3
Public Administration	4.9	5.0	5.1	5.3	5.3
Education	8.4	8.8	9.5	10.0	10.4
Others	4.5	4.6	4.6	5.0	5.9
Total of Working Population	46.8	48.0	49.5	52.3	54.0

Source: Annual Abstract of Statistics 2009, NBS

(4) Inflation and Foreign Exchange Rate

Table 1-9 presents the consumer price index (CPI) of Nigeria and foreign exchange rate of Naira/US$ during these 6 years. It is noted that the CPI of the last five years from 2008 recorded more than 10% increase per year.

Table 1-9 Inflation and Foreign Exchange Rate

Item	Particulars	2007	2008	2009	2010	2011	2012
CPI	% (12-month average)	5.4	11.6	12.5	13.7	10.8	12.2
Foreign Exchange Rate	Naira/US$ (Year End)	116.3	130.75	147.6	148.67	156.2	155.27

Source: "Annual Abstract of Statistics 2009" and "Website" of NBS and Central Bank of Nigeria

(5) Poverty

Table 1-10 illustrates the poverty rate (note) in Nigeria. According to the "2010 Poverty Profile Report" by NBS, the poverty rate stood at 54% of national population in 2004. However, this soared to 69% in 2010, which equals to 112.5 million people living in relative poverty conditions.

Table 1-10 Poverty Rate

Area	2004		2010	
Nigeria	54.4%		69.0%	
	Highest Rate	Lowest Rate	Highest Rate	Lowest Rate
Region	North-East 72.2% North-West 71.2%	South-East 26.7%	North-West 77.7% North-East 76.3%	South-West 59.1%
State	Jigawa 95.0%	Anambra 22.0%	Sokoto 86.4%	Niger 43.6%

Note: Poverty rate is a relative poverty indicator computed mainly based on the household expenditures by NBS.
Source: Nigeria Poverty Profile 2010, NBS

1.1.4 Government Finance

(1) Federal Government Budget and FMWR

Table 1-11 shows FGN budget and the allocated funds to FMWR in these 4 years. The budget of FGN has increased gradually every year. Meanwhile, the allocated amount to FMWR has decreased due to capital budget decreasing, especially in RBDAs.

Table 1-11 Budget of FGN and FMWR (Naira in billion)

Allocated to	Budget Items	2010	2011	2012	2013
1.FGN	Statutory Transfer	183.6	417.8	372.6	380.0
	Recurrent	2,137.6	2,425.1	2,425.0	2,412.0
	Debt Service	542.4	495.1	559.6	591.8
	Capital	1,563.7	1,146.8	1,520.0	1,540.8
	Total	**4,427.2**	**4,484.7**	**4,877.2**	**4,924.6**
2.FMWR	Recurrent	6.0	8.9	8.6	7.9
(Consolidated)	Capital	112.4	62.1	76.4	39.9
	Total	**118.4**	**71.0**	**85.0**	**47.8**
FMWR and Relevant Organizations					
1) FMWR	Recurrent	1.0	1.8	1.7	1.5
	Capital	54.5	23.5	26	22.6
	Total	55.5	25.3	27.7	24.1
2) NIWRMC	Recurrent	0.4	0.4	0.4	0.3
	Capital	0.4	0.2	0.1	0.2
	Total	0.8	0.6	0.5	0.5
3) NHSA	Recurrent	0.3	0.4	0.32	0.3
	Capital	0.3	0.2	0.15	0.5
	Total	0.6	0.7	0.5	0.8
4) Gurara WMA	Recurrent	0.1	0.2	0.1	0.1
	Capital	0.0	0.2	0.1	0.2
	Total	0.1	0.4	0.2	0.3
5) NWRI-Kaduna	Recurrent	0.2	0.4	0.3	0.3
	Capital	0.1	0.2	0.2	0.5
	Total	0.4	0.6	0.5	0.8
6) RBDAs (12)	Recurrent	3.9	5.7	5.8	5.4
	Capital	57.1	37.8	49.8	15.9
	Total	61.0	43.5	55.6	21.3

Note: 2013 is the proposed budget, and the other 3 years were the approved budgets.
Source: Budget Office of the Federation and FMWR

(2) RBDAs (River Basin Development Authorities)

RBDAs are agencies of FMWR and play important role in development of water resources, construction of dam, irrigation and water supply, and its operation and management within the authorities' areas. JICA Project Team received financial statements from 6 RBDAs. The statements audited by external auditors disclosed the financial conditions through Balance Sheet, Profit & Loss (P/L) Statement and Cash Flow Statement. Table 1-12 presents the operational P/L of 6 RBDAs; excluding subventions of Government from revenue and capital investment from expenditure, but including depreciations. The table shows every RBDA recorded a substantial amount of operational loss in every year.

Table 1-12 Operational P/L of 5 RBDAs (Naira in million)

Name of RBDA	Account	2006	2007	2008	2009	2010	2011
1. Upper Niger	Revenue	n/a	26.2	25.1	n/a	n/a	n/a
	Expenditure		224.6	184.1			
	Net Income		-198.4	-159.0			
2. Hadeja-Jama'are	Revenue	55.4	63	55.5	n/a	n/a	n/a
	Expenditure	399.2	467.3	456.8			
	Net Income	-343.8	-404.3	-401.3			
3. Sokoto Rima	Revenue	n/a	41.6	38.9	26.5	n/a	n/a
	Expenditure		461.7	632.2	542.5		
	Net Income		-420.1	-593.3	-516.0		
4. Benin Owena	Revenue	n/a	56	41.2	45.6	78.8	n/a
	Expenditure		479.7	644.1	644.7	668.3	
	Net Income		-423.7	-602.9	-599.1	-589.5	
5. Anambra Imo	Revenue	46.0	78.0	143.9	72.4	n/a	n/a
	Expenditure	406.8	486.3	547.2	479.2		
	Net Income	-360.8	-408.3	-403.3	-406.8		
6. Ogun-Oshun	Revenue	n/a	142.3	72.3	170.2	205.3	50.4
	Expenditure		492.5	530.2	588.5	765.7	822.8
	Net Income		-350.2	-457.9	-418.3	-560.4	-772.4

Note: Subventions of Government are excluded from revenues.
Source: Financial Statement of each RBDA

It must be noted that the accounting policy varies among RBDAs.

For example:

- Capital-investment subventions of Government: some RBDAs accounted them as revenues; on the other hand other RBDAs recorded them as paid-in capital account.
- Depreciation: No consistency among RBDAs on the definition of depreciable assets and depreciation years

The differences in accounting policy impede proper financial management for RBDA and comparison among RBDAs for FMWR. Consequently, the adoption of unified accounting policy among RBDAs is strongly recommended.

(3) State Government Budget

The sum of 25 states' budget of the years 2010 and 2011 is presented in Table 1-13. Total expenditures were 3.6 Trillion Naira, out of which capital spending totaled 2.2 Trillion Naira (60%). Meanwhile, investment in Water Supply Sector amounted to 0.8 Trillion Naira, equivalent to 4% of the state capital expenditures.

Table 1-13 State Government Budget (25 States: Naira in billion)

Budget Items		2010	2011
1. Revenues	Internal own revenues	652.3	641.2
	State Allocation etc.	1,733.2	1,822.3
	Total	2,385.5	2,463.5
2. Expenditures	Recurrent	1,310.5	1,528.9
	Capital	2,214.1	2,146.8
	Total	3,524.6	3,675.7
3. Balance (Negative balances were generally set off with such as previous years' surplus carried forward, FG grants and loans.)		-1,139.1	-1,212.2
4. Capital Expenditures for	Water Supply Development	95.2	73.1
	Its ratio to total capital expenditures	4.3 %	3.4 %

Note: The figures are the sum of 25 states because the budget books for the other 11 states and FCT could not be obtained.

Source: Budget books of 25 states

1.2 Natural Condition

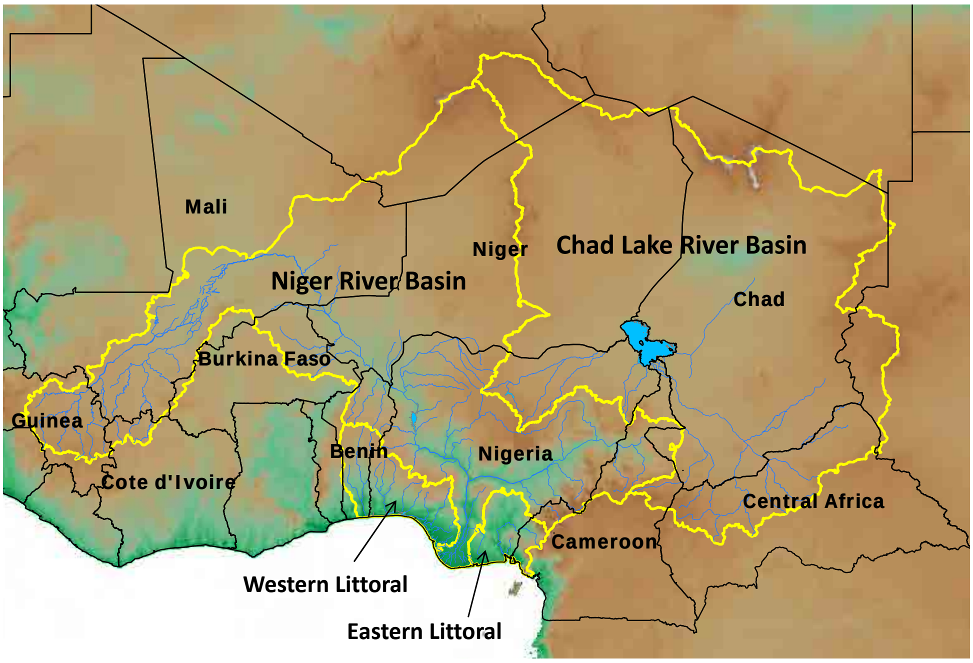
1.2.1 Topography

Nigeria is located on the African shield in terms of geomorphology with characteristic wide plateaus and few steep mountains. The Country is classified into two large geomorphological categories: Plateau and Lowland. The altitude of plateau is more than 200-300m, and that of the lowland is less than 200m. There is a close relationship between land classification and geological setting. The basement complex constitutes the plateau, while sedimentary rocks constitute the lowland.

Most of the plateau area encompasses within 300-900m in altitude. Jos plateau (1,800m) and high mountains bordering Cameroon which includes Adamawa plateau (2,400m) shows altitude of more than 900m. Due to heavy erosion, the plateau is flat. A special landscape is created by isolated steep hills of different sizes rising from flat plain called “Inserlberg”.

On the other hand, the lowland is usually located along large rivers and the coastal line with altitude of less than 300m. The lowland is also located in interior areas such as Sokoto plain and Chad basin.

As shown in Figure 1-1, from the hydrogeomorphological point of view, the territory of Nigeria can be classified into four areas: Niger river basin (Total drainage area: 2,090,000km^2), Chad river basin (Total drainage area: 2,400,000km^2), Eastern littoral area, and Western littoral area.



Source: JICA Project Team

Figure 1-1 River Basins and Countries around Nigeria

The Niger River flows into Kebbi State, which is located at northwestern Nigeria, from Benin and continues to flow toward the southeast. It merges with the Benue River and changes its flow direction to the south. The flow finally reaches Gulf of Guinea through the Niger Delta. The flow course of the Niger and Benue rivers is usually referred to as “Niger-Benue trough”, which shows “Y” shape. Following the “Y” shape, the land area of Nigeria can be classified into three areas: northern area, southwest area and southeast area.

In summary, the topographical classification in Nigeria is shown in Table 1-14.

Table 1-14 Topographical Classification

Category	Classification
Plateau	1. North Central Plateau, 2. Eastern and North-eastern highlands, 3. Western Uplands
Lowland	4. Sokoto Plain, 5. Niger-Benue trough, 6.Chad basin, 7. Interior lowlands in Western Nigeria, 8. Lowlands and scarp lands in Nigeria, 9. Coastlands

Source: JICA Project Team

1.2.2 Geology

Geology of Nigeria is roughly classified into basement complex and sedimentary rocks.

The basement complex forms the plateau and highlands covering almost half of Nigeria. It can be subdivided into three types as shown in Table 1-15.

Table 1-15 Classification of Basement Complex

Classification	Outline
Gneiss and Migmatite Complex	Gneiss and Migmatite Complex consist of those of Pre-Cambrian era.
Schist belts	The Schist Belts consist of low-grade metamorphic sedimentary rocks such as schist, phyllite, marble, dolomites and amphibolite. They are enclosed within the Gneiss and Migmatite Complex in the western half of Nigeria.
Younger Granite	The Younger Granite consists of rhyolite, quart-diorite and granite of Jurassic period and is distributed in SSW-NNE direction in the central part of Nigeria. They are ring-like intrusion into the older Basement Complex.

Source: JICA Project Team

Sedimentary rocks cover basement complex in unconformity with them and distributed in lowlands making clear contrast with basement complex. Sedimentary basin of Nigeria is classified into five areas: 1) Benue-Niger Trough, 2) Middle-Niger/Bida Basin, 3) Sokoto Basin, 4) Chad Basin, 5) Niger Delta, and 6) Dahomey Basin. Age of sedimentary rock of Nigeria is from Cretaceous to Quaternary, and characteristics of sedimentary rock are summarized in Table 1-16.

Table 1-16 Characteristics of Sedimentary Basins

Formation	Description
Cretaceous sediment	• Marine and continental sediments were deposited with large thickness in Cretaceous period. They are marine shale/limestone and continental sandstone of Cretaceous period. • Thick sediment was deposited especially in Benue Trough, which occurred as “Graben structure” that developed when African Continent and South American Continent separated from each other. • The Cretaceous overlies basement complex in an unconformity. In most formations, the sedimentary rocks before Santonian Age were deformed with fold activities and fault movements. Therefore, the sedimentary rocks before Santonian Age were distributed at different depths from place to place due to fold structure.
Tertiary sediment	• Sedimentation in Niger Delta began during the Cretaceous period with most of the basin covered mainly with tertiary sediments such as sandstone, clay stone and limestone. • Tertiary sediment was deposited in Niger Delta in Tertiary period following the Cretaceous period.
Quaternary sediment	• There were volcanic activities in Jos Plateau and Benue Trough areas including basaltic lava eruption. • Thick clay and sand formation were deposited in Chad Basin and Sokoto Basin in Quaternary period as well as in Niger Delta.
Effect of Coastline transgression and regression • Coastline transgression and regression occurred repeatedly after Cretaceous period in large scale. Marine sedimentary rocks such as shale and clay-stone, which is impermeable and forms aquiclude, were deposited during transgression. Lowlands experienced repeated transgressions and regressions, which made unique sedimentary structure of alternating sand and clay formations. • A continental sedimentary rock such as sandstones, which is permeable and forms aquifer, was deposited during regression.	

Source: JICA Project Team

1.2.3 Hydrogeology

The hydrogeological characteristics of aquifer in Nigeria are summarized in Table 1-17.

Table 1-17 Hydrogeological Characteristics of Aquifer in Nigeria

Type	Description
Pre-Cambrian Basement Rock	Basement Complex consists of granite, gneiss and schist of the Pre-Cambrian, which constitutes large plateau in the Central to Northern Nigeria. Generally, the Basement Complex is weathered in the depth from 30m to 100m below the ground, disintegrated into sands and gravels like materials, forming unconfined aquifer. Usually these aquifers have small scale and are distributed in wide area in Nigeria, which is suitable for rural water supply. In addition to above, fractured zone of Basement Complex also forms aquifer, though distribution of fractured aquifer is limited compared with weathered aquifer.
Sedimentary	Sedimentary rocks consist of sandstone and shale (mud stone). Sedimentary rock is distributed in lowland area, in contrast with the Basement Complex which is distributed in plateaus area. As a result, Main rivers such as Niger and Benue flow in sedimentary rock area. Weathered and fractured part of sandstone forms excellent aquifer. Such aquifer sometimes forms alternation of sand stone and shale. This structure makes sandstone aquifer confined. Groundwater level is usually deep in sedimentary rock area. For example, groundwater level is reported as 50- 100m below the ground in Sokoto-Rima Basin.
Quaternary	Quaternary aquifer is distributed in wide area around the Lake Chad in the northwestern area and Niger Delta area. Moreover, it is distributed in the coastal area along Gulf of Guinea. Quaternary (alluvial) is also distributed in inland area along rivers, size of which depends on scale of river discharge. Quaternary sediment consists of unconsolidated to half –consolidated sand and clay. Sand layers show high permeability and form excellent aquifer. It is reported that groundwater level is low at 50m to 100m below the ground in Lake Chad area in the northeastern area. On the contrary, it is high at 1m below the ground in Niger Delta area in the southern area.

Source: JICA Project Team

1.2.4 Soil

Type of soil is determined by type of parent rock, vegetation and climate.　Importance of soil in water resources management is that soil properties has strong relationship with capacity of moisture content within soil, which determines evaporation from soil and transpiration from vegetation. Soil type in Nigeria is summarized in Table 1-18.

Table 1-18 Soil Type in Nigeria

Type	Description
Northern zone of sandy soil	Sandy soil is in the northern part of Nigeria due to long dry season, erosion of the basement complex and sandy dust from Sahara desert.
Interior zone of laterite soil	The soil is accumulated with iron and aluminium after leaching of other chemical elements from the upper-most part of the ground. Such soil is typical in the area where dry and rainy season are clearly divided and repeated. Such a situation is seen in the wide areas of the central Nigeria.
Southern belts of forest soil	The Forest soil is distributed between alluvial soil in the south and laterite soil in the north. The soil is covered with rich vegetation throughout the year; due to long rainy season and short dry season.　The Forest soil changes its properties from sandy loam to clayey loam following the type of their parent rocks.
Zone of alluvial soil	There is enough rainfall in Niger Delta area and alluvial soil can be seen in many places in the delta plain consisting of sand, silt and clay which were deposited after flood. Equally, alluvial soil is also deposited in flood plains of large rivers such as Niger and Benue River.

Source: JICA Project Team

1.2.5 Vegetation

The vegetation in Nigeria is summarized in Table 1-19.

Table 1-19 Vegetation in Nigeria

Type	Description
Mangrove, Freshwater/ seawater Wetland, Tropical Rain Forest	Mangrove, freshwater/ seawater wetland and tropical rain forest are distributed in the area with more than 1,500mm/year in precipitation. The mangrove area is along the coast line of the Gulf of Guinea. The freshwater/ seawater wetland and tropical rain forest consequently occur toward the inland area. These areas are covered by dense evergreen trees.
Guinea Savanna	Guinea Savanna is distributed in the area where rainy season continues 6 to 8 months with 1,000-1,500mm/year in annual precipitation. It occupies the broad areas from the southern to the middle belt of Nigeria, which is the most common vegetation type in Nigeria. Due to historical agricultural and other human activities, most of the Guinea Savanna has been secondary vegetation.
Sudan Savanna	Sudan Savanna is distributed in the area where rainy season continues 4 to 6 months with 600-1,000mm/year in annual precipitation. Most of northern Nigeria is covered by Sudan Savanna. Grassland with 1-2m in height dominates. The typical tree species such as Acasia and baobab are prevalent in this region.
Sahara Savanna	Sahara Savanna is distributed in the area where rainy season does not continue more than 4 months with less than 600mm/year in annual precipitation. This vegetation type appears around Chad lake. Grassland with 0.5-1m in height can be seen in the desert. The typical tree species is Acasia

Source: Geography of Nigeria

1.2.6 Land Use

The land use condition in Nigeria is summarized in Table 1-20. The typical land use in Nigeria is agricultural which covers more than 60% of the country. The grassland and shrub shares almost 20%, which is the second largest land use type. The forest land is only 5% of the total land area of Nigeria.

Table 1-20 Land Use in Nigeria

	Total	Forest	Grassland /Shrub	Agriculture	Wetland	Water body	Urban Area	Others
Area (km^2)	909,958	46,038	197,164	586,516	37,449	10,555	5,344	26,891
Ratio (%)	100.0	5.1	21.7	64.5	4.1	1.2	0.6	3.0

Source: JICA Project Team based on “FME, Land Degradation Mapping and Assessment for the Prevention and Control of Potential Erosion Hazard in Nigeria, Final Report, 2010”.

1.2.7 Meteorology

The meteorological condition in Nigeria is generally characterized by high temperature as is typical in the tropic. However, due to large land mass, the meteorological conditions in the south near the Gulf of Guinea and the north near the Sahara Desert are totally different. The southern area is characterized by tropical rainforest with humid conditions. There are a lot of lagoons associated with mangrove forest in the coastal area along the Guinea Gulf with about 800km in width. The climate gradually changes toward the north with decreasing precipitation from tropical rainforest to savanna and finally to semi-arid conditions near the border to Niger and Chad.

The average precipitation and air temperature in the last 40 years (1970-2009) are estimated at 1,150mm/year and 26.6 degree Celsius, respectively, based on the analysis by JICA Project Team. The annual precipitation varies from 3,000mm/year around Niger delta to 400mm/year in the north.

There are clear dry and rainy seasons. The duration of rainy season in the southern area is 9-12 months with two peaks in July and September, whereas 2-3 months with a peak in August in the northern area.

1.2.8 Hydrology

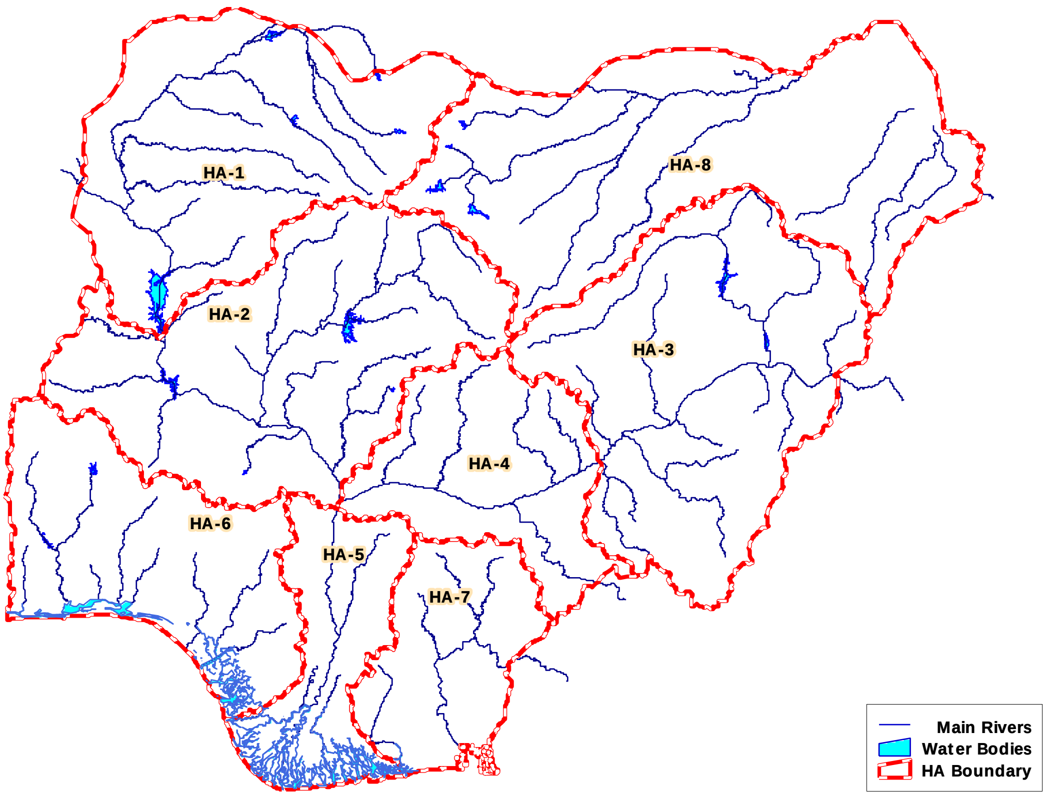
On the basis of the analysis by JICA Project Team on the meteorological and hydrological data during the last 40 years (1970-2009), it is estimated that about 24% of the total precipitation are runoff while the remaining is lost though evapotranspiration and others. The water resources potential within the territory of Nigeria is estimated at 287BCM/year. Adding water resources flows into Nigeria from outside the country, the total water resources potential would become 375BCM/year. Among the total water resources potential, 88BCM is from outside the country. It can be said that about 24% of the total water resources relies on contribution from neighboring countries. The groundwater resources potential as renewable resources is estimated at 156BCM/year

Associated with precipitation pattern in the country, there are unevenly distributed water resources: 25mm/year on water resources (500mm/year in average precipitation and 5% in runoff rate) in the northern area, 1,000mm/year on water resources (2,000mm/year in average precipitation and 50% in runoff rate) in the southern area.

There is a unique hydrological regime in the Niger River, which is influenced by the upper reach of the Niger River. The Niger River originated from the Guinean high land and flows toward an inland delta in Mali. In the inland delta, the flow is retarded very much and almost half of the flow is lost by evaporation in the wetland area. Because the inflow to Nigeria is influenced by the retarding and loss in the inland delta, the peak inflow discharge appears around March to April, which shows almost half year delay from the precipitation event in the upper reach of the Niger River. On the other hand, the runoff in the lower reach of the Niger almost coincides with the precipitation event, which brings about the peak runoff at round August and September. The discharge in the lower reach of the Niger River is determined by the combination of the inflow to Nigeria and the runoff in the lower reach. It should be also noted that the contribution from Benue river basin to the total runoff volume in the Niger River is relatively large compared to its drainage area.

1.2.9 Hydrological Area

As shown in Figure 1-2, Nigeria is divided into eight hydrological areas from the purpose of water resources management, considering hydrological and topographical conditions.



Hydrological Area		Area (10^3km^2)	Precipitation (mm/year)	Mainly Related RBDAs	Mainly Related States	Population (2010) (10^6)	Population (2030) (10^6)
HA-1	Niger North	135.1	767	Sokoto-Rima	Katsina, Zamfara, Sokoto, Kebbi	17.1	27.2
HA-2	Niger Central	154.6	1,170	Upper Niger, Lower Niger	Niger, Kwara, Kaduna, Kogi, FCT	17.0	31.5
HA-3	Upper Benue	156.5	1,055	Upper Benue	Adamawa, Taraba, Gombe, Bauchi	12.2	19.4
HA-4	Lower Benue	74.5	1,341	Lower Benue	Plateau, Nassarawa, Benue, Kogi	8.3	13.9
HA-5	Niger South	53.9	2,132	Anambra-Imo, Niger Delta	Bayelsa, Delta, Edo, Kogi, Anambra, Rivers	19.6	31.1
HA-6	Western Littoral	99.3	1,541	Ogun-Osun, Benin-Owena	Lagos, Ogun, Oyo, Osun, Ondo, Edo, Ekiti	35.9	57.8
HA-7	Eastern Littoral	57.4	2,106	Cross River	Abia, Anambra, Imo, Enugu, Ebonyi, Cross River, Akwa Ibom, Rivers	20.8	32.6
HA-8	Lake Chad	178.5	610	Hadejia-Ja’mare, Chad	Kano, Jigawa, Yobe, Borno, BAuchi, Plateau, Adamawa	27.4	44.4

Source: JICA Project Team

Figure 1-2 Hydrological Areas in Nigeria

1.3 Organizations and Institutional Responsibilities in Water Resources Sector

1.3.1 Historical Perspective of FMWR

In Nigeria, the first administrative structure in charge of water resources management at federal level was a creation of Water Resources Division which was established in the 1960s as one of the divisions of Federal Ministry of Agriculture. Since then, merger and demerger between Federal Ministry of Water Resources and Federal Ministry of Agriculture and/or Rural Development was repeatedly carried out. In 2010, the present FMWR was ensured as an independent federal organ in the water resources sector, apart from Federal Ministry of Agriculture.

FMWR has sixteen (16) parastatals and agencies made up of twelve (12) River Basin Development Authorities (RBDAs), Nigeria Hydrological Services Agency (NIHSA), Nigeria Integrated Water Resources Management Commission (NIWRMC), Gurara Water Management Authority (GWMA), and the National Water Resources Institute (NWRI). The first two RBDAs - Chad Basin Development Authority (CBDA) and Sokoto-Rima River Basin Development Authority (SRRBDA) were created in 1973, through the Decree Nos. 32 and 33 of 1976. In 1976, based on the Decree No. 25 of 1976, nine (9) additional RBDAs were established, and as a result, the number of RBDAs becomes 11. In 1984, with separation of Niger River Basin Development Authority into two RBDAs – such as Upper Niger River Basin Development Authority (UNRBDA) and Lower Niger River Basin Development Authority (LNRBDA), the number of RBDA become 12 and these RBDAs long continue with the operation to date.

The National Water Resources Institute (NWRI) was established legally in 1985, through the enactment of the NWRI Act No.3, 1985. However, NWRI began to operate as a nation’s training center on water resources at national level in 1979, about 6 years earlier than the official foundation.

With the global movement to the water resources problems, the principles of Integrated Water Resources Management (IWRM) were first explicitly indicated on the Dublin Declaration in the World Conference on Water and Environment held in Dublin in 1992. It was further pledged on the United Nations Conference on the Environment and Development (UNCED Earth Summit) in Rio de Janeiro in 1992. Following the first World Water Forum held in Marrakesh in 1997, in 2000, at the UN Millennium Summit, the Millennium Development Goals (MDGs) were declared.

Under the international trends and agreements in water resources sector as stated above, the revision of the National Water Policy has been taken up since 2003. Furthermore, drafting of a new National Water Resources Bill for Nigeria has also started in October 2006. It is revealed that the revision work on draft policy document has reached the final stage. Hence, it is expected that a new Bill is completed and become effective as soon as possible to serve as a principal legislation in water resources sector replacing the Water Decree No. 101 of 1993.

In terms of institutional changes and reforms in the past few years, it must be cited that the Integrated Water Resources Management Commission (NIWRMC) was created in 2007. In 2010, the Nigeria Hydrological Services Agency (NIHSA) was newly established as well. It is said that an idea of establishment of an organization which is responsible for water resources management at basin and catchment level known as River Basin Management Commission (RBMCs) was first proposed in the Report of Nigeria Water Resources Strategy which was prepared with technical cooperation from the Commission of the European Communities. It has now been superseded by that of the Nigeria Integrated Water Resources Management Commission (NIWRMC). Despite the National Assembly passed the Bill for an Act to Establish NIWRMC in June 2011 and forwarded to the President of the Nation for his Assent, the President’s Assent has not yet been obtained.

1.3.2 Organizational Structure and Function of FMWR

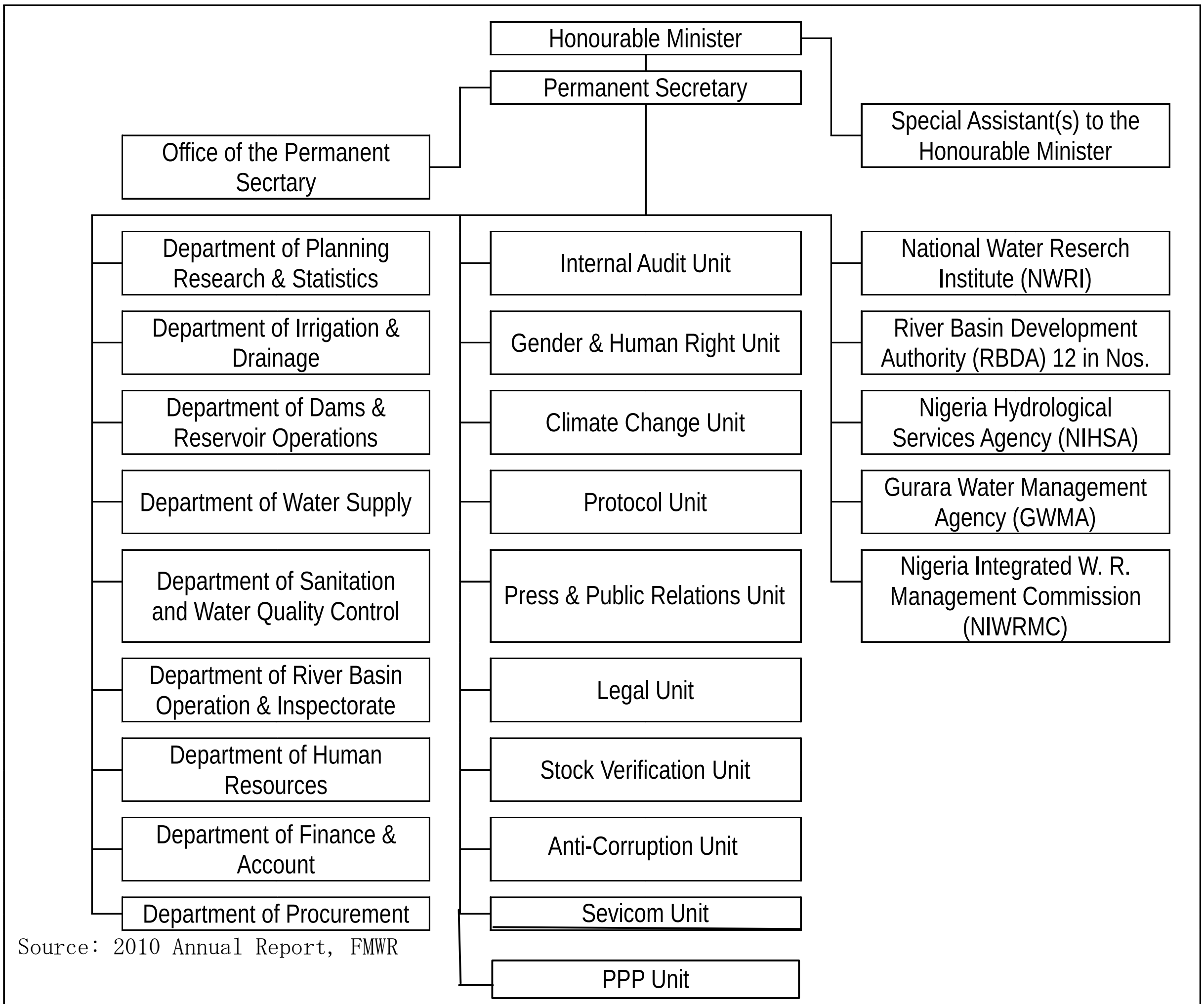
(1) Organizational Structure

The powers and functions relating to water resources development and management are executed by various ministries and agencies depending on the water sub-sector. Of the various water sub-sectors, FMWR is mainly responsible for water resources development (surface and groundwater), water supply and sanitation, and irrigation and drainage. The responsibilities for other water sub-sectors, such as hydro-electric power generation, flood and erosion control, inland transportation, fisheries/aquaculture/stock raising, and mining are taken by such other federal ministries, as Power, Environment, Transport, Agriculture and Rural Development, and Mines and Steel Development.

There is an overlapping of the powers and functions in a single water sub-sector. To take an example, FMWR, through Department of Water Supply and Department of Sanitation and Water Quality Control, shall be responsible for formulation and implementation of national water supply policy, strategies and guidelines, water quality control, and water sanitation technology, etc. On the other hand, Federal Ministry of Environment (FMEnv) and the National Environmental Standards and Regulations Enforcement Agency (NESREA) have similar areas of the authority such as to make policies and strategies for water quality, sanitation and pollution and to enforce the laws and regulations for water pollution control and water quality standards. In the dam and reservoir sector, construction, operation and maintenance of federal dams which are developed for the purpose of hydro-power generation is one of the major functions of Federal Ministry of Power. On the other hand, FMWR, through RBDAs, are responsible for construction, operation and maintenance of reservoir dams for the achievement of the RBDAs functions that call for hydro-power component in some cases.

Base on a share in institutional responsibility in the water resources sector as stated above, FMWR is organized into a vertical organizational structure comprising of ten (10) Departments which include four (4) Service and five (5) Operational Departments, nine (9) Units as well as sixteen (16) Parastatals and Agencies. However, because of a bureaucratic approach in water resources management, and lack of coordination and collaboration with other ministries and agencies, etc. makes it difficult to carry out their tasks.

Organization chart of FMWR is shown in Figure 1-3.



Source: 2010 Annual Report, FMWR

Figure 1-3 Organization Chart of FMWR

(2) Functions

The Fourth draft of the National Water Resources Bill comprising 14 parts and 90 sections states clearly the powers and functions of FMWR in Part III. The following summarizes the core powers and functions of FMWR.

General Powers

- To promote the protection, use, development, conservation, and management of water resources throughout Nigeria; and
- To make regulations, policies and strategies for the proper carrying out of the provisions of the Water Resources Act.

Powers related to Trans-Boundary Rivers within Nigeria

- Through NIWRMC, by establishing and chair coordination committees for each of the hydrological basins, to coordinate and assist for the situation where development or management of the water resources affects more than one hydrological zone

Powers related to International Agreements, Negotiations and Meetings

- To facilitate and execute international and trans-boundary coordination and collaboration

Powers related to Water Supply and Sanitation

- In consultation with the States, to formulate guidelines for the development and funding of State water supply and sanitation sectors, including the encouragement of public-private partnerships. This guideline shall include setting of national standards for water services and standards for tariffs, and establishment of a regulatory framework and accountability procedures for water services institutions and intermediaries

The Nigerian system of government is composed of three tiers of government - Federal, State and Local. Local government area/authority (LGA) is the lowest level of administrative structure. There are 36 State Governments in addition to the Federal Capital Territory (FCT). The number of LGA is 775 at present.

Institutional responsibilities in water resources sector are delegated to federal, state and local government based on the institutional structure under the federal system. Table 1-21 shows the major roles and responsibilities of the Federal Government (FMWR), the State Government (State Ministry of Water Resources, Environment, Rural Development, Agriculture, etc.), and LGAs. As already mentioned before, there are overlapping responsibilities with regard to water resources management. Taking the water supply and sanitation sector as an example, FMWR is directly responsible for the implementation of federal intervention in the rural water supply projects and programs which include many programs financed by international agencies and development partners such as UNICEF, AfDB, JICA, etc. But, in many other cases, the institutional responsibilities in the water supply in three segments such as urban, small town and rural water supply are shared with the state water supply agencies (State Water Boards/Corporations), Small Towns Water Supply and Sanitation Agency, Rural Water Supply and Sanitation Agencies (RUWASSA) and the Rural Water Supply and Sanitation Department (RWSS Dept.) of LGAs, based on various state edicts, acts, etc. The other institutions mandated play a complicated role in water resources management are RBDAs. In the dams and drainage sector, FMWR, through RBDAs, are responsible for both the provision of federal irrigation infrastructures and small-scale public irrigation schemes in collaboration with the State Ministry of Water Resources or the State Ministry of Agriculture. Notwithstanding the above-stated situation, there is no doubt that the nation’s responsibility in the water resources management rests with FMWR.

In Nigeria, with a land area of about 924 thousand square kilometers, and the population of more than 150 million (2010 estimate), it is becoming more and more difficult to efficiently carry out water resources development and management through the centralized management or bureaucratic top-down approach at three tiers of the government. So, FMWR must have the major responsibility for overseeing water resources management in Nigeria. In addition, it is also required to be organized along vertical lines of all level of governments with cooperative management system.

Table 1-21 Major Roles of Federal, State and Local Institutions in Water Resources Sector

Level of Governance	Major Roles/Responsibilities	Institutions
Federal (FMWR)	• Formulation of National Water Resources Policy, Strategy and Master Plan • Implementation of large infrastructure for water resources sector • Planning, development and management of projects and programs in Dams/Reservoir, Irrigation, Water Supply and Sanitation, etc. • Study and management on national hydrological and hydrogeological data • Formulation and update of water resources legislation • Facilitate and execute international and trans-boundary coordination and collaboration • Liaison, negotiation and conclusion of agreements and memorandums with national and international agencies on all matters relating to water resources	• NCWR • Federal Ministry of Water Resources and its parastatals and agencies such as RBDAs, NIHSA, NIWRMC, GWMA and NWRI
State	• Water resources development (hydrological and hydrogeological investigations and data storage) • Planning, construction and improvement of water supply and sanitation schemes (Urban/Small Towns/Rural) • Planning, construction and improvement of irrigation schemes (in collaboration with the State Ministry of Agriculture, etc.) • Supervision and Support to LGAs in the area of water supply and sanitation	• State Ministry of Water Resources, Environment, Rural Development, Agriculture, etc. • State Water Supply Agencies (Water Boards/Corps), Small Towns Water Supply and Sanitation Agencies, RUWASSA
LGA	• Provision of services to the communities in the area of water supply and sanitation, including operation and maintenance of completed rural water infrastructure • Assistance to RUWASSA in coordination with WASHCOM or WASCOM activities including promotion of hygiene and sanitation practices at households and communities	• RWSS Depts. of LGAs

Source: JICA Project Team

1.3.3 Organizational Structure and Function of RBDAs

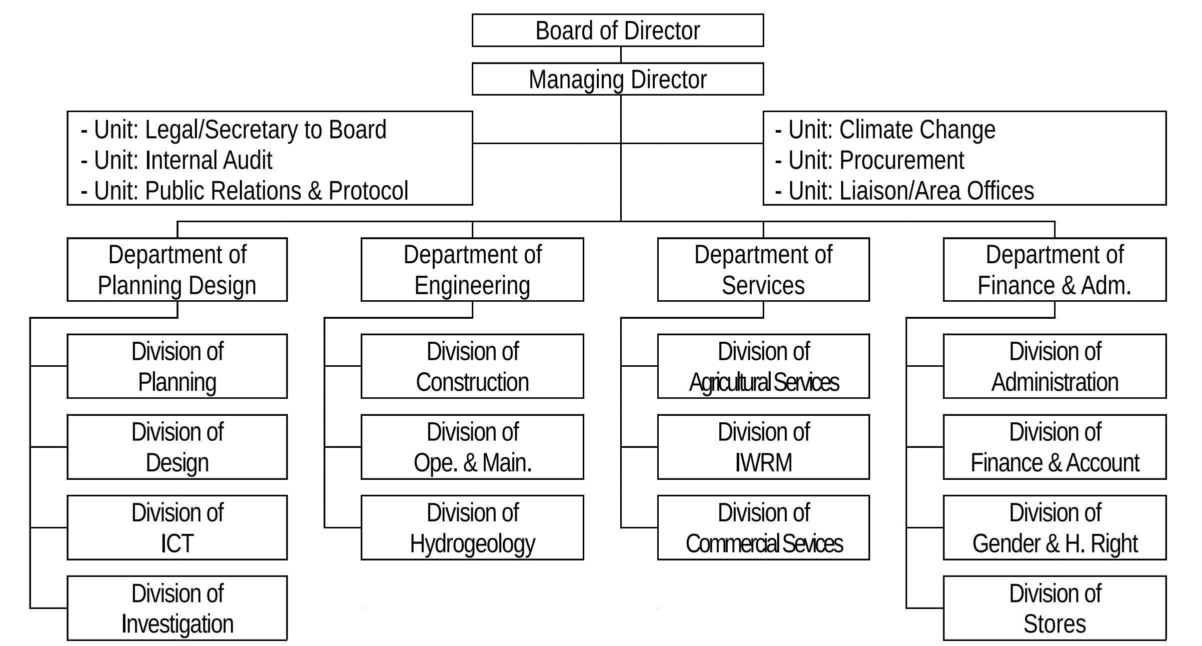
(1) Organizational Structure

The twelve (12) River Basin Development Authorities (RBDAs) are listed in Table 1-22. Figure 1-4 shows the organization chart of Sokoto-Rima River Basin Development Authority (SRRBDA) founded in 1973 which is one of the oldest RBDAs. All RBDAs have almost the same type of organizational charts. The total of staff for twelve RBDAs is 4,400 in round numbers in 2011, which is larger than that of the total of the Departments, Units and other Agencies of FMWR Headquarters in Abuja.

Table 1-22 List of RBDAs

	RBDA	Area of Operation	Office	No. of Staff
1	Anambra-Imo River Basin Development Authority (AIRBDA)	Abia, Anambra, Ebonyi, Enugu and Imo States	Oweri	458
2	Benin Owena River Basin Development Authority (BORBDA)	The regions of the River Benin and Owena and the senatorial district in Delta State	Benin-City	321
3	Chad Basin Development Authority (CBDA)	Borno, Yobe State and northern part of Adamawa State	Maiduguri	329
4	Cross River Basin Development Authority (CRBDA)	Akwa Ibom and Cross River States	Calabar	324
5	Hadejia Jama' Are River Basin Development Authority (HJABDA)	Kano, Jigawa States and north and central parts of Bauchi Sate	Kano	415
6	Lower Benue River Basin Development Authority (LBRBDA)	The catchment states of Benue, Plateau, Nassarawa States and Kogi State East of the River Niger	Mukardi	327
7	Lower Niger River Basin Development Authority (LNRBDA)	Entire geographical boundaries of Kwara State and a part of Kogi State, west of the River Niger	Ilorin	471
8	Niger Delta Basin Development Authority (NDBDA)	Delta and Bayelsa States	Port Harcourt	409
9	Ogun-Osun River Basin Development Authority (OORBDA)	Lagos, Ogun, Oyo and Osun States	Abeokuta	307
10	Sokoto-Rima River Basin Development Authority (SRRBDA)	Katsina, Zamfara, Sokoto and Kebbi	Sokoto	520
11	Upper Benue River Basin Development Authority (UBRBDA)	Gombe, Taraba, two senatorial districts of Adamawa State and one senatorial district of Bauchi State	Yola	305
12	Upper Niger River Basin Development Authority (UNRBDA)	Niger, Kaduna States and the FCT	Minna	256

Source：Based on the Information from FMWR



Source: SOKOTO-RIMA RBDA

Figure 1-4 Organization Chart of Sokoto-Rima RBDA

(2) Function

The following summarizes the functions for all of the RBDAs in common.

- To undertake comprehensive water resources development of both surface and groundwater for multipurpose use such as irrigation, control of flood and erosion, etc.
- To construct, operate and maintain reservoir dams, dykes, polders, wells, boreholes, irrigation and drainage systems
- To supply water from RBDAs completed storage schemes to all users for a fee to cover the cost of the services for irrigation, etc. The fees (user charges) shall be determined by RBDA subject to the approval of the Minister of FMWR
- To construct, operate and maintain infrastructure services such as roads, bridges, etc. linking project sites
- To develop and keep up-to-date comprehensive water resources master plans identifying all water resources requirements in each RBDAs area of operation

As mentioned above, RBDAs have a broad range of powers and function such as water supply and allocation, construction, operation and maintenance of water infrastructure, formulation and updating of comprehensive water resources plans, etc.

The main issues that most RBDAs face are discussed below.

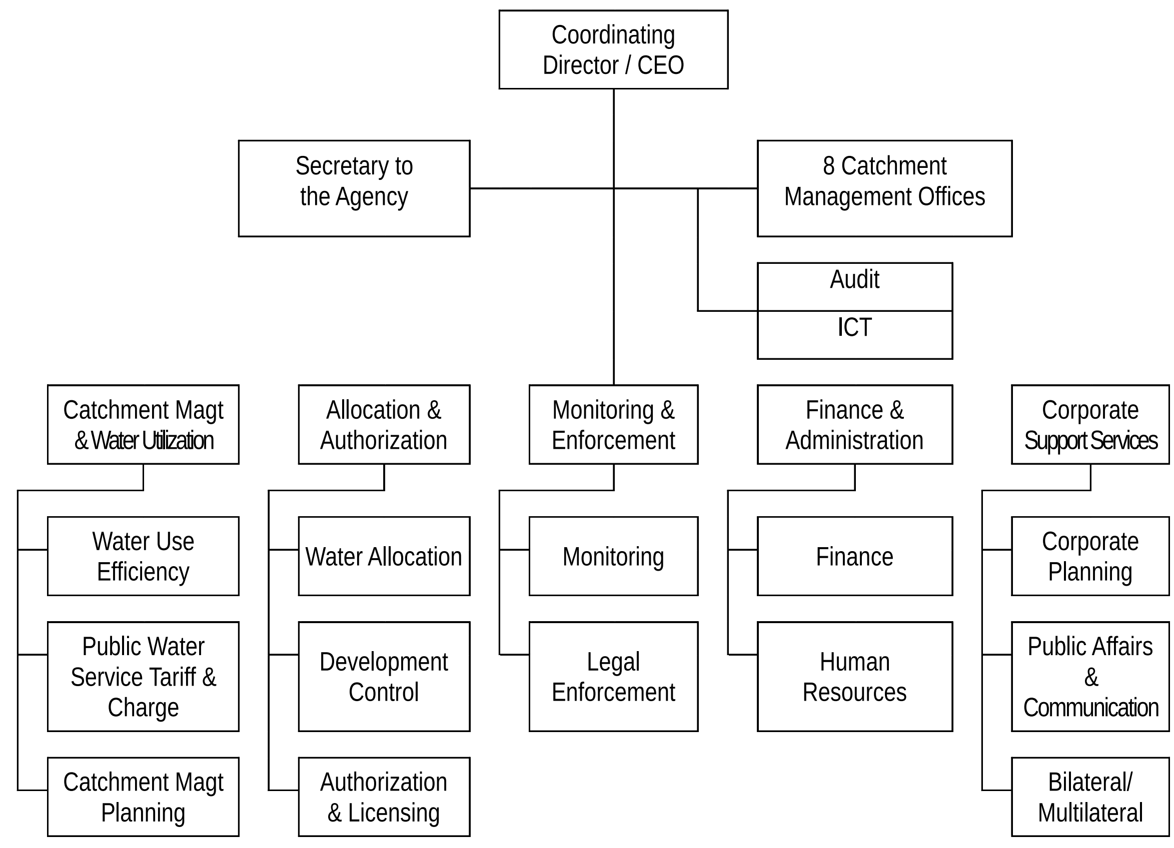
- Of all their primary functions, the one which they have most focused on is the water resources and land development for the purpose of irrigation systems
- They are authorized by the RBDA Act to deliver their services not only as “Suppliers of water but also as “Users of water” (coexist of two different functions in a single institution)
- The RBDA Act authorizes RBDAs to supply water to all users for a fee. But, in fact, RBDAs have not been able to fully collect the fee from its major water users such as the State Water Agencies, etc. properly, and thus most RBDAs depend on the Federal Government for most of their funds.

There were a number of recommendations to reform RBDAs in the past. For instance, in the 1990s, privatization of RBDAs was seriously considered. The National Water Resources Master Plan (M/P1995, JICA) examined the mandated functions of RBDAs at that time, and recommended for the revision of scope of operation in terms of irrigation infrastructure. The National Water Resources Bill which is now in legislative process argues the necessity of encouraging and promoting private sector involvement in the provision, management and utilization of irrigation services.

1.3.4 Organizational Structure and Function of NIWRMC

(1) Organizational Structure

The organizational structure of NIWRMC is shown in Figure 1-5. The total number of staff is 131 as of 2013. It is comprised of 80 in five (5) Departments, 21 Coordinating Directors including the Chief Executive Officers (CEO), and 30 in eight (8) Hydrological Catchments Management Offices (CMOs); Niger-North, Lake Chad, Niger-Central, Upper-Benue, Lower-Benue, Niger-South, Western Littoral and Eastern Littoral. It must be noted that no staff is disposed in Upper Benue CMO at present.



Source: FMWR

Figure 1-5 Organization Chart of NIWRMC

(2) Functions

The powers and functions of NIWRMC are stipulated in detail in Section 8, Part II of Bill for an Act to Establish NIWRMC (the NIWRMC Bill). In summary, NIWRMC has three key roles, which include but not limited to the following.

- Issues on permit of water use and regulations for all stakeholders including public and private institutions (Implementation of Regulatory function)
- With the integrated approach, strengthening of the management of water resources at basin and catchment level for achieving the MDGs (Implementation of Management function)
- Formulation of the Catchment Management Strategy and Plans (Implementation of Planning function)

As previously discussed, despite the fact that the National Assembly passed the NIWRMC Bill in June 2011, it is still pending, and the delay in assenting to the NIWRMC Bill by the President is a major constraint in executing its functions. While, the National Water Resources Bill (Fourth Draft-July 2011) points out that there are some potential areas of overlap between the NIWRMC Bill and the National Water Resources Bill which need to be considered by the relevant authorities. It is expected that the NIWRMC Bill will be finalized in the near future to provide NIWRMC with the legal basis for ensuring adequate delivery of the roles and responsibilities sufficiently.

The main functions of each department of NIWRMC are outlined below.

Catchment Management & Water Utilization Department

Water Use Efficiency Division is in charge of the policies and guidelines for various water uses in water supply, agriculture, industry and other uses, and the preparation of water efficiency strategies. Public Water Service Tariff & Charge Division has the responsibility for promotion of strategies on the provision of safe water charges for all Nigerian water consumers, including the code of practice. The main function of Catchment Management Planning Division is to prepare and update the Catchment Management Strategies and Plans.

Allocation & Authorization Department

Water Allocation Division is responsible for the determination and regulation of sector and geographical water allocation, enforcement of the polluters- and users- pay principles, and in collaboration with other agencies, on an acceptable level pollution by discharge that meet water quality standards in the river basin. The main function of Development Control Division is to deal with dams operation and safety, field monitoring and evaluation of the approved development projects, and review of Environmental Impact Assessment (EIA). Authorization and Licensing Division is responsible for overseeing approve and license for water abstractions from rivers and aquifers and discharge into the rivers.

Monitoring and Legal Enforcement Department

Monitoring Division is responsible for effective monitoring and evaluation (M & E) for water sector programs and projects, including monitoring for performance and compliance of the licensees. Legal Enforcement Department shall deal with arbitration of disputes among all stakeholders. The activities of this Division include, among others, receiving and investigating complaints from the licensees, developers, consumers and other stakeholders.

Corporate Support Service Department

It is the responsibilities of Corporate Planning Division to do strategic planning and program development budgeting. Public Affairs & Communication Division is asked to undertake press relations and public consultation as the following cases show; organizing of workshops, seminars and meetings for IWRM, coordination of gender mainstreaming activities. Bilateral and Multilateral Cooperation Division is in charge of liaison with various relevant bodies within and outside Nigeria.

Finance & Administration Division

Finance Division is responsible for the funds and account and payments. Human Resource Division is responsible for the personnel management and staff welfare activities, which include, among others, implementation of the human resources policies, procedures and controls, and capacity building.

Catchment Management Offices (CMOs)

In terms of promoting the policies, implementation and coordination relating to the development of natural resources including water resources at catchment level, Catchment Management Office (CMOs) is established for each hydrological zone. CMOs are required, as the executive arm of NIWRMC in each hydrological zone, to provide secretariat and technical assistance and support to the Catchment Management Coordinating Committees (CMCCs), which is organized for the catchments decision-making forum for a catchment area and comprising a representative from each of the following sectors; such as water resources, land and environment.

The main issues that face NIWRMC at present are;

- The NIWRMC Bill which defines the statutory authorities still remains pending without having the assent from the President of the Nation. This lack of legal backing results in the difficulties in the staff recruiting, budgetary allocation that affect sufficient implementation of the roles and responsibilities of NIWRMC.
- Most CMOs have the difficulties in disposition of necessary staff due to the same reason mentioned above. In order to move forward the water resources management at catchment level, it is an urgent issue to increase the manpower of the CMOs.

- In addition to the manpower development of CMOs, it is also necessary for NIWRMC to be staffed with the multidisciplinary and cross-sector engineers and the specialists including those in the middle- to- top class.

1.3.5 Outline of Other Parastatals and Agencies of FMWR

In addition to twelve (12) RBDAs and NIWRMC, the functions of FMWR are carried out by three (3) other Parastatals and Agencies; they are National Water Resources Institute (NWRI), Gurara Water Management Authority (GWMA) and Nigeria Hydrological Service Agency (NIHSA). Table 1-23 shows the outline of the existing responsibilities and legislations in these three institutions.

Table 1-23 Responsibilities and Supporting Legislation of Other Federal Institutions

Federal Institution	Established	Legislations/ Regulations	No. of Staff	Main Responsibilities
National Water Resources Institute (NWRI)	1979	National Water Resources Institute Act No. 3 of 1985	123	● Promotion and development of training courses in water resources, and provision of training in various aspects of water resources disciplines for the ministries and agencies ● Research and development for water resources ● Management and dissemination of water resources data on hydrology and hydrogeology
Gurara Water Management Authority (GWMA)	2007	Executive Council’s Meeting of May 16, 2007	29	● Water supply to FCT via Usuma Dam ● 30MW Hydroelectric power generation ● Water supply for 6000 hectares Irrigation land ● Operation and maintenance of Gurara Dam and 75km transfer pipelines ● Development of tourism, fishery, agro-allied industry and the environment
Nigeria Hydrological Services Agency (NIHSA)	2010	NIHSA Establishment Act, 2010	172	● Collection, processing, analysis and storage of hydrological and hydrogeological data ● Assessment of quality and quantity and distribution of development potentials of water resources ● Provision of information for planning, design and operation of water resources development projects and programs ● Monitoring and evaluation of water resources

Source: 2010 Annual Report, FMWR/Based on Questionnaires by JICA Project Team (GWMA and NIHSA)

1.4 Water Use and Water Resources Development

(1) Current Condition of Water Use

The total volume of water use in 2010 is estimated at 5.9BCM/year, based on the results of the water demand estimation in the present project. The share among municipal, irrigation and other agriculture (livestock and freshwater aquaculture) is 52%, 32% and 16%, respectively. The volume of surface water source and groundwater source is estimated at 2.4BCM/year (41%) and 3.5BCM/year (59%), respectively.

The current (2010) volume of water for municipal use is estimated at 3.1BCM/year, under the condition that the coverage of municipal water supply is about 50% on average. The share of surface and ground water source is 24: 76; the rate of groundwater use is much higher.

Most of the currant agricultural produce in Nigeria relies on rain-fed cultivation. The existing irrigation area is estimated at about 310,000ha, which is about 0.5% of the total agricultural area, and its water use is 1.9BCM/year. The irrigation scheme can be divided into public scheme and small private scheme. The former mainly uses surface water source. The planned public irrigation area is 440,000 ha. However, the developed area is 130,000ha and the actual irrigated area is only 70,000ha. The small private irrigation may be further sub-divided into Fadama irrigation (93,000ha) that cultivate flood plain area after recession of floods and others that mainly use groundwater (90,000ha).

The water use for livestock and freshwater aquaculture is estimated at 1.0BCM/year. It should be noted that the water use in freshwater aquaculture is increasing rapidly.

(2) Surface Water Resources Facilities

The number of existing dams confirmed in the present project is 171, and their total storage capacity is 37.46BCM. This is equivalent to about 10% of the total water resources potential in Nigeria. Among the total storage capacity of 37.46BCM, 25.80BCM is associated with large hydropower dams such as Kainji, Jebbe and Shiroro. The remaining storage of 11.66BCM is mainly used for irrigation and municipal water supply. The average effective storage is about 78% of the total storage capacity.

The total storage capacity for irrigation and municipal water use is much larger than the current surface water use. However, because the water supply and demand do not always match well, it is possible that the future water supply may not meet the demand at the local level, although the macro water balance shows some excess water volume.

The water purification plant currently has capacity of 1.54BCM/year in total. Its operation rate is, however, only 45%.

(3) Groundwater Resources Facilities

Groundwater is distributed and used in the entire country. There are around 57,600 boreholes for public water supply in Nigeria, pumping about 458m^3/day of groundwater. Groundwater is used for wide purpose, such as water supply, private irrigation, livestock and aquaculture. Motorized and hand pumps are installed into boreholes. Depth of boreholes is 50m on average in Basement Complex area, where groundwater of weathered rock is pumped up. On the other hand, depth of boreholes is 50 to 400m in sedimentary rock area, depth of which is different according to the location. Yield from boreholes is 10 to 150m^3/day in Basement Complex area, 10 to 500m^3/day in sedimentary rock area. Operation rate of boreholes is 63% due to breakdown of pumps. It is recommended that pump maintenance should be improved.

(4) Water Use of Niger and Benue Rivers as Trans-boundary Rivers

The trans-boundary Rivers flowing into Nigeria are the Benue and Niger rivers. The two rivers join at Lokoja approximately 400km from the estuary and flow into the Gulf of Guinea. These rivers play important roles in Nigeria in terms of the use of water resources. The amount of water resources flowing annually into Nigeria as trans-boundary water from Cameroon, Guinea, Mali and Niger is 88BCM. This amount corresponds to about 24% annual amount of water resources (374 BCM) of Nigeria.

Along the sections of Niger and Benue rivers where trans-boundary water flows down, there are all types of water use such as water supply, irrigation, hydroelectric power generation, navigation, fishery etc.. Hydroelectric power generation is being operated at Kainji Dam (maximum output 700MW) and Jeba Dam (maximum output 570MW) on River Niger. In addition to power generation, these dams serve the purpose of water supply, irrigation and domestic uses and the fisheries.

On the other hand, in the upper reaches near the border, there are dams which regulate the flow into the country. Kandaji Dam (Total storage capacity: 1.5BCM, Purpose: irrigation and hydroelectric power generation) is under construction upstream of River Niger. In addition, the Lagdo Dam (Total storage capacity: 8BCM, Purpose: irrigation and hydroelectric power) is under operation upstream of Benue River in Cameroon.

For the proper water use of international rivers, Nigeria is participating in the international organizations such as NBA (Niger Basin Authority), NNJC (Nigeria-Niger Joint Commission), NCJC (Nigeria Cameroon Joint Commission) in order to strengthen the partnership among the countries concerned for exploring problem-solving, but the arrangements relating to the use of water has not been made yet.

CHAPTER 2 REVIEW OF EXISTING NATIONAL WATER RESOURCES MASTER PLAN 1995

2.1 General

(1) Background

In Nigeria, the government led water resources development projects have been carried out full-fledged since the 1970s. Federal Ministry of Water Resources and Rural Development (FMWRRD) undertook the formulation of “National Water Resources Master Plan” with the assistance of FAO, aiming at efficient management and development of water resources. However, due to lack of funds, this work did not reach conclusion, coming up with only preliminary draft report. In order to complete the master plan, FMWRRD requested the Japanese government to implement the study on the water resources master plan. By accepting the request from the Nigerian government, the Government of Japan dispatched in October 1991 Japan International Cooperation Agency (JICA) to the Nigeria to discuss the “Scope of Work” summarizing the framework of the master plan study. This “Scope of Work” was agreed and signed on 6 November 1991.

Then, JICA has formed a team of consultants and sent to Nigeria. The master plan study was conducted over a period of three years from the end of March 1992 until the end of March 1995. The final report of the Study, including all the study results, is contained in the Main Report, Sector Report, Inventory Summary Report, Database Diagram, Diagram of Satellite Image Interpretation, and so on. The Main Report explains the analysis results of Current Status and Problem related to water resources, the plans of water source development, water supply, irrigation and so on. Also, the Main Report shows the implementation plans of the project proposed in the master plan.

(2) Basic Strategies

Along the basic approach of “Draft National Long-Term Plan, December 1992, NPC” the National Water Resources Master Plan set the basic policies. Draft National Long-Term Plan was targeting the Human-Centered Development Plan along the overall policy of promotion of achievement of people independence on the basis of the implementation of the “Structural Adjustment Program, SAP”. As for water resources, "Construction of facilities to provide safe water for life", "Expansion of irrigated agriculture to meet the growing food demand due to population growth", "Preservation of the quality of water environment" were woven as key policies. Along with the basic policies, National Water Master Plan has been formulated with the following strategies.

- Establishment of a system to enforce “Federal Water Resources Decree, August 1993 ”
- Development and implementation of monitoring surface and ground water observation network
- Implementation of water management and rehabilitation of existing water resource development projects
- Completion of the unfinished end systems of water source development
- Promotion of new small and medium-sized projects of water resources development

(3) Project Outline of Main Sectors

According to the basic policies and strategies mentioned above, National Water Resources Master Plan (hereinafter “M/P1995”) has been drafted targeting the year 2020. The outline plans of the major sectors proposed in the M/P1995 are as follows. Table 2-1 shows the plan index of the M/P1995, and Figure 2-1 shows the general plan of the M/P1995.

Water Storage

There are new retention dam projects to develop 10 BCM to meet new demands (12 BCM) by the year 2020, for public irrigation and water supply. In addition, the water storage project includes the rehabilitation project of existing 50 dams and improvement of dam operation programs in the Chad and Sokoto-Rima basins.

Irrigation and Drainage

Out of 320,000 ha of irrigation area planned in the existing irrigation and drainage plan, about 70,000 ha of irrigation area requires rehabilitation. The unimplemented irrigation area (250,000 ha) is scheduled for implementation by the end of 2005. By the year 2020, there will be a total new irrigation area of 800,000 ha. In the year 2020, the total irrigation area will be 1,500,000 ha composing of public irrigation area (1,120,000 ha) and private irrigation area (380,000 ha), with a demand for total irrigation water of 16.8 BCM/year.

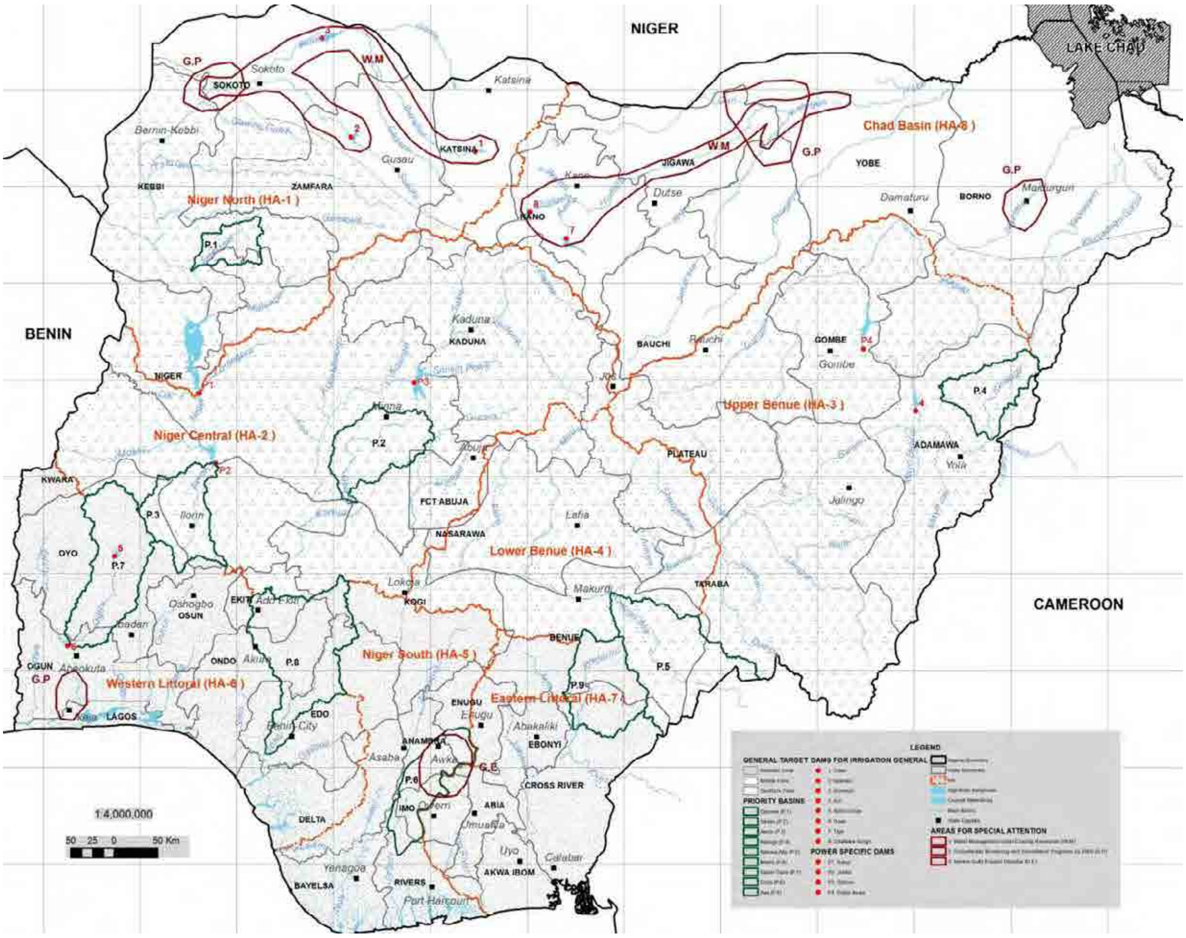
Public Water Supply

Rehabilitation of existing water supply facilities will increase the capacity: 910 MCM/year from 620 MCM/year for surface source, and 460 MCM/year from 260 MCM/year for groundwater source. Considering the new capacity, newly developed water supply volume will be 4,440 MCM/year for Urban and 1,590 MCM/year for rural uses. Total demand of water supply in 2020 will be 7.4 MCM/year.

Table 2-1 Major Indicators in M/P1995

<table>
<tr><th colspan="2" rowspan="2">Hydrological Area / Items</th><th>NW</th><th>NE</th><th>CW</th><th>CE</th><th>SW</th><th>SE</th><th rowspan="2">Total/ Average</th></tr>
<tr><th>HA-1</th><th>HA-8</th><th>HA-2</th><th>HA-3
HA-4</th><th>HA-6</th><th>HA-5
HA-7</th></tr>
<tr><td colspan="2">1. Area (1000km3)</td><td>131.6</td><td>188.0</td><td>158.1</td><td>231.9</td><td>100.5</td><td>113.7</td><td>923.8</td></tr>
<tr><td rowspan="3">2. Population</td><td>- 1991 (Million)</td><td>10.3</td><td>16.8</td><td>10.6</td><td>9.7</td><td>22.3</td><td>18.9</td><td>88.5</td></tr>
<tr><td>- 2020 (Million)</td><td>17.0</td><td>28.2</td><td>25.3</td><td>24.4</td><td>49.3</td><td>41.8</td><td>186.0</td></tr>
<tr><td>- Growth Rate (%p.a.)</td><td>1.74</td><td>1.80</td><td>3.08</td><td>3.23</td><td>2.77</td><td>2.77</td><td>2.69</td></tr>
<tr><td colspan="2">3. Water Resources Potential</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">3.1 Surface W.</td><td>(a)Annual Yield (BCM)</td><td>22.4</td><td>8.2</td><td>32.6</td><td>83.0</td><td>35.4</td><td>85.7</td><td>267.3</td></tr>
<tr><td>(b)Specific Yield (mm p.a.)</td><td>38</td><td>44</td><td>206</td><td>245</td><td>352</td><td>674</td><td>178</td></tr>
<tr><td rowspan="2">3.2 Ground W.</td><td>(a)Annual Yield (BCM)</td><td>4.3</td><td>5.6</td><td>8.2</td><td>11.4</td><td>9.0</td><td>13.4</td><td>51.9</td></tr>
<tr><td>(b)Specific Yield (mm p.a.)</td><td>33</td><td>30</td><td>52</td><td>49</td><td>132</td><td>118</td><td>56</td></tr>
<tr><td colspan="2">4. Water Resources Development</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">4.1 Existing</td><td>(a) Num. of Dams</td><td>20</td><td>23</td><td>32</td><td>35</td><td>32</td><td>18</td><td>160</td></tr>
<tr><td>(b) Effective Vol. (MCM)</td><td>13,269</td><td>5,951</td><td>7,980</td><td>2,413</td><td>1,053</td><td>2</td><td>30,668</td></tr>
<tr><td>(c) Storage Rate (%)</td><td>59</td><td>73</td><td>24</td><td>3</td><td>3</td><td>0</td><td>11</td></tr>
<tr><td rowspan="3">4.2 Planned</td><td>(a) Num. of Dams</td><td>64</td><td>20</td><td>304</td><td>362</td><td>141</td><td>193</td><td>1,084</td></tr>
<tr><td>(b) Effective Vol. (MCM)</td><td>950</td><td>100</td><td>4,090</td><td>4,690</td><td>1,410</td><td>1,720</td><td>12,960</td></tr>
<tr><td>(c) Storage Rate (%)</td><td>4</td><td>1</td><td>13</td><td>6</td><td>4</td><td>2</td><td>5</td></tr>
<tr><td rowspan="4">4.3 Total</td><td>(a) Num. of Dams</td><td>84</td><td>43</td><td>336</td><td>397</td><td>173</td><td>211</td><td>1,244</td></tr>
<tr><td>(b) Effective Vol. (MCM)</td><td>14,219</td><td>6,051</td><td>12,070</td><td>7,103</td><td>2,463</td><td>1,722</td><td>43,628</td></tr>
<tr><td>(c) Storage Rate (%)</td><td>63</td><td>74</td><td>37</td><td>9</td><td>7</td><td>2</td><td>16</td></tr>
<tr><td>(d) Ave. Vol. (MCM/dam)</td><td>169</td><td>141</td><td>36</td><td>18</td><td>14</td><td>8</td><td>35</td></tr>
<tr><td colspan="2">5 Irrigation and Drainage</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">5.1 Existing</td><td>(a) Public (1000ha)</td><td>8</td><td>27</td><td>12</td><td>12</td><td>3</td><td>8</td><td>70</td></tr>
<tr><td>(b) Private (1000ha)</td><td>35</td><td>98</td><td>10</td><td>3</td><td>0</td><td>4</td><td>150</td></tr>
<tr><td>(c) Total (1000ha)</td><td>43</td><td>125</td><td>22</td><td>15</td><td>3</td><td>12</td><td>220</td></tr>
<tr><td rowspan="3">5.2 Planned Area 2020</td><td>(d) Public (1000ha)</td><td>120</td><td>95</td><td>305</td><td>304</td><td>115</td><td>180</td><td>1,120</td></tr>
<tr><td>(e) Private (1000ha)</td><td>75</td><td>190</td><td>40</td><td>45</td><td>10</td><td>20</td><td>380</td></tr>
<tr><td>(f) Total (1000ha)</td><td>195</td><td>185</td><td>345</td><td>349</td><td>125</td><td>200</td><td>1,500</td></tr>
<tr><td colspan="2">6 Public Water Supply</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">6.1 Volume</td><td>(a) Existing</td><td colspan="7">Urban:108LCD, Rural: 40LCD</td></tr>
<tr><td>(b) Planned</td><td colspan="7">Urban: 216LCD, Rural: 80LCD</td></tr>
<tr><td rowspan="3">6.2 Rate</td><td>(a) Existing-Urban (%)</td><td>67</td><td>58</td><td>82</td><td>44</td><td>45</td><td>35</td><td>60</td></tr>
<tr><td>(b) Existing-Rural (%)</td><td>10</td><td>9</td><td>10</td><td>9</td><td>10</td><td>6</td><td>9</td></tr>
<tr><td>(c) Planned (%)</td><td colspan="7">Urban and Rural: 80%</td></tr>
<tr><td rowspan="3">6.3 Deep Well</td><td>(a) Existing (1000)</td><td>32.8</td><td>54.0</td><td>3.0</td><td>2.9</td><td>41.6</td><td>54.8</td><td>265.4</td></tr>
<tr><td>(b) Planned (1000)</td><td>4.2</td><td>5.2</td><td>38.4</td><td>49.7</td><td>3.1</td><td>3.0</td><td>21.4</td></tr>
<tr><td>(c) Total (1000)</td><td>37.0</td><td>59.2</td><td>35.4</td><td>46.8</td><td>44.7</td><td>57.8</td><td>286.8</td></tr>
<tr><td colspan="2">7 Water Use Rate</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">7.1 Existing</td><td>(a) Surface water (%)</td><td>2.1</td><td>14.6</td><td>1.1</td><td>0.3</td><td>0.8</td><td>0.2</td><td>1.0</td></tr>
<tr><td>(b) Groundwater (%)</td><td>0.5</td><td>1.1</td><td>0.2</td><td>0.1</td><td>0.9</td><td>0.5</td><td>0.5</td></tr>
<tr><td>(c) Total (%)</td><td>2.6</td><td>15.7</td><td>1.3</td><td>0.4</td><td>1.7</td><td>0.7</td><td>1.5</td></tr>
<tr><td rowspan="3">7.2 Planned</td><td>(g) Public (1000ha)</td><td>9.1</td><td>35.6</td><td>13.5</td><td>5.5</td><td>9.8</td><td>3.3</td><td>7.6</td></tr>
<tr><td>(h) Private (1000ha)</td><td>7.8</td><td>11.1</td><td>4.5</td><td>3.7</td><td>10.8</td><td>8.9</td><td>7.5</td></tr>
<tr><td>(i) Total (1000ha)</td><td>16.9</td><td>46.7</td><td>18.0</td><td>9.2</td><td>20.6</td><td>12.2</td><td>15.1</td></tr>
</table>

Source: M/P1995



General Target

1. Northern Zone: Water Resources Management
2. Middle Zone: Water Resources Development for Irrigation and Water Supply
3. Southern Zone: Water Resources Development for Water Supply and Irrigation

Priority Basins for Water Resources Development

P.1 Danzaki (SHA 110): Sokoto-Rima RBDA
P.2 Gbako (SHA 214): Upper Niger RBDA
P.3 Awun (SHA 204): Lower Niger RBDA
P.4 Kilange (SHA 301): Upper Benue RBDA
P.5 Katsina-Ala (SSHA 4052-3): Lower Benue RBDA
P.6 Mamu (SHA 504): Anambra Imo RBDA
P.7 Upper Ogun (SSHA 6022-3): Ogun-Oshun RBDA
P.8 Osse (SHA 608): Benin-Owena RBDA
P.9 Aya (SHA 702): Cross RBDA

Area for Special Attention

WM : Water Management under Existing Dams GE : Gully Erosion Disaster
GP : Groundwater Monitoring and Surveillance Programs by 2000

Existing Major Dams

(For Irrigation Dam)
1. Zobe, 2. Bakolori, 3. Goronyo, 4. Kiri, 5. Ikere Gorge, 6. Oyan,7. Tiga, Challawa Gorge
(For Hydropower Generation)
P1 Kainji, P2 Jebba, P3 Shiroro, P4 Dadin Kowa
Source: M/P1995

Figure 2-1 Map of M/P1995

2.2 Evaluation of Water Resources Potential

2.2.1 Catchment Delineation

For management of water resources in Nigeria, the whole territory of Nigeria has been divided into eight (8) hydrological areas, in accordance with their hydrological characteristics. The boundary of the hydrological areas (HAs) and their Sub-Hydrological areas (SHAs) were set-up and approximated before the M/P1995. The M/P1995 which was assisted by JICA improved the delineation of the boundary of HAs and SHAs, based on 1/500,000 and 1/250,000 topographic maps as well as Landsat images. As a result of the M/P1995, eight (8) HAs were sub-divided into 89 SHA with 200 Small-SHAs (SSHAs). The water resources potential in the M/P1995 was on the basis of the delineated HAs, SHAs and SSHAs, which has been used till date.

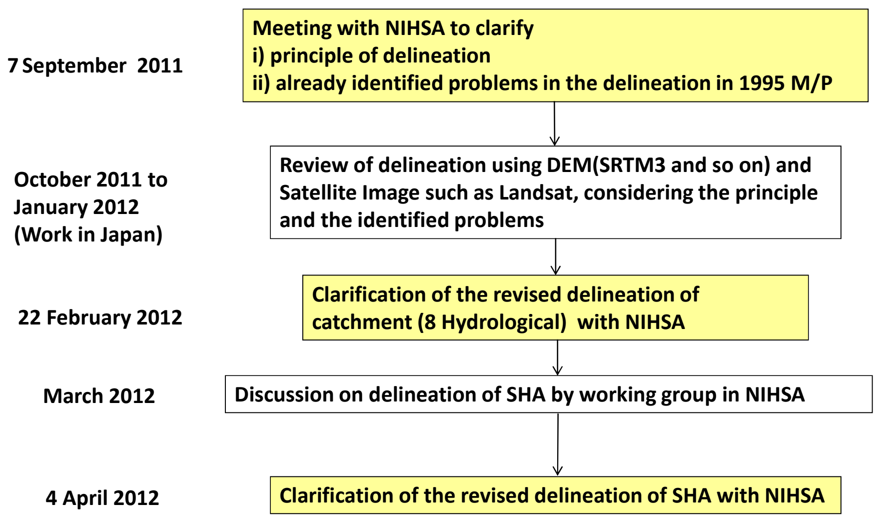
On the other hands, NIHSA recently prepared a map which shows the boundary of hydrological areas. It is somehow different from the one prepared in the M/P1995.

During the preparatory study on the Project, JICA Preparatory Study Team and FMWR recognized the difference between the boundaries of HAs determined in the M/P1995 and that shown in the map recently prepared by NIHSA. After the discussion, both sides agreed on the followings.

- The Project conforms to the boundaries determined in the M/P1995 in principle. However,
- Both sides recognized that some boundaries determined in the M/P1995 could not be accurate, which may need review, although the Project basically follows the boundary determined in the M/P1995.
- Both sides agreed that the boundaries would be reviewed and refined in the earlier stage of the project with close cooperation of NIHSA.

(1) Procedure of Review on Catchment Delineation

JICA Project Team started discussion with NIHSA on the issues of boundaries of hydrological areas after commencement of the Project. Figure 2-2 shows the process of the joint effort of NIHSA and JICA Project Team on the review of catchment delineation.



Source: JICA Project Team

Figure 2-2 Process of Review on Catchment Delineation

(2) Discussion with NIHSA on HA Boundaries

During the meeting with NIHSA on 7th September, 2011, JICA Project Team explained the schedule and procedure for reviewing and refining the boundaries of hydrological areas to the staff of NIHSA. Then, discussion on the principle for the delineation and the problems that has been already identified in the boundaries in the M/P1995 was made among the relevant staff of NIHSA and JICA Project Team. As a result, the following principles were agreed between NIHSA and JICA Project Team.

- The delineation point on Niger River between HA-1 and HA-2 shall be Kainji dam (downstream end of the Kainji dam reservoir).

- The delineation point on Benue River between HA-3 and HA-4 shall be just downstream of the confluence point with Donga River.

NIHSA also pointed out the following areas to be carefully reviewed on the boundaries.

- Katsina area between HA-1 and HA-8
- Damaturu area between HA-3 and HA-8
- Imo River area between HA-5 and HA-7
- Boundary of HA-6 with HA-2 and HA-5

It was also agreed that JICA Project Team would work on delineation of hydrological boundary, considering the above principle agreed as well as the areas pointed out by NIHSA. The delineation would be based on the digital elevation model and available satellite image such as Landsat.

After presenting the refined HA boundaries to NIHSA on 22 February, 2012, the refined HA boundaries were basically agreed by NIHSA. It was also agreed that it would be necessary to clearly show the limitation of accuracy and spatial resolution on HA boundaries due to the data source which were applied in the review. Therefore, it could be modified again by NIHSA when more accurate and reliable data source would be available in future.

(3) Discussion with NIHSA on SHA boundaries

After the meeting on 22 February, 2012, the working group to review the SHA boundaries was constituted to discuss more details on the catchment delineation. Several meetings had been held among the members of the working group. The followings were mainly discussed.

- Problems identified in the previous SHA
- Principle of delineation of SHA
- Criteria of delineation of SHA
- Principle of dealing with delineation of HA, SHA and SSHA Data
- Coding of SHA
- Some notes

The working group identified the problems in the previous SHA as follows.

- In the previous SHA, SHA has been determined by combining the catchment of a tributary and the residual catchments of main river
- The catchment area for right bank and left bank side has been separated.
- In this case, it is difficult to estimate the water resources for the tributary.

Based on the identified problems, the working group decided to set the principle of the delineation of SHA boundaries as follows.

- SHA should be delineated at the confluence point of the tributary.
- SHA should not be separated by the center line of the river.

The refined SHA boundaries were presented in the meeting in NIHSA on 4th April, 2012, and were basically agreed by NIHSA with some notes shown as follows.

- The delineation of SHA was mainly based on the desk work utilizing available information and data. The field verification was limited for this work because of the resource constraint and current security condition in Nigeria. Therefore, in future, it could be modified when it will be confirmed by the field work or more accurate information and data. To do so in future, the GIS data and related data should be provided to NIHSA.
- When better GIS data on drainage system in Nigeria will be ready for the Team, it will be used for improving the SHA delineation.

2.2.2 Surface Water Resources Potential

In the M/P1995, surface water resources potential was evaluated on the following basis.

- Observed discharge data during 1970s-1980s with many gaps are used.
- Precipitation data during 1970s-1980s are also used for evaluating average runoff rate.

- Based on the average runoff rate, average annual runoff volume is estimated.

The evaluated surface water resource potential is summarized in the following table.

Table 2-2 Surface Water Resources Potential Evaluated in M/P1995

Hydrological Area	Evaluated Potential (MCM/year)	Remarks
HA-1	22,400	Outlet of HA-1, including water from outside of Nigeria
HA-2	32,600	Outlet of HA-2, including water from outside of Nigeria
HA-3 & 4	83,000	Outlet of HA4, including water from outside of Nigeria
HA-5 & 7	85,700	Including water from outside of Nigeria, Delta area is excluded.
HA-6	35,400	Delta area is excluded.
HA-8	8,200	Not outlet of HA8, but the sum of available water at key station
Total	267,300	

Source: M/P1995

The significance of the evaluation was that it was the first comprehensive evaluation of water resources potential across Nigeria. However, when we consider proper water management, there are also some shortcomings as follows.

- The data used were limited to short period (1970s-1980s).
- Only average annual runoff volume was evaluated. Drought condition was not evaluated due to lack of data.
- Effect of operation of significant reservoirs was not separated in evaluating water resources potential.

In the Project, the evaluation of the surface water resource potential is updated, considering the following key points for improvement.

- Use longer duration of discharge
- Estimate quasi-natural condition without effect of operation of significant reservoirs
- Evaluate not only annual average volume in a year, but also the average volume in drought condition and reliability of flow as well as seasonal flow

2.2.3 Groundwater Resource Potential

Groundwater potential was defined as groundwater recharge in the M/P1995. Result of analysis and its associated problems are shown below.

<u>Estimation of Groundwater Recharge</u>

Groundwater recharge was estimated as shown in Table 2-3 in the M/P1995.

Table 2-3 Estimated Groundwater Development Potential

	Basement	Sedimentary
Area(km^2)	442,900	480,900
Precipitation (mm)	1,087	1,019
Permeability (%)	10	18
Adjustment (%)	35	39
Groundwater recharge ($10^6 m^3$)	17,230	34,700

Source: M/P1995

<u>Problems</u>

The issues listed below were pointed out on the estimation of groundwater recharge.

- It is not reasonable that ratio of groundwater recharge depends on only geology type. It is different from place to place depending on temperature and soil condition and so on. Two geological classifications are not enough for analysis of the entire country.
- Process of calculation to evaluate groundwater recharge was not explained in the Report.
- Meaning and basis of “Permeability” and “Adjustment”, which are used in the Report, were not explained. Moreover, basis for the above values were not made clear in the Report.

Method and parameters for analysis of groundwater recharge must be made clear so that result of the analysis can be examined easily. Moreover in the Project, groundwater potential will be expressed as function of climate and hydrogeological conditions.

2.3 Projection of Water Demand

2.3.1 Projected Population

The M/P1995 estimated the year 1991 population (The 1991 census population was not yet announced officially during the time of the M/P1995.) and projected 2010 and 2020 population as presented in Table 2-4. The population growth rate of the M/P1995 was projected at 2.65% and 2.59% respectively on the basis of the estimated 1991 population.

Meanwhile, after M/P1995, two census results of the years 1991 and 2006 were announced as shown in Table 2-4. The census revealed that the actual population growth rate between 1991 and 2006 was 3.18%. Thus the projected population of the M/P1995 could be judged likely to be lower than actual. Despite this, the M/P1995 projected the composition ratio of two geographical regions such as CW and SW, namely HA 2 and HA 6, quite higher than actual ratio.

Table 2-4 Projected Population of M/P1995 (millions of people)

Geog. Region	NW	NE	CW	CE	SW	SE	Total	Growth rate
HA	1	8	2	3/4	6	5/7		
M/P1995								
1991 (Estimate)	10.3	16.8	10.5	9.7	22.3	18.9	88.5	-
2010 (Projection)	14.0	23.0	19.0	18.3	38.5	32.6	145.4	2.65%
(Composition ratio)	10%	16%	13%	13%	26%	22%	100%	-
2020 (Projection)	17.0	28.2	25.4	24.4	49.3	41.7	186.0	2.59%
Census								
1991	10.3	15.5	10.4	11.2	22.2	19.4	89.0	-
2006	15.2	24.2	14.8	18.2	31.9	36.1	140.4	3.18%
(Composition ratio)	11%	17%	11%	13%	23%	26%	100%	-

Source: M/P1995 and NSB

2.3.2 Water Demand Projection

The M/P1995 projected water demand of water supply and irrigation both in 1995 as current demand and in 2020 as a future demand. Table 2-5 shows conditions for water demand calculation and projection.

Table 2-5 Conditions for Water Demand Calculation

Sector	Current (1995)				Target (2020)			
Irrigation	Planned Irrigation Area: Public 320,000 ha Private 150,000 ha				Planned Irrigation Area: Public 1,120,000 ha Private 380,000 ha			
Water Supply		Population	lit/c/d	Coverage		Population	lit/c/d	Coverage
	Urban	49,055,000	108	50%	Urban	83,800,000	216	80%
	Rural	39,462,000	40	9%	Rural	65,000,000	80	80%

Source: M/P1995

Based on the above conditions, Tables 2-6 and 2-7 show current water demand in 1995 and future water demand in 2020 respectively.

Table 2-6 Current Water Demand in 1995

Zone	NW	NE	CW	CE	SW	SE	Total
HA	1	8	2	3 / 4	6	5 / 7	($10^6 m^3$)
1. Surface Water							
(1) Water Resources Potential	22,400	8,200	32,600	83,000	35,400	85,700	267,300
(2) Water Demand	470	1,200	360	210	280	190	2,710
Public Irrigation	80	260	140	150	40	110	780
Private Irrigation	320	880	70	20	0	20	1,310
Water Supply	70	60	150	40	240	60	620
(3) Utilization Ratio: (2)/(1) (%)	2.1	14.6	1.1	0.3	0.8	0.2	1.0
2. Groundwater							
(1) Water Resources Potential	4,340	5,580	8,180	11,380	9,020	13,430	51,930
(2) Water Demand	20	60	20	10	80	70	260
Water Supply	20	60	20	10	80	70	260
(3) Utilization Ratio: (2)/(1) (%)	0.5	1.1	0.2	0.1	0.9	0.5	0.5

Source: M/P1995

Table 2-7 Future Water Demand in 2020

Zone	NW	NE	CW	CE	SW	SE	Total
HA	1	8	2	3 / 4	6	5 / 7	($10^6 m^3$)
1. Surface Water							
(1) Water Resources Potential	22,400	8,200	32,600	83,000	35,400	85,700	267,300
(2) Water Demand	2,030	2,920	4,410	4,560	3,470	2,820	20,210
Public Irrigation	1,160	910	3,480	3,820	1,680	2,420	13,470
Private Irrigation	690	1,710	300	400	70	110	3,280
Water Supply	180	300	630	340	1,720	290	3,460
(3) Utilization Ratio: (2)/(1) (%)	9.1	35.6	13.5	5.5	9.8	3.3	7.6
2. Groundwater							
(1) Water Resources Potential	4,340	5,580	8,180	11,380	9,020	13,430	51,930
(2) Water Demand	350	620	360	430	970	1,200	3,930
Water Supply	350	620	360	430	970	1,200	3,930
(3) Utilization Ratio: (2)/(1) (%)	8.1	11.1	4.4	3.8	10.8	8.9	7.6

Source: M/P1995

Estimated utilization ratio of surface water in Lake Chad basin (HA-8) in the north east zone is 35.6% relatively higher, but other utilization ratios of surface water and groundwater are between 3.3% and 13.5%. These facts indicate that water resources potential has enough capacity nationwide.

For water demand projection of water supply, future per capita consumptions, 216 lit/c/d for urban and 80 for rural were applied in prospect of lifestyle change and improvement in living standards, but present standard per capita consumptions in 2012 are 120 for urban, 60 for semi-urban and small town, and 30 for rural. Accordingly, this fact shows that the future per capita consumptions were overestimated.

2.4 Water Resources Development Plans

2.4.1 Surface Water Resources Development

The proposed surface water resources development in the M/P1995 are categorized into the following two programs: a) Rehabilitation of water source works as a short-term program, b) Program for construction of distributed mid-small scale multi-purpose dams, as shown in Table 2-8.

Table 2-8 Surface Water Resources Development Plan in M/P1995

Short-term Plan (Target Year: 2000)	Long-term Plan (Target Year: 2020)
Rehabilitation of water source works	Program for construction of distributed mid-small scale multi-purpose dams Mid-scale 264dams, Total effective storage = 8,860MCM Small scale 820dams, Total effective storage = 4,100MCM

Source: M/P1995

The surface water resources development plan for each hydrological area is shown in Table 2-9.

Table2-9 Surface Water Resources Development Plan for Each Hydrological Area in M/P1995

Hydrological Area		Proposed Projects
8	Lake Chad	Formulate a water resources management project concerning the use of the Alau Dam reservoir on the Ngadda River while taking into consideration the water supply to the Maiduguri urban area, groundwater recharge, and conservation of the Sambissa Wetland upstream of the dam.
1	Niger North	Construct dams in 64 locations as new water sources (total water storage capacity of 950 x 106m^3) (after 2000).
2	Niger Central	Construct dams in 304 locations in this water resources rich area. Higher priorities should be given to the Awun and Gbako river basins, for which F/S is to be completed by 2000.
3&4	Upper Benue Lower Banue	Construct 362 small dams in this area with high development potential. Give top priority to the Kilange and Katsina-Ala river tributary basins as model projects of UBRBDA and LBRBDA. Aim to complete the Dadin Kowa Dam Hydropower Plant by 2000 and incorporate it into NEPA's national power distribution network.
4	Western Littoral	Construct 141 small-to-medium multipurpose dams as new water sources. Construction of large dams is difficult for reasons in social and environmental security
5&7	Niger Central Eastern Littoral	Construct 193 small-to-medium multipurpose dams in this water rich area. Construction of large dams is difficult for reasons in social and environmental security.

Source: M/P1995

The proposed rehabilitation of water source works as the short-term program has been gradually implemented. The construction of many distributed mid-small scale multi-purpose dams has hardly been implemented. It has been confirmed that only 4 proposed dams are now under construction. The proposed hydropower plant in Dadin Kowa dam has not yet been implemented.

In the M/P1995, the following problems on the existing dams were pointed out.

- Hardly any of the dams have established rules for operating the reservoirs, thus not releasing water properly to their respective beneficiary areas.
- Some dams, especially those in the northern region, have too large storage volume relative to inflow and are thereby uneconomical.
- A large portion of the irrigation land in the beneficiary areas is underdeveloped and thus not utilizing the water-storage dams effectively.

Basically, not much improvement has been made to the above problems to this day (The details are described in Chapter 7.1). The actual condition of the operation of almost all of the dams is not well monitored by FMWR, because the operation records are scattered in each dam office or lost, and thus are not managed and arranged systematically.

The Project should focus on how to improve the management of the existing dam reservoirs, emphasizing the benefit of proper management, as well as examine the necessity for new water resources development.

The M/P1995 did not give much attention to hydropower development related to surface water resources. Considering the importance of development of renewable energy, the Project should examine the potential areas for small-scale hydropower projects at least at conceptual level.

2.4.2 Groundwater Resources Development

Five proposals were made with respect to groundwater management and development in the M/P1995, namely:

1. Activities for promotion of groundwater development
2. Proposal for groundwater development by hydrological area
3. Introduction of new technology for groundwater development
4. Coordination of groundwater development projects among responsible organizations
5. Collection of borehole drilling data for unified management

How many of the proposals above have been realized by the Nigerian side are described below.

(1) Activities for Promotion of Groundwater Development

Methods listed below were proposed by the M/P1995 for promotion of groundwater development.

Table 2-10 Activities for Promotion of Groundwater Development

No.	Proposal of M/P1995	Implementation
1	Improvement of geophysical survey technique (electric survey and electro-magnetic survey) to increase success rate of boreholes.	Technical level of geophysical survey has been gradually and steadily improved upon through training at NWRI, Kaduna and on the-job–training of each organization.
2	Implementation of proper pumping test with enough pumping time and precise analysis to know optimum pumping rate of boreholes.	Some pumping tests under supervision of Federal and State organizations are implemented properly but not all due to lack of technique and instrument. There are many problems encountered in pumping test by private drilling companies.
3	Formulation of proper installation plan for monitoring wells.	Location of monitoring wells is properly planned by NIHSA.
4	Training of engineers in groundwater monitoring and development (geophysical and hydrogeological engineers).	Training of engineer s is implemented at NWRI and on-the-job-training. However, it is not enough and technical level is still unsatisfactory

Source M/P1995

Nigerian side has implemented activity to promote groundwater development after the M/P1995, though it is not enough. As long as technical improvement is concerned, development side is emphasized more than Management side in the M/P1995. But, more focus will be paid to management side in the Project. For example, technique for monitoring will be introduced to the Nigerian side to prevent land subsidence and sea water intrusion due to over pumping.

(2) Proposal for Groundwater Development by Hydrological Area

The M/P1995 proposed that groundwater should be developed mainly for water supply for small towns and rural communities. Following the principle above, the method for groundwater development was proposed for each hydrological area as shown below.

Table 2-11 Method for Groundwater Development by Hydrological Area

HA No.	Proposal of M/P1995	Implementation
1	Groundwater level is lowering due to over-pumping. Groundwater extraction must be controlled based on result of monitoring. Groundwater development is expected along Sokoto River for small scale irrigation scheme. Groundwater potential estimation is necessary for the irrigation along Sokoto River.	There is no regulation on over-pumping of groundwater, and number of boreholes is increasing though groundwater level is lowering. Groundwater monitoring is implemented in Fadama areas, but groundwater potential is yet to be evaluated.
2	Groundwater is not fully developed. There are enough potential for groundwater development in this area. Further groundwater development is expected for future.	Number of boreholes in increasing steadily.
3 and 4	Groundwater development is delayed compared with the other areas. Groundwater development is less important in this area than the other areas because of rich surface water potential.	Number of boreholes is steadily increasing. However, groundwater development is still delayed compared with other areas.
6	Groundwater is developed in large scale using motorized pumps. Saline water intrusion is taking place in the coastal aquifer around Lagos. Groundwater monitoring is necessary, and water extraction must be controlled based on the monitoring result. Basement complex is distributed in the central and northern part of the catchment area, where groundwater development potential is low. Consequently, rural water supply in the area should use not only groundwater but also surface water in the future.	It is said that groundwater is being contaminated around industrial area in Lagos. However, data showing contamination is not obtained. Same as above, sea-water intrusion is pointed but there is no data showing it. There is few data on the area.
5 and 7	Groundwater development potential in sedimentary aquifers is highest of the 8 catchment areas, though number of boreholes and wells of the area is smallest. Groundwater is used for water supply even for large urban areas. However, water supply rate (liter/person/day) is small for both urban and rural water supply, which must be improved in the future. Urban and rural communities are located on top of hills, which necessitates deeper boreholes with high pumping cost. Optimum demarcation between groundwater and surface water for water supply should be examined in terms of supply cost.	Number of boreholes is increasing. Many boreholes are installed with motorized pumps because of high capacity of aquifer. Ratio between groundwater use and surface water use for water supply has no big difference compared with situation in the M/P1995 period.
8	Groundwater development is necessary due to scarcity of surface water. Optimum groundwater development is important based on detailed analysis of groundwater recharge. Groundwater level is lowering in Maiduguri area due to over–pumping. Ground water extraction must be controlled based on monitoring result. It is expected to develop underground flow along the rivers.	It is said that groundwater level of Maiduguri city is still lowering. Borehole number is increasing, and groundwater pumping is not regulated. The Stakeholders have agreement on groundwater management but actual result has not yet been obtained.

Source M/P1995

It can be said that groundwater development has not yet been implemented as proposed in the M/P1995. Groundwater development plan should be reviewed in the Project based on hydrogeological characteristics of each hydrological area. Southern part of Nigeria is rich in water resources bur the

Northern part is less endowed; so that groundwater development and management plan should be different between the north and south. Groundwater management is currently not so active as to prevent water shortage in HA-1 and HA-8 where water shortage is expected and incidence is gradually apparent. Groundwater management is necessary especially in area of water shortage. Methods of groundwater resources management will be proposed in the Project.

(3) Introduction of New Technology

The M/P1995 proposed methods for acceleration of groundwater recharge and underground dam as new technology. Content of proposal and actual achievement is shown in Table 2-12. However, the achievement is not enough, and the Project needs consideration below:

- It is experimentally known that river water, which is discharged from reservoir, will be recharged into aquifer through river bed. Moreover, groundwater can be recharged effectively by planned discharge, which is proved from the example of other countries. It cannot be said that discharge is controlled for groundwater recharge through river bed. It will be proposed in the Project, and applicability of it will be examined.
- Groundwater recharge through bottom of lakes and ponds can be regarded as kind of artificial recharge. Applicability of this recharge will be examined in the Project in viewpoints of geology.
- Areas suitable for underground dam reservoir are limited due to geological condition required for dam construction. Underground dam reservoir needs high technology for design and construction, so that it will not be easily applied in Nigeria. Applicability and possibility of its introduction to Nigeria will be examined in the Project.

Table 2-12 Proposals for Groundwater Recharge and Underground Dam

No.	Proposal of M/P1995	Implementation
1	Flood retention dams should be constructed for i) flood control and ii) groundwater recharge through river bed of downstream area of retention dam.	Water is discharged experimentally from dam reservoir for purpose of groundwater recharge from river bed in part of northern Nigeria. But it is not common.
2	Shallow wells should be constructed on the bottom of lakes and ponds in dry season. Then, groundwater will be recharged through those shallow wells in rainy season. Groundwater can be extracted from the above wells in dry season.	It is not yet practiced. However, Nigerian side has interest in these methods as measures against impact of Climate Change.
3	Underground dam should be constructed for effective use of underground flow of the rivers in dry season.	It is not practiced. Underground dam is still not acknowledged by the Nigerian side.

Source: M/P1995

(4) Coordination of Groundwater Development Project among Responsible Organizations

The M/P1995 proposed coordination among organizations for effective project implementation as shown in Table 2-13.

Table 2-13 Coordination of Groundwater Development Project among Responsible Organizations

No	Proposal of M/P1995	Implementation
4	There are many public organizations which implement rural water supply projects. However, coordination is lacking among them, which make inefficient project implementation. LGA and State Government should take initiative in deciding priority order of drilling sites and types of the facilities.	There are still many organizations that implement rural water supply projects, and lack of coordination is same as before. After the M/P1995 period, RUWASSA was established in many States and authorized as responsible for rural water supply. However other organizations implement rural water supply projects without coordination with RUWASSA and others, which cause inefficient project implementation as before.

Source:M/P1995

Further importance of project coordination for rural and small town water supply will be proposed in the Project.

(5) Collection of Borehole Drilling Data for Unified Management

The M/P1995 proposed collection and management of borehole data by a single organization as shown in Table 2-14.

Table 2-14 Collection of Borehole Drilling Data for Unified Management

Proposal of M/P1995	Implementation
Organizations that implement groundwater development keep borehole data without unification and coordination with other organizations. Many borehole data will be scattered and lost without effective use during their custody. FMWR should take responsibility in borehole data collection covering the entire country.	Groundwater development is implemented for mainly water supply by state government and agencies, which keep borehole drilling data. However, borehole data is not compiled effectively and sometimes lost without any use. NIHSA is responsible for collection of borehole data nation-wide. They are collecting borehole data with standard borehole data format prepared by them. But data accumulation is not enough, and more cooperation with state organization is necessary.

Source: M/P1995

2.5 Sector Development Plans and Implementation

2.5.1 Water Supply and Sanitation

(1) Rehabilitation Project of Existing Water Supply Schemes

A considerable number of existing water supply schemes have aged and deteriorated due to poor operation and maintenance nationwide. Actual water supply capacity in 1995 in proportion to designed capacity of raw water and treatment facility was estimated at 68% for surface water and 57% for groundwater. Table 2-15 shows designed capacity, actual water supply capacity and utilization ratio by zone in 1995. Development plan of the M/P1995 included recovery of the water supply capacity by 2008 through rehabilitation of existing schemes, and estimated increase in the capacity from 620 x 10^6m^3 to 910 x 10^6m^3 for the schemes using surface water, and 260 x 10^6m^3 to 460 x 10^6m^3 for the schemes using groundwater.

Table 2-15 Utilization (Operating) Ratio of Existing Water Supply Facilities

Zone HA	NW 1	NE 8	CW 2	CE 3 / 4	SW 6	SE 5 / 7	Total (10^6m^3)
1. Designed Capacity							
Schemes using Surface Water	90	110	210	90	330	80	**910**
Schemes using Groundwater	40	90	30	20	160	120	**460**
2. Actual Water Supply in 1995							
Schemes using Surface Water	70	60	150	40	240	60	**620**
Schemes using Groundwater	20	60	20	10	80	70	**260**
3. Utilization Ratio（2/1）							
Schemes using Surface Water	76%	55%	71%	44%	73%	75%	**68%**
Schemes using Groundwater	50%	67%	67%	50%	50%	58%	**57%**

Source: M/P1995

(2) New Development Projects of Water Supply Schemes

For future water demand in the target year 2020, new development projects were planned to make up for the water demand excluding portion to be covered by the capacity to be recovered through the above rehabilitation projects. Table 2-16 shows water supply capacity to be newly developed by zone. Because of large urban population in the south, water supply capacities for urban areas to be newly developed are 1,950 x 10^6m^3 in south west zone and 960 x 10^6m^3 in south east zone. These account for 66% of national urban water supply capacity, and 48% of the whole national water supply capacity.

Table 2-16 Water Supply Capacity to be newly developed by Zone

Zone HA	NW 1	NE 8	CW 2	CE 3 / 4	SW 6	SE 5 / 7	Total (10^6m^3)
1. Urban Water Supply	210	400	540	380	1,950	960	**4,440**
Schemes using Surface Water	90	190	410	250	1,370	210	**2,520**
Schemes using Groundwater	120	210	130	130	580	750	**1,920**
2. Rural Water Supply	190	320	220	280	250	330	**1,590**
Schemes using Surface Water	0	0	10	0	20	0	**30**
Schemes using Groundwater	190	320	210	280	230	330	**1,560**
3. Total (1+2)	400	720	750	660	2,200	1,290	**6,020**
Schemes using Surface Water	90	190	420	250	1,390	210	**2,550**
Schemes using Groundwater	310	530	330	410	810	1,080	**3,470**

Source: M/P1995

Water sources for water supply schemes using surface water, accounting for 57% of urban water supply capacity to be newly developed, were planned to be secured by construction of small or medium-scale multipurpose dams and pumping of river water. Meanwhile, total capacity of urban and rural water schemes using groundwater surpasses the one using surface water, because 1) rural water supply is significantly lagging behind, 2) most rural water supply schemes rely on groundwater as a water source, and 3) some urban water supply schemes rely on groundwater totally or partially.
Number of boreholes to be newly developed was estimated at 265×10^3 in 2020 to secure groundwater,

as shown in Table 2-17. Boreholes to be developed for urban water supply in the south are not many conditional upon 100 m^3/hr of yield by motorized pump due to high capacity of water sources. On the other hand, boreholes for rural areas in the north are many conditional upon 12 m^3/hr of yield by handpump.

Table 2-17 Estimated Numbers of Boreholes to be newly developed by Zone

Zone HA	NW 1	NE 8	CW 2	CE 3 / 4	SW 6	SE 5 / 7	Total (10^3)
Boreholes for Urban	1.8	1.8	1.7	1.7	5.5	2.1	**14.6**
Boreholes for Rural	31.0	52.2	33.7	45.1	36.1	52.7	**250.8**
Total	32.8	54.0	35.4	46.8	41.6	54.8	**265.4**

Source: M/P1995

Furthermore, the above new development projects were proposed by period as shown in Table 2-18.

Table 2-18 New Development Plan for Water Supply by Period

Zone HA	1996 2000	2001 2005	2006 2010	2010 Mid-Total	2011 2015	2016 2020	Total (10^6m^3)
1. Urban Water Supply	600	400	790	**1,790**	1,120	1,550	**4,460**
Schemes using Surface Water	280	240	470	**990**	660	890	**2,540**
Schemes using Groundwater	320	160	320	**800**	460	660	**1,920**
2. Rural Water	410	180	240	**830**	330	430	**1,590**
Schemes using Surface Water	10	0	0	**10**	10	10	**30**
Schemes using Groundwater	400	180	240	**820**	320	420	**1,560**
3. Total Water Supply (1+2)	1,010	580	1,030	**2,620**	1,450	1,980	**6,050**
Schemes using Surface Water	290	240	470	**1,000**	670	900	**2,570**
Schemes using Groundwater	720	340	560	**1,620**	780	1,080	**3,480**
4. No. of Boreholes (10^3)	67.6	29.6	40.8	**138.0**	54.4	73.0	**265.4**
Urban Water Supply	2.6	1.3	2.4	**6.3**	3.4	4.9	**14.6**
Rural Water Supply	65.0	28.3	38.4	**131.7**	51.0	68.1	**250.8**

Source: M/P1995

(3) Actual Achievement

In relation to rehabilitation projects, by comparison between 57% utilization (operating) ratio of schemes using groundwater in the M/P1995 and 63% concluded by borehole inventory survey by FMWR in 2006, there is little improvement in existing water supply schemes using groundwater. Meanwhile, rehabilitation projects of the scheme using surface water, in particular, urban water supply, are in progress with the support of international donors such as the World Bank and African Development Bank. This is limited to some states; it is not nationwide. For update of the M/P1995, the Project will look into current utilization (operating) ratio of schemes using surface water, and propose practical approach in development plan.

On the other hand, it is difficult for the Project to conclude in quantitative terms about actual achievement of new development projects because there is little statistical information on new development projects to compare with the total as at 2010 shown in Table 2-19. However, the Project can make an inference of progress from water supply coverage as follows;

The M/P1995 found the coverage at 50% in urban and at 9% in rural in 1995 and set mid-term target in 2010 and long-term target at 2020 respectively, as shown in Table 2-19. By comparison between the target coverage in 2010 and current coverage in 2008, it gives the appearance that there is no big gap and progress as planned. But, given that per capita consumption for calculation of the target coverage largely surpasses standard per capita consumption (120liter/person/day for urban, 60 for semi-urban and small town and 30 liter/person/day for rural) for calculation of the current coverage, degree of attainment of development is still about half.

Table 2-19 Comparison between Target Water Supply Coverage of M/P1995 and Current Coverage

Coverage (%)		Benchmark	Target Coverage		Current	Per Capita Consumption (l/c/d)		
		1995(M/P)	2010(M/P)	2020(M/P)	2008(JMP)	1995(M/P)	2020(M/P)	2008(JMP)
Water Supply	Urban	50.0	**75.0**	80.0	**75.0**	108	216	120 (60)
	Rural	9.0	**55.0**	80.0	**42.0**	40	80	30
	National	-	-	-	58.0	-	-	-

JMP: Joint Monitoring Programme, 2008 (by WHO and UNICEF)
Source: M/P1995 and JICA Project Team

2.5.2 Irrigation and Drainage

The recommendations of the M/P1995 and process of their implementation in the area of irrigation and drainage are described below;

(1) Rehabilitation and Early Completion of Existing Public Irrigation Schemes

Rehabilitation has been going on slowly in some schemes which had severe facility degradation, but the rehabilitation of existing irrigation schemes is generally delayed. Out of the selected schemes at that time, some schemes are yet to be constructed while others are still on the drawing board.

(2) Public Irrigation Schemes

In 1995, the planned area was 320,000ha, by 2010 the planned area has become 441,000ha, that is, an increase of 121,000ha. It is very difficult to achieve the targeted planned area of 1,120,000ha target by 2020 as recommended in the M/P1995, even though areas under irrigation is increasing.

(3) Private Irrigation Schemes

In 1995, the planned area was 150,000ha, by 2010 the planned area including fadama area has become 183,000ha, an area increase of 33,000ha. It is very difficult to achieve the targeted planned area of 380,000ha recommended in the M/P1995 , even though area under irrigation is increasing.

(4) Issue of Irrigation Sector

By the existing process of implementation of the M/P1995 presumed at roughly 42%, it is very difficult to achieve the target set by 2020. Actually, the planned area is slowly increasing. However, irrigation facilities development covers 143,000ha which is 30% compared to planned area. Also the actual cropped irrigated area is 67,000ha which is only 15% compared to planned area 441,000ha. This is very low level indeed. Crops cultivated in public irrigation schemes are diverse, including rice, maize, tomatoes and other vegetables, however, rice generally constitutes the major crop cultivated in rainy season. About 80% of the entire irrigation schemes require rehabilitation while it is considered that around 60% of them have given up irrigation due to shortage of fuel or of breakdown of facilities. These schemes have reverted back to rain-fed cultivation as in old times.

The poor utilization of the developed irrigation area in the public irrigation sector can be attributed to several factors including:

- Lack of a coherent irrigation sub-sector development policy and strategy;
- Uncertain financial and economic viability.
- Insufficient attention to management systems;
- Inadequate funding (including poor cost recovery);
- High capital and operating costs;
- Low level of project ownership acceptance by the direct beneficiaries;
- Poor operation, repair and maintenance;
- Inadequate agricultural extension support services;

Table 2-20 Proceeding of Implementation Status of M/P1995

	Implementation Schedule of M/P1995	Proceeding	Remarks
Existing public irrigation scheme	● Out of 320,000ha of existing public schemes, rehabilitation 7000ha carried out irrigation should be completed up to 2000. ● Remain on drawing board 250,000ha should be completed up to 2005.	● Rehabilitation has been slowly going on some schemes which had severe facilities degradation, but whole rehabilitation for overall existing irrigation schemes is generally delayed. ● Out of selected schemes at that time, some schemes are not built and still on the drawing board.	● Lack of fund ● Poor management
New public irrigation scheme	● Planned area 800,000ha should be achieved up to 2020. Development should give preference to medium/small scheme. - Medium scheme 3000ha - Small scheme 300ha	● In 1995 the planned area was 320,000ha, by 2010 the planned area becomes 441,000ha, that is an increase of 121,000ha.	● It is very difficult to achieve the target planned area of 1,120,000ha by 2020 recommended in the M/P1995, even though areas is increasing.
Private irrigation scheme	● Planned area 380,000ha should be achieved by 2020. (150,000ha in 1995)	● In 1995 the planned area was 150,000ha, by 2010 the planned area including fadama area is 183,000ha, that is an increase of 33,000ha.	● It is very difficult to achieve the target planned area of 380,000ha recommended in the M/P1995, even though areas is increasing.
Planned area	Exi. pub. + New pub. + Private 320,000 + 800,000 + 380,000 = 1,500,000 ha	Exi. pub.& New pub. + Private 441,000 + 183,000 = 624,000 ha	44% achieved

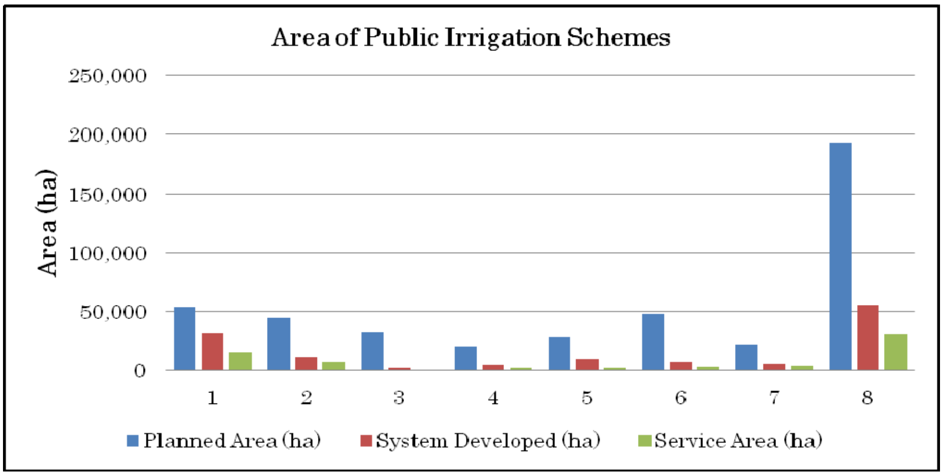
Source: M/P1995

Table 2-21 Area of Public Irrigation Scheme Comparing 2010 with M/P1995 (×1,000 ha)

Item	HA-1	HA-2	HA-3	HA-4	HA-5	HA-6	HA-7	HA-8	計
2010 year									
1.Large scale public irrigation scheme									
(1) Planned area	51.3	37.6	31.5	19.0	27.9	40.0	16.6	189.5	413.4
(2) Developed area	30.2	7.7	1.7	4.3	9.1	4.3	2.4	53.6	113.4
(3) Irrigated area	14.2	5.8	0.8	2.1	2.0	1.6	2.1	30.4	59.0
2.Mediun and Small public irrigation scheme									
(1) Planned area	2.6	6.7	1.5	1.3	1.4	3.7	6.3	3.9	27.4
(2) Developed area	1.9	3.5	0.8	0.7	0.9	1.5	3.7	1.7	14.7
(3) Irrigated area	1.3	1.7	0.2	0.2	0.4	1.1	2.0	1.2	8.0
3.Total									
(1) Planned area	53.9	44.2	33.0	20.3	29.3	43.7	23.0	193.4	440.9
(2) Developed area	32.1	11.3	2.5	5.0	10.0	5.7	6.1	55.3	128.1
(3) Irrigated area	15.5	7.6	1.0	2.3	2.4	2.7	4.1	31.5	67.1
1995 year									
1.Large scale public irrigation scheme									
(1) Planned area	55.5	45.9	23.6	11.7	17.8	39.6	5.3	80.3	279.7
(2) Developed area	11.2	10.2	9.6	4.8	5.0	1.6	0.6	39.7	82.7
(3) Irrigated area	6.6	8.6	9.0	1.1	4.2	1.6	0.6	24.7	56.4
2.Mediun and Small public irrigation scheme									
(1) Planned area	3.6	9.3	2.1	3.1	1.9	4.5	4.5	9.7	38.7
(2) Developed area	1.3	3.5	1.0	0.6	0.9	0.8	1.9	4.0	14.0
(3) Irrigated area	1.3	3.1	0.9	0.5	0.5	0.8	1.5	2.5	11.1
3.Total									
(1) Planned area	59.1	55.2	25.7	14.8	19.7	44.1	9.8	90.0	318.4
(2) Developed area	12.5	13.7	10.6	5.4	5.9	2.4	2.5	43.7	96.7
(3) Irrigated area	7.9	11.7	9.9	1.6	4.7	2.4	2.1	27.2	67.5

Source: M/P1995

More progress had been made on public irrigation schemes in the northern zone (HA-1) where annual rainfall is lower than in central and southern zones that have comparatively higher annual rainfall. The consolidation of irrigation schemes has been on a limited scale in the southern zone.



Source: JICA Project Team

Figure 2-3 Area of Irrigation Schemes by Hydrological Area

2.5.3 Erosion and Flood Control

The proposed policies for erosion and flood control were as follows. The current problems and issues were pointed out and the necessity of countermeasures was emphasized.

(1) Problems and Issues in 1995

At the time of the M/P1995, the problems and issues were as follows.

- Gully Erosion

Even though gully erosion is a nationwide problem in Nigeria, special attention was paid to the gully erosion problems in Anambra and Imo states because they are large-scale and destructive. The typical scale of gully erosion in the zone is 100 m in length, 20 m in width and 15 m in depth. The fundamental causes of gully erosion are weak, sandy soil, bare land surface and high intensity of rainfall. Other factors that accelerate gully erosion are inappropriate drainage system of road and house construction along the boundaries of existing urban areas.

- Flood Control

In Nigeria, flood control is regarded as the control of flood over the floodplain downstream of dams.

- River Management

Based on the recognition that a well-coordinated river management is effective for economic development of the regions and the country, river management was regarded as responsibility of the central government. In 1975 when FMWR was created, the responsibility for national river management was not given to it, while FIWD was managing the inland waterway transport of the Niger and Benue rivers. Prior to enactment of the Water Resources Law in 1983, there was no organization that manages the comprehensive usage and conservation of water resources and river system. Consequently, the problem on watershed management was mainly the lack of coordination between organizations on river management. Relatedly, because soil conservation and reforestation were affecting flood runoff and sediment generation it was pointed out that the Federal Ministries such as FMANR, FEPA and FMWRRD should be involved actively.

(2) Contents of M/P1995

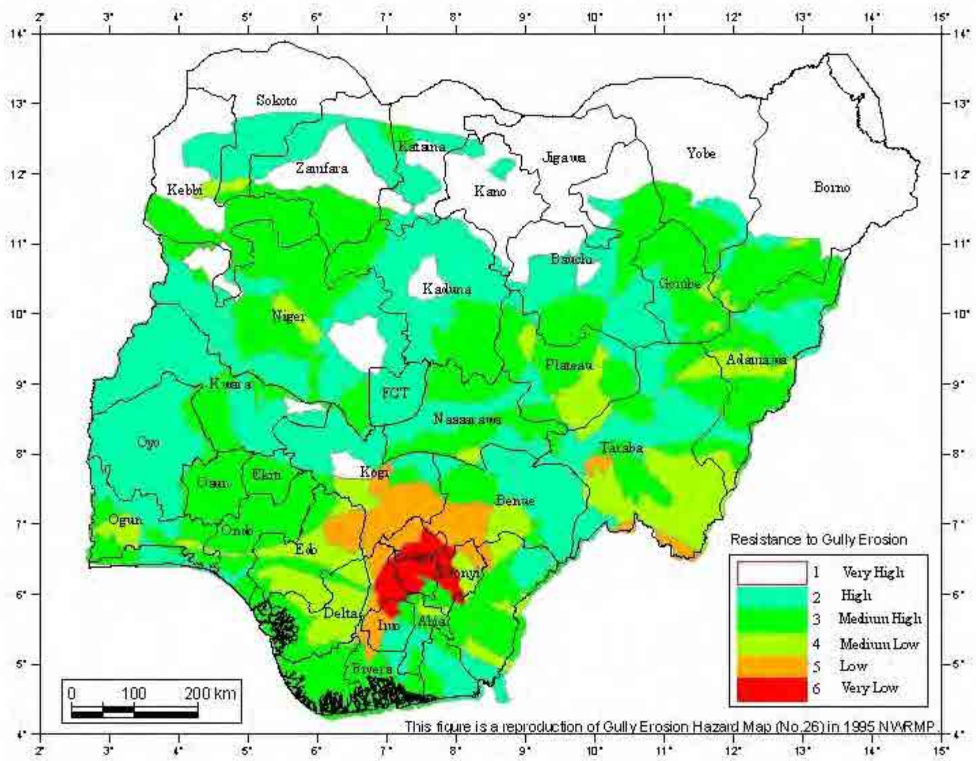
- Gully Erosion

The plan on gully erosion countermeasures was detailed in Section 7C.3 of the M/P1995. It proposed that coordination between relevant organizations and improvement of technology for gully erosion countermeasures was necessary. Also tentative technical guideline on planning, design, construction and maintenance was attached as an annex to the M/P1995.

Also the M/P1995 included the implementation program for the over 1,000 gully erosion sites in the country. Such gully erosion sites were categorized into 6, based on site characteristics. For each category, appropriate countermeasures and unit cost of civil works were studied in order to estimate the total project cost. At the time of the M/P1995, the total project cost was 7.6 billion Naira including site investigation cost.

The tentative guideline included the hydraulic study procedures and practical countermeasures such as sand bagging, terrace work, sabo dam, hillside work and vegetation works.

The specific sites that require countermeasure were not shown in map on the M/P1995, however, the gully erosion hazard map was shown as Map No.26 in the report. Figure 2-4 is a reproduction of that Map No.26 for reference purpose.



Source: M/P1995

Figure 2-4 Gully Erosion Hazard Map prepared in M/P1995

- Flood Control

Regarding the necessity of countermeasures in the future, the proposals were as follows,

The plan on flood control is described in Section 7B.3 of the M/P1995. Assuming that flood control is to prevent inundation in lowland area, some of the necessary measures are to control the entering of sediment and construction of ring dike in such area. For the former measure, especially reforestation in upstream area and appropriate planning and construction of infrastructure in urban areas were proposed.

It was stated that the Niger Delta should be given the highest priority.

In Nigeria, the traditional irrigation in floodplain should be maintained to make use of floodwater for irrigation when the flood recedes. In order to ensure such irrigation scheme, flood control should be planned not to affect flooding regime. As example of physical measures, bank protection works and gabion works to use wooden pile and bamboo were recommended.

The M/P1995 stated that any large scale river improvement works shall not be implemented until 2020 in Northern Area except for local river improvement works such as protection of road, bridge and village from flooding.

(3) Progress after M/P1995

When the Federal Ministry of Environment was created, the role of erosion and flood control of the Federal Ministry of Water Resources was transferred to FME. Consequently the countermeasure of erosion and flood control which was proposed in the M/P1995 has been mostly implemented by FME as part of the National Policy on the Environment in 1998.

In the Project, it is necessary to study and propose the contents considering the above institutional changes.

2.6 Water Resources Management Plan

2.6.1 Surface Water Management

The proposed items for surface water management in the M/P1995 and their implementation are summarized in the following table.

Table 2-22 Proposed Items for Surface Water Resources Management in M/P1995 and their Implementation

Proposed Items in M/P1995	Implementation
Establishment of hydrological monitoring network including rehabilitation and new installation 1) Precipitation station:70 2) Evaporation station:66 3) Gauging stations for river discharge:434 4) Deep monitoring wells:68 5) Shallow monitoring wells:300	1) Almost no precipitation and evaporation stations have been established by FMWR. 2) The number of available gauging stations has decreased, because of lack of operation and maintenance. 3) The observed data after 1990s till around 2005 have been scattered and not usable in many stations. 4) After establishment of NIHSA, the effort for establishing monitoring stations and data retrieval have been gradually activated.
Preparation of integrated databank for water resources inventory data.	Inventory survey for each water sector has been gradually conducted. Integrated databank has not yet been established.
Preparation of program for operation of reservoirs	Basically, not implemented. Only some research activities have been conducted.
Implementation of study on Integrated river basin management for the selected pilot area	The study was not implemented. However, river basin management plan have been studied in some river basin recently.
Increase of benefit for beneficiaries by projects implementation through active participation of local residents.	For example, FADAMA project assisted by World Bank considered the participation of local residents well.
Effective use of existing reservoirs, expansion of beneficial areas, conservation of wet-land areas	It is considered in the Catchment Management Plan prepared in Chad river basin in 2006.

Source: M/P1995 and JICA Project Team

Gaps exist between the proposed condition in the M/P1995 and the current condition. These centered mainly on the reasons for non-implementation of some aspect of the M/P1995. The issues are summarized in the following table. In the Project, the issues shown in the above table should be considered.

Table 2-23 Issues on Implementation of M/P1995 with regard to Aspect of Water Resources Management

Issues	Description
Preparation of enough funding	There has been lack of fund for implementing the proposed plan
Securing consistency in policy	M/P1995 was not used as a guide for project implementation.
Regulatory body for monitoring and evaluation of project implementation	After the project for formulating the M/P1995, there has been no coordination on implementing the proposed plan. In this sense, M&E (Monitoring & Evaluation) strategy in master plan is important.
Preparation of action plan to implement the proposed plan in master plan	There was a target and strategy on hydrological monitoring system in the M/P1995, which seems to be still valid. However, how to achieve the target was not well discussed in the M/P1995.
Stakeholders involvement	Stakeholders related to water resources monitoring should be involved when the M/P1995 is formulated.
Discussion with NIHSA as a key player	It is important to discuss with NIHSA on hydrological monitoring in the course of the Project. The periodic meetings held between NIHSA and JICA Project Team is essential.
Institutional analysis of water resources monitoring	Responsibility of the relevant organization on water resources monitoring should be examined based on the laws establishing those Agencies.
Development of Databank on hydrological data	In the M/P1995, it was proposed to establish “National Water Resources Databank”, which was not implemented. NIHSA proposes to establish “Hydrological Databank”, which is limited to hydrological data only. The “Hydrological Databank” should include both water quantity and quality.
Flood forecasting	In the M/P1995, flood forecasting was not included. It should be included in the Project.

Source: Discussion between NIHSA and JICA Project Team

2.6.2 Groundwater Management

The M/P1995 proposed activities listed below for groundwater management.

- Monitoring system should be installed in Chad and Sokoto basins to monitor groundwater level fluctuation.
- Monitoring wells should be installed in the aquifer to observe salt concentration in Lagos and the coastal areas.
- Monitoring wells should be installed for promotion of Fadama irrigation.

Proposal of the M/P1995 on groundwater monitoring and its implementation is shown in Table 2-24.

Table 2-24 Proposal and Implementation of Monitoring Wells

	Proposal		Implementation	
Water supply	Maiduguri Area	5 site × 3 boreholes (dep.=50m, 250m, 500m)	3 wells	■ Groundwater monitoring for water supply begun since 2007 after installation of 11 monitoring wells with automatic recorders in sedimentary rock areas. ■ Groundwater monitoring for Fadama irrigation is under implementation at around 30 monitoring wells with automatic recorders, which are located in food plain of large rivers. ■ Monitoring wells were installed following the proposals of the M/P1995. However, number of installation is fewer than proposal. Reasons are: ● Hydrogeologists from the Nigerian side did not approve necessity to install the entire monitoring wells. ● Decision-makers of budget allocation did not understand importance of monitoring wells. ● Installation of some wells out of the entire proposed wells was approved due to lack of budgetary provisions.
	Chad Basin	4 site × 2 boreholes (dep.=40m, 200m)		
	Sokoto-Rima River Basin	3 aquifer × 3 boreholes (dep.=150m)+1 borehole (Basement Complex)	3 wells	
	Lagos Area	5 boreholes (dep. =100m) to monitor groundwater level and salt concentration	2 wells	
	Niger South	-	2 wells	
	Easter Littoral	-	1	
	Total	38 wells	11	
Fadama irrigation	Catchment area-1	40 wells	30 wells	
	Catchment area -2	60 wells	0	
	Catchment area -3	35 wells	0	
	Catchment area -4	30 wells	0	
	Catchment area -5	20 wells	0	
	Catchment area 6	10 wells	0	
	Catchment area -7	25 wells	0	
	Catchment area -8	80 wells	0	
	Total	300 wells	30 wells	

Source: JICA Project Team

Monitoring wells have not yet been constructed as proposed in the M/P1995 so far. On the other hand, it is sure that groundwater environment is gradually worsening. It is not only because of lack of budget but also lack of understanding of the importance of monitoring. That monitoring activity is not active. Importance of monitoring in groundwater management will be emphasized in the Project.

Considering the result above, it may be important for JICA Project Team to directly explain and discuss the importance of monitoring with policy makers of FMWR and NPC for future implementation of the monitoring work.

2.6.3 Water Environment Management

The table below shows the issues on water environment identified in the M/P1995 and during the Project.

Table 2-25 Comparison of Issues in M/P1995 and the Project

	Issues detected in M/P1995	Issues observed in the Project
A	Surface Water	
1	There is no national program for the monitoring of the quality of surface water	The FMWR is operating currently 6 Laboratories for water quality monitoring, however, due to financial problems and lack of sufficient human power these Laboratories cannot cover the operational areas efficiently and the number of samples analyzed is very poor. Additional 6 new Laboratories are under construction which will start operation from 2013. It is expected that with these 12 Laboratories, the FMWR can design a systematic water quality monitoring program to cover all hydrological basins of Nigeria
2	The quality of water (surface and groundwater) serving the rural population is largely unmonitored	
3	Available information on water quality are of short term, usually collected for studies, design and construction of major projects	
4	FEPA is mainly concerned with the pollution of water by industry	
B	Groundwater	
	Deterioration of Groundwater quality in some parts of the country due to:	
	a) overexploitation allowing intrusion of seawater into the wells	This problem remains till date.
	b) infiltration of surface water into groundwater	In 2002 some cases of infiltration of polluted surface water into groundwater were confirmed.
	c) chemical fertilizers leaching into groundwater	In 2004 some cases of groundwater pollution by agrochemicals were confirmed.
	d) high nitrate concentration or bacterial presence in boreholes due to poor sanitation practices	In 2008 pollution of 40 shallow wells due to its proximity to the sanitation system was confirmed.
	e) pollution of groundwater (boreholes) by petroleum products	This problem remains till date.
C	Dense aquatic weed covering reservoir area and closing the intake mouth	Removal of weeds in existing dams is an ongoing project assisted by the African Development Bank for the period 2007-2011.
D	Water related diseases	
1	Typhoid, cholera and diarrhea are endemic in all States of Nigeria	At national level, by 2010, from all cases reported having water related diseases, about 55% was diarrhea diseases.
2	Guinea worm prevalent in all States of Nigeria	Not more cases were reported to date
3	Malaria, Onchocerciasis, schistosomiasis	Malaria is still a big problem in Nigeria
F	Drinking Water	
1	Polluted domestic water without proper treatment is often supplied to the service area by many existing waterworks	A study made on drinking water quality in the period 2004-2005revealed that many samples presented coliforms attributable to pollution and poor treatment by water companies
2	Lack of Water Quality Standard	Currently in use is the Water Quality Standard of 2007.
G	Pollution sources	
1	Domestic septage is thrown into the open drain around the houses	This behavior is still seen in many parts of Nigeria
2	Very few sewerage system exist in Nigeria	This has not changed. Currently there is no promotion for construction of sewerage system.
3	Untreated industrial water degrades water quality	So far, many industries are still polluting Nigerian water courses
4	There is a leachate problem from all the solid waste dumping sites	It is assumed that the this problem still continues to date
5	Agrochemicals runoff contaminating both surface and groundwater	It is assumed that the this problem still continues to date
6	Watercourses are used for solid waste disposal	This problem remains till date.
H	Eutrophication problem in the lagoon waters of Lagos, Ogun, Ondo and Bendel States	This problem remains till date.

Source: M/P1995 and JICA Project Team

2.6.4 Organization and Institution

(1) Recommendations in M/P1995

In respect of organization and institutions, the following recommendations were made in the M/P1995

a. To achieve a unitary administration and proper coordination for the enforcement of the 1993 Water Resources Decree;
    - Create the Department of Water Administration within FMWR (replace with the existing Department of Hydrology and Hydrogeology); and
    - Provide three divisions within the new Department of Water Administration, namely:
        - Water Use Coordination
        - Hydrology and Hydrogeology
        - Environmental Management (for EIA and Watershed Management)

b. To confine the responsibilities of 12 RBDAs taking 1988 Privatization and Commercialization Decree into account;
    - Limit the scope of business of the RBDAs relating to construction and maintenance of canal for irrigation and water supply to such points as being delivered to the Water Users Association (for irrigation) and to the State Water Agency (for water supply); and
    - Temporarily execute the State-run water resource projects for the State Ministries concerned taking their weakness of engineering capability into consideration.

c. To promote decentralization, privatization and users' participation in water resources management and development;
    - Organize a functional water users association with participation of users;
    - Institutionalization for project formulation; and
    - Users' participation in construction and management of the project.

d. To realize the M/P1995 smoothly;
    - Strengthen the department concerned with staff training at NWRI; and
    - Promote technical transfer programs with external experts in all technical and administrative fields.

(2) Review of M/P1995

The FMWR published the official document on water resources entitled "Ministerial Press Briefing 2010". This document provides the following information concerning reform measures in the FMWR:

- The present reform effort of the Ministry (FMWR) commenced in 1999 prior to its demerger from the Federal Ministry of Agriculture and Water Resource.
- Under the reforms of the Ministry, three Bills were forwarded to the National Assembly for the creation of two Agencies and one Commission.
- One of them is the Nigeria Hydrological Services Agency (NIHSA) that has been passed into law, meanwhile, the other two, i.e., the Nigerian Integrated Water Resources Commission (NIWRMC) is awaiting the President assent and the Gurara Dam Management Authority (GDMA) is before the National Assembly.

Thus, though structure and organization of the FMWR at present is not identical with those recommended in the M/P1995, creation of the NIHSA, the new agency statutorily in charge of carrying out hydrological and hydrogeological activities and services is an example of the progress that has been made on the recommendations in the M/P1995.

The publication revealed that in order to meet the manpower need in the water resources sector, the NWRI in Kaduna has trained a number of stakeholders in various fields of water resources. In addition, the project[1] for capacity development of stakeholders in rural water supply and sanitation has been in progress since 2010.

The result of review of the M/P1995 as stated above was based on available data collected in the first work in Nigeria and therefore it has so far not been done in detail. Thus, it is required in subsequent survey to gather information available to assess progress on the recommendations in the M/P1995.

[1] Project for Enhancement the Function of Rural Water Supply and Sanitation Center for Capacity Development in National Water Resources Institute (RWSSC Project)

2.7 Conclusion and Feedback

Based on the projects proposed in the M/P1995 and overall performance of its implementation, the Project should consider the followings:

(1) National Policies and Basic Strategies of Water Master Plan

The M/P1995 take into account water policies shown in the "National Long Term Plan, 1992, NPC" such as 1) Expansion of irrigated agriculture to meet the growing food demand due to population growth, 2) Provision of facilities to supply safe and clean domestic water, and 3) Preservation of the quality of water environment. Strategies of the M/P1995 have been developed along with these basic policies. These policies, still important national water policies, should be retained by the Project in accordance with the latest national plans (Nigeria Vision 20: 2020, Water Sector Roadmap etc.).

(2) Evaluation of Water Resources Potential

In the M/P1995, the water resources potential has been evaluated by using the observed flow and rainfall observations of the 1970s and 1980s. It was the first time comprehensive evaluation of water resources across the country as a whole. However, it has several drawbacks from the viewpoint of appropriate water resources management. For example, regarding the evaluation of surface water potential, 1) Evaluation period using data is short. 2) Potential is evaluated only in average and drought is not evaluated. 3) There is no discussion on flood discharge. In the Project, using long-term observation data (long-term rainfall data is available) as long as possible, evaluation should clarify the flow regime, flood discharge and probability of flow. Regarding the evaluation of groundwater potential, evaluation shall take into account not only meteorological conditions but also hydrogeological conditions of the area.

(3) Demand Projection and Implementation of Water Resources Development Plan

The M/P1995 shows water demand to satisfy as target of the national plan, but the process to decide final amount of demand which is a base of development plan for water supply and irrigation is not clear. Demand options should be compared based on various development scenarios. As an evaluation of the present, the planned demand seems to be somewhat excessive. About this, it may be said that progress of various projects is late adversely. Water development project (for surface water and groundwater development), water supply project and irrigation project shows the delayed progress. The delay of the project extends to the rehabilitation project for existing facilities as well as a new project. Although it is pointed out that the project is delayed due to budget shortfall, there seems to be a problem with not only budget shortfall but also the project operation systems. Concerning sub-sectors other than water supply and irrigation, there is insufficient discussion in the M/P1995 due to the jurisdiction of other ministries.

In recent years, the demands for flood / erosion control and small scale hydropower generation are increasing. In the Project, discussion on these new demands should be deepened from the viewpoint of "Integrated Water Resources Management (IWRM)".

(4) Implementation of Water Resources Management Plan

The M/P1995 has proposed the foundation of monitoring system to observe the quantity and quality of water resources elements (climate, surface water and groundwater) but its implementation is very late. Since monitoring of water resources is the cornerstone of water resources management, in the Project, the method of early realization of water resources monitoring system should be examined.

New organizations such as NIHSA and NIWRMC were established changing the form but taking over the functions of the organization proposed in the M/P1995. NIWRMC was established to be responsible for water resources management. The M/P1995 does not mention the contents of water resources management. The Project should discuss the contents of water resources management that NIWRMC should carry out. Also, these new organizations have important issues in addition to existing organizations. One of the challenges is Capacity Development (CD). In addition to CD mentioned above, the Project should discuss current and important challenges concerning water resources management such as information management, risk management (including drought, flood, cross boundary water), adjustment of water right, conservation of water environment, promotion of PPP, effective application of monitoring and evaluation (M&E) etc. The Project should also propose the practical measures to realize them.

(5) Conclusion

The M/P1995 outlined how to achieve the targets set in the national policy at the time (on water supply, and irrigation etc.). Implementation of the projects proposed in the M/P1995 does not proceed as scheduled after some 20 years have passed from the planning, and it is also difficult to achieve goals for the target year (2020).

There are such reasons as

- Is it correct demand projection? (water supply unit rate, irrigation scale, cropping pattern, combination with irrigation and rain-fed agriculture etc.),
- Is it weak implementation structure? (deficient regulatory & operational system, lack of human capacity, insufficient participation of stakeholders etc.),
- Is it lack of budget? (unsuitable project environment such as consensus building, poor project justification note, lack of lobbying for budget acquisition).

In the Project, measures to solve these issues, or measures to realize the plan should be carefully examined.

CHAPTER 3 CONCEPTS OF NATIONAL WATER RESOURCES MASTER PLAN 2013

3.1 Water Policy and Strategy

This section describes the overview of the following important policy frameworks for water resources development and management by the Federal Government of Nigeria. National water resources master plan is formulated in line with these upper policies and strategies.

- Nigeria Vision 20:2020
- The Nigeria Water Sector Roadmap
- Millennium Development Goals, 2000
- The Africa Water Vision
- National Water Resources Policy (Revised 2009)

(1) Nigeria Vision 20:2010

Followed by the National Economic Empowerment and Development Strategy: (NEED and NEED-2), Nigeria Vision 20:2020 regards the water resources sector as an important sector in national development. The objectives in water resources sector are as follows:

Table 3-1 Outline of Water Sector Policy in Nigeria Vision 20:2020

Sub Sector	Basic Objectives	Development Contents
Water Supply and Sanitation	Provide sustainable access to portable water and basic sanitation	Access to improved water source: 100% Access to improved sanitation facilities: 80%
Hydroelectric Power Generation	Develop sufficient and efficient infrastructure to support sustained economic growth	To ensure stable power, power generation capacity including hydroelectric power generation increased to 35,000 MW installed by 2020
Irrigation and Drainage	Eradicate extreme hunger and poverty and promote economic growth	To support massive agricultural production in terms of food security, irrigated schemes to be increased
Flood and Erosion Control	Preserve the environment for sustainable socio-economic development	Protection of soil contamination

Source: Nigeria Vision 20:2020

(2) Nigeria Water Sector Roadmap

For the purpose of achieving the Vision 20:2020 targets, the Nigeria Water Sector Roadmap was formulated in 2011.This roadmap received major inputs from the existing National Water Resources Master Plan (M/P1995) document and the outcomes of the National Council on Water Resources. Projects and programs of this roadmap will be implemented over short, medium and long terms. The outline of the long term (2016-2025) goals is as follows.

Table 3-2 Long Term Goals in the Nigeria Water Sector Roadmap

Sub Sector	Description
Water Supply and Sanitation	- The achievement of 100% coverage in the provision of portable water supply - The achievement of 95% coverage in the provision of improved sanitation
Irrigation and Drainage	The expansion of irrigated facilities to realize the nation's irrigation potential of about 3.14 million hectares
Dam	- 10,000 MW of electricity by hydropower - The development of new mini hydro projects

Source: Nigeria Water Sector Roadmap

(3) Millennium Development Goals

The MDGs were developed out of eight chapters of the Millennium Declaration such as reducing child mortality rates, improving maternal health, ensuring environmental sustainability etc., and 18 targets. Of these, Target 10 of Goal 7 (Ensuring environmental sustainability) is: Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation.

According to the Water Sector Roadmap, the Medium Term Goals and Strategy aims at achieving increase the national water supply access of 75%. However, the current water supply service coverage in the country is 58% urban and 45% in rural water supply schemes (Data from JMP), which mean the achievement is still behind the target.

(4) The Africa Water Vision

The Africa Water Vision on water was created to achieve the MDG goal in the sector.

This vision aims at the MDGs target of 100% of the population with access to safe drinking water, while 95% of the population with access to basic sanitation, by 2025.

(5) The National Water Resources Policy (Revised 2009)

The National Water Resources Policy which is the revised version of the National Water Resources Policy of 2004 contains national water policy, principles and strategies for the development and management of water resources which is under the jurisdiction of the Federal Ministry of Water Resources.

This National Policy on Water Resources 2009 set out the policies as well as key issues in each sector incorporated in the previous version on the one side and new policies such as the development of new legislation etc.

3.2 Framework of National Water Resources Master Plan 2013 (M/P2013)

As mentioned in the previous section, the national plans such as "Nigeria Vision 20:2020", "Water Sector Roadmap" which are the top plans of national water resources master plan set the goals to improve the current situation in the water sector:

- Low rate of access to safe and clean water and sanitation facilities
- Low contribution of irrigation to national food security, and
- Insufficient utilization of hydropower for renewable energy

National water resources master plan is a plan stimulating concrete actions to solve these problems. To break through this situation, it is necessary to formulate a plan integrating development, utilization and management of water resources through evaluation of water resources potential and demand projection on the basis of the philosophy of Integrated Water Resources Management (IWRM). This section introduces the framework of the updated/new master plan that was prepared to address these issues.

3.2.1 Definition

This Project defines the technical terms of the updated/new national water resources master plan as follows:

(1) National Water Resources Master Plan 2013 (M/P2013)

The National Water Resources Master Plan (hereinafter M/P2013) is a review and update of the existing national water resources master plan, 1995 (M/P1995) which was prepared also by the technical cooperation of JICA. The M/P2013, targeting the year 2030, will be a part of the National Plan through formal and established procedures. JICA Project Team prepared the M/P2013 (Draft M/P2013) in collaboration with Nigerian Counterpart Team. The M/P2013 is formulated analyzing available data and information on the basis of the philosophy of IWRM. The Main components of the plan are: 1) **Water Sources Development Plan**, 2) **Water Sub-sector Development Plan** and 3) **Water Resources Management Plan**. Refer to Figure 3-1.

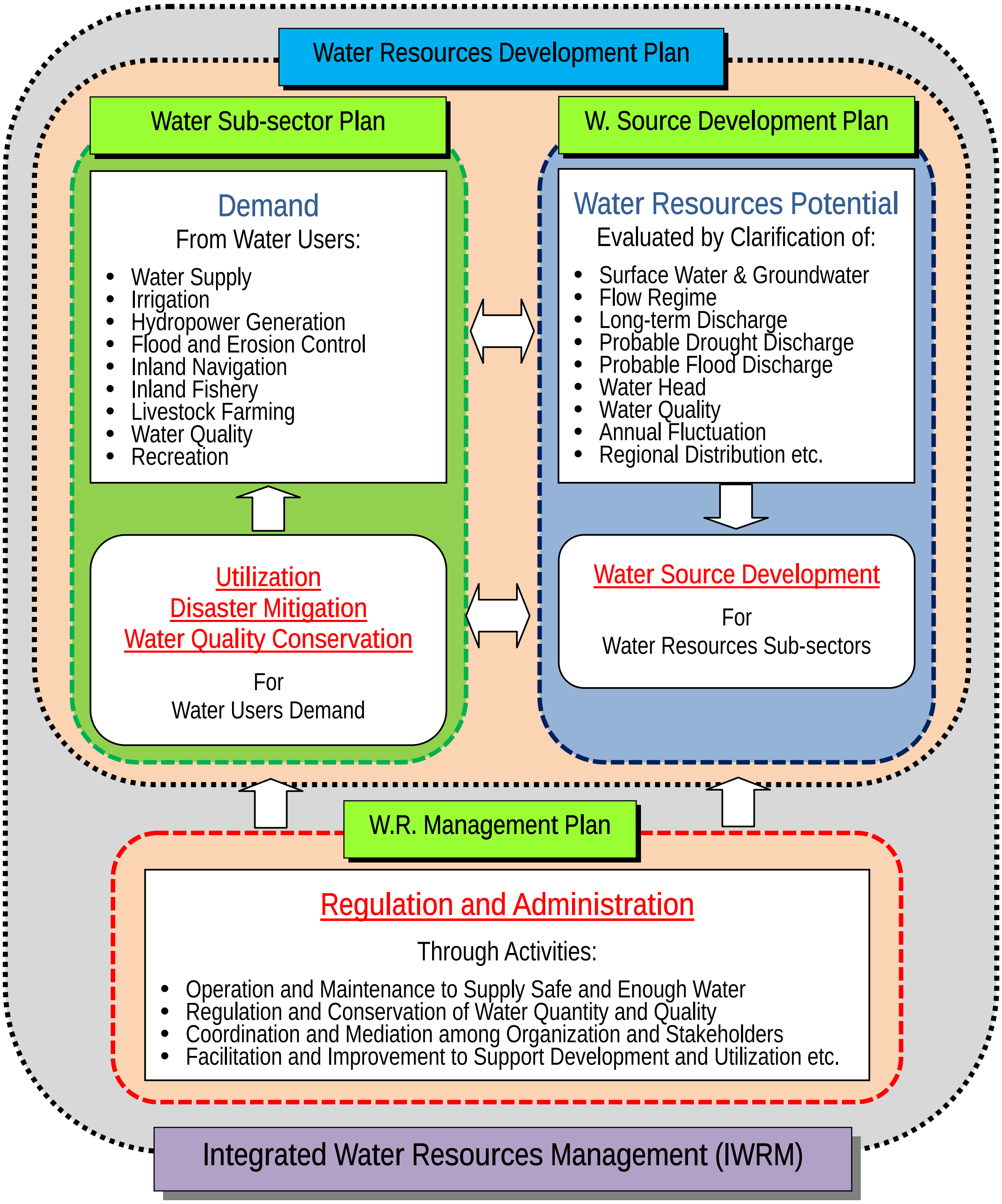
(2) Integrated Water Resources Management (IWRM)

Integrated Water Resources Management (IWRM) is being recognized internationally as an effective method on the development and management of water resources. IWRM is a process which promotes the coordinated development and management of water, land and related resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems and the environment. IWRM is targeting the following three integrations (see Figure 3-1):

- Integrated consideration on natural world: To consider, in an integrated manner, any form and stage of water in natural water cycle such as water resources & land resources, water quantity & quality, surface water & groundwater and so on, that is, "Evaluation of Water Resources".
- Integrated consideration on various sectors related to water: To consider, in an integrated manner, various sectors which conventionally have been managed separately. (water for ideal rivers, flood control, water supply and sewerage, irrigation, industry and environment), that is, "Clarification and Projection of Water Demand".
- Participation of various stakeholders: To employ participatory approach to stakeholders at all levels including central government, local government, private sectors, NGO and residents, that is, "Consensus of Stakeholders".

(3) Water Sources Development Plan (WSDP)

Water Sources Development Plan (WSDP) is the approach of water resources development (such as dam/reservoir, intake facility, channel, well and so on) to meet the needs of water users, on the basis of evaluation of water resources potential and projection of users' demand WSDP plans facilities and also basic operation systems. WRDP targets basically new projects for water resources development. If the new water source is developed by the change or remodeling of facility and system, this re-development project is planned in WSDP. Also WSDP plans the mitigation measures for flood disaster. Target water resources are generally conventional ones such as surface and groundwater. But in semi-arid areas, non-conventional ones such as desalinated sea water and reclaimed waste water are targets of development as well as conventional ones. Refer to Figure 3-1.

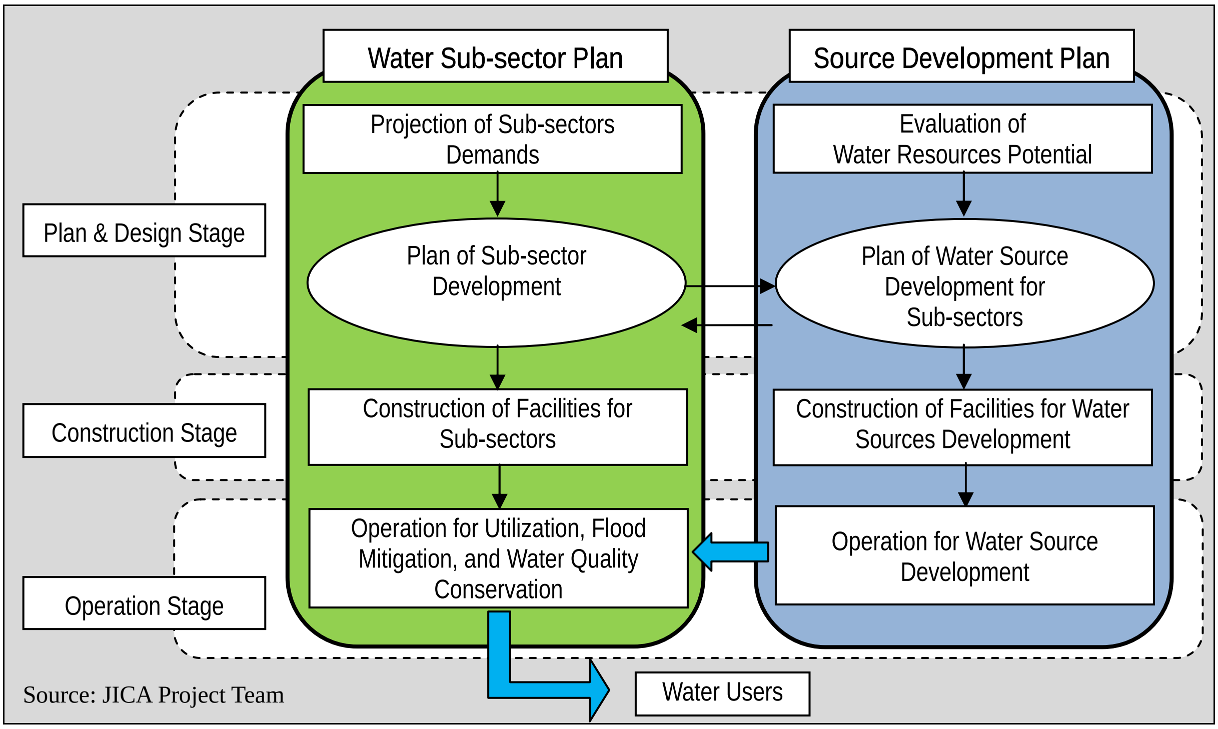


Source: JICA Project Team

Figure 3-1 Concept of National Water Resources Master Plan 2013

(4) Water Sub-sector Development Plan (WSSP)

Water Sub-sector Development (WSSP) plans the approach of utilization of facilities and systems to meet demands of such sub-sectors as water supply, irrigation, hydropower generation and so on. This plan is referred to as Sector Development Plan (such as Water Supply Plan and Irrigation Development Plan and so on). Refer to Figure 3-2.

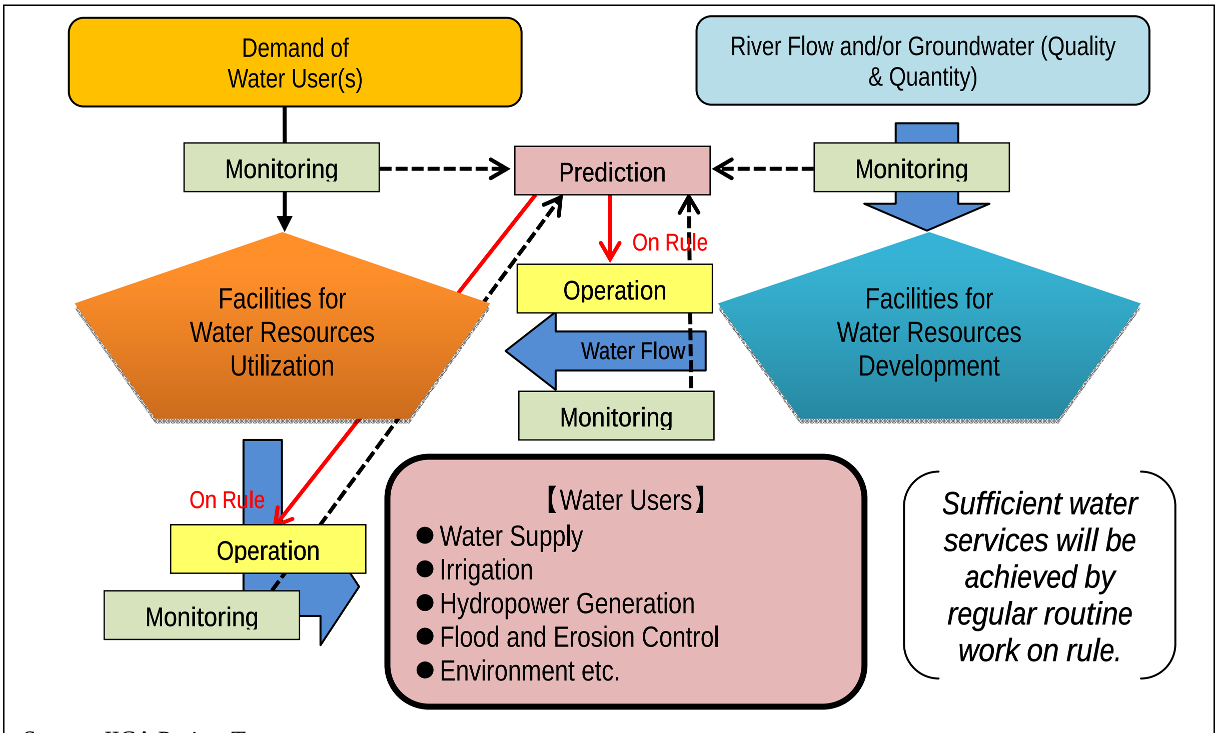


Source: JICA Project Team

Figure 3-2 Concept of Water Resources Development

(5) Water Resources Management Plan (WRMP)

Water Resources Management Plan (WRMP) is the approach of proper delivery of water services to meet water user's needs such as water supply, irrigation, hydropower, flood control and environmental protection, on basis of sufficiency, efficiency, equitability and sustainability, by using facilities and operation systems established by WSDP and WSSP. A principle of water resources management is to operate facilities and systems on routine process of monitoring - prediction (evaluation) - operation. Refer to Figure 3-3. Additionally, it is an important element of water resources management to continue to maintain, repair and improve the facilities and systems for water resources development / utilization / management. Also, WRMP includes the activity plans to support and improve water technology and human resources.



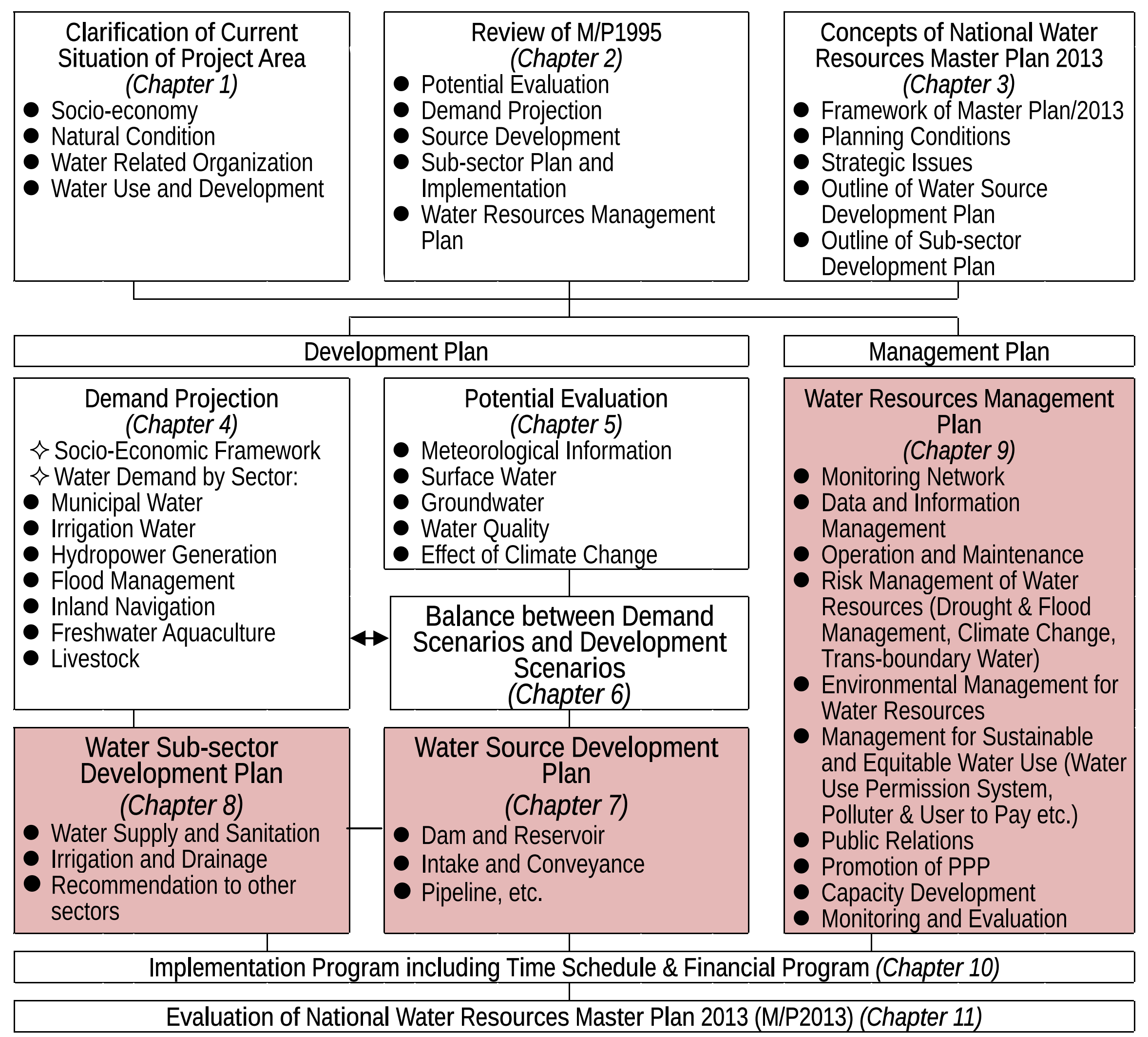
Source: JICA Project Team

Figure 3-3 Basic of Water Resources Management (Monitoring, Prediction and Operation)

3.2.2 Contents of National Water Resources Master Plan 2013 (M/P2013)

Figure 3-4 shows the contents of the M/P2013 including main three plans: 1) Water Sources Development Plan, 2) Water Sector Development Plan and 3) Water Resources Management Plans. Further, based on the results of the M/P1995 review discussed in Chapter 2, its feedback is reflected in the discussion of the M/P2013. The main points are as follows.

- Regarding the evaluation of water resources potential in the M/P1995, it is pointed out that 1) the used data period (1970s and 1980s: 20 years) is short, and 2) the potential is evaluated only in average and drought is not evaluated. In the M/P2013, flow regime and possibility of flow are discussed using the long term data (from 1970s to 2000s: 40 years). These evaluated potential values are used for planning water supply and irrigation projects.
- Regarding such projects under the jurisdiction of FMWR as water source development, water supply and irrigation, more feasible plans are discussed in the M/P2013 as the implementation of the projects has been delayed. Further, regarding other projects under the jurisdiction of other ministries such as flood & erosion control, small scale hydropower generation and so on (the demands are increasing recent years) are discussed also in the M/P2013 based on the concept of IWRM.
- The M/P2013 deepened the discussion of the topics on operation & maintenance of development facilities and systems which is a key theme of water management and not be discussed deeply in the M/P1995. Also, in addition to an important issue of human resource development, M/P2013 discusses the recent important themes such as information management, risk management on drought, flood, climate change, trans-boundary water etc., water allocation, water environment, PPP, M&E and so on.



[Note] (Chapter XX): Contents are discussed in this Chapter (Chapter XX).
Source: JICA Project Team

Figure 3-4 Contents of National Water Resources Master Plan (M/P2013)

3.2.3 Planning Conditions

In principle, the planning conditions shown in Table 3-3 are applied in the formulation of the M/P2013. The planning conditions shown below have been discussed and basically agreed in the technical committee meeting held during the process of formulation of the M/P2013.

Table 3-3 Planning Conditions

Item	Planning Condition
Flow and Climate Condition	1) Future climate condition is still uncertain. Therefore, the planning will be based on the existing climate and runoff conditions. 2) As a basic condition of the climate, the existing climate condition (40 years: 1970-2009) is applied. Based on the existing runoff condition as well as the existing climate condition, the alternative options for water demands and water resources development will be examined.
Climate Change Impact	1) The possible climate change impact on water resources and water demand will be treated as a risk factor which we cannot control as is the case of uncertainty associated with trans-boundary water. The sensitivity of the risk factor may be analyzed. 2) For the climate change scenario, the scenario based on the output of GCM would be applied.
Trans-boundary Water	1) There are large amount of inflow through the Niger River, Benue Rivers and its tributaries, and Cross River. These inflows may be affected by the water resources development and use in the neighboring countries, which is a risk factor that is not basically controlled. The risk factor may be examined by sensitivity analysis, if necessary. 2) Especially, i) Operation of Lagdo dam in the Benue River, ii) Operation of Kandaji dam (under construction) in the upper Niger River will be carefully treated. The regulated water by these dams is not considered as a usable water source unless the minimum flow is set, by the assumption that the regulated water is basically utilized in the upstream countries.
Target Safety Level for Surface Water Development	1) The following target safety level for surface water development will be basically applied. a) Municipal Water Supply= 90% yearly dependable (1/10 years safety level: Lack of water at once in 10years can be accepted.) b) Irrigation Water Supply= 80% yearly dependable (1/5 years safety level: Lack of water at once in 5years can be accepted.) c) Other Water Supply = 80% yearly dependable (1/5 years safety level: Lack of water at once in 5years can be accepted.) It is noted that municipal water supply includes domestic, industrial and commercial through water supply system.
Priority of Water Use	1) The following principles are considered, when the surface water resources development is planned. a) The highest priority is given to domestic water use, without compromising against deterioration of environment. b) The second priority is given to irrigation water use in order to keep food security. 2) Based upon the above-mentioned principles, the following priority order of consumptive water use will be basically applied, when the surface water resources development is planned. 1st priority: Minimum stream flow requirement 2nd priority: Municipal water supply 3rd priority: Irrigation water supply 4th priority : Other water supply, if any When the hydropower component that is non-consumptive water use is included in the water resources development, the optimum use of hydropower will be considered, under the above-mentioned priority order. 3) For actual operation during extreme event such as drought and flood conditions, the priority should be discussed among stakeholders case by case. This is a part of risk management of water resources. To do so, the master plan may recommend the establishment of the committee of water use in each HA.
Minimum Stream Flow Requirement	1) Q_{97DS}90%Y (90% yearly dependable 97 percentaile daily flow for a single year), which has been estimated in the present project and may represent the drought condition according to the flow regime in each area in Nigeria, will be applied as the minimum stream flow requirement, when the surface water resources development is planned in the present project. 2) In the future, when more data for river discharge and as well as river conditions will be accumulated, more details to set appropriate minimum stream flow requirement should be discussed among stakeholders.
Groundwater Development	1) Basically, the groundwater use that exceeds safe yield should not be planned.

Source: JICA Project Team

3.2.4 Strategic Socio-Environmental Consideration

The main target of the M/P2013 is to enhance the social welfare and to contribute to Nigeria's economic growth according to the national plans such as "Nigeria Vision 20:2020", although some negative socio-environmental impacts by implementing the M/P2013 could appear. In order to avoid significant negative socio-environmental impacts, the followings are strategically considered for formulating the M/P2013.

- **Water Source Development**
  - Groundwater development is to be less than safe yield so as to secure sustainable usage of groundwater.
  - Necessary new dam sites would be proposed on the basis of water balance study utilizing currently available information and data.
  - The potential dam and reservoir sites where large town could be inundated would not be selected even though they are economically efficient sites, in order to avoid significant social impact of resettlement.
- **Water Supply and Sanitation**
  - New development of water supply facilities would be minimized, by promoting effective use of the existing water supply facilities by means of rehabilitation of the facilities.
  - Considering the expected increase in waste water according to the increase of municipal water demand and use, sanitation and waste water management would be more highlighted compared to the M/P1995, in order to secure clean and safe water.
- **Irrigation and Drainage**
  - Standard cropping pattern for each hydrological area would be proposed, in consideration with precipitation and flow pattern for each hydrological area, so that water resources are efficiently utilized.
  - In general, new irrigation scheme would not be proposed in the existing Fadama area, so that the existing small private famers in Fadama area could secure their current practical life style.
  - Supplemental irrigation scheme which utilizes rain water efficiently would be promoted in such area where precipitation is high as HA-5 and -7, in order to minimize water source development.

3.2.5 Usage of National Water Resources Master Plan 2013 (M/P2013)

The M/P2013 deals with nationwide water resources development and management in Nigeria comprehensively. However, many activities of water resources development and management should be carried out at the level of hydrological area or state, and some of the sub-sectors are under the jurisdiction of other federal ministries or agencies.

Therefore, the M/P2013 is formulated with respect to water usage as follows:

- Application to Catchment Management Plan (CMP) as master plan for each hydrological area
- Application to sub-sector development plans except water supply, sanitation, irrigation and drainage

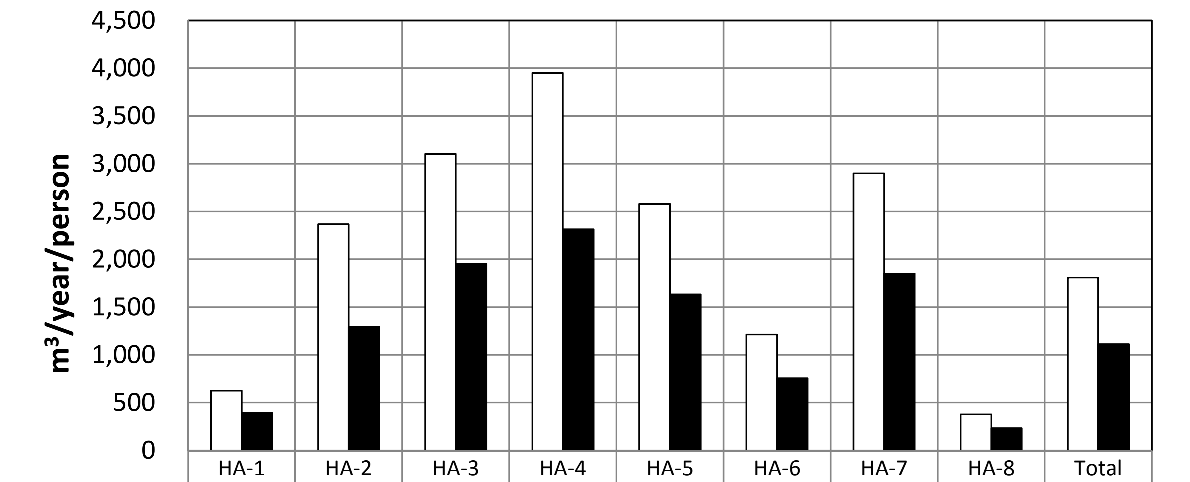
3.3 Outline of National Water Resources Master Plan 2013 (M/P2013)

3.3.1 Strategic Issues

Through the present project, the strategic issues on water resources in Nigeria have been identified. The following strategic issues are taken into account in formulating the M/P2013.

Strategic Issue-1: Water Resources Management and Development in Consideration of Unevenly Distributed Water Resources and Demand

The hydrological condition in Nigeria varies much from place to place, resulting in the uneven distribution of water resources. The internal generation of water resources potential in the northern area such as HA-1 and 8 is less than 10 BCM /year, whereas in the southern area such as HA-5, 6, 7 is more than 50 BCM /year. Similarly, the population is also unevenly distributed. The water resources potential per person (only internal generation) by hydrological areas differs with more than ten times. Although the average is 1,800m^3/year/person in 2010 and 1,100m^3/year/person in 2030, respectively, those in HA-1 and 8 are especially low. It is necessary to consider these unevenly distributed water resources for effective and sustainable water use. The water resources management and development plan would be formulated based upon the water balance between supply capacity of water source and water demand. The water resources potential has been examined by a unit of SHA on the basis of the results of rainfall-runoff model in the M/P2013, which is utilized in the water balance study.



	HA-1	HA-2	HA-3	HA-4	HA-5	HA-6	HA-7	HA-8	Total
□2010	624	2,368	3,101	3,951	2,581	1,214	2,899	376	1,809
■2030	393	1,293	1,954	2,314	1,631	754	1,850	232	1,112

Source: JICA Project Team

Figure 3-5 Water Resources Potential per Person (Only internal generation)

Strategic Issue-2: Addressing Increasing Municipal Water Demand on the Premise of Current Low Operation Rate of Water Supply Facilities

The current (2010) population of 150 million in Nigeria is expected to reach to 250 million in 2030 that is the target year of the M/P2013. It is most fundamental and important in the water sector to secure the adequate volume of domestic water to meet the increasing population.

When the target of municipal water supply is set at 100% coverage in 2030, following Nigeria Vision 20:2020, the national development plan, as well as the existing Water Sector Road map, the municipal water demand of 3.1BCM/year in 2010 would increase to 9.0BCM/year in 2030: In other words, almost three times volume of water would be required in 2030.

Meanwhile, the existing water supply facilities are not fully utilized; the average operation rates of water purification plant and production wells are 46% and 63% of those design capacity, respectively. This could be one of the major reasons for current low coverage (about 50% in average) of municipal water supply. In order to improve the coverage of municipal water supply, it is necessary to increase the operation rate of existing facilities as well as secure high operation rate for newly installed facilities.

The first priority to improve the coverage of municipal water supply is to increase the operation rate of existing facilities through rehabilitation. The next step will be to develop new facilities.

Strategic Issue-3: Promotion of Sound and Self-reliant Irrigation Development

Nigeria Vision 20:2020, the national development plan, targets the expansion of irrigation area so as to attain food security in the country.

However, the developed irrigation area and the actually irrigated area are 130,000ha and 70,000ha, respectively, although the planned irrigation area is 440,000ha. The low operation rate of the developed irrigation area could be mainly caused by high operation and maintenance cost as well as deterioration of facilities, especially for the schemes that require external energy such as pumps.

It is necessary to develop new schemes that are more economically efficient and self-reliant, instead of further developing existing schemes with low efficiency; in order to increase the irrigation area effectively. For example, gravity schemes without pump and integrated scheme with hydropower component that can supply energy for internal use within a project would be considered for the new schemes.

The important ones among existing schemes that are slated for further development would be selected first, and they would be rehabilitated and expanded. Then, the new schemes would be introduced for further increase of the irrigation area. Although most agricultural production in Nigeria relies on rain-fed cultivation, the irrigation area of about 500,000ha in 2030 can secure 100% self-production of rice in combination with improvement of rain-fed cultivation, which coincides with existing policy on rice production.

Strategic Issue-4: Effective Utilization of Existing Water Source Facilities in View of Contemporary Needs

Nigeria has constructed numerous dams with 37.4billion m^3 in total storage capacity. The number of confirmed existing dams is about 170. Among the total storage capacity of 37.4BCM, 25.8BCM is associated with large hydropower dams such as Kainji, Jebba and Shiroro. The remaining storage of 11.6BCM is mainly used for irrigation and municipal water supply. The total storage capacity is much larger than the expected total surface water demand in 2030. However, because the water supply and demand do not always match well at the local level, there would be excess volume of water in some places and lack of water in some other places. Unfortunately, the distance between these water sources is usually quite far from each other. It is therefore difficult to utilize the excess water for places where demand is higher than the capacity in many cases. This, therefore, requires solving the problem locally.

It is an important issue to identify how the excess volume of water is effectively utilized to meet contemporary needs, when it is expected that the existing dams have excess volume even if water demand in 2030 is considered. For example, part of excess volume can be converted for flood control purpose if there is problem of flooding downstream, or part of the excess volume may be converted to increase hydropower generation and enhance river and flood plain environment. Reliable supply of energy is a major issue of development in Nigeria; therefore, the conversion of the excess surface water volume for hydropower generation could be the solutions. As a result, the optimum utilization of excess volume of water in existing dams would be promoted.

It is difficult to determine exactly how the excess volume of water in each dam would be utilized in the course of formulation of the M/P2013, because it is necessary to discuss it among stakeholders at the local level. It should be discussed during formulation of Catchment Management Plan for each hydrological area.

Strategic Issue-5: Enhancement of Water-related Data/Information and Its Uniform Management

Currently, water-related data/information such as dams, water purification plants, irrigation schemes and production wells are not uniformly managed. This makes it difficult to grasp rapidly and correctly existing condition of water resources facilities in Nigeria. It causes severe impediment to planning and design in any kind of water resources plans and projects, which brings about inefficient and less accurate planning, design and consequently many waste. Furthermore, meteorological, hydrological data as well as water use data are also not managed uniformly. This also poses an impediment to daily operation of water resources facilities.

It is important to establish the framework for regular collection and uniform management of water-related data/information and to sustain the system. The cost of investment for enhancing water-related data/information is usually much less compared to the investment in large scale infrastructure projects. All stakeholders should recognize that this relatively small investment would benefit all water-related projects. Investment in the water-related data/information should therefore be made.

The strategy would be to enhance the capacity of FMWR and relevant agencies for periodical collection and uniform management of water-related data/information as well as promote awareness on importance of water-related data/information.

Strategic Issue-6: Consideration of Increasing Risk on Water Resources

It is possible that changes in water resources associated with climate change can increase flood hazard as well as reduce safety level of water supply. Although the future tendency of climate condition in the world could be predicted nowadays, the prediction by different climate models at local level are still widely varied, which makes it difficult to judge future conditions. However, the possibility of changes in water resources resulting from climate change cannot be ignorable, because it is almost sure that some changes would occur in the future. Such kind of uncertainty would be treated as a risk factor, and it is important to address the risk.

Besides, the trans-boundary water which flows into Nigeria from upstream countries is also uncertain, because it is influenced by water resources development and management in these countries. It should also be treated as a risk factor.

From the view point of risk management, the identification of the risk as well as the coping strategy is important. In order to identify the risk correctly, the enhancement of fundamental data/information including proper communication with neighboring countries should be promoted. As for coping with the risk, the following should be considered; i) establishment of flexible implementation structure which can adapt future changes, and ii) enhancement of emergency response for flood and drought conditions. It should be noted that both rely on the availability of fundamental water-related data/information.

Strategic Issue-7: Active Involvement of Water Resources Administrator in Management of Important Rivers and Flood Plains

Although rivers and flood plains are the places where water is used, their main management body is not clearly defined. There were devastating damages in such rivers and flood plains during the large scale flood along the Niger and Benue Rivers in 2012. Due to the importance of proper management of rivers and flood plains, as the place where water is used and flood often disturb human activity with been increasing frequency, it is necessary for the water resources administrator to be involved actively in the management of the rivers and flood plains.

The strategy is that the main rivers such as rivers where large scale dams are located are first identified and designated as important rivers, on which active management such as grasp and prediction of flood situation, information dissemination, as well as control of low flow condition are then be conducted through intensive monitoring of the rivers. It is necessary to establish the monitoring system and enhance its capacity.

Strategic Issue-8: Water Quality Monitoring to Secure Clean and Safe Water

It is important to secure clean and safe water by proper water environmental management, in addition to adequate water quantity conservation and development. However, because the current water quality condition for both surface and groundwater is not well grasped, it is difficult to assess the water quality for existing and future conditions and to consequently undertake decision making.

In order to conduct proper water environment management, the condition of water quality in terms of water use should be studied by FMWR as water resources administrator. The capacity of FMWR on the water quality monitoring should therefore be enhanced.

Strategic Issue-9: Institutional Development & Strengthening of Water Resources Management

FMWR have the powers and functions mainly in such water sub-sectors as water resources development (surface water and groundwater), water supply and sanitation, irrigation and drainage. Other sub-sectors such as hydro-electric power generation, flood control, inland transportation, fisheries/aquaculture/livestock etc. are undertaken by Federal Ministry of Powers, Federal Ministry of Environment etc. In addition, even in a single sub-sector, roles and responsibilities are further compartmentalized in some institutions. The current water resources management is a multi-sectorial management. A lack of adequate coordination and cooperation is considered the challenge to be addressed. In addition, inconsistency of policies and strategies in some ministries and agencies causes fragmentation in the management.

Under the circumstances mentioned above, it is important to establish and strengthen effective development and management which is to be guided not at administrative boundaries but at river basin level as the most appropriate unit, on the basis of a general principle in IWRM. Hence, as basis of new institutional arrangement, the completion and implementation of the National Water Policy and promulgation of the National Water Resources Bill are urgently required. In addition, the enactment of a Bill to establish NIWRMC which is now in process is highly required (Awaiting the Presidential Assent).

Taking the current situation and issues with regard to water resources management into account, development and strengthening of institutional framework shall be established. Hence, we suggest the basic policies below for the purpose of addressing this challenge.

- Cooperative Institutional Arrangement
- Participatory Management Administration
- Fair Regulatory Framework
- Decentralization and Coordination

3.3.2 Outline of Water Source Development Plan

The water source development plan is proposed on the basis of water balance between water demand and water supply capacity, in consideration of the unevenly distributed water resources potential. The basic concept for water source development plan for surface water and groundwater is shown in Table 3-4.

Table 3-4 Basic Concepts on Water Source Development

Source	Basic Concept
Surface Water	<u>Effective Utilization of Existing Dams</u> Many of the existing dams do not keep their original functions, because of lack of proper operation and maintenance including management of information on reservoir operation. It is necessary to revive these dams urgently, in order to prepare for the expected increase in water demand. <u>Preparation of Sufficient Surface Water Source to Address Increasing Water Demand in Consideration of Unevenly Distributed Water Resources in the Country</u> The primary objectives of the surface water resources development is to prepare and supply sufficient volume of surface water in view of the expected increase in water demand from water users; such as municipal water supply and irrigation water. Water resources development should consider the uneven distribution of water resources in the country. The following are considered. ● The necessary water resources development would be proposed by utilizing the proposed dams in the M/P1995 as the potential dams as well as other potential sites. ● By examining water balance for the potential dam sites, efficiency of each site is roughly evaluated. The priority for development should be given to the sites with higher efficiency. ● In the area where water resources is very limited and future demand is expected to be more than the supply capacity of water source, demand control such as reduction of planned irrigation area and/or changing the crop should be considered as one of options for managing the available water, in order to avoid conflict among water users. ● The integrated development with hydropower generation and irrigation components is proposed in order to promote self-reliant project.
Groundwater	<u>Sustainable and efficient groundwater development</u> Items below should be considered in groundwater development ● Amount of groundwater development should be less than amount of groundwater recharge for sustainable groundwater development ● Aquifer capacity should be taken into account in groundwater development of each region. ● Efficient location of boreholes should be planned for maximum yield from boreholes with minimum drawdown of groundwater level. <u>Rehabilitation and repair of borehole facilities</u> ● Borehole operational rate is currently only 63% in Nigeria. Breakdown of pumps is main reason of nonoperational boreholes. Broken pumps should be repaired to recover borehole capacity, and borehole maintenance should be strengthened to keep high borehole operational rate. ● Yield of boreholes should be increased by changing pump type from hand pump to motorized pump to meet future groundwater demand with minimum number of boreholes.

Source: JICA Project Team

The basic concept for water source conservation is shown in Table 3-5.

Table 3-5 Basic Concepts on Water Source Conservation

Source	Basic Concept
Surface Water	Conservation of surface water resources would be implemented in dams and reservoirs as well as in watershed areas. Both activities are related to each other. The former is a part of dam management activities, and as one of the measures for recovering and upgrading existing dams. This is mainly implemented by dam owners. On the other hand, the latter needs cooperation among wider range of stakeholders in a watershed, which deals with environmental management, water quality management, erosion control and so on.
Groundwater	Groundwater conservation in quantity and quality is important for sustainable usage of groundwater. It is taking place in many boreholes: i) lowering of groundwater level and drying up of boreholes due to over pumping, ii) deterioration of groundwater quality by sea water intrusion and infiltration of domestic drain and factory pollutant into aquifer. Pumping will be controlled as quantity conservation measure based on aquifer capacity assessment. On the other hand as quality control measure, pumping will be controlled against sea water intrusion, and pollutant discharge will be controlled against pollutant infiltration based on water quality standard. Guideline for measures will be prepared, and technical transfer is necessary for NIWRMC, CMO, NIHSA, which are in charge of groundwater management and conservation.

Source: JICA Project Team

3.3.3 Outline of Water Sub-Sector Development Plan

The basic concept of sub-sector development plan related to water resources development has been prepared for the following sub-sectors which is under jurisdiction of FMWR; Water Supply and Sanitation, and Irrigation and Drainage. For the other sub-sectors such as hydropower generation, flood and erosion control, inland transportation, inland fishery, livestock, recommendations are provided. Table 3-6 shows the basic concept of sub-sectors.

Table 3-6 Basic Concepts on Sub-Sector Development

Subsector	Basic Concept
Water Supply and Sanitation	● Water supply plan for new infrastructure, upgrading, rehabilitation and expansion of existing infrastructure, to respond to increase in water demand ● Water supply plan for optimum and sustainable utilization of water resources (surface and groundwater) and areal demand distribution ● Sanitation plan with criteria on standard sanitation facilities in accordance with settlement classification
Irrigation and Drainage	● To complete early on-going public irrigation schemes ● To implement rehabilitation and expansion of public irrigation schemes which FMWR identifies as high priority ● To develop new water resource for high priority public irrigation schemes ● To utilize existing dams for public irrigation schemes and expand its system in developed area ● To develop new proposed irrigated farmland ● To develop effective structure for operation and maintenance to run schemes
Hydropower generation	● On the basis of updated results for water resources, potential sites for hydropower generation would be examined at conceptual level. The recommendation would be provided for future development of hydropower generation from the view point of water resources management. ● Necessity of coordination of water users when hydropower plant is installed in a multi-purpose dam managed by FMWR would be examined at conceptual level. Recommendation would be provided.
Flood and Erosion Control	● Strategies related to water resources are as follows: - Proper development and management of floodplain along Niger and Benue Rivers, - Implementation of flood control projects in urban centers and developing flood warning system for disaster management, and - Implementation of erosion control project. ● Considering the strategies shown above, the concept for dealing with the sector is as follows: - The role of FMWR on flood and erosion control would be examined from the view point of water resources management. The items related to flood and erosion control to be addressed by FMWR would be proposed.
Inland Transportation	● National strategies on the sector are as follows: - Operation and maintenance of inland navigation routes, and - Securing enough investment for developing inland navigation as a part of integrated transportation system. ● Considering the strategies shown above, the concept for dealing with the sector is as follows: - Recommendations would be made on necessary measures in floodplain management in view of navigation management.
Inland Fishery	● Water demand for freshwater aquaculture would be estimated and its water balance with water supply capacity would be checked. Recommendation on necessary coordination of other water users would be provided.
Livestock	● Water demand for livestock would be estimated and its balance with water supply capacity would be checked. Recommendation on necessary coordination of other water users would be provided.

Source: JICA Project Team

3.3.4 Outline of Water Resources Management Plan

As mentioned below, Water Resources Management Plan (WRMP) shows the approach of proper delivery of water services meeting water user's needs on the basis of 3Ss (sufficiency, sustainability, safety) and 2Es (efficiency, equity) by using facilities and operation systems to be established by WSDP and WSSP.

WRMP is established based on the following strategies:

- Strategy-1 Organization and Institution for Public Water Services
- Strategy-2 Operation and Maintenance for Provision of Proper Water Services
- Strategy-3 Allocation and Regulation of Public Water
- Strategy-4 Facilitation and Improvement of Water Resources Development / Utilization / Management

In order to realize appropriate water resources management, the M/P2013 proposes the plans for the following items to be controlled:

- Organization and institution of public water services
- Operation and maintenance of water resources development facilities
- Hydrological monitoring
- Data and information management of water resources
- Floodplain control
- Consideration of risks caused by climate change and trans-boundary water
- Water environment conservation
- Water allocation and regulation
- Public relation of water resources
- Public-Private Partnership
- Human resource development, and
- Monitoring and Evaluation

CHAPTER 4 PROJECTION OF FUTURE WATER DEMAND

4.1 Future Socio-Economic Framework

4.1.1 Population

The long-term projection of population is indispensable for formulating the future framework of socio-economic structure in project areas. The projected population up to 2030 was carried out based on the following data:

- Census Population of 1991 and 2006: details in Chapter 1.1.2 (1) and Table 1-2.
- Estimated Population of 2010 by the United Nations: details in Chapter 1.1.2 (2) and Table 1-2.

The future population projection of Nigeria has not been officially disclosed by NPC until now. However, "Road for Nigeria Water Sector, January 2011, FMWR" estimates the future population of Nigeria as presented in Table 4-1.

Table 4-1 Estimated Population of Nigeria by FMWR

Year	2020	2025	2050
Population of Nigeria	210 million	225 million	389 million

Source: Road for Nigeria Water Sector, January 2011, FMWR

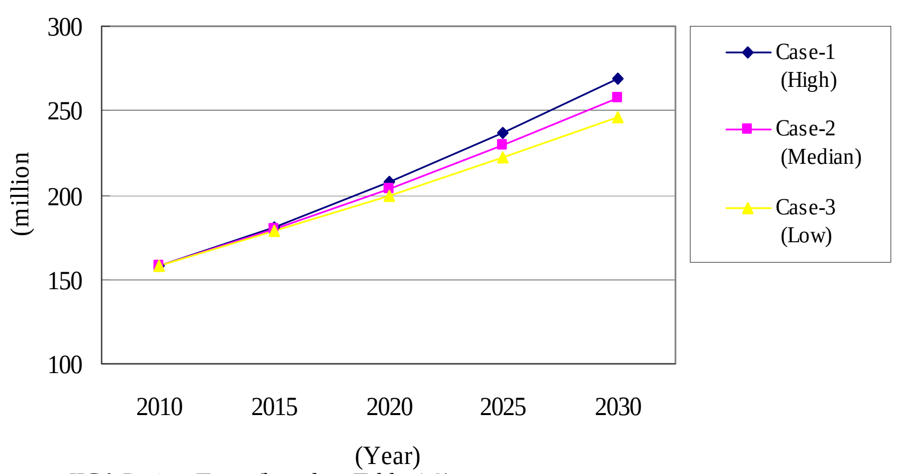
Meanwhile, "The 2010 Revision of World Population Prospects" of the United Nations projected the three different cases of future national population of Nigeria as presented in Table 4-2 and Figure 4-1. It is obvious that the Case-2, median case, is similar to the estimated population of FMWR. Accordingly, based on the Case-2, the JICA Project Team projected the state-wise and HA-wise future population up to 2030 as shown in Table 4-3.

Population is projected also in LGA-wise and sub-HA-wise. Figure 4-2 and 4-3 show the LGA-wise population of 2010 and 2030. Figure 4-4 and 4-5 present the population density of respective years. Also, refer to Section SR1.1.1, Volume-5 Supporting Report.

Table 4-2 Projected Population of Nigeria by United Nations (People in million)

Population		2010	2015	2020	2025	2030	2050
Case-1	Population	158.4	181.1	207.6	237.1	269.2	433.2
High	(Growth Rate)	-	(2.72%)	(2.77%)	(2.69%)	(2.58%)	(2.41%)
Case-2	Population	158.4	179.7	203.8	229.7	257.8	389.6
Median	(Growth Rate)	-	(2.56%)	(2.55%)	(2.42%)	(2.33%)	(2.09%)
Case-3	Population	158.4	178.4	200.0	222.4	246.3	348.3
Low	(Growth Rate)	-	(2.41%)	(2.31%)	(2.15%)	(2.06%)	(1.75%)

Source: "The 2010 Revision of World Population Prospects" of the United Nations



Source: JICA Project Team (based on Table 4-2)

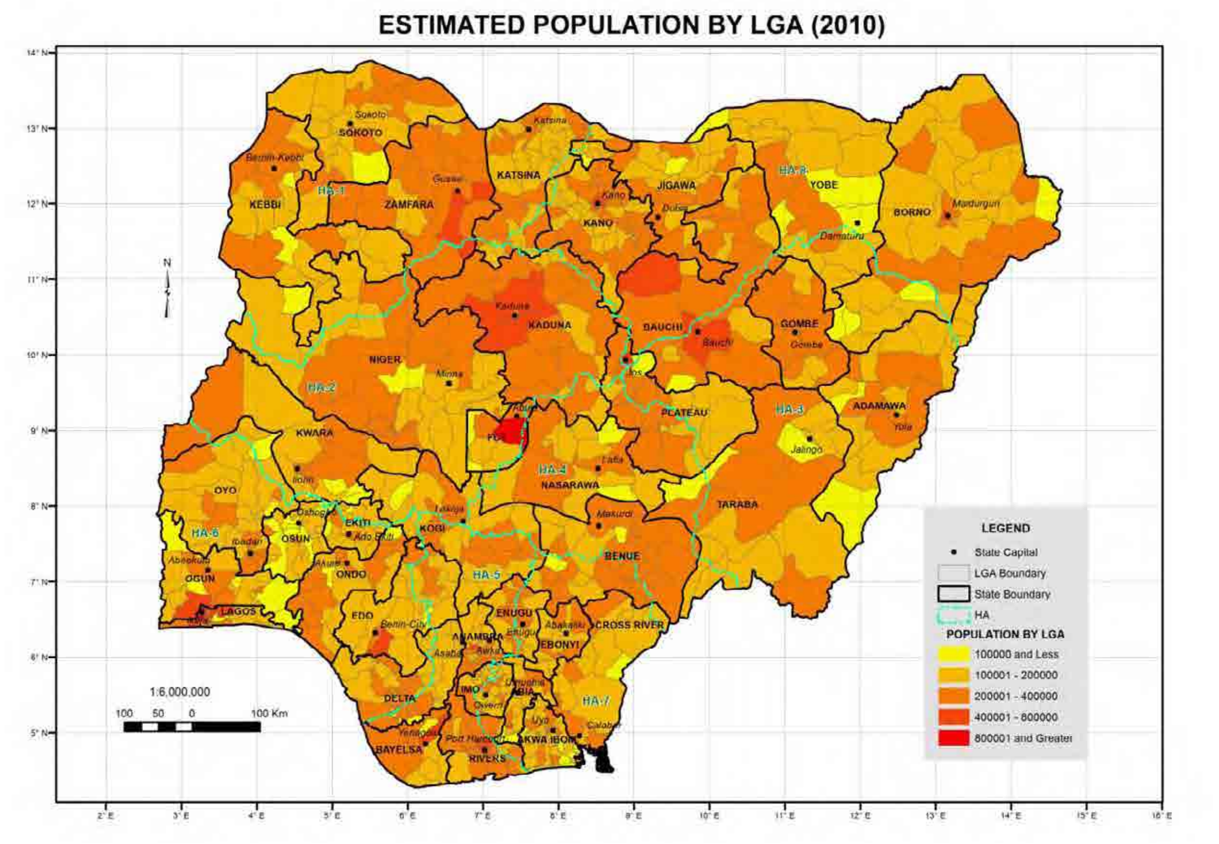
Figure 4-1 Projected Population of Nigeria from 2010 to 2030

Table 4-3 Census and Projected Population (People in thousands)

Region		Census [1)]		Estimate[2)]	Projection [3)]			
		1991	2006	2010	2015	2020	2025	2030
Nigeria		88,992	140,432	158,423	179,791	203,869	229,796	257,815
Growth Rate		-	3.18%	3.06%	2.56%	2.55%	2.42%	2.33%
State-wise [3)]								
1	Abia	1,914	2,845	3,157	3,519	3,918	4,334	4,771
2	Adamawa	2,102	3,179	3,543	3,968	4,436	4,930	5,450
3	Akwa Ibom	2,410	3,902	4,427	5,049	5,749	6,500	7,305
4	Anambra	2,796	4,178	4,642	5,180	5,774	6,396	7,050
5	Bauchi	2,862	4,653	5,284	6,034	6,878	7,783	8,756
6	Bayelsa	1,122	1,704	1,902	2,133	2,388	2,656	2,940
7	Benue	2,753	4,254	4,767	5,370	6,038	6,746	7,497
8	Borno	2,536	4,171	4,751	5,442	6,222	7,062	7,966
9	Cross River	1,911	2,893	3,225	3,612	4,040	4,490	4,965
10	Delta	2,590	4,112	4,641	5,266	5,965	6,710	7,505
11	Ebonyi	1,454	2,177	2,420	2,703	3,014	3,341	3,684
12	Edo	2,172	3,233	3,589	4,002	4,456	4,932	5,432
13	Ekiti	1,536	2,399	2,696	3,046	3,435	3,848	4,288
14	Enugu	2,125	3,268	3,658	4,115	4,621	5,157	5,724
15	Gombe	1,489	2,365	2,670	3,029	3,431	3,860	4,318
16	Imo	2,486	3,927	4,427	5,017	5,675	6,377	7,124
17	Jigawa	2,876	4,361	4,864	5,451	6,100	6,783	7,504
18	Kaduna	3,936	6,114	6,861	7,739	8,715	9,750	10,849
19	Kano	5,810	9,401	10,663	12,160	13,843	15,646	17,581
20	Katsina	3,753	5,802	6,503	7,326	8,239	9,205	10,231
21	Kebbi	2,068	3,257	3,668	4,152	4,692	5,267	5,880
22	Kogi	2,148	3,314	3,713	4,181	4,699	5,248	5,831
23	Kwara	1,548	2,365	2,643	2,968	3,327	3,707	4,108
24	Lagos	5,725	9,114	10,293	11,687	13,247	14,912	16,690
25	Nassarawa	1,208	1,869	2,096	2,362	2,657	2,970	3,302
26	Niger	2,422	3,955	4,496	5,141	5,866	6,646	7,484
27	Ogun	2,334	3,751	4,247	4,835	5,495	6,200	6,955
28	Ondo	2,250	3,461	3,875	4,359	4,896	5,464	6,066
29	Osun	2,158	3,417	3,854	4,369	4,946	5,559	6,214
30	Oyo	3,453	5,581	6,328	7,215	8,211	9,278	10,423
31	Plateau	2,105	3,207	3,581	4,018	4,501	5,011	5,550
32	Rivers	3,188	5,199	5,908	6,752	7,703	8,723	9,821
33	Sokoto	2,397	3,703	4,150	4,674	5,255	5,871	6,524
34	Taraba	1,512	2,295	2,560	2,869	3,211	3,572	3,952
35	Yobe	1,400	2,321	2,650	3,042	3,486	3,964	4,481
36	Zamfara	2,073	3,279	3,697	4,190	4,742	5,329	5,955
37	FCT (Abuja)	372	1,406	1,974	2,816	3,998	5,569	7,639
HA-wise[3)]								
1	Niger North	-	15,252	17,142	19,361	21,829	24,448	27,231
2	Niger Central	-	14,802	17,018	19,779	23,064	26,828	31,171
3	Upper Benue	-	10,866	12,220	13,807	15,565	17,427	19,398
4	Lower Benue	-	7,299	8,301	9,513	10,909	12,454	14,173
5	Niger South	-	17,504	19,644	22,161	24,959	27,924	31,078
6	Western Littoral	-	31,864	35,910	40,690	46,036	51,735	57,821
7	Eastern Littoral	-	18,578	20,803	23,410	26,302	29,359	32,593
8	Lake Chad	-	24,267	27,385	31,070	35,205	39,621	44,350

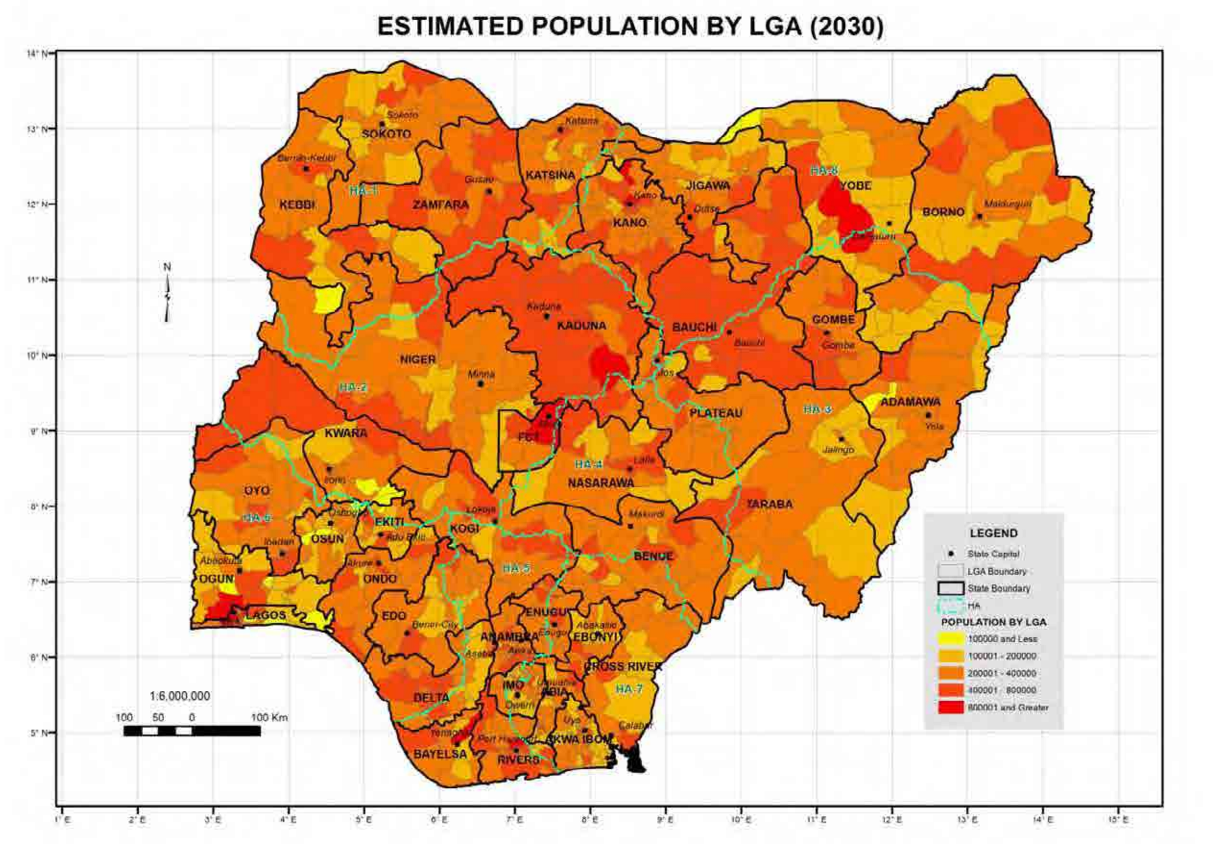
Note: A figure of the Case-2 (median growth) set out in Table 4-2 is applied for projection from 2015.

Source: 1) NPC - Census, 2) & 3) United Nations - estimate and projection on Nigeria, and 3) JICA Project Team - State-wise and HA-wise projection on the basis of the projection on Nigeria by the United Nations



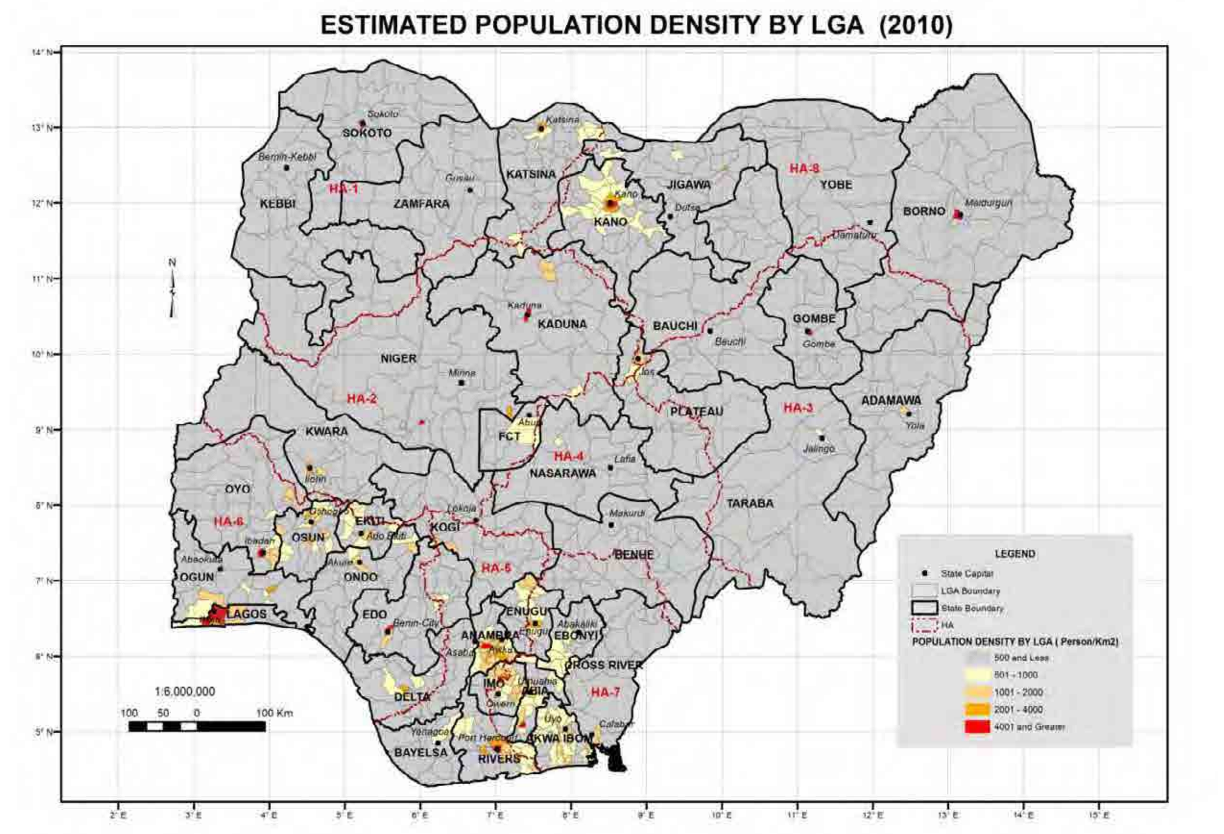
Source: JICA Project Team (based on Table 4-3)

Figure 4-2 Estimated Population by LGA in 2010



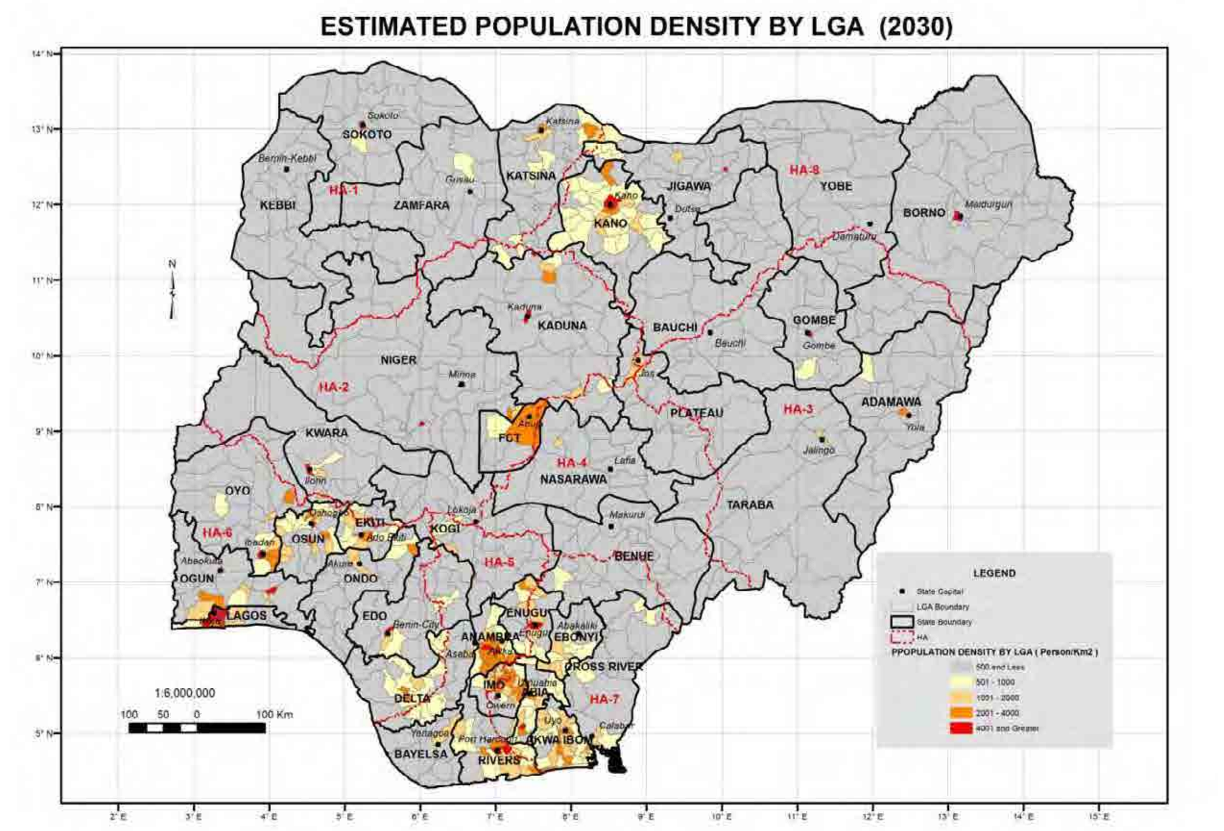
Source: JICA Project Team (based on Table 4-3)

Figure 4-3 Estimated Population by LGA in 2030



Source: JICA Project Team (based on Table 4-3)

Figure 4-4 Estimated Population Density by LGA in 2010



Source: JICA Project Team (based on Table 4-3)

Figure 4-5 Estimated Population Density by LGA in 2030

4.1.2 Economic Growth of Industry

The long-term projection of GDP is also indispensable for formulating the future framework of the socio-economic structure in project areas. In this section, particularly the future economic growth of manufacturing sector is discussed.

(1) National Aspirations

Nigeria Vision 20:2020 envisages two specific economic targets by 2020 as follows;

- GDP : not less than US$ 900 billion
- Per Capita Income : not less than US$ 4,000

To attain the above targets, the Government puts the sector-wise aspirations as indicated below.

- Agriculture : to encourage the sector to be export oriented
- Manufacturing : to contribute to GDP not less than 40%

(2) Industrial Cluster Development

To pursue the above aspirations, the Government blueprint involves the cluster development strategy on four (4) key facilities: industrial parks, industrial clusters, enterprise zones and incubators. The details of the facilities are described below.

(2-1) Industrial parks: not less than 3,050 km^2

The location and type of industry of the parks are blueprinted are as follows.

- North East : Agriculture and solid mineral: gypsum, biomass, ethanol, biodiesel, etc.
- North West : Gum Arabic, livestock and meat processing, tanneries, bio fuel, etc.
- North Central : Fruit processing, cotton. Manufacturing, OTC drugs, plastic, leather goods, garments, etc.
- South East : Palm oil refining, palm tree processing into biomass particle boards
- South West : Manufacturing (garments, methanol, plastics, etc.)
- South-South : Petrochemicals, manufacturing (plastics, fertilizers, fabrications, etc.)

(2-2) Industrial Clusters: between 100-1,000 ha

Industrial cluster is a geographic concentration of interconnected businesses, suppliers, and associated academic institutions in a particular field. The Government envisages the clusters for the organized private sector (not informal sector) with the participation and assistance of states and local governments.

(2-3) Enterprise zones: 5-30 ha

These are platforms targeted at incorporating the informal sector (over 70% of Nigeria's private sector) into the organized private sector and located in state capitals and local government areas.

(2-4) Incubators

This promotes business especially in information and communication technology (ICT).

(3) Priority 10 Sub-Sectors

The 10 sub-sectors of industry have been prioritized as follows;

- High Priority (up to 2015)	1. Chemical and pharmaceuticals 2. Non-metallic mineral products 3. Basic metal, iron/steel, and fabricated metal 4. Food, beverage and tobacco 5. Textiles, wearing apparel, carpet, leather/leather footwear
- Medium Priority (up to 2020)	6. Plastic and rubber 7. Pulp, paper, printing and publishing 8. Wood and wood products
- Low Priority (post 2020)	9. Electricals and electronics 10. Motor vehicles and miscellaneous assembly

(4) Projection of Manufacturing Sector Growth

GDP of Nigeria amounted to US$ 240 billion in 2011. In order to attain US$ 900 billion of national GDP in real base by the year 2020 that the Government envisages in Vision 20:2020, the yearly growth rate of real GDP during the period must be more than 16%. However, the highest growth rate was only 7.9% of the year 2010 in last 5 years until 2011. On the other hand, the contribution of manufacturing sector was very small: to a maximum 4.2% in 2009 in the same period.

So, before determination of the future economic growth of the manufacturing sector, it was necessary to confirm the progress of Industrial Cluster Development and its implementation schedule that were envisaged in the above “National Aspirations” with the relevant authorities of Government.

The interviews with NPC and FMTI revealed:

- No blueprint of Industrial Cluster Development exists at the moment.
- Neither organization nor budget has been set up for this purpose.

It takes more than a decade to complete all necessary process for development of industrial park such as planning and preparation, infrastructure construction, enterprises’ investment and facilities construction, and its operation start-up. So, the remarkable contribution of manufacturing sector to the national economic growth envisaged in Vision 20:2020 could not be counted until the target year 2020.

Consequently, it is concluded that the “National Aspirations” of Vision 20:2020 could not be reflected in the M/P2013. However, following from this, an annual rate of 8.5% is applied for the manufacturing sector GDP growth in terms of the industrial water demand projection.

- NBS estimates the average GDP growth rate of 7.3% in “Revised Economic Outlook for 2012 – 2015, September 2012”.
- The GDP growth rate of the manufacturing sector has generally recorded higher than that of the nation’s GDP.
- The real growth rate of the manufacturing sector was 8.4% on average over the period between 2006 and 2011.

4.2 Municipal Water

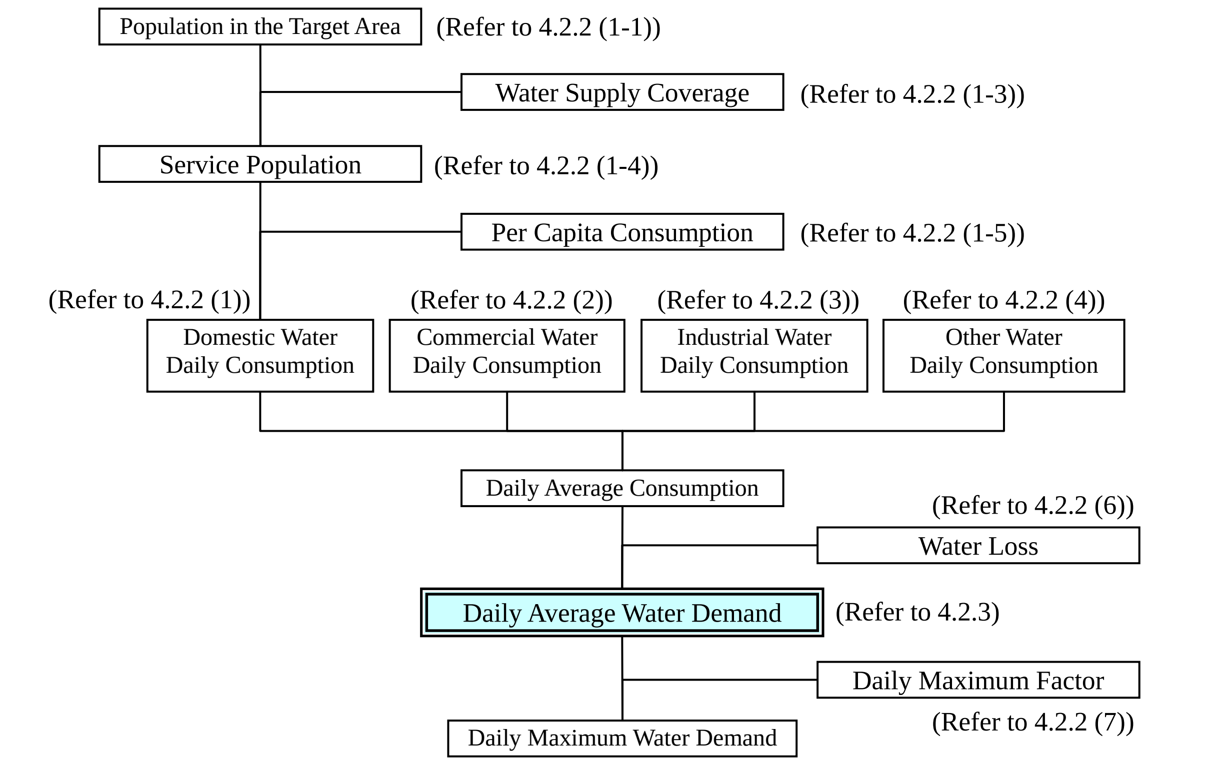
4.2.1 Method of Water Demand Projection

(1) Basic Concept

Future water demand projection is of importance for not only examination of balance between water demand and water resources potential, but also to ensure adequate water supply and appropriate development of water supply infrastructure. The Project gives priority to improvement of water supply coverage, and conducts a sensitivity analysis with some scenarios of the projection for comparison.

(2) Flowchart of Water Demand Projection

Figure 4-6 shows flowchart of water demand projection.



Source: JICA Project Team

Figure 4-6 Flowchart of Water Demand Projection

4.2.2 Basic Conditions and Framework for Water Demand Projection

The Project estimates water demand according to the following basic conditions and frame.

(1) Domestic Water

Domestic water consists of drinking, cooking, bathing, flushing and washing water, and also other water usage in our daily lives. It typically grows by not only increase in population served but also lifestyle change and improvement in living standards.

Daily average domestic water consumption is calculated by multiplying population served by per capita consumption (lit/cap/day).

(1-1) Population

The Project estimates population by local government area (LGA) as the smallest unit, which is described in 4.1.1 above (see Table 4-3).

(1-2) Categorization of Settlement on Water Demand Projection

Categorization of settlement by population size, consisting of three categories for water supply planning, has been defined by the Federal Ministry of Water Resources (FMWR). The Project, in principle, conforms to this categorization shown in Table 4-4. And, per capita consumption of domestic water by this categorization is applied in water demand projection for the Project, as described in 4.2.2 (1-5) below.

However, water demand projection by settlement category based on population size only may cause inaccuracy because there is mixture of various water supply schemes, various living or water usage situations, and various income groups in the settlement. In the process of water demand projection, the Project put additional category shown in Table 4-4 and allocate population based on referenced indicators such as household using flush toilet.

Table 4-4 Categorization of Settlement on Water Demand Projection

Population Size		Settlement Category	Typical Water Supply Scheme	Category on Water Demand Projection
1	More than 20,000	Urban	Surface water, piped supply, house or yard connection	Urbanized water usage (referenced indicator: household using flush toilet)
2	5,000 to 20,000	Semi-Urban or Small Town	Surface or groundwater, small scale piped supply, communal standpipes, house or yard connection	Semi-urbanized water usage (except the above 1 and the below 3)
3	Less than 5,000	Rural	Ground water, 250m radius, 250-500 persons per point	Ruralized water usage (referenced indicator: household using handpump)

Source: FMWR and JICA Project Team

(1-3) Water Supply Coverage

National water supply coverage of 75% in 2015 as midterm goal and 100% in 2025 as long-term goal specified in the Sector Roadmap 2011 by FMWR are considered as guidepost. But, water supply coverage in each target year should be set by the above settlement categories based on population size, because water supply infrastructure development is determined by socioeconomic activities.

The Project utilizes the water supply coverage by settlement category at the State level, published by the results of Core Welfare Indicators Questionnaire Survey (CWIQS), 2006 in order to estimate present water demand. It then applies them respectively as an average to the local government areas across the board in each State (see 8.1.3 (3) Table 8-5 below).

Summation of water consumption by LGA on the basis of the above supply coverages and 100% attainment in 2025 with constant improvement of supply coverage resulted in national water supply coverage of 56% in 2010, 71% in 2015 and 85% in 2020 as each target coverage. Refer to Table 4-5.

On the assumption that development and improvement are not carried out as planned, sensitivity analysis includes the scenario in which national water supply coverage is a variable.

Table 4-5 National Water Supply Coverage by Settlement Category in Target Years

Target Year	National Water Supply Coverage			
	Nationwide	Urban	Semi-Urban, Small Town	Rual
2010 (Current) Estimated by the Project	56%	72%	51%	40%
2015	71%	81%	68%	60%
2020	85%	91%	84%	80%
2025	100%	100%	100%	100%
2030	100%	100%	100%	100%

Source: JICA Project Team

(1-4) Population Served

Based on the above coverage, the Project estimates population served shown in Table 4-6:

Table 4-6 Population Served by State

National, State and HA		Population Served (1,000 persons)				
		2010	2015	2020	2025	2030
Nigeria (Nationwide)		79,848	120,287	170,100	229,796	257,815
State-wise						
1	Abia	1,657	2,392	3,285	4,334	4,771
2	Adamawa	783	1,908	3,284	4,930	5,450
3	Akwa Ibom	2,349	3,468	4,848	6,500	7,305
4	Anambra	1,398	2,765	4,427	6,396	7,050
5	Bauchi	1,971	3,510	5,438	7,783	8,756
6	Bayelsa	215	868	1,677	2,656	2,940
7	Benue	2,419	3,605	5,045	6,746	7,497
8	Borno	2,257	3,532	5,127	7,062	7,966
9	Cross River	965	1,919	3,090	4,490	4,965
10	Delta	1,761	3,087	4,731	6,710	7,505
11	Ebonyi	1,083	1,707	2,458	3,341	3,684
12	Edo	2,228	2,985	3,886	4,932	5,432
13	Ekiti	1,603	2,223	2,971	3,848	4,288
14	Enugu	789	1,963	3,413	5,157	5,724
15	Gombe	799	1,614	2,629	3,860	4,318
16	Imo	1,625	2,900	4,478	6,377	7,124
17	Jigawa	3,387	4,348	5,483	6,783	7,504
18	Kaduna	4,537	5,983	7,723	9,750	10,849
19	Kano	5,829	8,482	11,748	15,646	17,581
20	Katsina	2,359	4,215	6,490	9,205	10,231
21	Kebbi	1,467	2,491	3,754	5,267	5,880
22	Kogi	1,260	2,340	3,664	5,248	5,831
23	Kwara	1,595	2,182	2,886	3,707	4,108
24	Lagos	7,961	9,921	12,246	14,912	16,690
25	Nassarawa	975	1,520	2,184	2,970	3,302
26	Niger	2,944	3,957	5,190	6,646	7,484
27	Ogun	2,838	3,767	4,889	6,200	6,955
28	Ondo	2,171	3,080	4,177	5,464	6,066
29	Osun	2,892	3,641	4,534	5,559	6,214
30	Oyo	4,678	5,954	7,490	9,278	10,423
31	Plateau	1,167	2,206	3,483	5,011	5,550
32	Rivers	3,110	4,619	6,486	8,723	9,821
33	Sokoto	2,265	3,258	4,459	5,871	6,524
34	Taraba	479	1,315	2,342	3,572	3,952
35	Yobe	1,070	1,832	2,793	3,964	4,481
36	Zamfara	2,165	3,032	4,086	5,329	5,955
37	FCT Abuja	796	1,698	3,206	5,569	7,639

Source: JICA Project Team

(1-5) Per Capita Consumption of Domestic Water

In view of the present water supply coverage and high growth of water demand due to increase in population, progress of the coverage should be emphasized above everything else, although revision of the per capita consumption is normally considered due to possibility of future improvement in living standards. So, the Project applies current standard per capita consumption shown in Table 4-7 until 2030, the target year of the M/P2013.

Table 4-7 Per Capita Consumption of Domestic Water

Settlement (Water Supply) Category		Category on Water Demand Projection	Per Capita Consumption
1	Urban	Urban water usage	120 lit/cap/day
2	Semi-Urban or Small Town	Semi-urban or small town water usage	60 lit/cap/day
3	Rural	Rural water usage	30 lit/cap/day

Source: Federal Ministry of Water Resources (FMWR)

(2) Commercial Water

Commercial water is defined as water for public and private institutions, stores and shops, accommodation facilities, hospitals and clinics, educational institutions, urban greening, etc.. It typically grows by not only development of urban activities but also as a result of improvement in facilities and equipment of institutions.

Daily average commercial water consumption is calculated at the ratio of 10% of daily average domestic water consumption across the board at the State level; and at 20% for Kano, Lagos States and FCT Abuja.

These ratios are referred to instances from Japan, the Philippines (Manila), Colombia (Bogota), Indonesia (Bali) and Brazil (Sergipe), because useful reference data in Nigeria have not been confirmed. Refer to Section SR 1.2.1, Volume-5 Supporting Report.

(3) Industrial Water

Industrial water is defined as water for raw material of commodity and production, treatment, coolant, cleaning, et al. It typically grows by development of socioeconomic activities.

Daily average industrial water consumption in 2010 is calculated at the ratio of 1.25% of daily average domestic water consumption in the Northern area, 2.5% in the Southern area and 5.0% in Kano and Lagos States. It is estimated that daily average industrial water consumption increases at an annual ratio of 8.5% (GDP growth rate).

As it was in respect of commercial water, these ratios for calculation of industrial water consumption in 2010 are referenced to instances from Japan, the Philippines (Manila), Colombia (Bogota), Indonesia (Bali) and Brazil (Sergipe) from "GRDP Contribution of Manufacture Sector" and "The percentage of Industrial Water Consumption to Domestic Consumption", because useful reference data in Nigeria have not been confirmed. Refer to Section SR1.2.1, Volume-5 Supporting Report.

(4) Other Water

Other water is, for example, in-house usage water for water supply services by State Water Agencies and water use caused by metering inaccuracies and so on. It is normally a very little proportion of total water consumption, so it can be regarded as negligible and as being included in commercial water or water loss described below.

(5) Recycled Wastewater

Although utilization of recycled wastewater in industry should be taken in into water demand projection in consideration of current status, popularization and advancement, the Project assumes recycled wastewater is not utilized because of non-familiarity, lack of statistical information, high cost and difficulty in realization

(6) Water Loss

Water loss is defined as total volume of water leakage from pumping equipment, reservoirs and pipelines, and also missing water by illegal connections, that is, synonymously with unaccounted for water (UFW). But, most State Water Agencies can not figure out water loss ratio accurately because flat rate tariff is much more common in water supplies in Nigeria, which means there is almost no water meter installation. Furthermore, poor data management of existing facilities causes difficulty of status analysis. In view of these facts, 30% of water loss ratio is applied across the board except for rural water supply.

With the prospect of replacement of aged or damaged pipes, improvement of revenue from water through demand management, sensitivity analysis includes the scenario in which water loss rate is reduced as a variable.

(7) Daily Maximum Factor

Daily maximum factor, to be used for water supply planning and designing, is not applied to water demand projection in this Chapter, because the main objective is evaluation of water resources potential and hydrological balance. The factor is supposed to be incorporated in the process of water supply development plan, but the Project does not apply it due to other additions in consideration of production efficiency (see the 8.1.4 (1-4) Table 8-12).

4.2.3 Result of Water Demand Projection

Table 4-8 shows result of water demand projection by the States respectively, based on the above basic conditions and frame. Also, Section SR1.2.2, Volume-5 Supporting Report show them including water usage category such as domestic, commercial and industrial water.

The estimated nationwide water demand will nearly triple between 2010 and 2030, and the growth of states differs in degree.

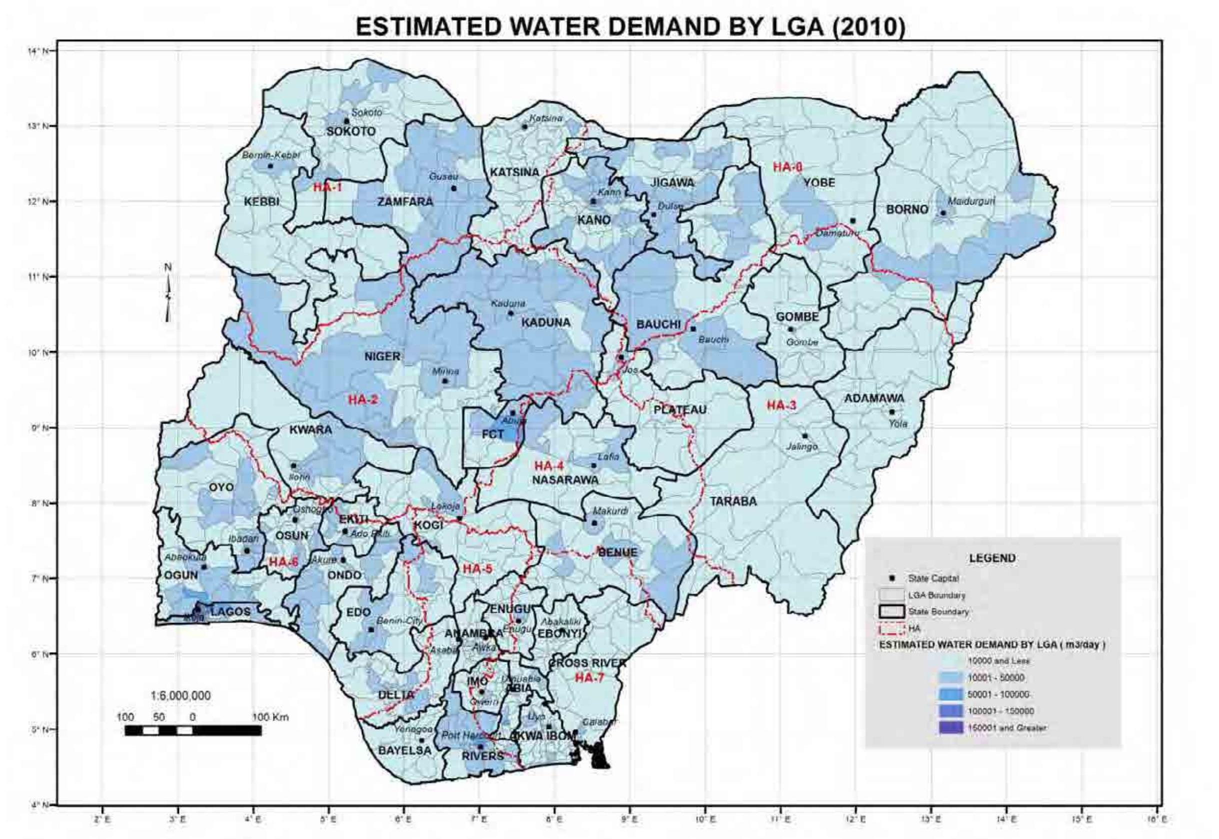
Figures 4-7 and 4-8 show estimated water demand by LGA of 2010 and 2030 in GIS.

Table 4-8 Water Demand Projection by State

National, State or HA		Water Demand (Million Liter per Day : MLD)					2030/2010 Ratio
		2010	2015	2020	2025	2030	
National		8,254	11,666	15,890	20,994	23,876	2.9
State-wise							
1	Abia	211	276	355	447	495	2.3
2	Adamawa	60	142	241	360	398	6.6
3	Akwa Ibom	225	308	411	534	606	2.7
4	Anambra	157	292	454	646	714	4.5
5	Bauchi	174	274	398	547	617	3.5
6	Bayelsa	9	70	149	245	275	31.3[1)]
7	Benue	202	282	378	492	552	2.7
8	Borno	199	293	407	545	613	3.1
9	Cross River	107	173	253	348	386	3.6
10	Delta	189	309	457	635	713	3.8
11	Ebonyi	88	131	182	242	270	3.0
12	Edo	266	328	401	486	541	2.0
13	Ekiti	150	203	267	343	388	2.6
14	Enugu	78	186	319	479	534	6.8
15	Gombe	67	125	198	285	319	4.8
16	Imo	155	260	390	548	618	4.0
17	Jigawa	265	335	419	516	576	2.2
18	Kaduna	394	498	622	767	852	2.2
19	Kano	629	869	1,165	1,521	1,741	2.8
20	Katsina	186	322	489	689	770	4.1
21	Kebbi	114	183	268	370	416	3.7
22	Kogi	111	195	298	422	473	4.3
23	Kwara	151	200	259	327	364	2.4
24	Lagos	1,397	1,716	2,102	2,555	2,934	2.1
25	Nasarawa	87	128	179	237	267	3.1
26	Niger	253	327	417	523	592	2.3
27	Ogun	319	402	502	620	707	2.2
28	Ondo	197	262	341	433	486	2.5
29	Osun	258	319	392	478	541	2.1
30	Oyo	458	566	696	848	959	2.1
31	Plateau	123	194	280	381	422	3.4
32	Rivers	355	500	679	893	1,014	2.9
33	Sokoto	197	268	353	453	506	2.6
34	Taraba	39	99	172	261	291	7.4
35	Yobe	84	138	206	289	327	3.9
36	Zamfara	171	227	294	374	420	2.5
37	FCT Abuja	130	267	496	855	1,182	9.1

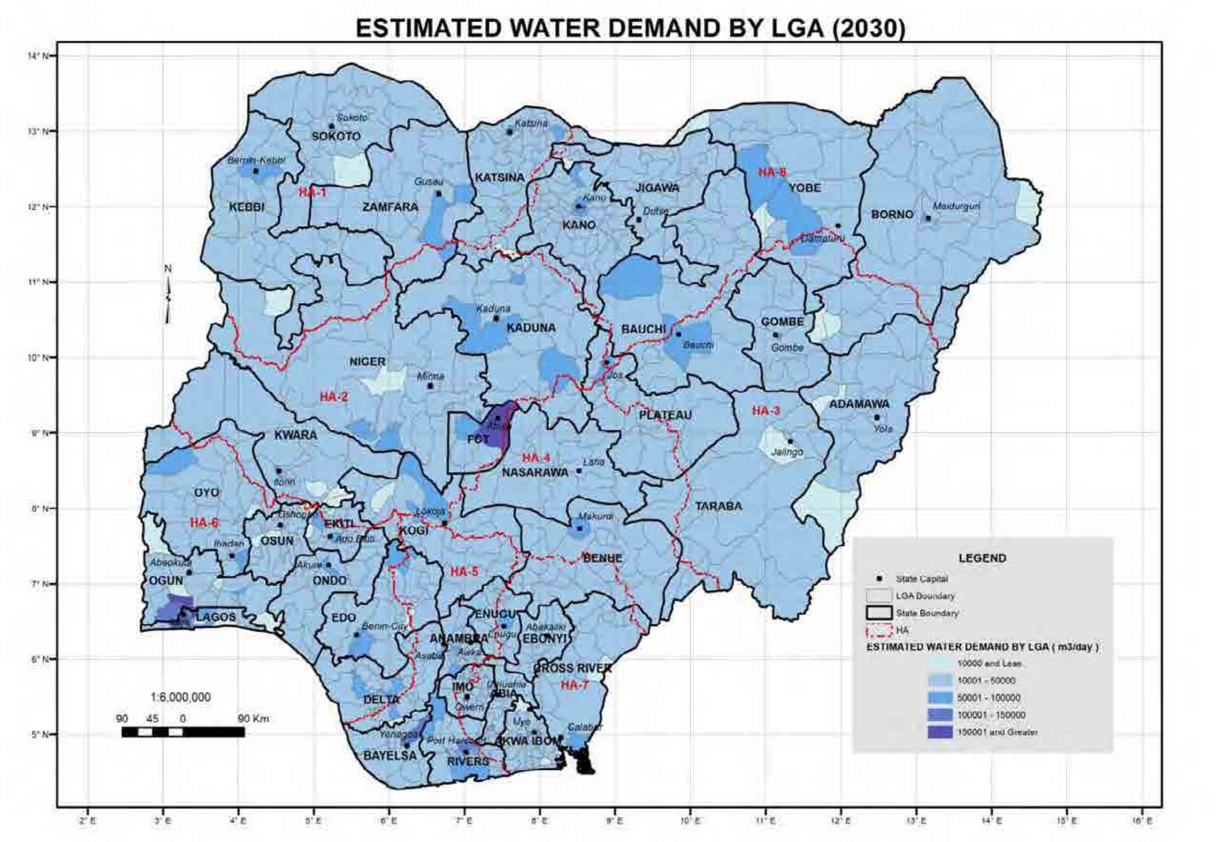
Note 1) : The reason why the 2030/2010 ratio of Bayelsa State is very high is because water supply coverage of benchmark year 2010 is relatively low compared with other states (refer to 8.1.3 (3) Table 8-5).

Source: JICA Project Team



Source: JICA Project Team

Figure 4-7 Estimated Water Demand by LGA in 2010



Source: JICA Project Team

Figure 4-8 Estimated Water Demand by LGA in 2030

4.2.4 Sensitivity Analysis on Water Demand Projection

(1) Conditions of Scenarios

In consideration of water demand subject to management of water demand and realistic aspect of water supply coverage, the Project compares the water demand projection based on the basic conditions described in 4.2.2 with other alternative projections in the following three scenarios.

Basic Scenario : Water demand projection based on basic conditions

This scenario based on basic conditions described in the above 4.2.2 is positioned "Basic Scenario" in the M/P2013.

Scenario-1 : Water demand projection based on basic conditions with the exception that 100% of water supply coverage of 2025 can not be attained.

On the assumption that infrastructure development does not progress as planned, this scenario makes nationwide water supply coverages down at 89% in 2025 and100% in 2030, the target year of the M/P2013.

Scenario-2 : Water demand projection based on basic conditions with the exception that water loss ratio is reduced from 30% to 10% until 2030

On the assumption that water demand management and measures against non -revenue water are carried out effectively, this scenario makes nationwide water loss ratio reduced from 30% to 10% in stages until 2030.

Scenario-3 : Water demand projection based on same basic conditions as Scenario-1, with the exception that water supply coverage of 2025 can not be attained and also water loss is improved from 30% to 10% in 2030

This scenario is combination of both Scenarios-1 and 2.

Table 4-9 shows conditions of the above four scenarios.

Table 4-9 Condition Setting for Sensitivity Analysis

Items		Basic Scenario	Scenario-1	Scenario-2	Scenario-3
Domestc Water (lit/cap/day)					
Urban		120 lit/cap/day	120 lit/cap/day	120 lit/cap/day	120 lit/cap/day
Semi-Urban and Small Town		60 lit/cap/day	60 lit/cap/day	60 lit/cap/day	60 lit/cap/day
Rural		30 lit/cap/day	30 lit/cap/day	30 lit/cap/day	30 lit/cap/day
Commercial Water (Ratio to Domestic)		10%, 20%	10%, 20%	10%, 20%	10%, 20%
Industrial Water (Ratio to Domestic)		1.25%, 2.5%, 5%	1.25%, 2.5%, 5%	1.25%, 2.5%, 5%	1.25%, 2.5%, 5%
Water Supply Coverage					
Nationwide	2010	56%	56%	56%	56%
	2015	71%	67%	71%	67%
	2020	85%	78%	85%	78%
	2025	100%	89%	100%	89%
	2030	100%	100%	100%	100%
Urban	2010	72%	72%	72%	72%
	2015	81%	79%	81%	79%
	2020	91%	86%	91%	86%
	2025	100%	93%	100%	93%
	2030	100%	100%	100%	100%
Semi-Urban and Small Town	2010	51%	51%	51%	51%
	2015	68%	64%	68%	64%
	2020	84%	76%	84%	76%
	2025	100%	88%	100%	88%
	2030	100%	100%	100%	100%
Rural	2010	40%	40%	40%	40%
	2015	60%	55%	60%	55%
	2020	80%	70%	80%	70%
	2025	100%	85%	100%	85%
	2030	100%	100%	100%	100%
Water Loss * Except Rural Water Supply	2010	30%	30%	30%	30%
	2015	30%	30%	25%	25%
	2020	30%	30%	20%	20%
	2025	30%	30%	15%	15%
	2030	30%	30%	10%	10%

Source: JICA Project Team

(2) Results of Sensitivity Analysis and Comparison of Scenarios

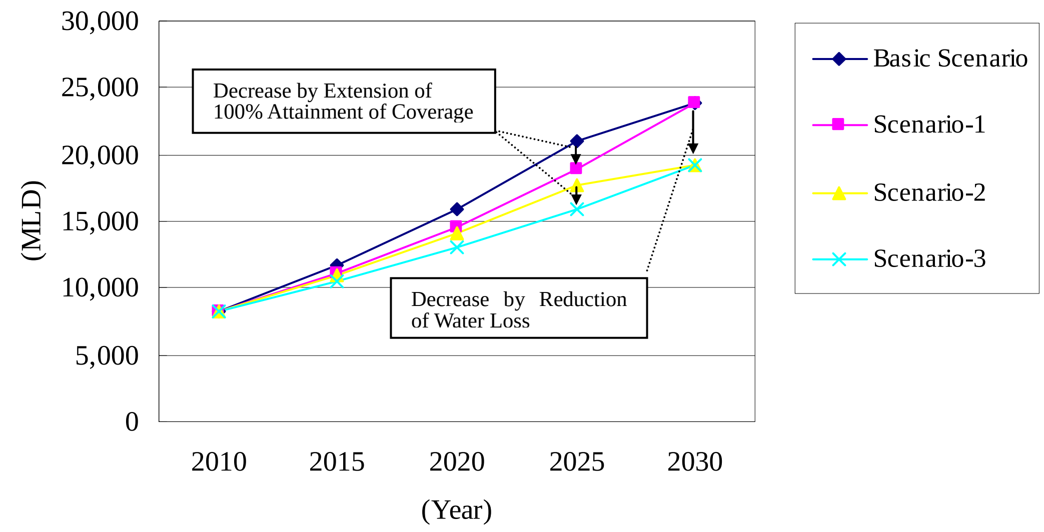
Table 4-10 and Figure 4-9 show results of sensitivity analysis of nationwide water demand projections based on the conditions in the above Table 4-9, and also ratio of each scenario to the Basic Scenario.

Results of sensitivity analysis of water demand projections by State and Hydrological Area (HA) and comparison of scenarios are shown in Section SR1.2.3, Volume-5 Supporting Report.

Table 4-10 Results of Sensitivity Analysis of Nationwide Water Demand Projection

Scenarios	Estimated Water Demand (MLD) and Ratio (%)				
	2010	2015	2020	2025	2030
(I) Basic Scenario Water Demand	8,254	11,666	15,890	20,994	23,876
(2) Scenario-1 Water Demand	8,254	11,106	14,614	18,827	23,876
Ratio to Basic Scenario (2)/(1)	100.0%	95.2%	92.0%	89.7%	100.0%
(3) Scenario-2 Water Demand	8,254	10,970	14,135	17,750	19,221
Ratio to Basic Scenario (3)/(1)	100.0%	94.0%	89.0%	84.5%	80.5%
(4) Scenario-3 Water Demand	8,254	10,440	12,990	15,896	19,221
Ratio to Basic Scenario (4)/(1)	100.0%	89.5%	81.8%	75.7%	80.5%

Source: JICA Project Team



Source: JICA Project Team

Figure 4-9 Result of Sensitivity Analysis of Nationwide Water Demand Projections

- **Comparison of Scenario-1 with Basic Scenario**

  Differences are water supply coverages of each year and target year of 100% attainment, but water demand of 2030 is same. Compared with Basic Scenario, decrease in water demand is respectively 4.8% in 2015, 8.0% in 2020 and 10.3% 2025.

- **Comparison of Scenario-2 with Basic Scenario**

  Difference is reduction of water loss. Compared with Basic Scenario, water demand decreases gradually since 2011 and finally about 20% of scale-down is possible in 2030.

- **Comparison of Scenario-3 with Basic Scenario**

  Differences are water supply coverages of each year and target year of 100% attainment, and also reduction of water loss. Although about 20% of scale-down of water demand in 2030 is same as one of Scenario-2, water demand between 2010 and 2030 is the lowest in all scenarios.

These indicate that decision about water supply coverage and target year of 100% attainment has an effect on water supply development plan and its feasibility. Also reduction of water loss can improve water demand management including measures against non-revenue water.

The Project adopts the basic scenario for analysis of hydrological balance because of 100% attainment of water supply coverage to be prioritized by water supply development plan. This is because of uncertainty of current water loss as well as lack of information on water leakage, illegal use and existing distribution network, which are addressed in operation and maintenance.

4.3 Irrigation Water

4.3.1 Agricultural and Irrigation Policies

Major crops produced in Nigeria are rice, cassava, yam, maize, sorghum, millet, groundnut, etc. The country is self-sufficient in most basic staples such as cassava, yam, etc, but it is still heavily dependent on import of processed agricultural products, particularly rice, wheat, sugar, livestock products and fish. The vision is to ensure sustainable food security to all Nigerians and to transform into on agricultural exporting country.

- Significantly improve Nigeria's agricultural productivity in the short-term;
- Expand and improve large-scale production, improve storage and processing capacities, and provide infrastructure necessary to support food supply stability in the medium-term;
- Seek to derive more than 50 percent of the national foreign exchange through agricultural exports in the long-term.

Table 4-11 Strategic Important Crops by Zone

Crop	North West	North Central	North East	South West	South Central	South East
Rice	x	x	x	x	x	x
Wheat	x		x			
Maize	x	x	x			
Millet	x	x	x			
Sorghum	x	x	x			
Vegetable	x	x	x	x	x	x
Sugar cane	x	x	x			
Cassava	x	x	x	x	x	x
Cowpea	x	x	x	x		
Tomato	x	x	x			
Cotton	x	x	x			
Ginger	x					
Yam		x		x	x	x
Cocoa				x	x	x
Oil palm				x	x	x

Source: National Agriculture and Food Security Strategy (NAFSS) (2010-2020), 2010

The crops shown in Table 4-11 are of strategic importance and rice and cassava are specially identified as significant crops in the nation. Potential irrigable area of 3.14 million hectares spread across Nigeria but irrigated paddy is at about 48,000 hectares. It is necessary to expand irrigable farmland and rain-fed paddy for food security, and also to enhance rehabilitation and expansion of existing public irrigation schemes and development of new irrigated farmlands.

4.3.2 Development of Agriculture and Irrigation

Keys to Nigerian agricultural and irrigation policies are (a) enhanced agricultural productivity, (b) expanded irrigated farmland, and (c) internal reform of irrigated farming. In order to achieve these, the followings should be promoted.

- Completion of ongoing schemes for irrigation development and rehabilitation,
- Development of new irrigated farmland,
- Increased rice production,
- Expansion of rain-fed farmland and growth of crop production, and
- Creation of employment opportunity

(1) Planted area and yield of rain-fed rice cultivation

Rain-fed upland rice and lowland rice is predominant in Nigeria and irrigated paddy field is less common. In 2008, the farmland areas of these three types of rice cultivation are 510,050ha, 1,243,151ha, 47,799ha, respectively.

According to statistical data of National Bureau of Statistics and Regional Office, the rates of annual increase of rice cultivation in the past 16 years are 0.83% and 3.98% in the last 5 years. On the other hand, annual rate of yield in the past 16 years is 0.92%.

(2) Required rice production for accomplishing 100% self-sufficiency

To achieve 100% self-sufficiency in rice production for the population in 2030, 11.9 million tons of rice production is required[1].

- Polished rice consumption : 30 kg/capita/yr (Source: NRDS)
- Projected population in 2030 : 257,8000,000
- Projected polished rice consumption in 2030 : 30 (kg/capita/yr) × 257,800,000 (people) × 1.0 (self-sufficiency ratio) = 7,700,000 (t/yr: milled)
- Rice grain yield necessary in 2030 (before polishing) : 7,700,000 (tons) / 0.65 = 11,900,000 (tons)

(3) Rice production by rain-fed upland and lowland rice

Production of rain-fed upland and lowland rice as of 2030 are in the following table calculated based on acreage under cultivation and annual rate of increase in yield mentioned above.

Table 4-12 Production of Rain-fed Rice as of 2030

	Area Growth Rate	Cropping area (ha)	Yield growth 1.0%		Yield growth 1.5%		Yield growth2.0%		Yield growth 2.5%	
			Yield (t/ha)	Production (,000ton)	Yield (t/ha)	Production (,000ton)	Yield (t/ha)	Production (,000ton)	Yield (t/ha)	Production (,000ton)
R. upland	1.0%	634,950	2.0	1,270	2.2	1,397	2.5	1,587	2.8	1,778
R. lowland		1,547,535	2.5	3,869	2.8	4,333	3.1	4,797	3.4	5,262
Total		2,182,485		5,139		5,730		6,384		7,040
R. upland	2.0%	788,460	2.0	1,577	2.2	1,735	2.5	1,971	2.8	2,208
R. lowland		1,921,678	2.5	4,804	2.8	5,381	3.1	5,957	3.4	6,534
Total		2,710,138		6,381		7,116		7,928		8,742
R. upland	3.0%	977,160	2.0	1,954	2.2	2,150	2.5	2,443	2.8	2,736
R. lowland		2,381,588	2.5	5,954	2.8	6,668	3.1	7,383	3.4	8,097
Total		3,358,748		7,908		8,818		9,826		10,833
R. upland	4.0%	1,208,700	2.0	2,417	2.2	2,659	2.5	3,022	2.8	3,384
R. lowland		2,945,910	2.5	7,365	2.8	8,249	3.1	9,132	3.4	10,016
Total		4,154,610		9,782		10,908		12,154		13,400
R. upland	5.0%	1,491,750	2.0	2,984	2.2	3,282	2.5	3,729	2.8	4,177
R. lowland		3,635,775	2.5	9,089	2.8	10,180	3.1	11,271	3.4	12,362
Total		5,127,525		12,073		13,462		15,000		16,539

R. upland, R. lowland: Rain-fed upland rice, Rain-fed lowland rice; Growth rate of area and yield indicate per year.
Source: JICA Project Team

(4) Development area and rice production due to public irrigation scheme

Based on past performance and given the annual growth rates of currently cropped rice area, paddy yield by 2030 are 4.0% and 1.0%, respectively. Paddy production under rain-fed condition is 9.8 million tons. This is equivalent to 82% of the required amount of paddy production for projected population in 2030.

The planned and developed areas for the existing public irrigation schemes are 440,853ha and 128,097ha, respectively. It is proposed to develop new schemes as well as to complete the expansion of the existing promised schemes by 2030 (refer to Section SR5.2.1, Volume-5 Supporting Report)

According to irrigation development plan in Chapter 8, planned irrigation areas of public irrigation scheme is 468,752ha by 2030 (refer to Table 8-27) and rice cultivated areas 385,711ha[2] depending on planned cultivation pattern.

On the other hand, farmland areas of private small scale irrigation farming are 335,000ha by 2030 in which rice cultivation areas are 39,319ha[3]. Rice production is estimated based on annual yield and shown in the table below. It is possible to produce rice of about 1.9-2.6 million tons comprising public irrigation scheme and private small scale irrigation farming. The amount of rice production becomes about 11.7-12.4 million tons with adding 9.8 million tons by the rain-fed rice production. It is possible to secure almost or more than 100% of rice self-sufficient, when the irrigation area for rice production will be developed as planned by 2030.

1 National Rice Development Strategy, Nigeria.
2 (Annual crop intensity of rice) x (Planned public irrigation area)
3 (Annual crop intensity of rice) x (Planned private irrigation area)

Table 4-13 Production of Irrigated Rice as of 2030

Type of Irrigation	Rice cropping are (ha)	Yield growth 1.0%		Yield growth 1.5%		Yield growth2.0%		Yield growth 2.5%	
		Yield (t/ha)	Production (,000ton)	Yield (t/ha)	Production (,000ton)	Yield (t/ha)	Production (,000ton)	Yield (t/ha)	Production (,000ton)
Public scheme	385,711	4.4	1,697	4.9	1,890	5.4	2,083	6.0	2,314
Private small scale	39,319	4.4	173	4.9	193	5.4	212	6.0	236
Total	425,030		1,870		2,083		2,295		2,550

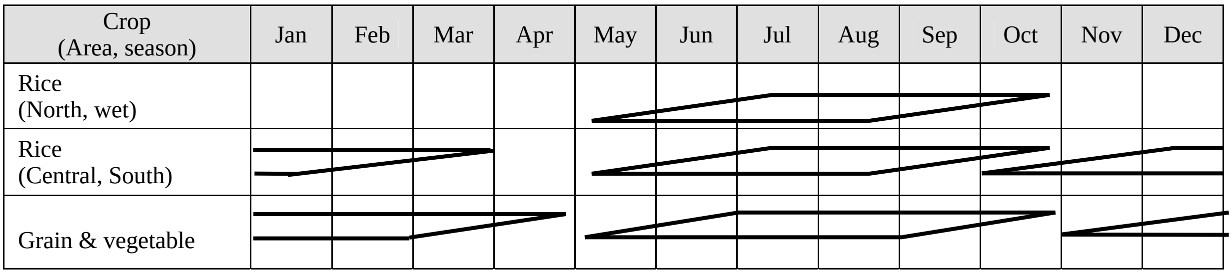
Note: Refer to Section SR1.3.2, Volume-5 Supporting Report
Source: JICA Project Team

4.3.3 Proposed Cropping Pattern

For the estimation of water demand, the following standard cropping colander and pattern are applied.

(1) Cropping Calendar

The following figure shows cropping seasons in the three large hydrological basins of Nigeria, which are obtained from various materials and interview surveys.



Source: JICA Project Team

Figure 4-10 Cropping Calendar

(2) Current Cropping Pattern

The following table shows the current cropping rate set based on RBDA's materials and cropping acreages of large-scale irrigation schemes. Vegetables and grains are major crops in small-scale private irrigation schemes.

Table 4-14 Current Cropping Pattern

HA	Irrigation scheme (%)				Small-scale private irrigation (%)			
	Wet Season		Dry Season		Wet Season		Dry Season	
	Paddy	Upland	Paddy	Upland	Paddy	Upland	Paddy	Upland
1	40	25	5	60	20	50	0	70
2	10	60	10	30	10	60	0	70
3	10	60	10	30	10	60	0	70
4	10	60	10	30	10	60	0	70
5	70	5	0	0	30	40	0	70
6	35	25	0	35	20	50	0	70
7	70	30	5	15	30	40	0	70
8	80	15	0	25	30	40	0	70

Source：JICA Project Team

(3) Proposed Cropping Pattern

The following table shows the proposed cropping rate set based on current cropping and agricultural policies that emphasize rice product.

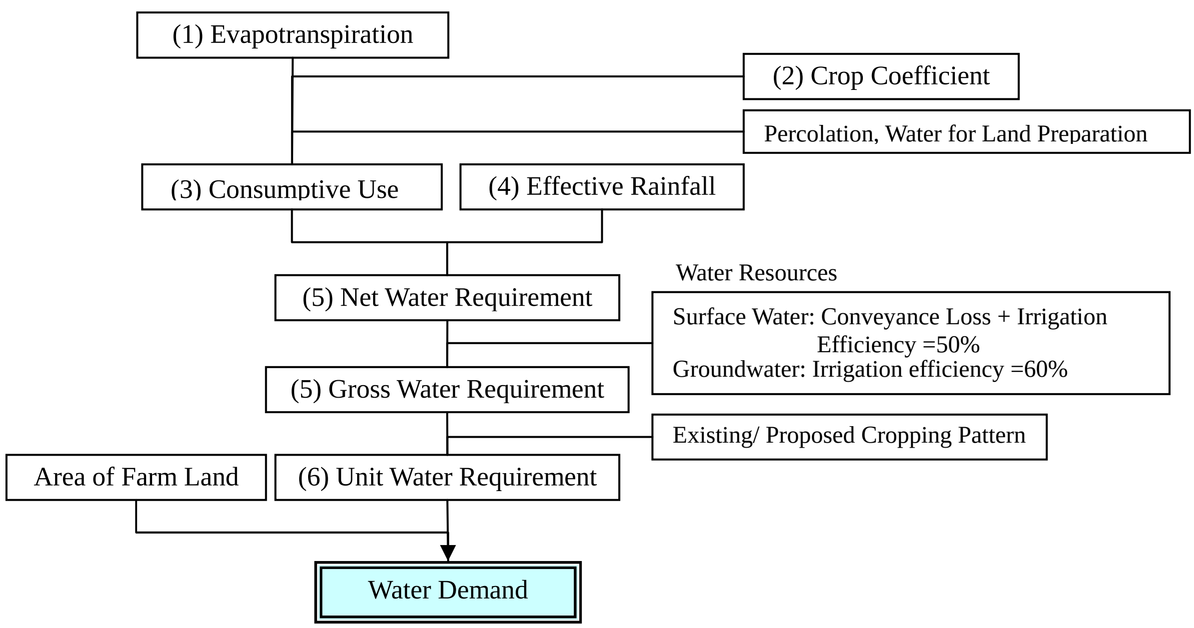
Table 4-15 Proposed Cropping Pattern

HA	Irrigation scheme (%)				Small-scale private irrigation (%)			
	Wet Season		Dry Season		Wet Season		Dry Season	
	Paddy	Upland	Paddy	Upland	Upland	Upland	Paddy	Upland
1	40	50	0	50	20	70	0	80
2	60	30	20	60	10	80	0	80
3	60	30	20	60	10	80	0	80
4	60	30	20	60	10	80	0	80
5	80	10	60	20	30	60	0	80
6	60	30	40	40	20	70	0	80
7	80	10	60	20	30	60	0	80
8	80	10	0	50	30	60	0	80

Source：JICA Project Team

4.3.4 Projection of Future Water Demand

The Calculation flow to estimate the water demand is shown as follows:



Remarks: Number in ( ) corresponds to the section number below. Source: JICA Project Team

Figure 4-11 Calculation Flow of Water Demand Projection

(1) Reference Evapotranspiration

Calculation of the reference evapotranspiration (ETo) applied is Hamon method[4].

Table 4-16 Reference Evapotranspiration (mm)

HA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	81	92	133	161	175	155	137	123	118	120	96	82
2	96	103	129	134	132	115	111	104	99	104	98	94
3	88	96	129	136	133	115	110	104	98	104	95	88
4	99	104	128	126	124	111	109	105	100	104	100	95
5	107	107	125	122	122	111	108	105	102	106	106	105
6	106	107	125	121	122	111	106	102	100	105	105	105
7	106	107	123	118	120	110	108	104	102	105	105	104
8	74	83	122	150	164	147	129	115	112	114	90	76

Source: JICA Project Team

[4] The modified Penman method requires much more data such as daily mean temperature, daily sunshine hours, daily average wind speed, daily average relative humidity, some of which are not available in the Project. Hamon method requires much less meteorological parameters.

(2) Crop Coefficient

The crop coefficient applied is based on FAO technical note as follows;

Table 4-17 Crop Coefficient

HA	Crop	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	Rice	-	-	-	-	0.17	0.69	1.04	0.99	0.61	0.15	-	-
	Others	0.88	0.85	0.39	0.05	0.11	0.41	0.75	0.85	0.54	0.14	0.15	0.52
2,3	Rice	1.10	0.66	0.16	-	0.17	0.69	1.04	0.99	0.61	0.32	0.69	1.11
	Others	0.84	0.91	0.57	0.15	0.13	0.45	0.78	0.86	0.54	0.14	0.15	0.50
4	Rice	1.10	0.66	0.16	-	0.17	0.69	1.04	0.99	0.61	0.32	0.69	1.11
	Others	0.84	0.91	0.57	0.15	0.13	0.46	0.79	0.86	0.54	0.14	0.14	0.50
5,6,7	Rice	1.10	0.66	0.16	-	0.17	0.69	1.04	0.99	0.61	0.32	0.69	1.11
	Others	0.81	0.87	0.54	0.14	0.13	0.46	0.79	0.86	0.54	0.14	0.14	0.48
8	Rice	-	-	-	-	0.17	0.69	1.04	0.99	0.61	0.15	-	-
	Others	0.89	0.85	0.39	0.05	0.11	0.41	0.75	0.85	0.54	0.14	0.16	0.53

Source: JICA Project Team

(3) Consumptive Use of Water

The consumptive use of water is estimated using reference evapotranspiration (ETo), crop coefficient (kc), deep percolation (Per), and water for land preparation (Pre). The loss due to deep percolation is assumed to be at 2 mm/day in this calculation, and the losses of water due to land preparation are assumed to be 150mm in paddy and 60mm in upland field respectively.

- Crop Evapotranspiration (ETc) = ETo × kc
- Consumptive Use of Water = ETc + Per +Pre

(4) Effective Rainfall

The effective rainfall is defined as the amount of precipitation consumed by crops. As for paddy, approximately 80% of the total precipitation is often regarded as the effective rainfall if daily precipitation is 5 to 80mm. Accordingly, the M/P2013 adopts 80% for the effective rainfall in paddies. Unlike the paddy, meanwhile, the upland field has no function to store rainfall and the effective rainfall in upland fields is calculated to be smaller than that in paddies. Therefore, the M/P2013 adopts 70% for the effective rainfall in upland fields.

Table 4-18 Effective Rainfall (Paddy) (mm)

HA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0	0	2	4	18	40	82	100	56	6	0	0
2	1	0	9	29	76	105	122	146	150	42	2	1
3	0	0	5	26	67	93	145	167	122	40	2	0
4	1	0	15	46	106	123	139	169	174	88	6	0
5	6	0	46	83	151	206	183	143	225	153	33	6
6	3	0	37	71	112	140	116	66	154	105	15	3
7	3	0	51	95	158	192	203	200	226	178	26	3
8	0	0	0	4	15	32	88	111	43	4	0	0

Source: JICA Project Team

Table 4-19 Effective Rainfall (Upland) (mm)

HA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0	0	1	3	13	28	57	70	39	4	0	0
2	1	0	6	20	53	74	85	102	105	29	1	1
3	0	0	4	18	47	65	102	117	85	28	1	0
4	1	0	11	32	74	86	97	118	122	62	0	0
5	4	0	32	58	106	144	128	100	158	107	23	4
6	2	0	26	50	78	98	81	46	108	74	11	2
7	2	0	36	67	111	134	142	140	158	125	18	2
8	0	0	0	3	11	22	62	78	30	3	0	0

Source: JICA Project Team

(5) Net Water Requirement, Conveyance, Application Efficiency, and Gross Water Requirement

The net water requirement is calculated by deducting the effective rainfall from the consumptive use of water. Public irrigation schemes take surface water as major water sources. Meanwhile, fadama farming and some small-scale private irrigation systems in floodplains mainly use sub-surface flows, which occur after flood recession. The other small-scale private irrigation systems outside floodplains have irrigation water mainly by extracting groundwater.

For surface water irrigation schemes, one must calculate the gross water requirement by making allowances for conveyance efficiency from the intake to fields and the application efficiency in the field. As for groundwater irrigation schemes, meanwhile, one only needs to take the application efficiency into account. The irrigation efficiency, which is the product of conveyance efficiency and the application efficiency, is generally estimated as follows.

- Surface Water: Conveyance efficiency × Application efficiency = 50%
- Groundwater: Application efficiency =60%

Hence, dividing the net water requirement by the irrigation efficiency gives gross water requirement.

(6) Diversion Water Requirement

The following diversion water requirements are calculated from gross water requirements and the cropping patterns. It is presumed that farmers in HA-1 and 8 do not grow paddy rice in the dry season because of low precipitation. Consequently, the plan shows net water requirements for paddy rice in those areas are zero in the dry season.

Table 4-20 Surface Water: Diversion Water Requirement (Current)

HA	Season	Net Water Requirement (mm)		Gross Water Requirement(m^3/ha)		Cropping Pattern (%)		Diversion Water Requirement (m^3/ha)
		Paddy	Upland	Paddy	Upland	Paddy	Upland	
1	Wet	579	221	11,580	4,420	40	25	5,737
	Dry	0	322	0	6,440	5	60	3,864
2	Wet	204	10	4,080	200	10	60	528
	Dry	720	362	14,400	7,240	10	30	3,612
3	Wet	187	17	3,740	340	10	60	578
	Dry	706	350	14,120	7,000	10	30	3,512
4	Wet	113	0	2,260	0	10	60	226
	Dry	670	357	13,400	7,140	10	30	3,482
5	Wet	21	0	420	0	70	5	294
	Dry	593	310	11,860	6,200	0	0	0
6	Wet	205	45	4,100	900	35	25	1,660
	Dry	642	331	12,840	6,620	0	35	2,317
7	Wet	0	0	0	0	70	30	0
	Dry	598	312	11,960	6,240	5	15	1,534
8	Wet	559	203	11,180	4,060	80	15	9,553
	Dry	0	304	0	6,080	0	25	1,520

Source: JICA Project Team

Table 4-21 Groundwater: Diversion Water Requirement (Current)

HA	Season	Net Water Requirement (mm)		Gross Water Requirement (m^3/ha)		Cropping Pattern (%)		Diversion Water Requirement (m^3/ha)
		Paddy	Upland	Paddy	Upland	Paddy	Upland	
1	Wet	579	221	9,650	3,683	20	50	3,772
	Dry	0	322	0	5,367	0	70	3,757
2	Wet	204	10	3,400	167	10	60	440
	Dry	720	362	12,000	6,033	0	70	4,223
3	Wet	187	17	3,117	283	10	60	482
	Dry	706	350	11,767	5,833	0	70	4,083
4	Wet	113	0	1,883	0	10	60	188
	Dry	670	357	11,167	5,950	0	70	4,165
5	Wet	21	0	350	0	30	40	105
	Dry	593	310	9,883	5,167	0	70	3,617
6	Wet	205	45	3,417	750	20	50	1,058
	Dry	642	331	10,700	5,517	0	70	3,862
7	Wet	0	0	0	0	30	40	0
	Dry	598	312	9,967	5,200	0	70	3,640
8	Wet	559	203	9,317	3,383	30	40	4,148
	Dry	0	304	0	5,067	0	70	3,547

Source: JICA Project Team

Table 4-22 Surface Water: Diversion Water Requirement (Proposed)

HA	Season	Net Water Requirement (mm)		Gross Water Requirement (m^3/ha)		Cropping Pattern (%)		Diversion Water Requirement (m^3/ha)
		Paddy	Upland	Paddy	Paddy	Upland	Paddy	
1	Wet	579	221	11,580	4,420	40	50	6,842
	Dry	0	322	0	6,440	0	50	3,220
2	Wet	204	10	4,080	200	60	30	2,508
	Dry	720	362	14,400	7,240	20	60	7,224
3	Wet	187	17	3,740	340	60	30	2,346
	Dry	706	350	14,120	7,000	20	60	7,024
4	Wet	113	0	2,260	0	60	30	1,356
	Dry	670	357	13,400	7,140	20	60	6,964
5	Wet	21	0	420	0	80	10	336
	Dry	593	310	11,860	6,200	60	20	8,356
6	Wet	205	45	4,100	900	60	30	2,730
	Dry	642	331	12,840	6,620	40	40	7,784
7	Wet	0	0	0	0	80	10	0
	Dry	598	312	11,960	6,240	60	20	8,424
8	Wet	559	203	11,180	4,060	80	10	9,350
	Dry	0	304	0	6,080	0	50	3,040

Source: JICA Project Team

Table 4-23 Groundwater: Diversion Water Requirement (Proposed)

HA	Season	Net Water Requirement (mm)		Gross Water Requirement (m^3/ha)		Cropping Pattern (%)		Diversion Water Requirement (m^3/ha)
		Paddy	Upland	Paddy	Upland	Paddy	Upland	
1	Wet	579	221	9,650	3,683	20	70	4,508
	Dry	0	322	0	5,367	0	80	4,294
2	Wet	204	10	3,400	167	10	80	474
	Dry	720	362	12,000	6,033	0	80	4,826
3	Wet	187	17	3,117	283	10	80	538
	Dry	706	350	11,767	5,833	0	80	4,666
4	Wet	113	0	1,883	0	10	80	188
	Dry	670	357	11,167	5,950	0	80	4,760
5	Wet	21	0	350	0	30	60	105
	Dry	593	310	9,883	5,167	0	80	4,134
6	Wet	205	45	3,417	750	20	70	1,208
	Dry	642	331	10,700	5,517	0	80	4,414
7	Wet	0	0	0	0	30	60	0
	Dry	598	312	9,967	5,200	0	80	4,160
8	Wet	559	203	9,317	3,383	30	60	4,825
	Dry	0	304	0	5,067	0	80	4,054

Source: JICA Project Team

(7) Monthly Variations of Diversion Water Requirement by Hydrological Area

Table 4-24 shows monthly variations of diversion water requirement in each hydrological area (HA). As for the surface water sources, the diversion water requirement in the north (HAs-1 and 8) is maximum in June, the beginning of wet-season irrigation. In the central and southern regions where annual precipitation is higher, meanwhile, it is maximum in December and January, the mid-term of dry-season irrigation. Here the diversion water requirement in the south (HAs-5 and 6) required is less in the wet season due to much precipitation.

Table 4-24 Monthly Variations of Diversion Water Requirement (mm)

HA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	71	78	51	5	130	204	142	101	62	47	44	73
2	162	152	98	0	61	100	65	20	0	37	121	156
3	152	142	102	2	73	119	35	0	0	40	119	152
4	166	154	88	0	24	71	41	0	0	14	115	160
5	240	158	19	0	0	0	0	34	0	0	183	236
6	206	155	44	0	17	50	67	139	0	14	157	202
7	242	158	12	0	0	0	0	0	0	0	192	238
8	66	71	48	5	196	292	177	105	94	71	44	70

Water Source: Surface Water Bodies
Source: JICA Project Team

In the case of fadama farming or small-scale private irrigation that mainly use sub-surface flows or groundwater (see Table 4-25), the diversion water requirement in the northern area (HAs-1 and 8) is maximum in June, the beginning of wet-season irrigation. In the central and southern regions, meanwhile, it is maximum in December and January, the mid-term of dry-season irrigation. In addition, farmers grow crops only in the dry season after flood recessions in the case of fadama farming or small-scale private irrigation farming that use sub-surface flows as major water sources.

Table 4-25 Monthly Variations of Diversion Water Requirement (mm)

HA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	95	104	68	7	81	134	94	68	45	29	59	97
2	107	125	91	0	9	24	12	3	0	1	59	101
3	99	116	93	3	10	38	5	0	0	1	57	99
4	109	127	83	0	3	10	6	0	0	0	53	104
5	111	124	48	0	0	0	0	11	0	0	29	101
6	112	124	56	0	5	14	22	81	0	0	45	104
7	112	124	40	0	0	0	0	0	0	0	36	104
8	88	95	64	7	96	155	88	52	58	35	59	93

Water Source: Sub-surface flows or groundwater
Source: JICA Project Team

(8) Private Small Irrigate Farming

About 70 percent of the area under private small irrigated farming nationwide is cultivated. The remaining is located in flood plains. In fadama area in the flood plain, crops are planted in dry season after flood recession

(9) Private Company Irrigation Scheme

Most private company irrigation schemes utilize surface water to produce sugar cane and vegetables. In the study of water balance in SHA, water demand of those schemes should be considered in addition to public irrigation schemes.

Table 4-26 Private Company Irrigation Schemes

No	HA	Name of Scheme	State	SHA	System Developed Area(ha)	Planned Irrigation Area(ha)	Evaluated Future irrigation Area(ha)
1	2	Basitao	Niger	209	5,600	9,000	9,000
2	3	Sabannah Sugar	Adomawa	311	7,000	12,200	12,200
3	3	Savannah Integrated Farm	Gombe	31405	109	4,000	4,000
4	3	Vegetablefru	Borno	31407	300	300	300
Total					13,009	25,500	25,500

Remarks: 1) Evaluated future irrigation Area: Amount of runoff from catchment area at schemes meets the demand of required irrigation water according to surface water potential analysis.
Source: JICA Project Team

(10) Current Irrigation Water Demand

The following table shows water demand of surface water irrigation schemes, fadama irrigation systems and a part of small-scale private irrigation systems with sub-surface flow water, and small-scale private irrigation systems with groundwater irrigation

The overall water demand is 872MCM in the wet season and 1,054MCM in the dry season, and the total amount is 1,926MCM year-round. The total amount corresponds approximately to 0.7% of Nigeria's total water abundance of 286,600MCM (internal generation only).

Table 4-27 Current Irrigation Water Demand

Water Source	Type	Area (ha)	Wet Season (MCM)	Dry Season (MCM)	Total (MCM)
Surface Water	Irrigation scheme	142,106	741	345	1,086
Sub-surface Flow	Fadama, partial Small-scale private irrigation	93,000	0	361	361
Groundwater	Small-scale private irrigation	90,000	131	348	479
Total		325,106	872	1,054	1,926

Source: JICA Project Team

(11) Proposed Irrigation Water Demand

The overall water demand is 2,052MCM in the wet season and 4,193MCM in the dry season, and the total amount is 6,245MCM year-round. The total amount corresponds approximately to 2.2% of Nigeria's total water abundance of 286,600MCM (internal generation only).

Table 4-28 Proposed Irrigation Water Demand

Water Source	Type	Area (ha)	Wet Season (MCM)	Dry Season (MCM)	Total (MCM)
Surface Water	Irrigation scheme	494,252	1,720	2,712	4,432
Sub-surface Flow	Fadama, partial Small-scale private irrigation	139,000	0	617	617
Groundwater	Small-scale private irrigation	196,000	332	864	1,196
Total		829,252	2,052	4,193	6,245

Source: JICA Project Team

(12) Preliminary Consideration on Water Demand Variations of Scenarios No.1 and No.2 Due to Climate Change

The Project considers impact of climate change on water demand based on the scenario which is set in Section 5.3.4. Taking projected air temperature variations into account, in this regard, the Project sets the future reference PET derived from the fundamental reference PET multiplied by the coefficients of air temperature variation shown in the table below. Here, the coefficients of air temperature variation are calculated and obtained by the Hamon's equation

Table 4-29 Coefficient of Air Temperature Variation

Items	HA-1	HA-2	HA-3	HA-4	HA-5	HA-6	HA-7	HA-8
Air Temp. Variation (^{o}C)	+2.5	+2.4	+2.4	+2.3	+2.1	+2.2	+2.2	+2.5
Coefficients of Air Temperature Variation	1.168	1.160	1.160	1.153	1.139	1.146	1.146	1.168

Source: JICA Project Team

As shown in below table, given the occurrence of Climate Change, it is projected that the water demand will increase by nearly 16% in total. Water demand will increase more in the wet season rather than in the dry season. Particularly, the groundwater demand for small-scale irrigation is projected to increase most by 18%.

Table 4-30 Variation of Water Demand due to Climate Change

Water Source	Type	Area (ha)	Wet Season	Dry Season	Total
Surface water	Irrigation schems	494,252	+22%	+12%	+16%
Sub-surface flow (Floodplain)	Fadama farming + some small-scale irrigation	139,000	0%	+14%	+14%
Groundwater	Small-scale irrigated farming	196,000	+28%	+14%	+18%
Total		829,252	+22%	+13%	+16%

Source: JICA Project Team

4.4 Other Sub-Sectors

4.4.1 Livestock

Dependence of livestock on surface water is greater in southern part of Nigeria than in northern part where by far large livestock herds rely on groundwater and remaining water in Fadama. As to method of estimating, annual water demand for livestock was calculated from the text of FAO livestock guideline in African region, Annual consumption rates by livestock specie applied to the projection toward 2030 are: 7.88, 0.84, 0.73, 1.20, 8.98, 8.10, 3.07 and 0.039 m^3 for head/ fowl of adult cattle, goat, sheep, pig, camel, horse, donkey and poultry. The projected water demand for livestock in 2030 amounts to 320.8 MCM, as against 232.8 MCM in 2010.

Table 4-31 Number of livestock heads / fowls in 1,000 head/fowl

Specie	2007	2008	2009	2010	2030
Cattle	16,279	16,538	16,488	17,893	27,102
Goats	51,208	52,489	54,200	52,085	61,831
Sheep	32,300	33,090	33,674	32,178	33,279
Pigs	9,298	9,555	9,808	10,108	15,461
Poultry	92,035	84,781	86,601	92,134	93,439
Camel	-	-	-	147	147
Horse	-	-	-	789	789
Donkey	-	-	-	371	371

Note : 1) Chicken, ducks and Guinea fowls are included in poultry.
2) Sheep is gradually on the decline in long term.
3) As to heads of camels, horses and donkeys data of 2010 are only available in recent term, so the data are also used for 2030 projection due to unpredictability.

Source: JICA Project Team

HA	Water Demand (MCM/year) 2010	Water Demand (MCM/year) 2030
1	55.7	77.7
2	18.2	25.0
3	46.0	65.1
4	7.7	11.0
5	7.6	10.6
6	10.7	14.6
7	6.8	9.3
8	80.1	107.5
Total	**232.8**	**320.8**

Source: JICA Project Team

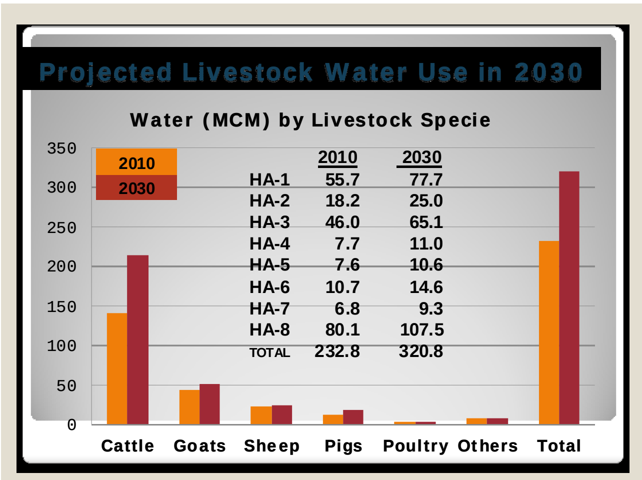


Figure 4-12 Water Demand of Livestock

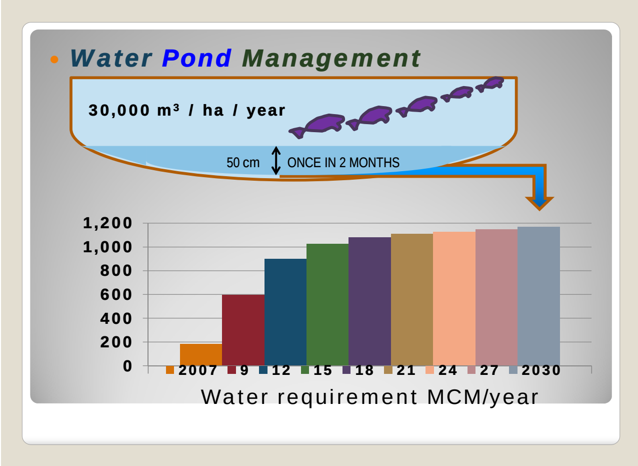
4.4.2 Freshwater Aquaculture

This sub-sector has recently been growing faster than ever supported by policy generated towards the application of subsidy for private facility development, and by rapid growth of domestic demand for fish. Southern states in HA-5 and HA-6 are center of this activity because many feed mills and fingerling hatcheries are available for fish farming.

The method for projecting future water demand for this subsector is based on the data in “Inventory of private and Government Fish Farms”. Water area in fish farms, summarized by fishery department of MFARD in 2007 was 6,126 ha, identified as the total area of fresh inland water. Fish yield per ha will grow from 1.4 t/ha in 2007 to 8.6 t/ha in 2030, then water surface area required for meeting future annual demand as projected for 2030 is estimated at 38,880ha, assuming this future yield. Water demand for inland fish farming will increase from 727.8 MCM in 2007 to 1,166.1 MCM in 2030.

About 80% of water demand will be met by groundwater, since it supplies suitable quality water with higher dissolved oxygen content for fish farming and relatively safer water than surface one that is often polluted.

HA	Water Demand (MCM/year)	
	2010	2010
1	17.9	28.6
2	35.6	57.0
3	17.5	27.9
4	22.4	35.8
5	158.3	253.7
6	315.4	505.2
7	66.5	106.8
8	94.2	151.1
Total	727.8	1,166.1



Source: JICA Project Team

Figure 4-13 Water Demand of Freshwater Aquaculture

4.4.3 Hydropower Generation

In Nigeria, stable supply of power is one of the key elements for national development. Hydropower generation can contribute to it, and is thereby being introduced.

Because water use by hydropower generation is basically non-consummative[5], total water quantity is not reduced by it. However, the flow regime can be altered in case of hydropower generation with storage dam. Even in case of run-of river type hydropower generation, it is possible that the reach with almost no flow can appear due to the intake flow that is introduced into the turbine off stream.

The optimum utilization of water for hydropower generation desired is on the condition that it would not inhibit other water uses such as municipal and irrigation in downstream reach.

4.4.4 Flood Control

Flood generally means the phenomena of rainwater stagnation or overflow from river channels in the area where it is usually dry, and flood control means controlling of such flooding to store rainfall and river water in ponds and reservoirs and/or to let river water flow downstream safely through man-made channel.

The water demand in urban and rural water supply, agriculture, fishery sectors means the water quantity required for such uses are calculated and quantified for natural river flow or groundwater. In the case of flood control, such water intakes and consumptive uses of water are not so common, and quantitative evaluation of water demand is not conducted.

However, flood control measures such as flood storage in multipurpose dam reservoir and rain water harvesting in arid area could contribute to water resources development. They should be considered in Nigeria in the future.

4.4.5 Inland Water Navigation

Inland Water Navigation is being developed to complement road transportation in Nigerian through appropriate policy initiatives. Since Inland water navigation is under the jurisdiction of NIWA in Federal Ministry of Transport, information on this sector is so limited that the water demand and discharge in navigation route cannot be addressed adequately. However, inland water navigation is one of the multi-modal transportation system composed of road, air and waterway in terms of the latest national policy. So the operation and maintenance of major rivers having navigation routes will be significant in Nigeria. Water demand in inland water navigation should therefore be evaluated comprehensively as part of river discharge for each river section when local water demand of other sectors on rivers are studied in detail.

4.4.6 Minimum Stream Flow Requirement

Aside from the water demand shown in the previous sections, the minimum stream flow should be

[5] In case of hydropower generation with storage dam, there is a loss due evaporation and so on, although it is generally small compared to total water resources.

kept as high priority in order to protect the environment of the water body or for other specific reasons. There is no official measure to determine the minimum stream flow requirement in Nigeria at the moment.

Since the Project is to formulate the national water resources master plan, the hydrological method to discuss the minimum stream flow would be applied[6]. There are many criteria for determining the minimum stream flow using the hydrological method. In the M/P2013, Q_{97DS}90%Y (90% yearly dependable 97 percentaile flow for a single year), which may represent the drought condition according to the flow regime in each area in Nigeria is applied. Similar parameter has been applied in UK. In UK, Q_{95D} (95percentaile flow for long-term multi-year) is usually used for the minimum stream flow requirement[4].

It should be noted that the minimum stream flow discussed in the M/P2013 could be used as a guide for the overall water resources planning and management. It may require more detailed study before a particular project is actually implemented, however. It is desirable that more appropriate minimum stream flow requirement for each of the rivers be set by discussion among stakeholders, when more reliable data of river conditions such as river discharge will be available.

[6] IUCN: Flow-The Essentials of Environmental Flows

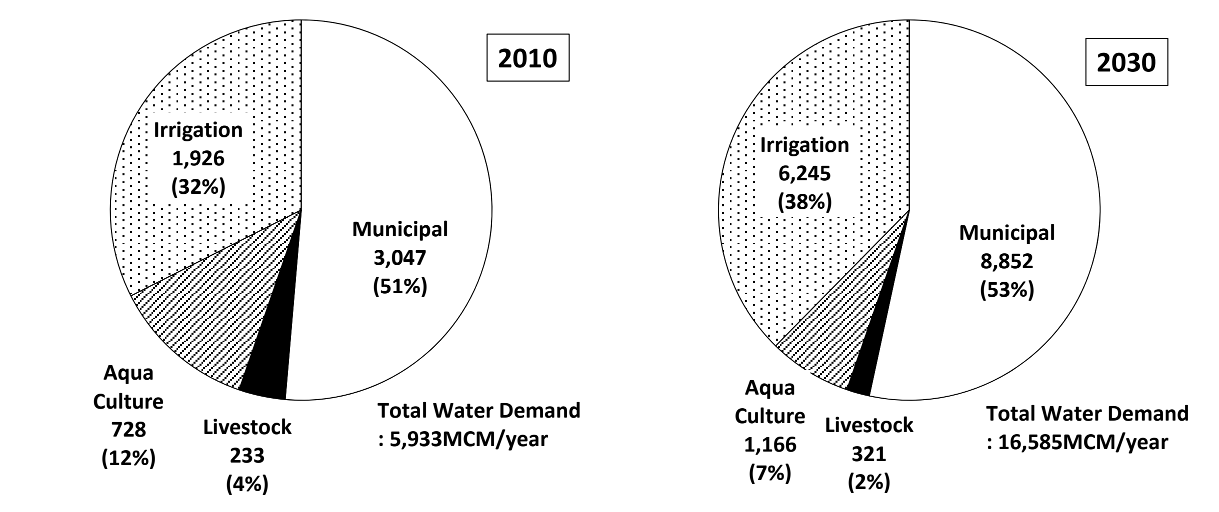
4.5 Water Demand Structure

The basic idea and the results of the water demand prediction are presented in the previous sections. In the present section, the water demand structure is discussed based on the following.

- For municipal water demand, which includes domestic, industrial and commercial water demand, the base case shown in Section 4.2 is applied. The demand in 2010 and 2030 are to be discussed.
- As for the municipal water demand, the demarcation between surface water and groundwater sources is estimated on the basis of existing condition and future plan for water supply facilities by state governments. The conveyance loss of 5% is additionally considered for surface water source. It is assumed that there is no conveyance loss in case of groundwater source.
- For other sub-sectors, irrigation, livestock and freshwater aquaculture in 2010 and 2030 are to be discussed.
- It is assumed that surface water source is mainly used in rainy season and groundwater source is utilized in dry season. The demarcation between surface water and groundwater sources is assumed to be 25:75.

The existing total water demand is estimated at 5.93 BCM/year. It is expected to increase to 16.58 BCM/year in 2030.

Figure 4-14 shows the share of water demand by each sector. The share of municipal water demand in 2010 and 2030 is about 50%. The share of irrigation water demand will increase from about 30% in 2010 to about 40% in 2030.

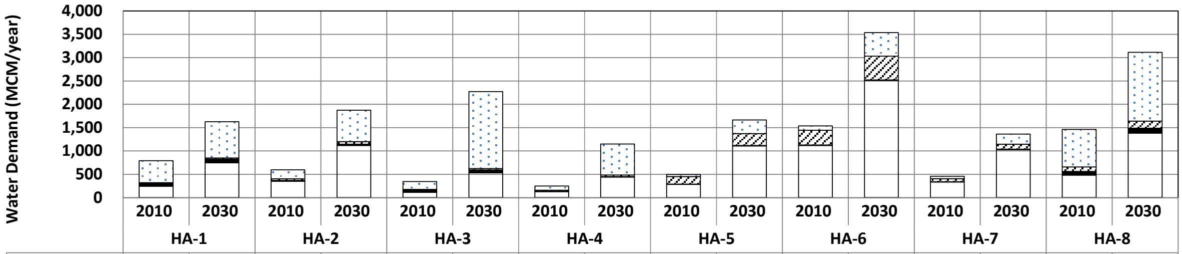


Source: JICA Project Team

Figure 4-14 Change in Share of Water Demand by Sectors

Figure 4-15 shows the water demand by each sector for each HA. From the figure, the followings are noted.

- Present municipal water demand is highest in HA-6, followed by HA-8. This will be maintained in the future (2030).
- Present total water demand is highest in HA-6, followed by HA-8. This will be maintained in the future (2030).
- The increasing rate of irrigation water demand in HA-3 is much larger than that in other HAs.



	HA-1 2010	HA-1 2030	HA-2 2010	HA-2 2030	HA-3 2010	HA-3 2030	HA-4 2010	HA-4 2030	HA-5 2010	HA-5 2030	HA-6 2010	HA-6 2030	HA-7 2010	HA-7 2030	HA-8 2010	HA-8 2030
Irrigation	471	774	191	672	169	1,650	94	661	48	293	96	507	49	215	808	1,473
AuqaCulture	18	29	36	57	17	28	22	36	158	254	315	505	67	107	94	151
Livestock	56	78	18	25	46	65	8	11	8	11	11	15	7	9	80	107
Municipal	246	745	350	1,118	113	527	126	439	282	1,106	1,116	2,510	333	1,027	481	1,381

Source: JICA Project Team

Figure 4-15 Water Demand by Sectors and by HAs

Table 4-32 shows the estimated municipal water demand by sources. The average ratio of surface water source to the total municipal water demand is estimated at about 24% in 2010 and would increase to about 33% in 2030.

Table 4-32 Estimated Municipal Water Demand by Sources

		HA-1	HA-2	HA-3	HA-4	HA-5	HA-6	HA-7	HA-8	Total
Present (2010)	**Total**	**246**	**350**	**113**	**126**	**282**	**1,116**	**333**	**481**	**3,047**
	Surface water	81	159	38	38	18	241	58	82	716
	Groundwater	164	190	75	88	265	875	275	398	2,330
Future (2030)	**Total**	**745**	**1,118**	**527**	**439**	**1,106**	**2,510**	**1,027**	**1,381**	**8,852**
	Surface water	162	476	131	147	181	1,242	189	359	2,888
	Groundwater	583	641	395	292	925	1,268	838	1,021	5,964

Unit: MCM/year
Source: JICA Project Team

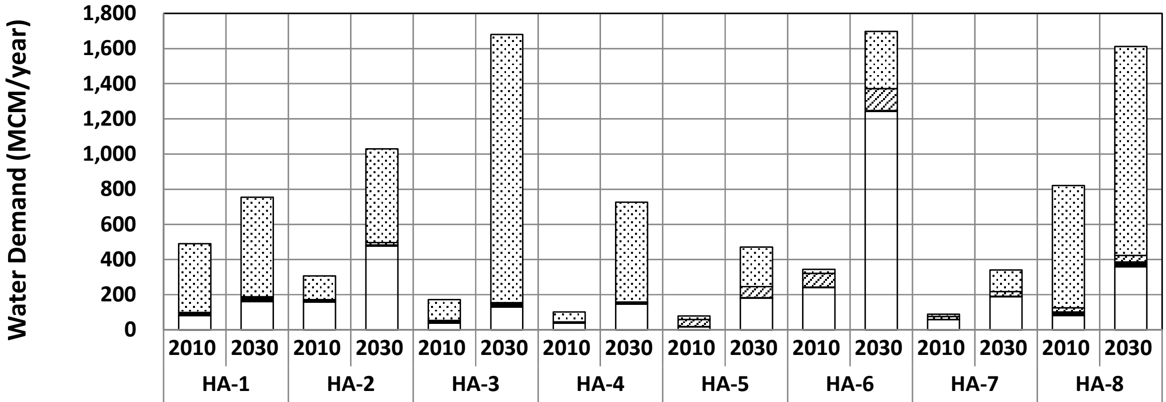
Table 4-33 summarizes the total water demand by sources. The average ratio of surface water source to the total water demand in the existing condition (2010) is estimated at about 40%. In the future (2030), the ratio would be increased to about 50%.

Table 4-33 Estimated Total Water Demand by Sources

		HA-1	HA-2	HA-3	HA-4	HA-5	HA-6	HA-7	HA-8	Total
Present (2010)	**Total**	**791**	**594**	**345**	**250**	**496**	**1,538**	**455**	**1,463**	**5,933**
	Surface water	489	307	172	102	79	345	89	820	2,403
	Groundwater	302	288	173	148	417	1,193	367	643	3,530
Future (2030)	**Total**	**1,625**	**1,872**	**2,270**	**1,147**	**1,663**	**3,537**	**1,359**	**3,113**	**16,584**
	Surface water	754	1,029	1,679	727	471	1,697	341	1,611	8,309
	Groundwater	871	843	591	420	1,192	1,840	1,018	1,502	8,276

Unit: MCM/year
Source: JICA Project Team

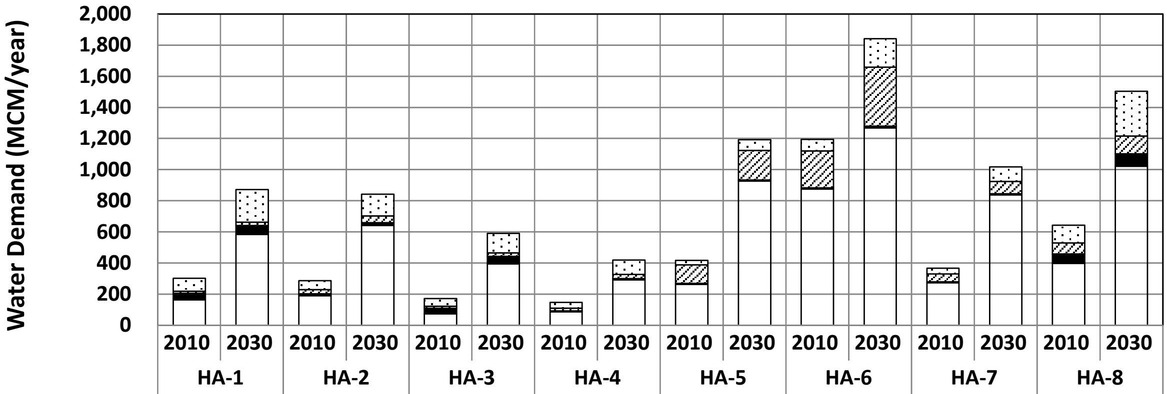
The water demand for surface water source by each sector for each HA and that for groundwater are presented in Figures 4-16 and 4-17, respectively.



	HA-1 2010	HA-1 2030	HA-2 2010	HA-2 2030	HA-3 2010	HA-3 2030	HA-4 2010	HA-4 2030	HA-5 2010	HA-5 2030	HA-6 2010	HA-6 2030	HA-7 2010	HA-7 2030	HA-8 2010	HA-8 2030
Irrigation	389	566	134	532	118	1,524	57	568	20	225	23	325	12	123	694	1,186
AquaCulture	4	7	9	14	4	7	6	9	40	63	79	126	17	27	24	38
Livestock	14	19	5	6	11	16	2	3	2	3	3	4	2	2	20	27
Municipal	81	162	159	476	38	131	38	147	18	181	241	1,242	58	189	82	359

Source: JICA Project Team

Figure 4-16 Water Demand for Surface Water Source



	HA-1 2010	HA-1 2030	HA-2 2010	HA-2 2030	HA-3 2010	HA-3 2030	HA-4 2010	HA-4 2030	HA-5 2010	HA-5 2030	HA-6 2010	HA-6 2030	HA-7 2010	HA-7 2030	HA-8 2010	HA-8 2030
Irrigation	82	209	57	140	51	126	37	93	28	68	73	182	37	92	114	287
AquaCulture	13	21	27	43	13	21	17	27	119	190	237	379	50	80	71	113
Livestock	42	58	14	19	34	49	6	8	6	8	8	11	5	7	60	81
Municipal	164	583	190	641	75	395	88	292	265	925	875	1,268	275	838	398	1,021

Source: JICA Project Team

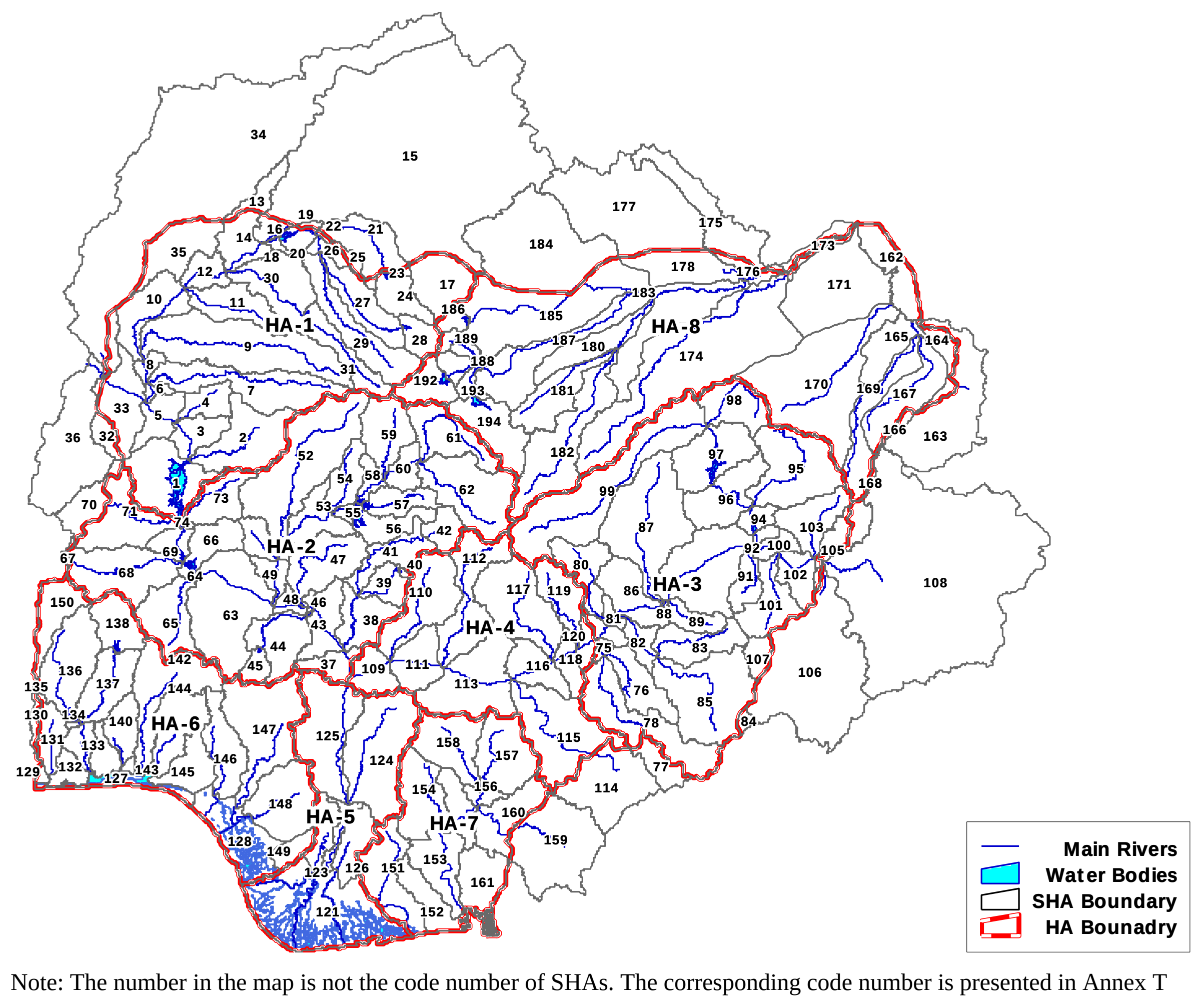
Figure 4-17 Water Demand for Groundwater Source

CHAPTER 5 EVALUATION OF WATER RESOURCES POTENTIAL

5.1 Catchment Delineation

The joint effort of NIHSA and JICA Project Team on the review of the catchment delineation has been made through the course of the project. The principles for delineation of Hydrological Area (HA, Sub Hydrological Area (SHA) and criteria for delineation of SHA have been discussed and agreed upon.

Major change from HAs prepared in M/P1995 appears in Katsina area. There are only minor changes for other areas. Totally, 168 related SHAs have been delineated, three (3) of which are located completely outside Nigeria. Some SHAs extend their areas to outside Nigeria. These SHAs are further sub-divided by national boundary of Nigeria, which results in 194 sub-divided SHAs in total. The aggregation of the portion of SHAs inside Nigeria for specific HA coincides with the HA boundary. The delineated SHAs are shown in Figure 5-1.



Note: The number in the map is not the code number of SHAs. The corresponding code number is presented in Annex T SR2-1, Section SR2.1, Volume-5 Supporting Report.
Source: JICA Project Team

Figure 5-1 Delineated Boundary of Sub Hydrological Areas (SHAs)

The delineation of catchment (HA and SHA) was mainly based on the desk research working on available information and data which have certain limitation of accuracy and spatial resolution. Considering the data source utilized, the spatial resolution of delineation could be as good as the order of 1/100,000 scale maps. The field verification was also limited for this work because of the limited resources and current security condition in Nigeria. Therefore, in the future, it could be modified by NIHSA when verified by field work or more accurate information and data.

The detail of catchment delineation is described in Section SR2.1, Volume-5 Supporting Report.

5.2 Meteorological Condition

There are two available sources of meteorological data. One is the internal dataset available in Nigeria, and another is the global dataset. The former is mainly managed by NIMET, that is, the agency responsible for meteorological observation in Nigeria. The latter is available on relevant web-sites. Table 5-1 summarizes the advantage and disadvantages of these data.

Table 5-1 Advantage and Disadvantage of Available Meteorological Data

Data Source	Data Manager	Summary	Advantage	Disadvantage
NIMET Synoptic Stations	NIMET	- Long-term observed data with reliable observation system - Require cost for obtaining the data. NIMET recommended 27 priority synoptic stations with important parameters including daily precipitation for last 30years	- Most reliable and official information - Daily precipitation available	- Only point observation data with 27 points are offered. - Costly for obtaining full dataset
CRU-TS 3.1[1]	BADC	- Gridded monthly data based on observed data by meteorological agencies in each country. - Often used for climate-related study - Grid size = 0.5degree - Duration= 1901-2009 - Freely available from web-site	- Monthly time series data with medium spatial resolution - Data outside Nigeria are also available - No cost	- Effect of altitude not considered
Worldclim[2]	Robert J. Hijiman	- Gridded long-term averaged (1950-2000) monthly precipitation and air temperature based on observed data with correction for altitude - Grid size = 0.5, 2.5, 5.0 and 10 minutes - Freely available from web-site	- High spatial resolution with consideration of effect of altitude - Data outside Nigeria are also available - No cost	- Only long-term averaged value available
GSMaP[3]	JAXA	- Gridded daily/hourly precipitation data based on satellite information such as TRMM - Grid size = 0.25 degree - Duration =1998-2006 - Freely available from web-site	- High resolution in time and medium resolution in space - Data outside Nigeria are also available - No cost	- Bias correction could be required before using them - Only recent data are available

NIMET: Nigerian Meteorological Agency, BADC: British Atmospheric Data Centre, JAXA: Japan Aerospace Exploration Agency
Source: JICA Project Team

Considering the advantage and disadvantage of meteorological data from these sources, the following strategies on the usage of these data are set in the present project.

- For the long-term analysis on assessment of availability of water resources covering entire country and the related surrounding catchment areas, the gridded (2.5minites) monthly precipitation, air temperature and potential evapotranspiration (PET) are prepared based on CRU-TS3.1 and Worldclim. The duration of dataset prepared is 51years from 1959 to 2009.
- Point observation data for daily precipitation by NIMET may be used for checking precipitation pattern within a month as well as frequency analysis for short-term heavy precipitation events for assessing overall flood condition.
- The data from GSMaP could be used for flood analysis for limited and specific pilot areas where the necessary information is available aside from precipitation data for the flood analysis, if necessary. It should be noted that GSMaP is available only after 1998.

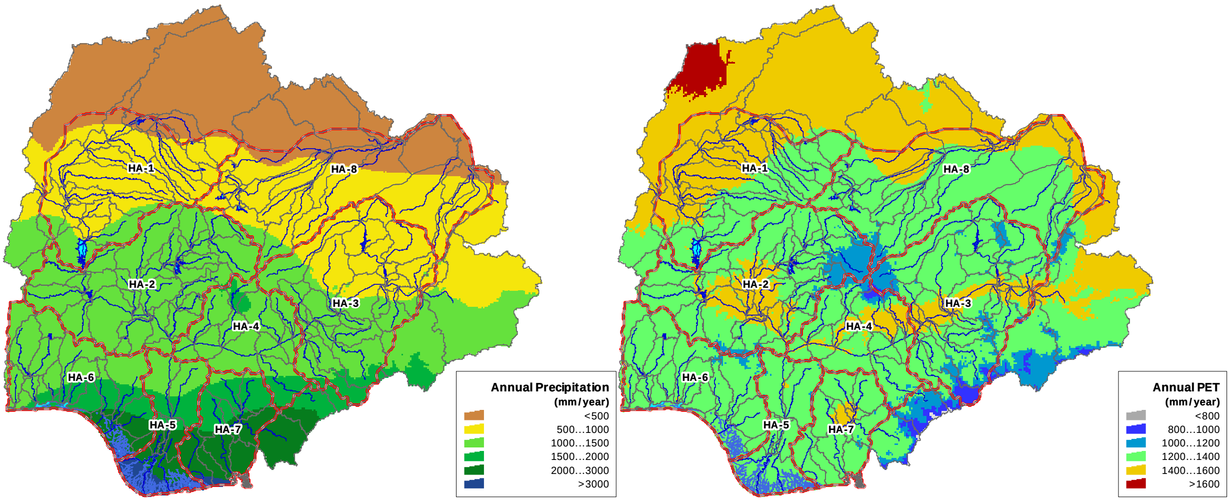
On the basis of the prepared gridded (2.5minites) monthly precipitation, air temperature and potential evapotranspiration (PET)[4], the annual precipitation and annual mean air temperature in Nigeria in the

[1] University of East Anglia Climatic Research Unit (CRU). [Phil Jones, Ian Harris]. CRU Time Series (TS) high resolution gridded datasets, [Internet]. NCAS British Atmospheric Data Centre, 2008. Available from http://badc.nerc.ac.uk/view/badc.nerc.ac.uk__ATOM__dataent_1256223773328276

[2] Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Available from http://www.worldclim.org/

[3] http://sharaku.eorc.jaxa.jp/GSMaP_crest/index.html

last 40 years (1970-2009) are estimated at 1,150mm/year and 26.6degree Celsius on average, respectively. Figure 5-2 shows the spatial pattern of annual precipitation and PET over the country. The annual precipitation varies from over 3,000mm in Niger delta area to about 400mm in the most northern part of the country. The annual PET is affected by altitude. In the high elevation areas along the country border in the south-east as well as around Jos, the annual PET becomes small. Table 5-2 summarizes the spatially averaged annual precipitation, annual mean air temperature and annual PET for each HA.



Note: Average in 1970-2009 (40years)
Source: JICA Project Team

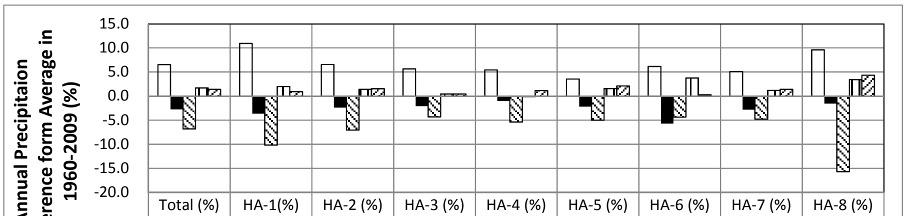
Figure 5-2 Spatial Patterns of Annual Precipitation and Annual PET

Table 5-2 Spatially Averaged Annual Precipitation, Annual Mean Air Temperature and Annual PET for Each HA

	Entire country	HA-1	HA-2	HA-3	HA-4	HA-5	HA-6	HA-7	HA-8
Annual P (mm/year)	1,148	767	1,170	1,055	1,341	2,132	1,541	2,106	610
Annual Mean T (degree Celsius)	26.6	27.4	16.5	26.0	26.8	26.7	26.5	26.9	26.5
Annual PET (mm/year)	1,337	1,419	1,318	1,290	1,338	1,325	1,314	1,338	1,347

P:Precipitation, T:Air Temperature, PET: Potential Evapotranspiration
Source: JICA Project Team

The annual precipitation for the entire country tends to slightly decrease in the last 50years, and the rate is -1.7% in 50years. The annual mean air temperature for the entire country tends to increase with +3.0% in 50years.



	Total (%)	HA-1(%)	HA-2 (%)	HA-3 (%)	HA-4 (%)	HA-5 (%)	HA-6 (%)	HA-7 (%)	HA-8 (%)
1960s	6.5	10.9	6.6	5.7	5.4	3.5	6.2	5.1	9.6
1970s	-2.8	-3.6	-2.4	-2.1	-1.0	-2.2	-5.7	-2.8	-1.6
1980s	-6.8	-10.2	-7.1	-4.4	-5.4	-5.0	-4.4	-4.8	-15.7
1990s	1.7	2.0	1.4	0.4	-0.1	1.6	3.7	1.2	3.4
2000s	1.4	0.9	1.5	0.4	1.1	2.1	0.2	1.4	4.3

Source: JICA Project Team

Figure 5-3 Variation of Annual Precipitation by Decades

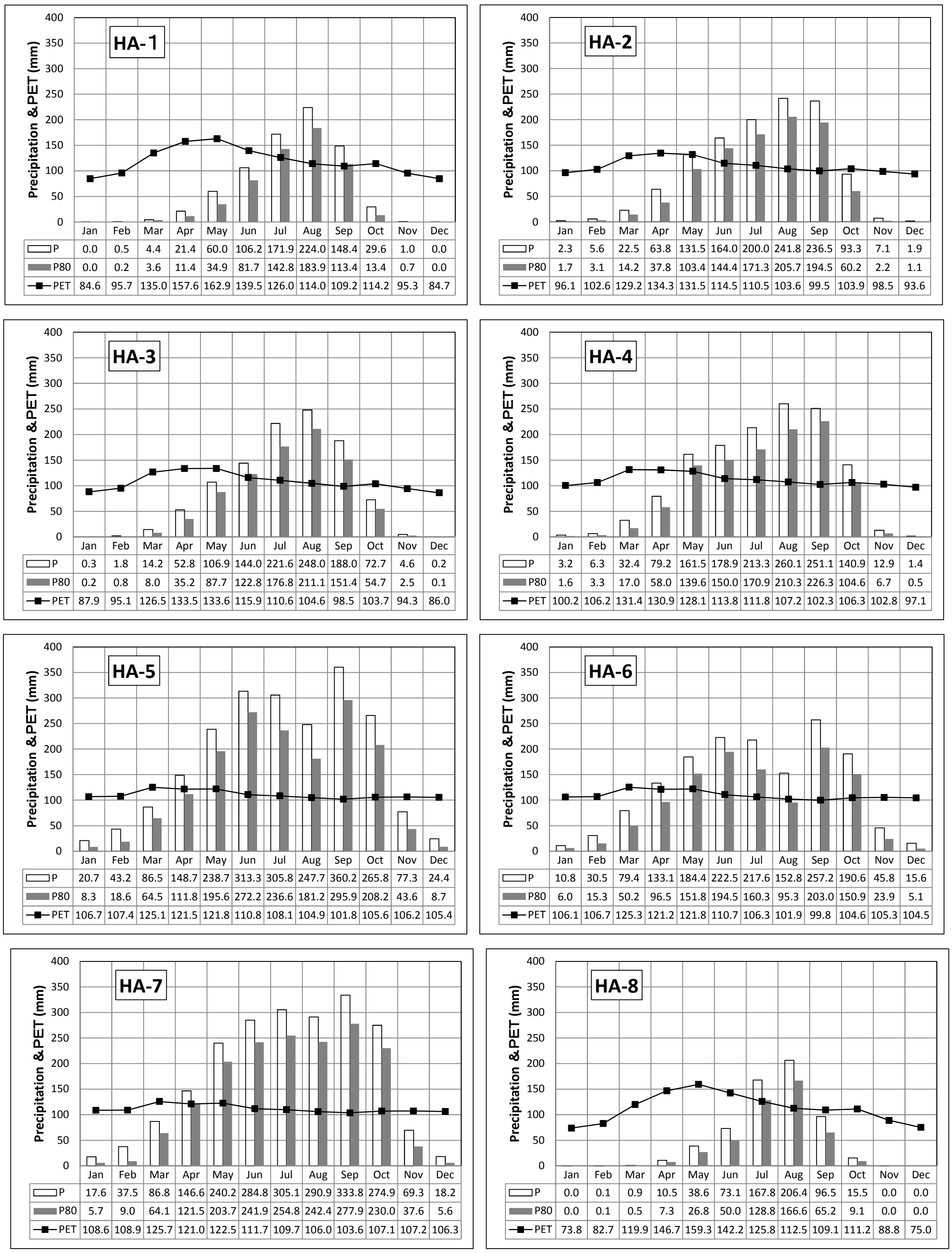
Figure 5-3 shows the variation of annual precipitation by decades. One can see that 1960s was

[4] Hamon method has been applied for estimating PET. (Hamon, W.R.: Estimating potential evapotranspiration, Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers, v. 87, p. 107–120, 1961.)

relatively wet (more precipitation) and 1970s-1980s was dry (less precipitation). 1990s-2000s became wet periods again. The magnitude of the fluctuation is much larger than the linear change rate of annual precipitation in 50years. On the other hand, annual mean air temperature has been increasing almost constantly without large fluctuation over five (5) decades.

The seasonal variation of precipitation and PET for each HA is presented in Figure 5-4. In the figure, 80% dependable precipitation for each month as well as average monthly precipitation and PET are presented. There are clear dry and wet seasons in a year for the entire country, although there are two peaks of precipitation in a year in the southern HAs such as HA-5, 6 and 7. In the northern HAs, there is almost no precipitation during dry season.

The detail of meteorological data is described in Section SR2.2, Volume-5 Supporting Report.



HA-1

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
P	0.0	0.5	4.4	21.4	60.0	106.2	171.9	224.0	148.4	29.6	1.0	0.0
P80	0.0	0.2	3.6	11.4	34.9	81.7	142.8	183.9	113.4	13.4	0.7	0.0
PET	84.6	95.7	135.0	157.6	162.9	139.5	126.0	114.0	109.2	114.2	95.3	84.7

HA-2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
P	2.3	5.6	22.5	63.8	131.5	164.0	200.0	241.8	236.5	93.3	7.1	1.9
P80	1.7	3.1	14.2	37.8	103.4	144.4	171.3	205.7	194.5	60.2	2.2	1.1
PET	96.1	102.6	129.2	134.3	131.5	114.5	110.5	103.6	99.5	103.9	98.5	93.6

HA-3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
P	0.3	1.8	14.2	52.8	106.9	144.0	221.6	248.0	188.0	72.7	4.6	0.2
P80	0.2	0.8	8.0	35.2	87.7	122.8	176.8	211.1	151.4	54.7	2.5	0.1
PET	87.9	95.1	126.5	133.5	133.6	115.9	110.6	104.6	98.5	103.7	94.3	86.0

HA-4

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
P	3.2	6.3	32.4	79.2	161.5	178.9	213.3	260.1	251.1	140.9	12.9	1.4
P80	1.6	3.3	17.0	58.0	139.6	150.0	170.9	210.3	226.3	104.6	6.7	0.5
PET	100.2	106.2	131.4	130.9	128.1	113.8	111.8	107.2	102.3	106.3	102.8	97.1

HA-5

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
P	20.7	43.2	86.5	148.7	238.7	313.3	305.8	247.7	360.2	265.8	77.3	24.4
P80	8.3	18.6	64.5	111.8	195.6	272.2	236.6	181.2	295.9	208.2	43.6	8.7
PET	106.7	107.4	125.1	121.5	121.8	110.8	108.1	104.9	101.8	105.6	106.2	105.4

HA-6

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
P	10.8	30.5	79.4	133.1	184.4	222.5	217.6	152.8	257.2	190.6	45.8	15.6
P80	6.0	15.3	50.2	96.5	151.8	194.5	160.3	95.3	203.0	150.9	23.9	5.1
PET	106.1	106.7	125.3	121.2	121.8	110.7	106.3	101.9	99.8	104.6	105.3	104.5

HA-7

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
P	17.6	37.5	86.8	146.6	240.2	284.8	305.1	290.9	333.8	274.9	69.3	18.2
P80	5.7	9.0	64.1	121.5	203.7	241.9	254.8	242.4	277.9	230.0	37.6	5.6
PET	108.6	108.9	125.7	121.0	122.5	111.7	109.7	106.0	103.6	107.1	107.2	106.3

HA-8

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
P	0.0	0.1	0.9	10.5	38.6	73.1	167.8	206.4	96.5	15.5	0.0	0.0
P80	0.0	0.1	0.5	7.3	26.8	50.0	128.8	166.6	65.2	9.1	0.0	0.0
PET	73.8	82.7	119.9	146.7	159.3	142.2	125.8	112.5	109.1	111.2	88.8	75.0

Note: P80=80% dependable monthly precipitation, Duration of date used =1970-2009 (40years)
Source: JICA Project Team

Figure 5-4 Seasonal Variation of Precipitation and PET

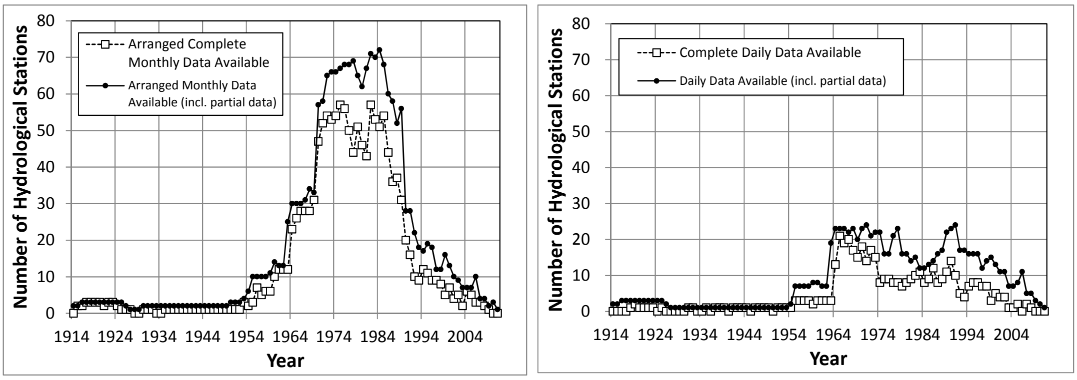
5.3 Surface Water Resources

5.3.1 Available Hydrological Data

In the present project, the available hydrological data have been collected in collaboration with NIHSA. By integrating the collected hydrological data, the data for monthly discharge at 101 stations are arranged. The followings can be observed on the availability of the data through the inventory list of the hydrological data. The detail of hydrological data is described in Section SR2.3.1, Volume-5 Supporting Report.

- Along the Niger River and Benue River as well as Hadejia-Jammare-Komadugu-Yobe River system, long-term daily discharge data are available in general. However, many of them are strongly affected by operation of significant storage dams.
- For other areas, only monthly data for limited time periods are available in general.
- For the stations along Niger River and Benue River outside Nigeria, only monthly data are available.
- For HA-6, available discharge data are very limited.

Figure 5-5 shows the change in number of hydrological stations with available monthly and daily data. The number of stations with available hydrological data was highest from 1970s to 1980s. However, after 1980s the number gradually decreases.



Source: JICA Project Team

Figure 5-5 Change in Number of Hydrological Stations with Available Data

5.3.2 Surface Water Resources Potential in Quasi-Natural Condition

It is always better to use directly observed data, if they are available and their quality is good. However, in the present project there are not enough discharge data in terms of space and time for proper assessment of water resources. Furthermore, the observed data at many stations are disturbed by operation of large dams. A long-term rainfall-runoff simulation model has been introduced in order to obtain supplemental information on runoff condition in space and time, especially for the quasi-natural condition[5] without effect of the large storage dams. The model can also be used for exploring the effect of climate change on runoff.

In the present project, a monthly-basis soil-moisture accounted model, which is called the Thornthwaite monthly water balance model[6] has been selected and were applied with semi-distributed manner[7,8,9] in a catchment for the long-term rainfall-runoff model. The model parameters are

5 It is not possible for us to know actual natural condition which has no influence of human activity. The quasi-natural condition is defined as the condition without influence of significant storage dams and abstraction in the present project.

6 G.J. McCabe and S.L. Markstrom: A Monthly Water-Balance Model Driven by a Graphical User Interface, USGS Open-File Report 2007-1088, 2007.

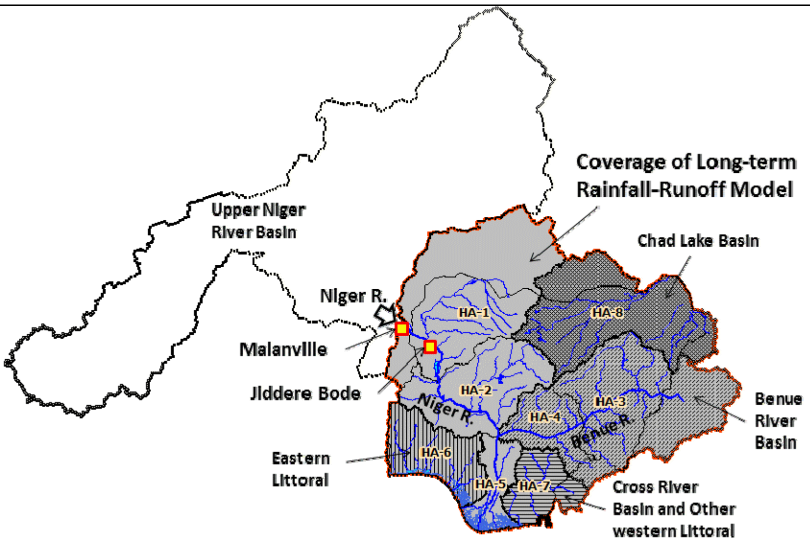
7 Moore, J.W. Trubilowicw and J.M. Buttle: Prediction of Streamflow Regime and Annual Runoff for Ungauged Basins using a Distributed Monthly Water Balance Model, J. of the American Water Resources Association, Vol.48, No.1, pp.32-42, 2012.

8 C. Gregory Knight, Heejun Chang, Marieta P. Staneva & DeyanKostov : A Simplified Basin Model For Simulating Runoff: The Struma River GIS,The Professional Geographer, 53:4, 533-545, 2001

9 FAO: Water Resources and irrigation in Africa, available from http://www.fao.org/nr/water/aquastat/watresafrica/index4.stm

calibrated against the observed discharge at the selected hydrological stations. The detail of long-term rainfall-runoff simulation is described in Section SR2.3.3, Volume-5 Supporting Report.

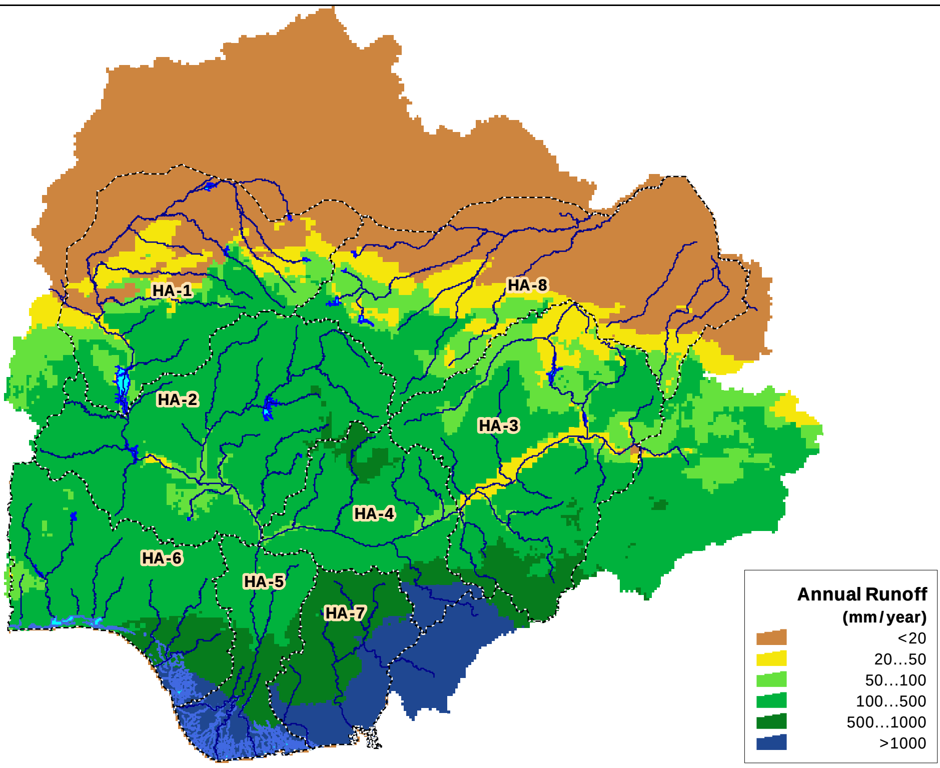
The simulated results are used for estimation of surface water resources potential in quasi-natural condition. The simulated results cover the entire Benue river basin, the Niger river basin in the downstream catchment from Malanville in Benin, and other catchment areas whose generated runoff come into Nigeria (see Figure 5-6). To estimate surface water resources potential comprehensively, it is necessary to give the discharge at Malanville as a boundary condition. The observed discharge at Malanville is available after 1970s. Therefore, it is decided to analyze the simulated runoff from 1970 to 2009 (40years), although the rainfall-runoff simulation was conducted from 1960 to 2009 (50years).



Source: JICA Project Team

Figure 5-6 Coverage Area of Long-term Rainfall-Runoff Simulation Model

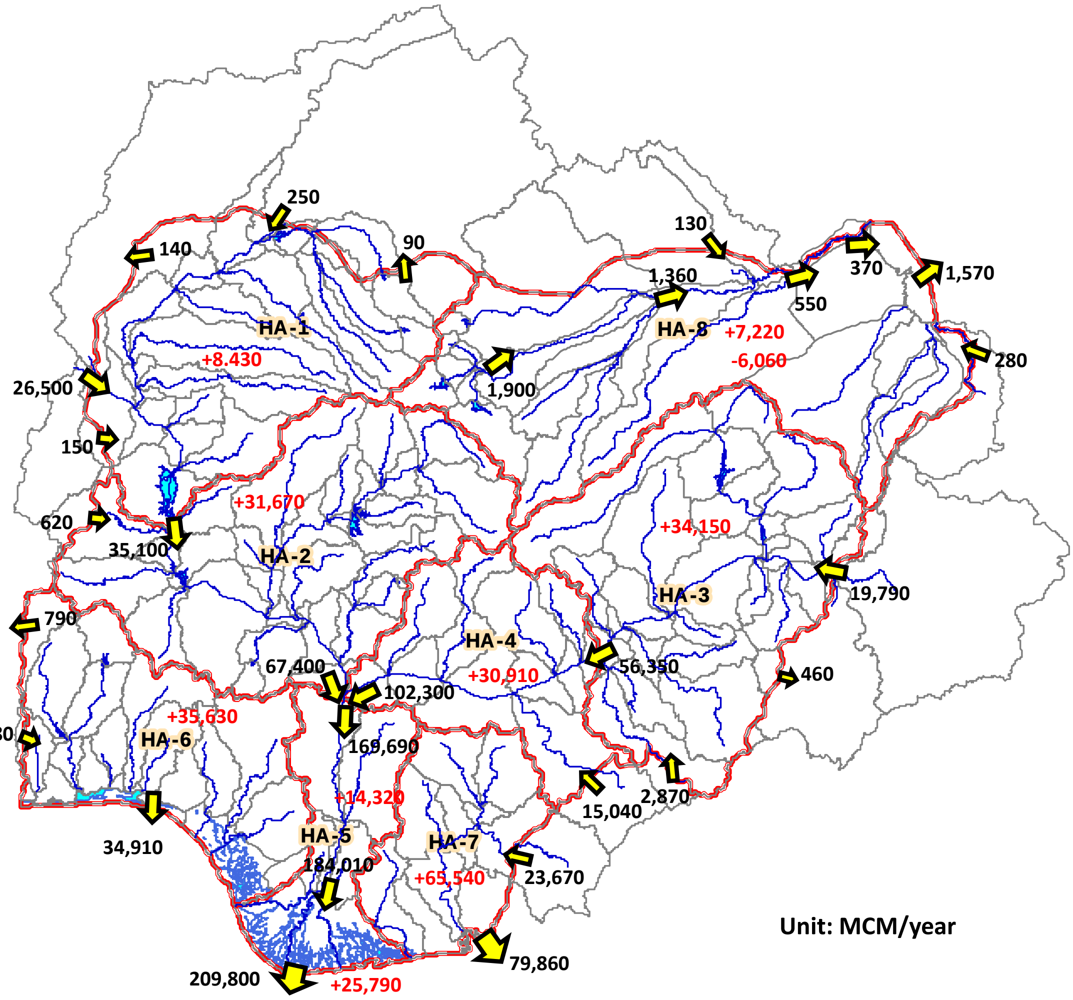
Figure 5-7 shows spatial distribution of the average annual runoff yield. The average annual runoff yield (height) varies significantly across the county. In the most northern part of the county, the runoff yield is less than 20mm/year, whereas it becomes more than 1,000mm/year in the southern end.



Note: Duration of data used =1970-2009 (40years)
Source: JICA Project Team

Figure 5-7 Spatial Distribution of Average Annual Runoff Yield

Figure 5-8 shows the long-term averaged water balance in terms of annual total runoff volume across Nigeria.



- At the Niger-Nigeria border along Niger River., the average inflow volume is estimated at 26,500MCM/year. The total annual runoff volume at the HA-1 and HA-2 border becomes 35,100MCM/year by adding the runoff from HA-1. At the outlet of HA-2, it increases to 67,400MCM/year, and after merging with Benue River the total runoff reaches to 169,690MCM/year.
- The Benue River and its tributaries provide larger runoff volume than that in Niger River itself, which is 102,300MCM/year at the confluence with Niger River. The inflow from Cameroon in the Benue River system is also large; 19,790MCM/year through the main channel of Benue River, 2,870MCM/year from upper Donga River, 15,040MCM/year from upper Katsina-Ala River.
- The total annual runoff volume from Cross River and other catchment in HA-7 reaches to 79,860MCM/year, 23,670MCM/year of which is provided from the territory of Cameroon.
- In the delta areas in HA-5, the total annual runoff volume is estimated at 25,790MCM/year. It is considerably large volume.
- In HA-8, the total generated runoff is estimated at 7,220MCM/year. However, only 1,570MCM/year reaches to the outlet of HA-8 that is Lake Chad, due to large amount of loss in the large wetland area along the river system.

Note: Duration of data used =1970-2009 (40years)
Source: JICA Project Team

Figure 5-8 Long-term Average Water Balance in terms of Annual Total Runoff Volume

Table 5-3 summarizes the comparison between the estimation of surface water resources potential in M/P1995 and that in the present project. The total water resource potential in the present project is evaluated slightly higher than that in M/P1995. This difference may be caused by the difference in the basis for the estimations as shown below.

- M/P1995: Observed discharge data during 1970s to 1980s (20years at most)
- Present Project: Simulated discharge during 1970-2009 (40years), on the basis of the calibration using the observed discharge

Considering that 1990s-2000s are relatively wet periods, the slight increase of the evaluated surface water resources potential is understandable.

Table 5-3 Comparison between Surface Water Resources Potential Evaluated in M/P1995 and that in the Present Project

Hydrological Area	Estimated Surface Water Potential		Remarks
	M/P1995 (MCM/year)	This Project (MCM/year)	
HA-1	22,400	35,100	Outlet of HA-1, including water from outside of Nigeria
HA-2	32,600	32,300	Outlet of HA-2, including water from outside of Nigeria
HA-3 & 4	83,000	102,300	Outlet of HA4,including water from outside of Nigeria
HA-5 & 7	85,700*	94,180*	Including water from outside of Nigeria *Delta area in HA-5 (25,800MCM/year) is excluded.
HA-6	35,400	35,700	
HA-8	8,200*	7,200** (1,600)***	*Not outlet of HA-8, but the sum of available water at key stations **Sum of runoff yield excluding loss along rivers ***Outlet of HA-8
Total	267,300	306,780* (301,180)**	*Excluding delta area in HA-5 (25,800MCM/year) **In case that water resources potential in HA-8 is 1,400MCM/year.

Source: M/P1995 and JICA Project Team

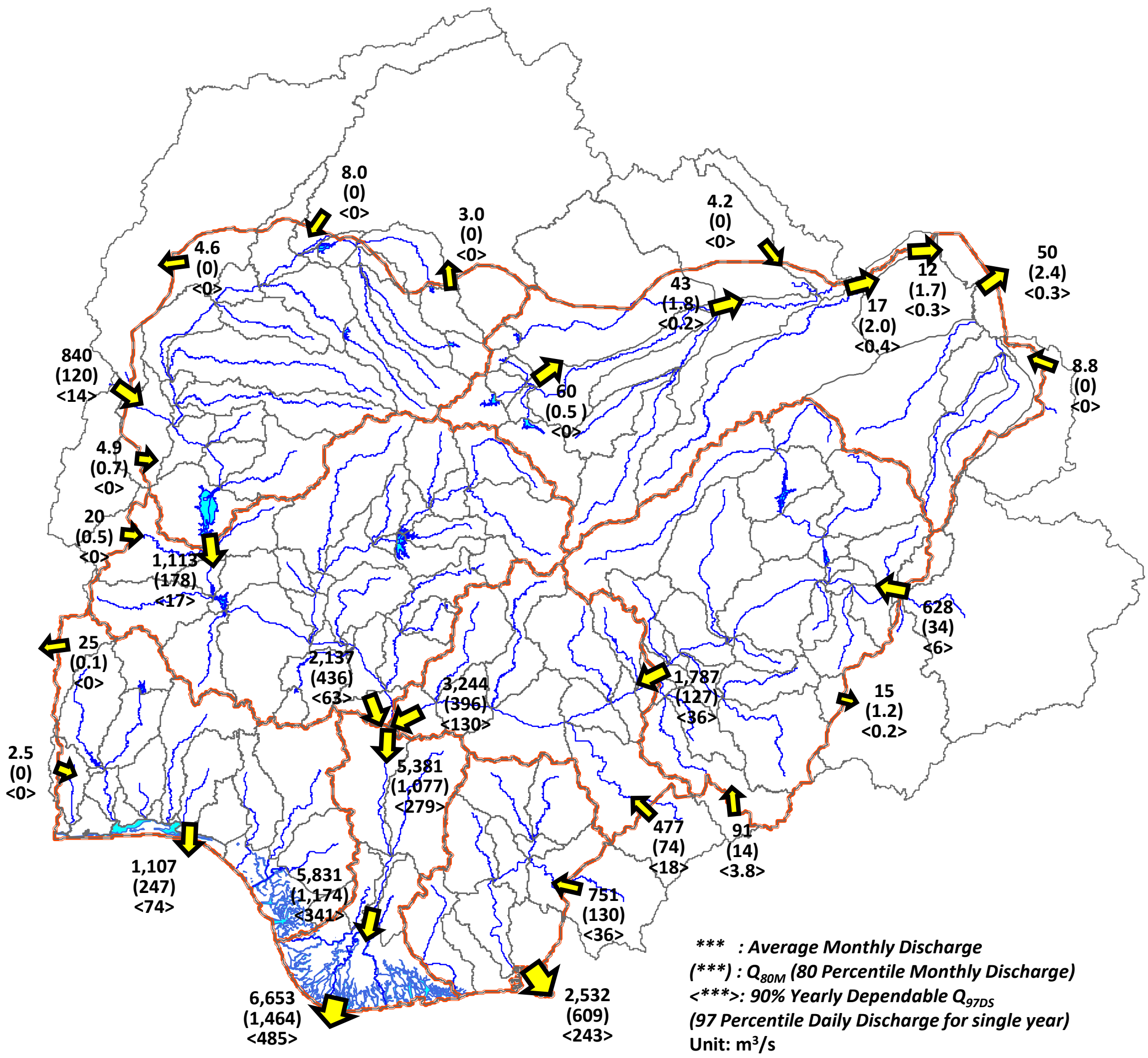
5.3.3 Available Surface Water Resources in Quasi-Natural Condition

There are clear dry and wet seasons in Nigeria. The usable water in dry season with stable manner is much smaller than the annual average discharge in quasi-natural condition. In order to evaluate the stably usable surface water in quasi-natural condition, the following indicators were computed at the representative points. The computed values are presented in Figure 5-9.

- Q_{80M}
  - 80% monthly discharge, [suffix M means that the value is based on monthly data].
  - This can be directly calculated from the simulated runoff.
- Q_{97DS}90%Y
  - 90% yearly dependable Q_{97DS} (Q_{97DS}: 97 percentile daily discharge for a single year, which is usually called as drought discharge, [suffix d represents daily, suffix s represents single year])
  - This indicator represents a drought condition of river flow.

The Q_{80M} is large in the central and southern areas such as Benue River and its tributaries, Cross River, which means that there is relatively high discharge in low flow condition. In the northern area, the Q_{80M} is almost zero, which shows much less low flow discharge.

The Q_{97DS}90%Y is 2-5% of average discharge in the central and southern areas in general. However, in the northern part of the country, it is almost zero in many places, which means that there is almost no stably usable water throughout the year in quasi-natural condition. In the northern area, it is inevitable to install storage dams for stable use of surface water throughout the year.



Note: Duration of data used =1970-2009 (40years)
Source: JICA Project Team

Figure 5-9 Average Discharge, Q_{80M} and Q_{97DS}90%Y

5.3.4 Effect of Climate Change on Runoff

In order to explore the possible change in climate conditions in future, the statistically downscaled output of GCMs, which is provided by CCAFS[10], are analyzed. The statistical downscaling as well a bias correction was conducted utilizing the spatial distribution of parameters provided by Worldclim dataset. The downscaled data for A1B scenario with grid scale of 10 minute are spatially averaged for each HA and other related catchment areas outside Nigeria for further analysis.

Although the outputs of the GCMs for precipitation are scattered, their average and standard deviation are computed. The following is noted from the figure.

- In general, the average change among the different outputs from the GCMs is much smaller than the standard deviation. This indicates that there is a lot of uncertainty on the change in precipitation.
- For all HAs, the precipitation tends to decrease during MAM (March, April, May) and increase during JJA (June, July, August) and SON (September, October, November).
- For the southern areas such as HA-5,-6 and-7, the precipitation tends to decrease during DJF (December, January, February), whereas it tends to increase in the central and northern areas.
- These tendencies could bring about drier dry season and wetter wet season, especially in the southern area.

[10] Ramirez, J.; Jarvis, A. 2008. High Resolution Statistically Downscaled Future Climate Surfaces. International Center for Tropical Agriculture (CIAT); CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Cali, Colombia. Data are available from web-site of CCAFS http://www.ccafs-climate.org/

- The rate of change increases gradually with time in general, which amplifies the initial direction of change.

As for the air temperature derived from outputs of the GCMs, the following is noted from the figure.

- In general, the average change among the different outputs from the GCMs is much larger than the standard deviation. This indicates that there is certain change in air temperature.
- The changes are almost same for all HAs and all seasons.
- The rate of change increases gradually with time.

In order to assess the effect of climate change on runoff, the scenarios for change in precipitation and air temperature are set as shown in Table 5-4, based on the output from the GCMs. The target year is set at 2050 and the outputs of GCMs for 30years around 2050 are utilized for setting the scenario.

The long-term rainfall-runoff simulation model was utilized for estimating the effect of the change in precipitation and air temperature on runoff. In the simulation, only the precipitation and PET were modified, based on the scenarios shown in Table 5-4.

The response of internal annual runoff volume, which is generated within the country, to the change in precipitation and air temperature, on the basis of the simulated results, are summarized as follows.

- The expected change in air temperature could bring about the reduction of annual runoff with about 20% (Case-1).
- The response of runoff against the expected change in precipitation is more sensitive in the area with less precipitation. It could mitigate the impact of the expected change in air temperature in the northern area (Case-2).
- The decreasing rate of 80, 90% dependable annul runoff volume is larger than that of the average runoff volume in general, which indicates that drought condition would become severer.

Table 5-4 Scenarios for Change in Precipitation and Air Temperature

Case	Item	Season	HA-1	HA-2	H-3	HA-4	HA-5	HA-6	HA-7	HA-8	HA-1e	HA-3e	HA-8e
1	P (%)	ANN	0	0	0	0	0	0	0	0	0	0	0
	T (°C)	ANN	+2.5	+2.4	+2.4	+2.3	+2.1	+2.2	+2.2	+2.5	+2.6	+2.4	+2.5
2	P (%)	DJF	+1.1	+0.9	+3.3	+2.7	-8.3	-3.2	-2.6	+12.3	+4.7	+10.0	+33.3
		MAM	-0.5	-4.3	-2.8	-4.2	-6.3	-7.5	-3.2	-0.5	+0.7	-2.2	+0.6
		JJA	+5.3	+3.2	+3.4	+3.4	+3.2	+1.9	+6.0	+7.9	+9.7	+2.8	+12.5
		SON	+7.6	+4.2	+5.2	+1.8	+1.9	+2.3	+4.0	+7.6	+13.1	+5.2	+11.8
	T (°C)	ANN	+2.5	+2.4	+2.4	+2.3	+2.1	+2.2	+2.2	+2.5	+2.6	+2.4	+2.5

Remarks:
1) P = Precipitation, T=Air Temperature
2) HA-1e: Catchment area outside Nigeria whose runoff comes into HA-1, HA-3e: Catchment area outside Nigeria whose runoff comes into HA-3, HA-8e: Catchment area outside Nigeria whose runoff comes into HA-8
3) DJF= December, January, February, MAM=March, April, May, JJA=June, July, August, SON= September, October, November, ANN=Annual

Source: JICA Project Team

The detail of effect of climate change on runoff is described in Section SR2.3.5, Volume-5 Supporting Report.

5.3.5 Surface Water Quality

It is difficult to assess the general condition of surface water quality in Nigeria, because no systematic water quality monitoring and analysis is implemented. The current water quality monitoring being implemented by the Water Quality Laboratories of FMWR is conducted poorly for proper water quality assessment of watercourses in Nigeria, due to financial constraints. A few studies performed were conducted on ad-hoc basis or on the request of some governmental institutions or in the frame of EIA of some projects.

Based on the draft report on Data Gathering for Development of Baseline Data for Water Quality Laboratory and Monitoring, which was recently implemented by the request the FMWR, Department of Water Quality and Sanitation, the following preliminary findings are noted.

- For the northern area of the country, generally the water quality of rivers is good in the wet season judging from the fact that the concentration of BOD and DO are maintained within the standards to support aquatic living environment. However, the water quality of rivers tends to be diminished in the dry season which is attributable, among other reasons, to the lower self-purification efficiency due to the low flow of the water courses.

- For the southern area of the country, generally the water quality of rivers is good both in the wet season and dry season judging from the fact that the concentration of BOD and DO are maintained within the standards to support aquatic living environment. This is attributable, among other reasons, to the higher rain pattern in the zone that helps to maintain the self-purification efficiency of the water courses.
- Presence of heavy metals had been detected in some rivers that call for further water monitoring research in order to understand their causes and to promote a sound management of the water quality of those affected rivers.
- Some found values in some rivers needs to be confirmed to assess their quality.

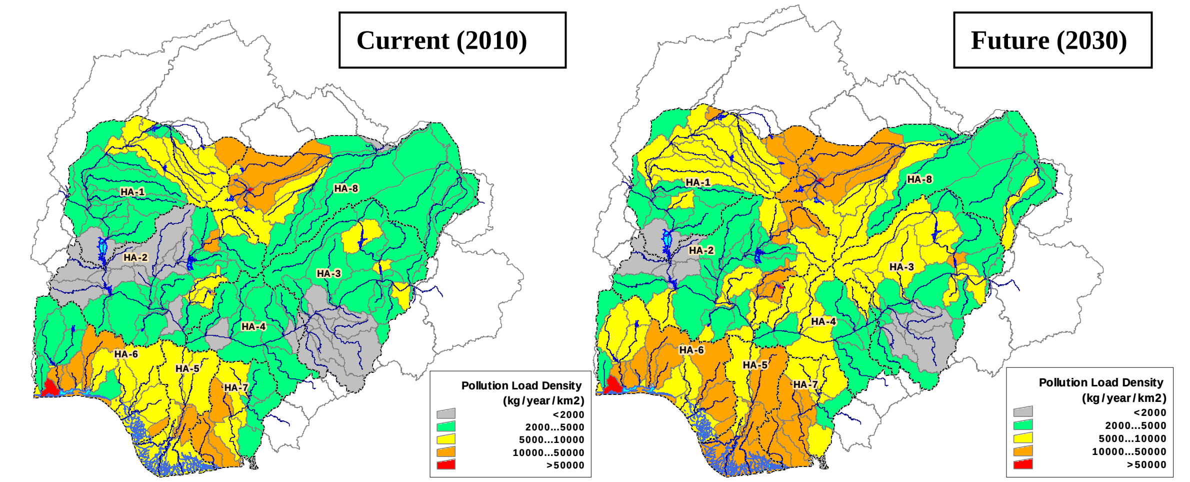
It should be noted that these preliminary findings are based on the monitoring data obtained only two times (one in wet season, another in dry season). Continuous monitoring is strongly recommended to assess current situation of water quality.

In Nigeria, the treatment of wastewater is poorly managed and most of them reach water courses without any treatment. The water quality of rivers is strongly influenced by human activities especially when passing through urban, industrial and agricultural areas due to poor wastewater treatment or management systems. As pollution rises, it will be more costly for the necessary treatment of water for human consumption. Available data and information from some hydrological areas (HAs) show the current situation of deterioration of surface water quality in urban/industrial areas.

The supplemental data and information on surface water quality is described in Item (1) & (2), Section SR2.3.6, Volume-5 Supporting Report.

The pollution load is estimated in order to assess its impact on the surface water quality under the present and future conditions. The parameter BOD is selected as the indicator of organic pollution for the estimation of the pollution load. The pollution load entering the water body is estimated from domestic, industrial and livestock sources, in order to give us an understanding of its distribution and the magnitude of their impact. The detailed methodology to estimate pollution load is described in Item (3), Section SR2.3.6, Volume-5 Supporting Report.

The preliminary estimated total pollution load for the entire country is 4,667x10^6kg/year for 2010 and 7,436x10^6kg/year for 2030, respectively. The ratio of domestic pollution load is estimated at 50% to 70% of the total pollution load. Figure 5-10 shows the unit total pollution load by SHA. One can understand that the unit total pollution load around highly urbanized areas such as Lagos and Kano is much higher than that in other areas. It is expected that the area where the unit total pollution load is high expand to wider areas in HA-5, 6, 7and 8.



Source: JICA Project Team

Figure 5-10 Preliminary Estimated Unit Total Pollution Load by SHA

5.4 Groundwater Resources

Groundwater potential means groundwater recharge, which is equivalent to maximum amount of groundwater to be developed. On the other hand, amount of groundwater which can be practically developed depends on both groundwater potential and aquifer capacity, in this part, aquifer capacity of Nigeria is mentioned firstly, and groundwater potential is mentioned secondly.

5.4.1 Aquifer type

Aquifer in Nigeria consists of Basement rocks and Sedimentary rocks, Geology of Nigeria is shown in 5-11.

(1) Rock Type of Basement Complex and Hydrogeological Characteristics

Basement Rock is classified into three types, namely a) Gneiss and Migmatite Complex, b) Schist Belts, c) Younger Granite. There is no large difference among them. However, items below should be taken into account.

- Crystalline and coarse-grain rocks such as gneiss and migmatite will become sandy and form aquifer when they are weathered.
- Argillaceous meta-sediment rocks will become clayey and impermeable when they are weathered, and they are classified as aquiclude.
- Old granite is intruded by Younger Granite, which is usually fractured to be promising as aquifer.

(2) Sedimentary rocks (layer)

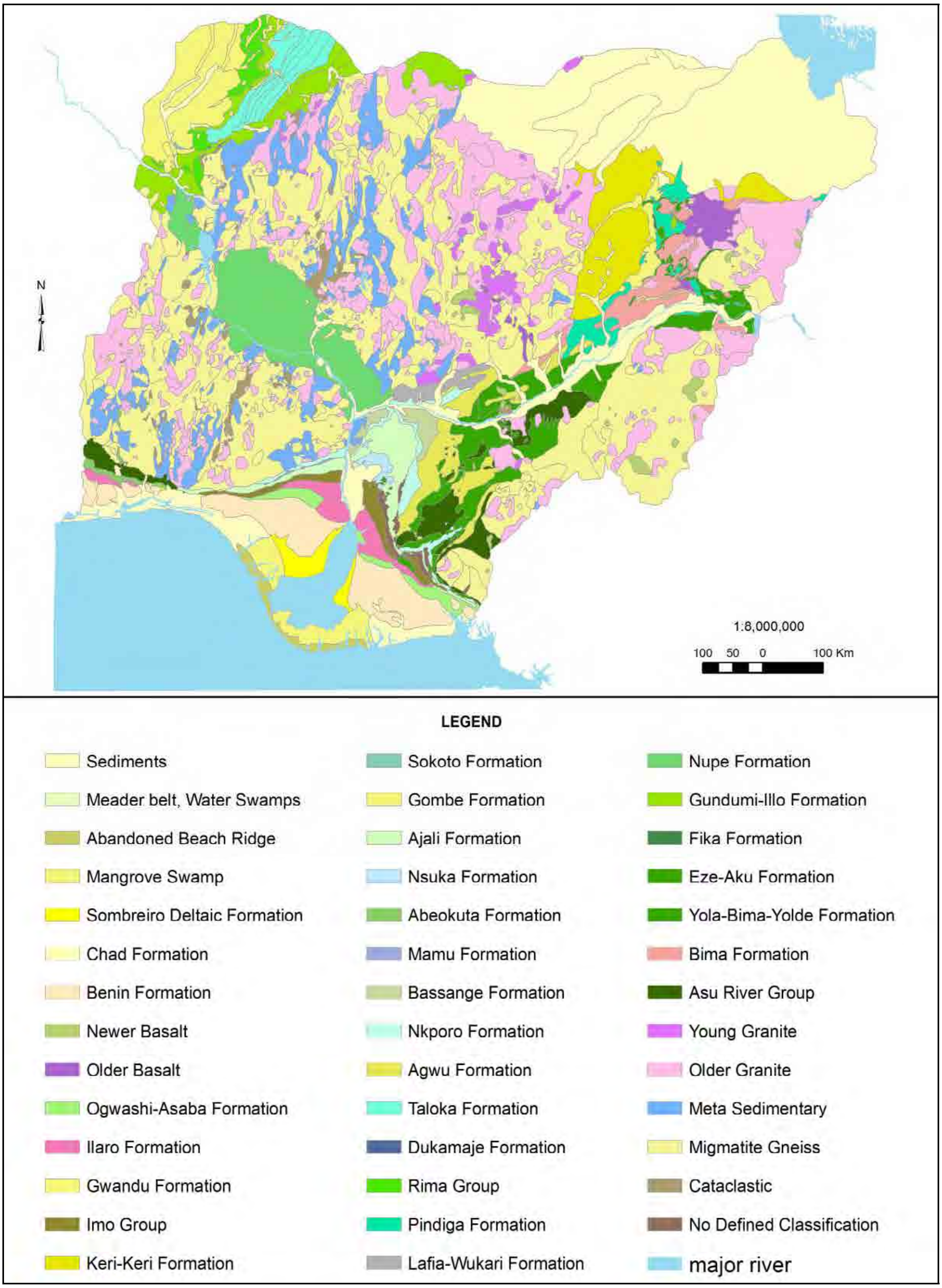
Sedimentary rock consists of sandstone and shale (claystone) of the Cretaceous, the Tertiary and the Quaternary (unconsolidated sand, silt and clay). Sandstone with good lateral continuity and large thickness usually forms aquifer of large scale. Large amount of groundwater can be extracted from sandstone aquifer with large scale and high permeability. More groundwater can be extracted from aquifer than the amount from groundwater recharge. As a result, groundwater in aquifer, which has been accumulated during long period of time, will be rapidly consumed, causing continuous lowering of groundwater level year by year. Amount of groundwater extraction must be less than amount of groundwater recharge for sustainable groundwater usage.

5.4.2 Groundwater Recharge

(1) Groundwater Recharge

Groundwater recharge was analyzed as the late component of Surplus (S) of the model explained in 5.3.2 of this Report. Result of analysis is shown in Table 5-5. Result should be interpreted as explained below:

- The Surplus is classified into two parts. The first part is those that flow into rivers within one month, and the second part is those that will flow into river after next month. For example, groundwater flowing in weathered basement rock will flow into river earlier within one month after rainfall. On the other hand, some groundwater flowing in sedimentary rock will take more than several months to flow into river, depending on hydrological structure of aquifer.
- Groundwater will finally flow into rivers, so it is considered that groundwater recharge is part of river runoff.



Source: JICA Project Team

Figure 5-11 Geology of Nigeria

Table 5-5 Groundwater recharge by HA

Item	Nation wide	Hydrological area							
		HA-1	HA-2	HA-3	HA-4	HA-5	HA-6	HA-7	HA-8
Area(km2)	909,979	135,128	154,616	156,546	74,519	53,914	99,333	57,440	178,483
Average precipitation (mm/year)	1,148	768	1,170	1,055	1,341	2,132	1,541	2,106	610
Average groundwater recharge (mm/year)	171	37	132	123	250	592	236	570	24
Same (%)	14.9	4.8	11.3	11.7	18.7	27.7	15.3	27.1	3.9
Same (BCM/year)	155.8	5.0	20.5	19.3	18.6	31.9	23.4	32.8	4.3

Source: JICA Project Team

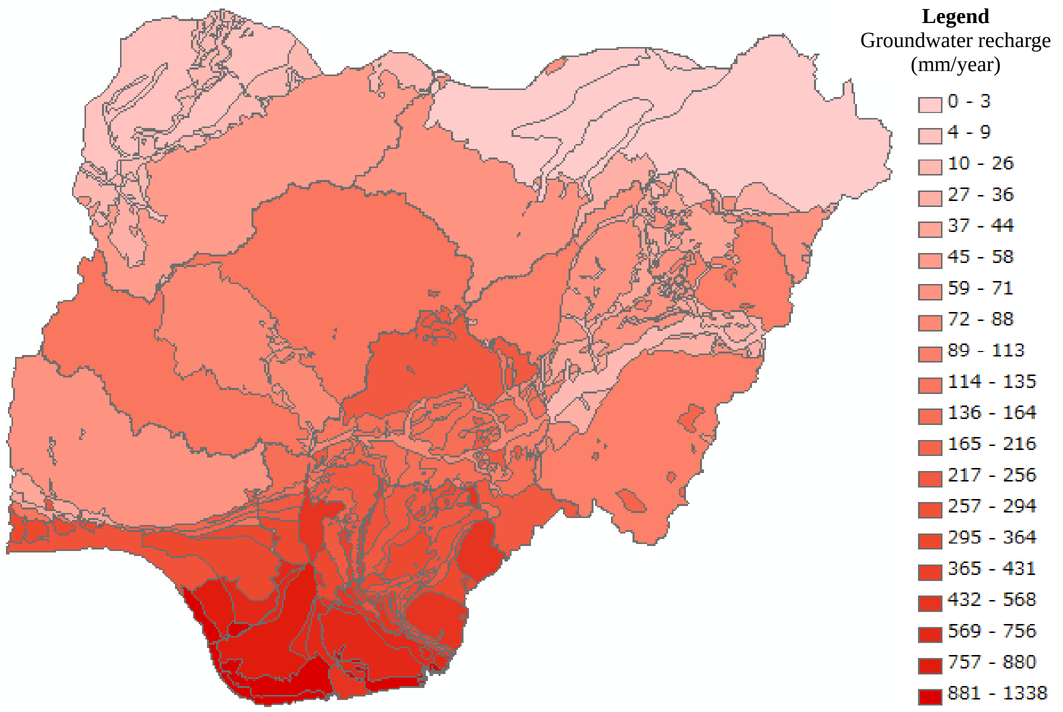
The analyzed result of groundwater recharge by SHA is rearranged by aquifer as shown in Table 5-6 and Figure 5-12.

Table 5-6 Groundwater Recharge by Aquifer

Age	Formation	Groundwater Recharge (mm/year)
HA-1		
Eocene	Gwandu Formation	24
Paleocene	Kalambaina Formation（Sokoto group ）	1
	Dange Formation（Sokoto group ）	1
	Wurno Formation（Rima Group）	18
Maestrichitian	Dukamaje Formation（Rima Group）	34
	Taloka Formation（Rima Group）	6
	Ill Formation	10
	Gundumi Formation	10
Pre-Cambria	Basement complex	40
HA-2		
Quaternary	Sand and gravel	18
Tertiary	Patti Formation	51
cretaceous	Lokoja Sandstone/Nupe Sandstone	37
Pre-Cambria	Basement complex	51
HA-3		
Holocene	Alluvium	7
Pleistocene	Chad Formation	9
Paleocene	Kerri-Kerri Formation	32
Maestrichtian	Lamja Sandstone/Gombe Sandstone	19
Campanian	Numanha shale/gulani sandstone/Pindiga Formation	20
Santonian	Sekule Formation/Pindiga Formation	20
Turonian	Jessu Formation/Pindiga Formation	20
	Dukul Formation/Pindiga Formation	20
	Yolde Formation	17
Cenomanian	Bima sandstone	43
Pre-Cambria	Basement complex	132
HA-4		
Paleocene	Volcanic	301
Maestrichtian	Lafia Formation	176
Senonian	Awgu Formation	128
Turonian	Ezeaku/makurdi Formation	59

Age	Formation	Groundwater Recharge (mm/year)
	Keana Formation	128
Cenomanian	Awe Formation	128
Mid-late Albian	Asu River Formation	59
Pre-Cambria	Basement complex	277
HA-5		
Quaternary	Upper deltaic	590
	Lower deltaic	458
Tertiary	Benin Formation	450
	Ogwashi Asaba Formation	331
	Ameki Formation/Nanka sandstone	189
	Imo shale	51
	Nsukka Formation	83
Cretaceous	Ajali Formation	122
Maestrichtian	Mamu Formation	91
	Nkporo Formation	63
Pre-Cambria	Basement complex	62
HA-6		
Quaternary	Alluvium	792
	Deltaic Formation	532
	Benin Fo`rmation	291
Tertiary	Ilaro Formation/Ameki Formation	124
	Ewekoro/Imo Shale /Oshuosun Formation	180
Cretaceous	Abeokuta Formation	86
Pre-Cambria	Basement complex	93
HA-7		
Quaternary	Benin Formation	872
Tertiary	Ameki Formation	516
	Imo Formation	378
	Nsukka Formation	378
	Ajali Formation	295
	Mamu Formation	295
	Nkporo shale	222
Cretaceous	Awgu Formation	173
	Ezeaku Formation	208
	Asu Formation	268
Pre-Cambrian	Basement complex	416
HA-8		
Pleistocene	Chad Formation	7
Paleocene	Kerri-Kerri Formation	7
Cretaceous	Gundumi Formation	1
Jurrassic	Younger Granite Complex	103
Pre-Cambria	Basement complex	61

Source: JICA Project Team



Source: JICA Project Team

Figure 5-12 Groundwater Recharge by Aquifer

(2) Water Balance by Groundwater Monitoring

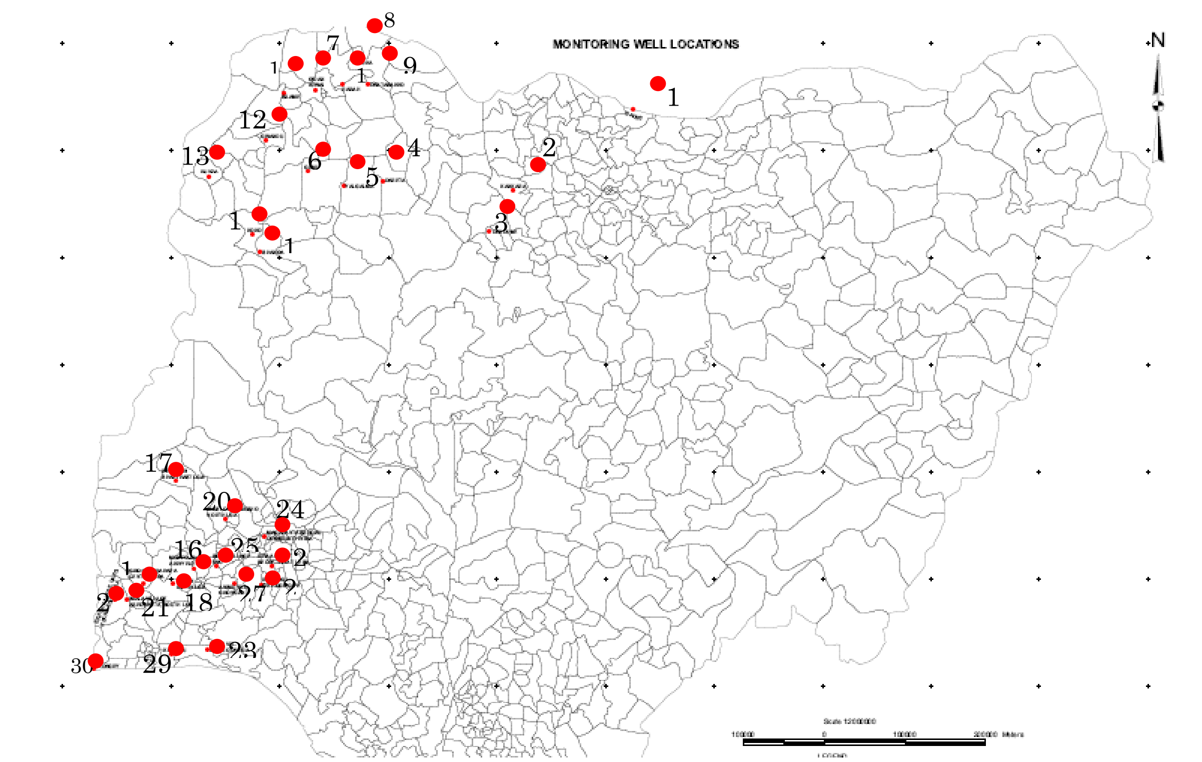
As explained in Table 5-6, groundwater recharge was analyzed by the method that dealt with both surface and groundwater at the same time. As a result of the analysis, groundwater recharge was calculated nationwide with the unified method, and it is easy to compare groundwater recharge of each area with the same accuracy. On the other hand, single method has limitation to analyze those of the large country such as Nigeria with various natural conditions. To address this disadvantage, groundwater monitoring is to analyze groundwater recharge in two hydrological areas (HA-1 and HA-6), where Catchment Management Plan will be formulated in this Project.

Analysis method

Rainfall will fall on the ground and infiltrate into the soil. Then surplus soil water will drain into shallow aquifer as a result of soil water balance. Groundwater recharge, which was drained from the saturated soil, can be directly observed as the fluctuation of groundwater table of shallow aquifer. So this can be observed in shallow hand-dug wells. For this purpose, shallow hand-dug wells were constructed as monitoring wells in this Project.

Installation of groundwater monitoring wells

Monitoring wells were selected at 30 sites by JICA Project Team and NIHSA, considering representative geological condition of the target areas and accessibility by observers. Groundwater level was monitored by the JICA Project Team during Phase-1 of the Project. Then, NIHSA took over the monitoring work from JICA Project Team and is continuing. Location of monitoring wells is shown in Figure 5-13.



Source: JICA Project Team

Figure 5-13 Location of Monitoring Well

<u>Monitoring survey from now on</u>

NIHSA continues groundwater monitoring since July 2013 until now. JICA Project Team will be provided with monitoring data for analysis of groundwater recharge.

(3) Influence of Climate Change

As shown in Table 5-7, groundwater recharge seems to reduce due to influence of Climate Change. Groundwater recharge will decrease by 21% in case -1, 15% in case-2 nationwide on average. Amount of decrease in groundwater recharge is different area by area. It should be noted that area with smaller groundwater recharge will have larger influence than the area with higher groundwater recharge even though amount of the decrease in groundwater recharge is the same. For example, in Niger North (HA-1) and Chad Basin (HA-8), the amount of the decrease in groundwater recharge is not as large as those in the other areas. However, they will receive more serious influence by the Climate Change because their current groundwater recharge is much smaller than the other areas.

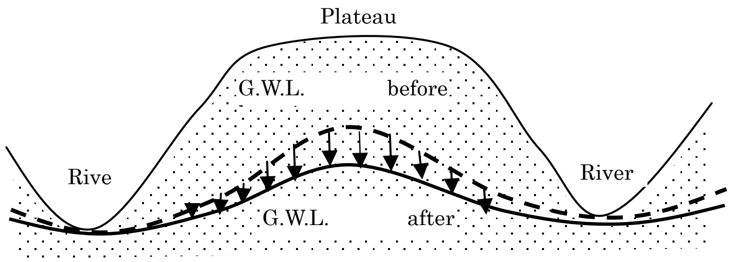
<u>Difference in lowering of groundwater level place by place</u>

Lowering of groundwater level due to reduction in groundwater recharge will be small around river because groundwater level will be almost constant at river beds. However, decrease in groundwater level will become larger in places far from rivers (see Figure 5-14). Therefore, inland area in the plateau far form rivers will effect more influence by decrease in groundwater recharge. Countermeasures against the Climate Change will take account of such a condition mentioned above.

Table 5-7 Groundwater Recharge Affected by Change of Precipitation and Temperature due to the Climate Change

Area (HA)		HA-1	HA-2	HA-3	HA-4	HA-5	HA-6	HA-7	HA-8	Nation -wide
Current estimation (mm/year)		37	132	123	250	592	236	570	24	171
Case -1	Groundwater recharge (mm/year)	22	91	92	204	509	186	499	17	136
	Ratio to current recharge (%)	59%	69%	75%	82%	86%	79%	88%	71%	80%
Case -2	Groundwater recharge (mm/year)	31	105	105	217	508	188	538	24	147
	Ration to current recharge (%)	84%	80%	85%	87%	86%	80%	94%	100%	86%

Source: JICA Project Team



Source: JICA Project Team

Figure 5-14 Groundwater Level Lowering after Decrease in Groundwater Recharge

5.5 Summary of Water Resources Potential

The estimated water resources potential is summarized in Table 5-8. The basis of estimation of water resources potential is as follows.

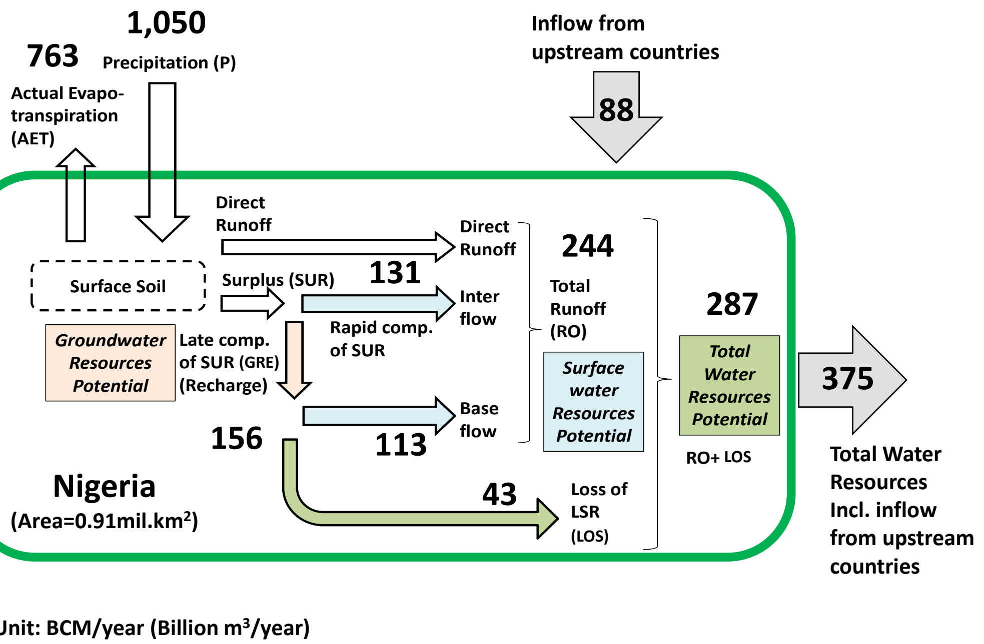
- The output of long-term rainfall-runoff model with the input data of precipitation and air temperature for 40years from 1970 to 2009 is used.
- The long-term rainfall-runoff model is set up based on the available observed discharge data at main hydrological stations, which covers the catchment area of rivers flowing into Nigeria except the upper Niger River as well as the territory of Nigeria.

The average precipitation over the country is about 1,150mm. Only 24% of the precipitation becomes runoff and the rest are lost as evapotranspiration and/or others. Total internal generation of the runoff is 244BCM/year and the surface water resources potential is estimated at about 333BCM/year. The total water resources potential can be evaluated by adding the component that is lost without becoming surface runoff among recharge. The internal generation of total water resources potential is estimated at 287BCM/year and the total water resources potential with inflow from neighboring countries is estimated at 375BCM/year. 88BCM/year of water comes from neighboring countries, which roughly indicates that almost 24% of surface water resources in Nigeria relies on neighboring countries. The total groundwater resources potential is estimated at 156BCM/year as a renewable source on the basis of the estimated groundwater recharge.

Table 5-8 Estimated Water Resources Potential

		HA-1	HA-2	HA-3	HA-4	HA-5	HA-6	HA-7	HA-8	Total
Water Resources Potential										
Total Water Resources Potential 1)										
Including inflow from outside Nigeria	(BCM /year)	37.4	40.9	60.2	47.9	50.7	43.7	84.0	10.3	375.1
Only internal generation in Nigeria	(BCM /year)	10.7	40.3	37.9	32.8	50.7	43.6	60.3	10.3	286.6
Surface Water Resources Potential										
Including inflow from outside Nigeria	(BCM /year)	35.1	32.3	56.4	46.0	40.1	35.7	79.9	7.2	332.7
Only internal generation in Nigeria	(BCM /year)	8.4	31.7	34.1	30.9	40.1	35.6	56.2	7.2	244.2
Groundwater Resources Potential										
Groundwater Recharge	(BCM /year)	5.0	20.5	19.3	18.6	31.9	23.4	32.8	4.3	155.8
Runoff Condition (Only internal generation in Nigeria)										
Precipitation (P)	(mm/ year)	767	1,170	1,055	1,341	2,132	1,540	2,106	609	1,148
Total Runoff (RO)	(mm/ year)	62	205	218	415	744	359	978	40	268
Groundwater Recharge (GRE)	(mm/ year)	37	132	123	250	592	236	570	24	171
Loss of Recharge (LOS)	(mm/ year)	18	56	24	25	197	80	72	17	47
Runoff Rate (RO/P)	(%)	8.1	17.5	20.7	30.9	34.9	23.3	46.4	6.6	23.4
Recharge Rate (GRE/P)	(%)	4.8	11.3	11.7	18.7	27.7	15.3	27.1	3.9	14.9
Loss Rate (LOS/P)	(%)	2.3	4.8	2.3	1.9	9.2	5.2	3.4	2.9	4.1
Total Water Res. Rate ((RO+LOS)/P)	(%)	10.4	22.3	22.9	32.8	44.1	28.5	49.8	9.5	27.4

Note:
1) **Total Water Resources Potential**
= Surface Water Resource Potential + Groundwater Recharge – Base Flow Runoff
= Surface Water Resource Potential + Loss of Groundwater Recharge
2) Water Resources Potential in HA-5, 6 include the runoff in the delta area.
3) Water Resources Potential in HA-8 shows the total runoff generation without the loss in the large wet land area.



Source: JICA Project Team

CHAPTER 6 WATER BALANCE BETWEEN DEMAND AND SUPPLY

6.1 Overall Water Balance between Total Water Demand and Water Resources Potential

Table 6-1 shows the total water demand and water resources potential by HA.

Table 6-1 Overall Water Balance between Total Water Demand and Water Resources Potential

			HA-1	HA-2	HA-3	HA-4	HA-5	HA-6	HA-7	HA-8	Total
Total Water Resources Potential											
Including inflow from outside Nigeria	(BCM /year)	(1)	37.4	40.9	60.2	47.9	50.7	43.7	84.0	10.3	375.1
Only Internal Generation	(BCM /year)	(2)	10.7	40.3	37.9	32.8	50.7	43.6	60.3	10.3	286.6
Groundwater Resources Potential	(BCM /year)	(3)	5.0	20.5	19.3	18.6	31.9	23.4	32.8	4.3	155.8
Total Water Demand											
Existing (2010)	(BCM /year)	(4)	**0.79**	**0.59**	**0.35**	**0.25**	**0.50**	**1.54**	**0.46**	**1.46**	**5.93**
	(%)	(4)/(1)	2.1	1.5	0.6	0.5	1.0	3.5	0.5	14.2	1.6
	(%)	(4)/(2)	7.4	1.5	0.9	0.8	1.0	3.5	0.8	14.2	2.1
Future (2030)	(BCM /year)	(5)	**1.63**	**1.87**	**2.27**	**1.15**	**1.66**	**3.54**	**1.36**	**3.11**	**16.58**
	(%)	(5)/(1)	4.3	4.6	3.8	2.4	3.3	8.1	1.6	30.2	4.4
	(%)	(5)/(2)	15.2	4.6	6.0	3.5	3.3	8.1	2.3	30.2	5.8

Remarks:
1) Water Resources Potential in HA-5, 6 include the runoff in the delta area.
2) Water Resources Potential in HA-8 shows the total runoff generation without the loss in the large wet land area.
Source: JICA Project Team

As shown in Chapter 4, the existing total water demand is estimated at 5.93BCM/year. It is expected to increase to 16.58BCM/year in 2030.

The water use rate is here defined as the ratio between the total water demand and the surface water resources potential. The water use rate in 2010 is just 1.6%. In 2030, the ratio will become 4.4%, however.

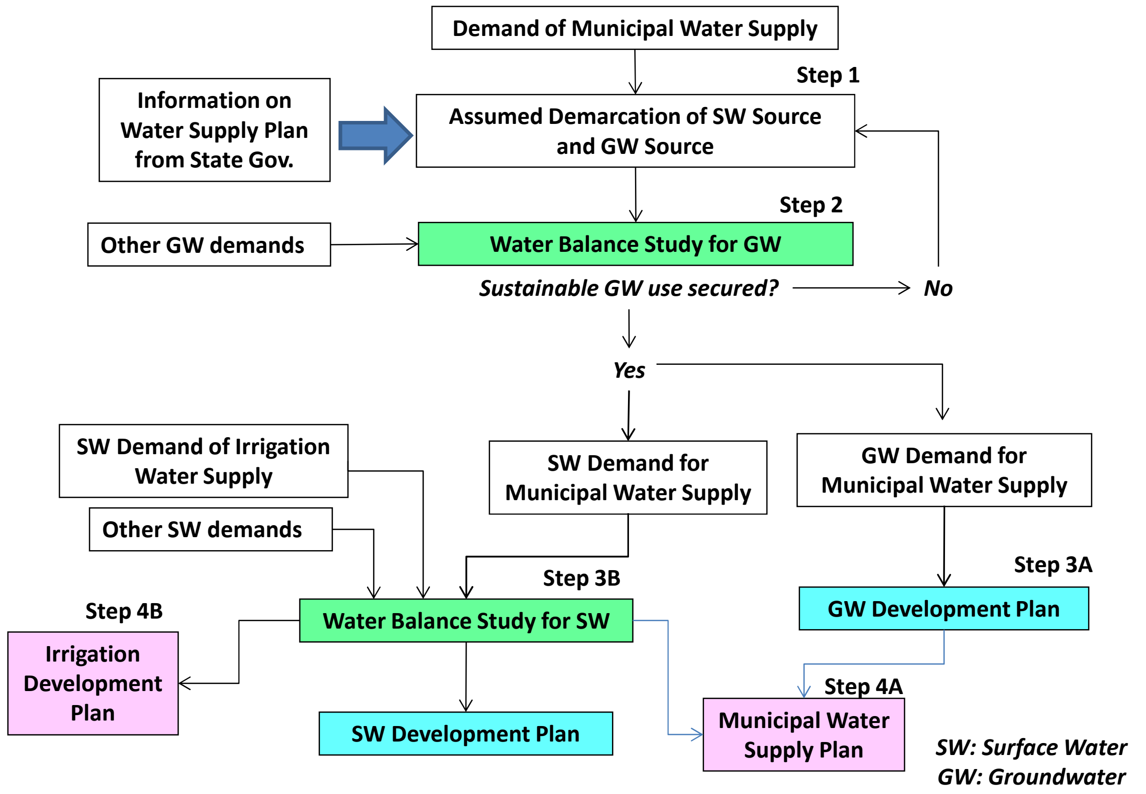
The water use rate varies from HA to HA. The rate in HA-8 in 2010 is 14%, which is much higher than the other HAs. In 2030, the water use rate in HA-8 may reach to about 30%, whereas the ratio in other HAs may be less than 10%.

The total water demand in 2030 is still much less than the total water resources potential. However, it should be noted that the currently usable water with stable supply for the demand is also much smaller than the surface water resources potential. Furthermore, because the water demand and water resources are unevenly distributed, the necessity of water resources development should be examined through the water balance between supply and demand al local level.

6.2 Procedure of Water Balance Study

Water usage in terms of source can be categorized into two types; groundwater and surface water uses. The water resources development plan should consider the water balance for both usages so as to secure sustainable use of water resources.

The current demarcation of water source in Nigeria is estimated that 40% for groundwater and 60% for surface water. The share of groundwater in municipal water supply is high. This ratio would be kept even in 2030, although the usage of surface water would increase in urban areas. Considering this situation, the sustainability of groundwater use would be firstly examined. Then, the water balance for both groundwater and surface water would be studied. Figure 6-1 shows the procedure for water balance study.



Step 1: The demarcation between usage of groundwater and surface water for municipal water supply is set, on the basis of existing plans by state government.
Step 2: The water balance for groundwater usage which include not only municipal water but also other purposes is checked, in order to secure sustainable usage of groundwater. If it is judged that the groundwater usage is sustainable, the next steps would be examined. If not, the demarcation between groundwater and surface water uses would be adjusted, and the groundwater balance would be checked again.
Step 3A: The necessary development of groundwater is determined based on the results of Step2. The groundwater development plan is formulated.
Step 3B: The surface water demand for municipal water supply is fixed based on the results of Step2. The water balance study for surface water is examined and the surface water development plan is formulated, considering the municipal water, irrigation water and other demands.
Step 4A: The municipal water supply plan is formulated utilizing the results of step 3.
Step 4B: The irrigation development plan is formulated utilizing the results of step 3B.

Source: JICA Project Team

Figure 6-1 Procedure of Water Balance Study

6.3 Balance of Groundwater Recharge and Groundwater Demand

6.3.1 Existing Groundwater Supply Facilities

(1) Existing Groundwater Supply Facilities

For information on groundwater supply facilities nationwide, there is “Baseline Survey for Water Supply and Sanitation Facilities” (FMWR, 2006). Borehole inventory survey was implemented in this Project, to know amount of current groundwater extraction for water supply. The result is shown below.

- Borehole with motorized pump : 19,758
- Boreholes with hand pump : 44,736
- Shallow hand-dug wells : 13,108

According to survey results, total number of boreholes (motorized pumps and hand pumps) is 64,494. Amount of groundwater extraction is estimated about 6,340 thousand m^3/day.

(2) Potential Supply Capacity

Case where borehole operation rate increases

Average operation rate of borehole is as low as 63% nationwide. Therefore, water coverage rate will be significantly increased by increasing borehole operation rate.

- Current extraction rate : 6,340,000m^3/day
- Assumed extraction rate in case of 100% borehole operation : 10,600,000 m^3/day

It also can be considered that decrease in borehole capacity by time might cause decrease in borehole operation rate. However, above reason cannot be proved due to lack of data. Therefore, it is concluded that low operation rate of boreholes is mainly caused by breakout of pumps in Nigeria.

Case where pump was replaced

Hand-pumps are installed into most of the existing boreholes for rural water supply. Pumping capacity of hand pump is around 10m^3/day. It means that groundwater extraction capacity of boreholes will be increased by replacing hand pumps with motorized pumps.

Of cause above proposal is based on assumption. Not all the boreholes have enough capacity for motorized pumps. It must be kept in mind that some boreholes do not have enough capacity even for hand pump.

Conclusion

Based on the discussion above, there are four (4) types of yield for boreholes.

a) Groundwater supply capacity of aquifer.
b) Current available yield of existing boreholes.
c) Available yields of existing boreholes in case where borehole operation rate is improved to 100%.
d) Available yield of existing boreholes in case where hand-pumps are replaced with motorized pumps.

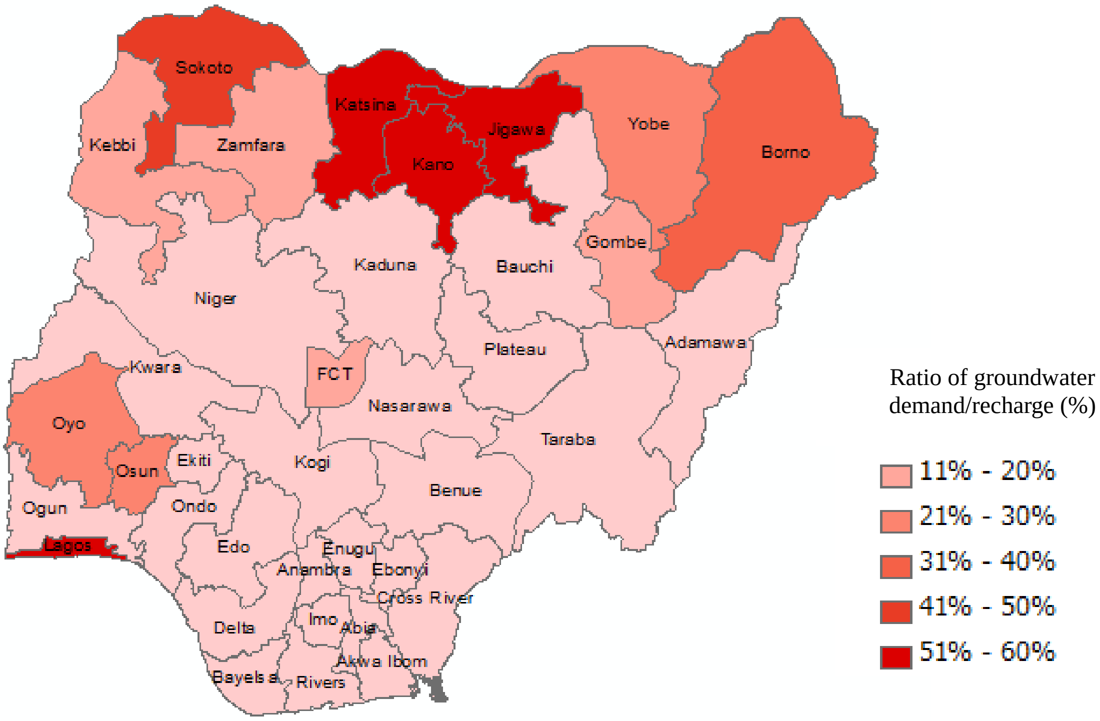
“b) Current available yield of existing boreholes” above will be regarded as current supply capacity of existing boreholes. Future demand will be satisfied by drilling new boreholes. Therefore, the future water demand will be compared with aquifer capacity as a way of analyzing water balance between demand and supply.

6.3.2 Balance of Demand and Supply of Groundwater

Balance between groundwater recharge and demand are shown in Table 6-2 and Figure 6-2. Ratio of groundwater demand/recharge is 5% on a national average.

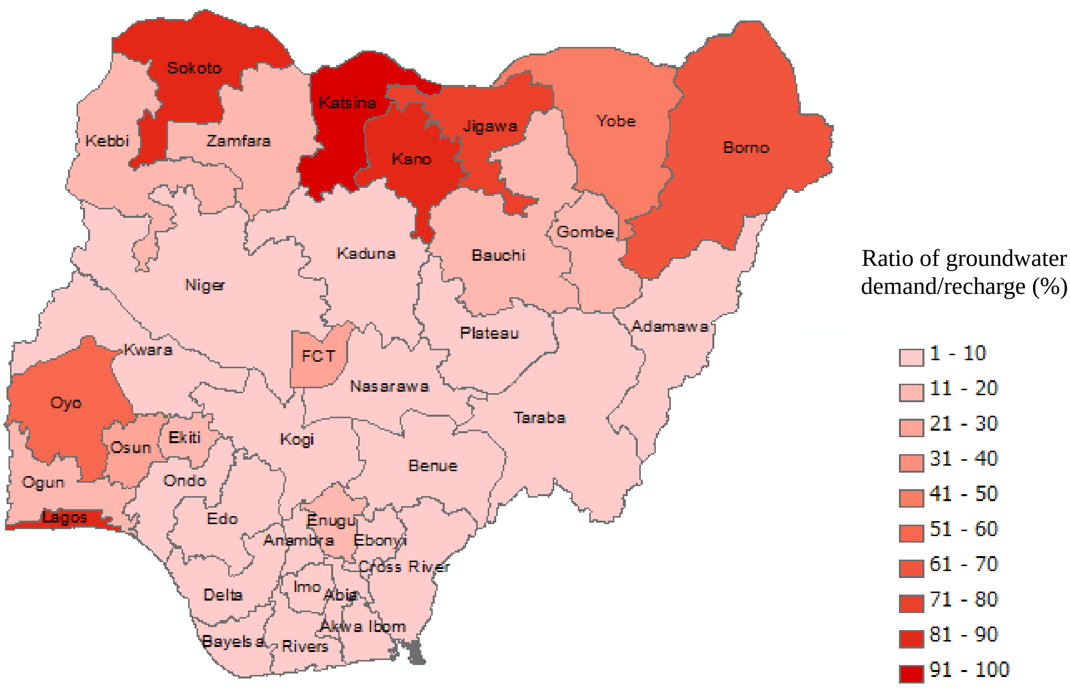
However it is 1-86% on a state by state basis, showing large difference among the states. This is because of significant difference in groundwater recharge between states. Ratio of groundwater demand/recharge is higher in the northern part of Nigeria, where there is sedimentary rock widely distributed, and groundwater recharge is smaller. However aquifer occurs over wide area crossing state boundaries, where groundwater can be extracted from boreholes collecting groundwater from large surrounding area to meet groundwater demand.

Balance of groundwater recharge and demand is shown in Table 6-3 and Figure 6-3 resulting from Climate change (Scenario Case-1, see 5.4.2 (3)). Ratio of groundwater demand/recharge is 7% on a national average. This is small increase from 5% in the case without Climate Change. However it is 1 to 136% on a state by state basis, showing a large difference. Accordingly, effect of Climate Change will make the difference larger in water balance among states.



Source：JICA Project Team

Figure 6-2 Balance of Groundwater Demand and Recharge in 2030



Source：JICA Project Team

Figure 6-3 Balance of Groundwater Demand and Recharge in 2030 by Effect of Climate Change

Table 6-2 Groundwater Recharge and Groundwater Demand (2030)

No	State	Groundwater recharge (MCM/year)	Groundwater demand (2030) (MCM/year)					
			Water supply	Private irrigation	Live stock	aquaculture	total	Groundwater demand/ recharge
1	Abia	2,810	165	9	1	7	182	6%
2	Adamawa	3,707	96	26	17	4	142	4%
3	Akwa Ibom	5,759	221	12	1	8	242	4%
4	Anambra	1,728	125	8	2	5	140	8%
5	Bauchi	3,970	205	69	13	3	290	7%
6	Bayelsa	11,010	100	4	1	2	107	1%
7	Benue	10,655	152	50	1	3	206	2%
8	Borno	570	197	47	26	2	272	48%
9	Cross River	14,620	84	24	0	52	160	1%
10	Delta	13,056	260	19	3	344	626	5%
11	Ebonyi	2,174	43	12	3	0	58	3%
12	Edo	6,867	187	38	1	2	228	3%
13	Ekiti	863	59	11	0	11	82	9%
14	Enugu	2,504	171	15	1	1	188	8%
15	Gombe	943	83	20	13	1	117	12%
16	Imo	3,135	195	9	1	9	214	7%
17	Jigawa	349	207	70	14	9	301	86%
18	Kaduna	8,446	157	53	7	8	225	3%
19	Kano	1,028	354	66	23	102	545	53%
20	Katsina	670	231	74	14	4	324	48%
21	Kebbi	1,626	126	40	7	8	180	11%
22	Kogi	4,142	148	46	3	5	202	5%
23	Kwara	2,521	87	26	1	12	126	5%
24	Lagos	736	425	5	1	10	441	60%
25	Nasarawa	4,657	67	29	2	11	109	2%
26	Niger	8,402	156	57	7	4	224	3%
27	Ogun	1,928	106	38	1	14	159	8%
28	Ondo	3,973	145	27	0	5	178	4%
29	Osun	888	100	18	1	68	187	21%
30	Oyo	1,329	154	46	6	81	287	22%
31	Plateau	3,917	113	31	10	27	181	5%
32	Rivers	9,957	370	8	2	41	421	4%
33	Sokoto	315	131	42	27	2	202	64%
34	Taraba	13,147	81	41	4	0	127	1%
35	Yobe	421	118	51	13	1	183	44%
36	Zamfara	1,539	126	51	12	5	195	13%
37	FCT Abuja	1,374	216	7	1	2	226	16%
	Total	155,736	5,964	1,199	241	875	8,276	5%

Source：JICA Project Team

Table 6-3 Groundwater Recharge and Demand by Effect of Climate Change (2030)

No	state	Groundwater recharge (MCM/year)	Groundwater demand(2030) (MCM/year)					
			Water supply	Private irrigation	Live stock	aquaculture	total	Groundwater demand/ recharge
1	Abia	2,415	165	10	1	7	183	8%
2	Adamawa	2,567	96	29	17	4	145	6%
3	Akwa Ibom	5,086	221	13	1	8	243	5%
4	Anambra	1,383	125	9	2	5	141	10%
5	Bauchi	2,841	205	78	13	3	299	11%
6	Bayelsa	9,892	100	5	1	2	108	1%
7	Benue	9,182	152	55	1	3	211	2%
8	Borno	295	197	53	26	2	278	94%
9	Cross River	13,067	84	26	0	52	162	1%
10	Delta	11,372	260	20	3	344	627	6%
11	Ebonyi	1,776	43	13	3	0	59	3%
12	Edo	5,462	187	42	1	2	232	4%
13	Ekiti	572	59	12	0	11	83	14%
14	Enugu	2,037	171	16	1	1	189	9%
15	Gombe	586	83	23	13	1	120	20%
16	Imo	2,739	195	10	1	9	215	8%
17	Jigawa	229	207	78	14	9	309	135%
18	Kaduna	6,511	157	61	7	8	233	4%
19	Kano	679	354	74	23	102	553	81%
20	Katsina	405	231	83	14	4	333	82%
21	Kebbi	965	126	45	7	8	185	19%
22	Kogi	2,719	148	52	3	5	208	8%
23	Kwara	1,335	87	30	1	12	130	10%
24	Lagos	531	425	14	1	10	450	85%
25	Nasarawa	3,349	67	32	2	11	112	3%
26	Niger	5,616	156	65	7	4	232	4%
27	Ogun	1,298	106	97	1	14	218	17%
28	Ondo	3,005	145	32	0	5	183	6%
29	Osun	593	100	20	1	68	189	32%
30	Oyo	747	154	52	6	81	293	39%
31	Plateau	2,945	113	34	10	27	184	6%
32	Rivers	8,856	370	9	2	41	422	5%
33	Sokoto	152	131	47	27	2	207	136%
34	Taraba	10,723	81	46	4	0	132	1%
35	Yobe	265	118	57	13	1	189	71%
36	Zamfara	1,017	126	58	12	5	202	20%
37	FCT Abuja	964	216	9	1	2	228	24%
	Total	124,178	5,964	1,409	241	875	8,486	7%

Source：JICA Project Team

6.3.3 Analysis of Groundwater Balance by Groundwater Simulation

(1) Prediction of Groundwater lowering in 2030

Groundwater balance was analyzed State by State in the previous section. However, distribution of groundwater recharge and demand is not even within a state. For example, groundwater demand shows large difference LGA by LGA. Moreover, aquifer occurs over a wide area crossing state boundaries. Therefore, it is not sufficient to evaluate groundwater balance within a state from hydrogeological viewpoint. To resolve the problem, groundwater simulation was performed to analyze more precisely un-even distribution of groundwater recharge, groundwater demand and aquifer.

Simulation was performed with steady state condition after water balance condition was established in the simulation model. Sustainable groundwater development will be examined whether calculated groundwater level stays in the depth from which planned boreholes can pump up groundwater or not.

Table 6-4 Outline of Groundwater Simulation Model and Given Condition

Item	Content
Software	Visual Modflow
Model structure	The entire country was modeled with 36,255 cells. Size of one cell is 5km×5km. Model has 10 layers structures in vertical direction to 500m depth below the ground surface. Conductivity of the model was given following aquifer type.
Groundwater recharge	Analyzed result of groundwater recharge was given to model.
Water demand	Groundwater demand in LGAs was given to the model by pumping rare (m^3/day) from boreholes. On the other hand, water demand of private irrigation, livestock and aqua-culture were given to the model as negative groundwater recharge.
Boundary and initial condition	As boundary condition, (a) Impermeable boundary was given to Basement rock areas, (b) Constant groundwater level condition was given to sedimentary rock areas. (c) Dain condition was given to along main rivers.

Source: JICA Project Team

Draw-down of regional groundwater level, which will be caused by proposed groundwater development, was calculated in steady state condition and the simulation result is shown in Figure 6-4. Important points of the result are as follows.

- Maximum draw-down is less than 5m in most of Nigeria. Consequently, proposed groundwater development can be available by adjusting borehole depth to meet future draw-down of groundwater level.
- Draw-down of groundwater level will be larger in Katsina, Sokoto and Osun States than the other states.
- Draw-down will not be so large in Chad Basin area than the above areas.

(2) Effect of Climate Change

Lowering of Groundwater level in 2030 under the influence of Climate Change (Scenario Case-1, 5.4.2 (3)) was predicted by groundwater simulation. Condition for simulation is shown in Table 6-5, and simulation result is shown in Figure 6-5.

Table 6-5 Outline of Groundwater Simulation Model and Given Condition by Climate Change

Condition	Content
Groundwater recharge	Scenario Case-1 of the Climate Change was applied to estimate groundwater recharge. Groundwater recharge of Table 6-4 was modified using decreasing rate by HA under the influence of Climate Change.
The others	Other condition is the same as those in Table 6-4.

Source：JICA Project Tram

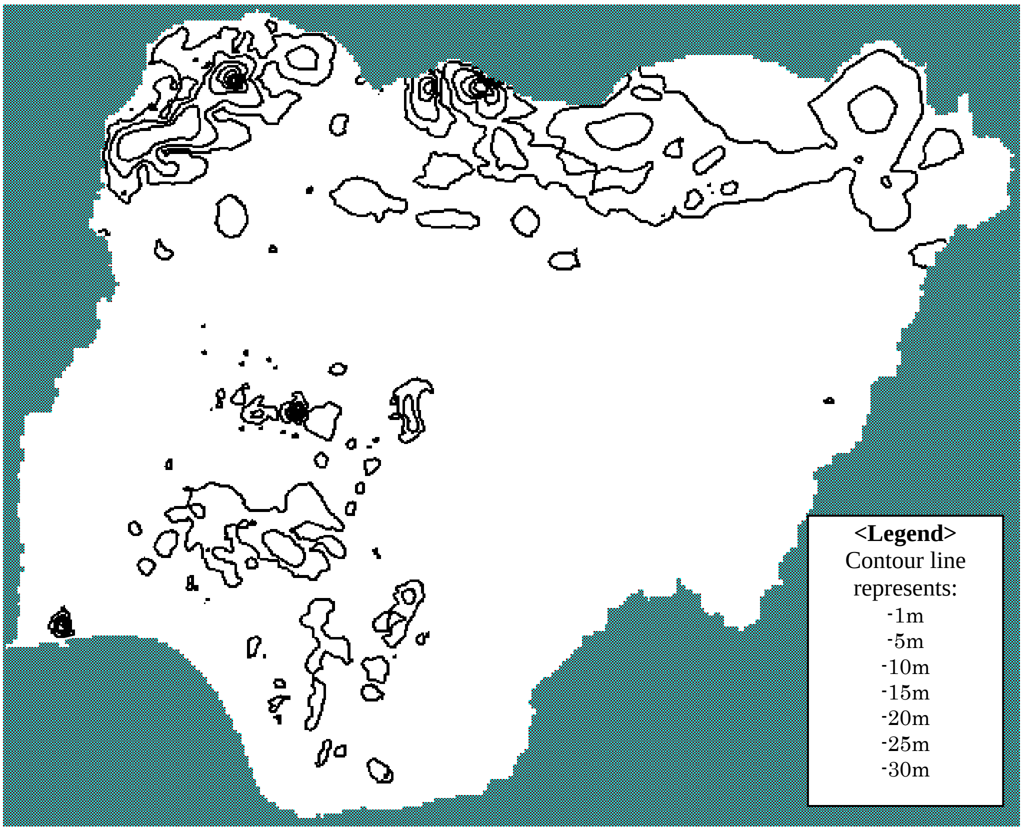
Compared with Figure 6-4, groundwater level in 2030 shown in Figure 6-5 will be lower additionally by 5 to 20m in the entire country due to decrease in groundwater recharge under the influence of

Climate Change. It should be noted that lowering of groundwater level without the influence of Climate Change is not clear in Plateau, compared with other regions. However, lowering of groundwater level is quite clear by influence of Climate Change. This means that in some areas in 2030, groundwater extraction cannot continue at the current borehole depth, due to serious lowering of groundwater level by Climate Change, even though groundwater recharge is greater than groundwater pumping. As explained in Chapter 5, lowering of groundwater level by Climate Change is more serious in high elevation areas than the others. Measures are proposed for future borehole planning, considering lowering of groundwater level by Climate Change.

- To drill borehole 20m deeper than current depth
- To make depth of pump location 20m deeper than now. Such arrangement should be considered in borehole construction plan.

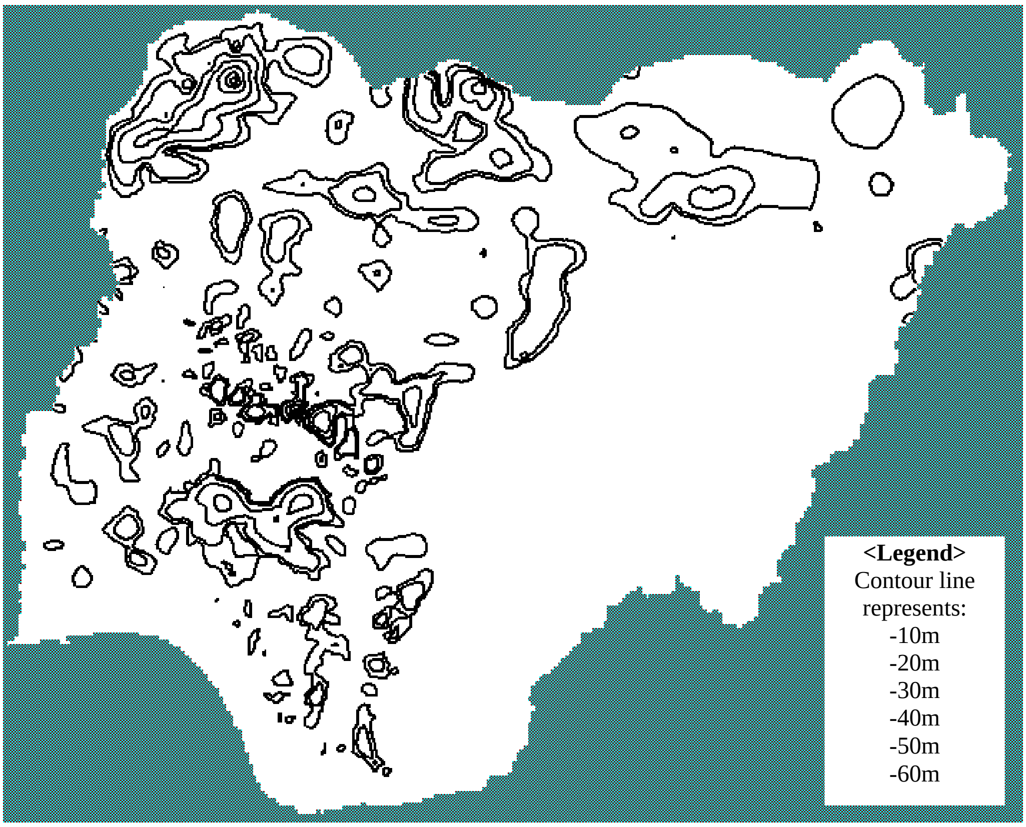
Impact of the lowering of groundwater level under the influence of Climate Change will be enlarged by over pumping. To prevent such situation, responding to the influence of Climate Change, groundwater pumping must be controlled where there are many boreholes. Legal and institutional framework must be established to support groundwater monitoring system for pumping control. NIWRMC should take responsibility of these activities.

Above discussion is based on uncertain risk of Climate Change. Further detailed analysis and discussion are necessary in the future.



Source: JICA Project Team

Figure 6-4 Predicted lowering of groundwater level in 2030



Source: JICA Project Team

Figure 6-5 Predicted Lowering of Groundwater Level in 2030 by Influence of Climate Change

6.4 Balance between Demand and Supply Capacity for Surface Water Source

6.4.1 Estimation of Surface Water Supply Capacity with Storage Dams

The usable water throughout a year is limited in quasi-natural condition. The installation and operation of storage dams can increase the stably usable water. In Nigeria, more than 170 dams, which are confirmed in the present project, have been constructed. The supply capacity of surface water source with the storage dams is approximately estimated by assuming a constant demand throughout a year (the detail methodology on water balance is shown in Section SR3.4.2, Volume-5 Supporting Report).

The eighteen (18) large storage dams whose active storage volume is more than 100MCM are modeled as a single dam, because they may affect the flow regimes in wider area. The remaining dams are aggregated by each SHA and considered as a single virtual dam. The dams considered are the existing ones or those under-construction whose location and dimension are known. The Lagdo dam which is located outside Nigeria in the upper reach of the Benue River is also modeled with available information at this moment. It is assumed that all active storage capacity is utilized for supplying water to meet the water demand downstream.

The estimated supply capacity for surface water source with the storage dams at the representative points for each HA is presented in Table 6-6. The supply capacity would be increased by the Lagdo dam, which is located in the upper Benue River in Cameroon. The estimated increment is 5,000MCM/year（157m^3/s）with 90% yearly dependability and 5,500MCM/year（175m^3/s）with 80% yearly dependability. However, such increment is not taken into account in the supply capacity in the table, because it is not under Nigerian control. The values shown in Table 6-6 have been subtracted by the increment from Lagdo dam.

One can see that at the downstream end of HA-2, 34,000MCM/year (1,080 m^3/s） for 90% yearly dependability and 36,000MCM/year（1,140 m^3/s）for 80% yearly dependability could be supplied. The large supply capacity in HA-2 and 5 (downstream reach of HA-2) is the results of regulation of flow by the existing large hydropower dams (Kainji, Jebba and Shiroro). As reference, the supply capacity excluding existing large hydropower dams (Kainji, Jebba and Shiroro) is presented in Table 6-7.

The increase in supply capacity in HA-1 is mainly contributed by Goronyo and Bakolori dams which have large storage capacity. In HA-3 and 4, the effect of Dadin Kowa dam, Kiri dams as the existing dams, and Kashimbilla as dam under-construction are large.

Table 6-6 Estimated Supply Capacity for Surface Water Source with Storage Dams at Representative Points for Each HA

HA	Ref. Points	MSFR (MCM/ year)	Supply Capacity - MSFR					
			90%Yearly Dependable (MCM/Year)			80%Yearly Dependable (MCM/Year		
			Quasi -Natural	with existing dams	with existing & UC dams	Quasi -Natural	with existing dams	with existing & UC dams
HA-1	Downstream end of HA-1	544	34	1,190	1,208	367	1,665	1,666
HA-2	Downstream end of HA-2	1,993	3	33,647	33,987	572	35,927	36,023
HA-3	Downstream end of HA-3	963	8	2,195	2,306	195	2,421	2,594
HA-4	Downstream end of HA-4	4,083	513	2,496	4,177	1,545	3,993	5,097
HA-5	Sum outlet of rivers in HA-5	13,093	989	33,713	34,589	3,265	38,708	38,933
HA-6	Sum outlet of rivers in HA-6	1,848	33	1,306	1,840	471	2,086	2,324
HA-7	Sum outlet of rivers in HA-7	6,731	460	459	556	1,367	1,427	1,502
HA-8	Before wet land area*	0	0	1,107	1,107	0	1,353	1,348

Note: MSFR=Minimum Stream Flow Requirement, UC=Under-Construction
* Sum of the values at the downstream end of SHA 802_i, 80401, 806, 807, 808061, 8080741, 808075
Source: JICA Project Team

Table 6-7 Estimated Supply Capacity for Surface Water Source with Storage Dams at Representative Points for Each HA in Case that Existing Large Hydropower Dams (Kainji, Jebba and Shiroro) are not Considered

HA	Ref. Points	MSFR (MCM/ year)	Supply Capacity - MSFR					
			90%Yearly Dependable (MCM/Year)			80%Yearly Dependable (MCM/Year		
			Quasi -Natural	with existing dams	with existing & UC dams	Quasi -Natural	with existing dams	with existing & UC dams
HA-1	Downstream end of HA-1	544	34	1,190	1,208	367	1,665	1,666
HA-2	Downstream end of HA-2	1,993	3	2,032	2,466	572	3,218	3,492
HA-3	Downstream end of HA-3	963	8	2,195	2,306	195	2,421	2,594
HA-4	Downstream end of HA-4	4,083	513	2,496	4,177	1,545	3,993	5,097
HA-5	Sum outlet of rivers in HA-5	13,093	989	2,098	3,069	3,265	6,000	6,402
HA-6	Sum outlet of rivers in HA-6	1,848	33	1,306	1,840	471	2,086	2,324
HA-7	Sum outlet of rivers in HA-7	6,731	460	459	556	1,367	1,427	1,502
HA-8	Before wet land area*	0	0	1,107	1,107	0	1,353	1,348

Note: MSFR=Minimum Stream Flow Requirement, UC=Under-Construction
* Sum of the values at the downstream end of SHA 802_i, 80401, 806, 807, 808061, 8080741, 808075
Source: JICA Project Team

6.4.2 Comparison between Water Demand and Water Supply Capacity at Scale of Entire HA

The comparison between water demand and water supply capacity at the representative point of HA (downstream end of HA) at the scale of HA is presented in Table 6-8. The table shows the case without large hydropower dams (Kainji, Jebba and Shiroro). For all HAs, the supply capacity with 90% yearly dependability is larger than the water demand. It should be understood that the water demand in 2030 could be supplied by existing dams and those under-construction, if one sees the balance in the scale of HA.

However, the distance between existing water source and demand site is usually far, some of the existing sources would not be able to be fully utilized for the demand. It is thereby necessary to examine local water balance between supply capacity and demand within HA. If the lack of water is expected at local water balance, new water source development may then be necessary to propose.

Table 6-8 Comparison between Water Demand and Water Supply Capacity at Scale of Entire HA

HA	Ref. Points	Supply Capacity – MSFR (without Large hydropower dams (Kainji, Jebbe and Shiroro)***				Water Demand (MCM/year)	
		90%Yearly Dependable (MCM/Year)		80%Yearly Dependable (MCM/Year)			
		with existing dams	with existing & UC dams	with existing dams	with existing & UC dams	Existing (2010)	Future (2030)
HA-1	Downstream end of HA-1	1,190	1,208	1,665	1,666	489	754
HA-2	Downstream end of HA-2	2,032	2,466	3,218	3,492	796	1,783
HA-3	Downstream end of HA-3	2,195	2,306	2,421	2,594	172	1,679
HA-4	Downstream end of HA-4	2,496	4,177	3,993	5,097	275	2,405
HA-5	Sum outlet of rivers in HA-5	2,098	3,069	6,000	6,402	1,150	4,660
HA-6	Sum outlet of rivers in HA-6	1,306	1,840	2,086	2,324	345	1,697
HA-7	Sum outlet of rivers in HA-7	459	556	1,427	1,502	89	341
HA-8	Before wet land area*	1,107	1,107	1,348	1,348	411**	870**

Note: MSFR=Minimum Stream Flow Requirement, UC=Under-Construction
* Sum of the values at the downstream end of SHA 802_i, 80401, 806, 807, 808061, 8080741, 808075
** The water demand whose source is Lake Chad is not included.
***The developed water volume by Lagdo dam is not included.
Source: JICA Project Team

6.4.3 Detailed Water Balance Study[1]

(1) Consideration of Groundwater Abstraction

The change in base flow due to abstraction of groundwater is approximately estimated on the basis of the simulated quasi-natural runoff and it is incorporated into the detailed water balance study.

(2) Classification of Water Use Facilities

It is inefficient to deal with all water use facilities that are scattered in nationwide and have various scales in same manner. In the present project, the water balance is examined by classifying the water use facilities into the following two (2) categories (refer to Figure 6-6).

- Water use facilities whose source is either significant dams or main rivers which flow across SHA
  - Directly modeled by the model network in MODSIM-DSS[2]; The nodes for inflow are basically given by SHA unit and the significant reservoirs whose total storage capacity is more than 100MCM is directly modeled by the model network.
  - 43 locations for municipal water supply, 49 locations for irrigation water supply
- Water use facilities whose source is in the catchment area of SHA
  - Aggregated in SHA, and modeled by spread sheet. The output of the spread sheet model is used for the input data for the model network in MODSIM-DSS

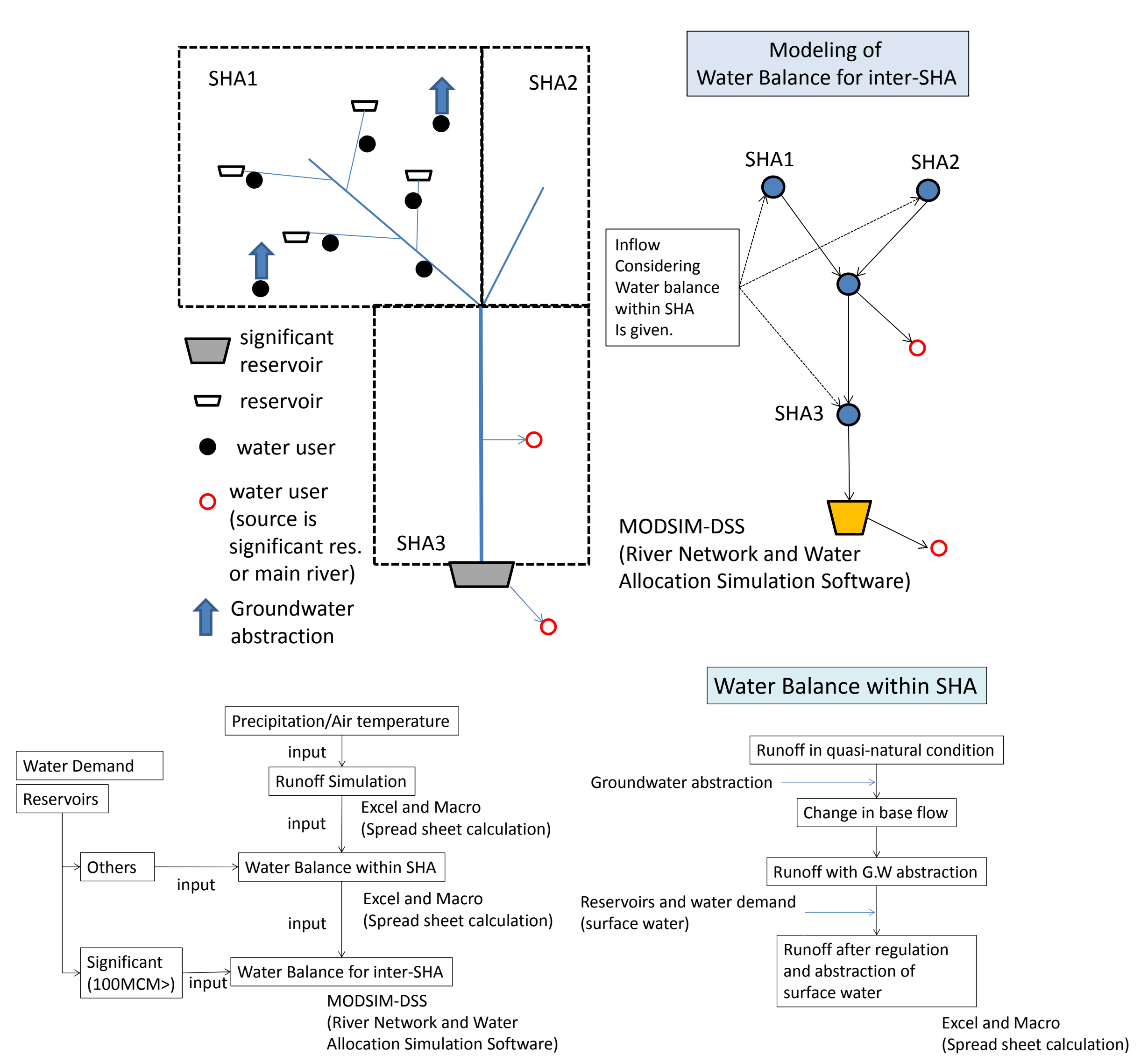
(3) Water Balance Study for Water Use Facilities whose source is in the Catchment Area of SHA

For the relatively large scale water use facilities whose source is in the catchment area of SHA, individual water balance is examined and accordingly necessary water resources development is proposed. The locations of water balance to be examined are shown in Figure 6-7.

- Municipal Water Supply: water purification plants whose volume of water source is more than 3MCM/year (58 locations in total)
- Irrigation Water Supply: Existing large scale irrigation scheme whose planed area is more than 500ha (75 locations in total)

[1] The detail of water balance study is described in Section SR3.4.4, Volume-5 Supporting Report.

[2] MODSIM-DSS is developed by Colorado State University. It supports the water allocation considering priorities among several multi-sector water users with Graphical User Interface. The software can be downloaded from its web-site http://modsim.engr.colostate.edu/ with free.



Source: JICA Project Team

Figure 6-6 Detail Water Balance Study for Surface Water

(4) Water Balance Study for Potential Water Resources Development Sites

The water balance study for the potential water resources development sites (288 sites in total) shown in Chapter 7 is also conducted. The results of the water balance study, together with roughly estimated cost for the construction, is utilized for evaluating economic efficiency of each site. The following is considered for the water balance study.

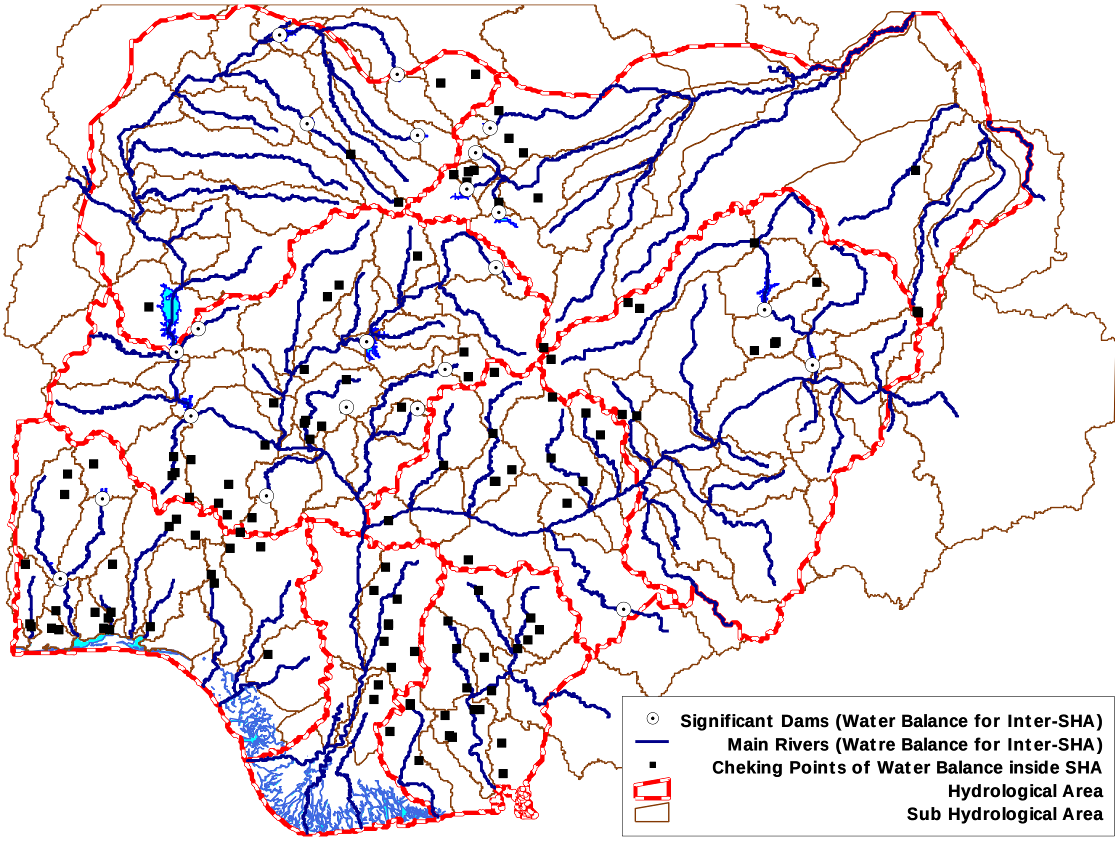
- It is assumed that the obligatory release associated with the existing water use by downstream water users within the same SHA in which the target new dam site is located, together with minimum stream flow requirement, are secured at first priority. The obligatory release is set based on the existing volume of water use and the ratio of the total runoff at the intake point of the existing water users and the runoff at the target new dam site.

(5) Remarks on Water Balance Study for Inter-SHA

- The followings are considered for water use by Fadama
  - In case that there are no significant dams, the loss of surface water by recharge in flood plain area is taken in to account in accordance with the abstraction of sub-surface water for water demand for Fadama. The total annual loss is set at the same volume as the annual water demand by Fadama, and the pattern of the loss is assumed to be proportional to river discharge.
  - In case that there are significant dams, the affected reach by the significant dams is firstly

specified, and then the constant release of water in accordance with the annual water demand by Fadama in the specified reach is set as the obligatory release from the dams. It is also assumed that the released water is lost by recharge to the swallow groundwater aquifer in the flood plain.

- In HA-8, the Catchment Management Plan (CMP) for the part of the HA has been prepared. On the basis of the CMP, the minimum stream flow at the downstream reach of the Hadejia River for keeping the wetland area good condition is additionally secured at 86MCM/year.
- It is assumed that the return flow from urban water use is 10% of the demand at source[3].
- It is assumed that the return flow from irrigation water use is set at 10% of the demand at source. The delay of the return flow is considered. The factor of the delay is set at 0.5, which means that 50% of the return flow would return within a month, and the remaining is taken over to the next month[4].
- The increase of low flow discharge due to the regulation by Lagdo dam located in the upper reach of the Benue River in the territory of Cameroon is not taken into account in the water balance study, because it is uncontrollable by Nigeria.



Source: JICA Project Team

Figure 6-7 Checking Points of Water Balance inside SHA

[3] Considering that the coverage rate of sewerage system in Nigeria is very low, it is assumed that most of supplied piped water for urban water use would not return to river course nearby. For conservative estimation, the 10% return is assumed.

[4] It is assumed that the unused water for crops (50% of diversion water requirement) would be infiltrated into surface soil and eventually run off to river course. The additional runoff volume could be 50% x 24% (average runoff rate in Nigeria) =12% of the diversion water requirement. For conservative estimation, the 10% return is assumed.

(6) Results of Water Balance Study

(6-1) Water Source for Municipal Water Supply

As the results of the water balance study for the relatively large scale water purification plants, it is evaluated that some water sources could experience the deficit for supplying necessary water volume with 90% yearly dependability. The recommended measures against those deficit as well as the results of the water balance study are summarized in Table 6-9. The municipal water supply plan in Chapter 8 as well as surface water development plan in Chapter 7 refers the recommendation shown in the table.

Table 6-9 Evaluation of Water Source for Municipal Water Supply and Recommended Measures

State	Surface Water Demand (MCM/Year)		Deficit (2030) (MCM /year)	Recommended Measures for Water Source	Recommended Measures for Water Purification Plant
	2010	2030			
Abia	9.18	16.25	-15.05	1. Construction of new dam for Aba Scheme (Dam SN:4012 GS=3.4MCM)	
Adamawa	14.90	52.06	-3.68	1. Construction of new dam for Mubi Scheme (Dam SN:3013 GS=6MCM)	
Anambra	0.00	142.57	-68.71	1. Construction of new dam for Greater Awka Scheme (Dam SN:4009 GS=9.5MCM) 2. Construction of new dam for Ihiala Regional Scheme (Dam SN:4010 GS=3.4MCM) 3. Construction of new dam for Nnewi Regional Scheme (Dam SN:4011 GS=24.2MCM)	
Bauchi	8.66	21.46	0.00	1. Change water source of 3.88MCM at Gubi dam to Waya dam	1. Construction of new WTW at Waya dam instead of at Gubi dam (InsCap=20,000m^3/day) or construction of pipiline from Waya dam to Gubi dam to convey water.
Borno	12.13	27.90	-6.50	1. Installation of diversion weir in Yedseram R. for Alau/Maiduguri Scheme	
Cross River	23.91	60.06	-5.36	1. Construction of new dam for Ogoja Scheme(Dam SN:2245 GS=5.4MCM)	
Ebonyi	4.40	69.10	-7.78	1. Construction of new dam for Ishielu/Ezzilo Scheme (Dam SN:4016 GS=2.3MCM)	
Ekiti	32.25	86.58	-0.38	1. Change water source of 0.38MCM at Ureja dam to Ogbessee dam	1. Construction of new WTW at Ogbesse dam (InsCap=1,240m^3/day at least)
Enugu	13.34	24.83	-23.61	1. Construction of new dam for Ajali Scheme (Dam SN:2185 GS=16.9MCM)	
Imo	18.19	32.19	-31.16	1. Construction of new dam for Okigwe Scheme(Dam SN:4015 GS=9.2MCM) 2. Construction of new dam for Owerri/Otamiri Scheme(Dam SN:4002 GS=3.9MCM)	
Jigawa	2.52	4.46	-1.33	1. Deficit is converted to GW source (additional GW scheme with 1.27MCM(=1.33/1.05) or 3470m^3/day)	
Kaduna	63.45	161.66	-11.02	1. Construction of new dam for Kwoi Scheme(Dam SN:4017 GS=2.5MCM) 2. Construction of new dam for Kafanchan Scheme(Dam SN:4003 GS=3.1MCM) 3. Construction of new dam for Kachia Scheme(Dam SN:4004 GS=3.5MCM)	
Kano	52.32	296.11	-21.06	1. Change water source of 6.44MCM at Guzuguzu, 3.38MCM at Karaye dam and 10.93MCM at Watari dam to Challawa R.	1. Construction of new WTW along Challawa R. (InsCap=67,667m^3/day at least)

State	Surface Water Demand (MCM/Year)		Deficit (2030) (MCM /year)	Recommended Measures for Water Source	Recommended Measures for Water Purification Plant
	2010	2030			
Katsina	27.62	52.05	-8.32	1. Change water source of 8.32MCM at Ajiwa dam to Zobe dam	1. Construction of new WTW at Zobe dam (InsCap=27,136m^3/day at least)
Kwara	27.28	48.29	-3.92	1. Construction of new dam for Oyun Scheme (Dam SN:2023 GS=18.9MCM)	
Lagos	93.71	678.51	-5.58	1. Construction of new dam for Otta Ikosi Scheme (Dam SN:2205 GS=20.6MCM)	1. Postponement of construction of the following WTWs (for demand up to 2030) 1) Yewa Phase-2 (WTW, Desalination) (InsCap=227,300m^3/day) 2) Odomola Phase-3 (WTW) (InsCap=431,870m^3/day)
Nasarawa	10.99	31.67	-15.89	1. Change water source of 3.09MCM at Lafia to Doma dam. 2. Construction of new dam for Keffi/Mada Scheme (Dam SN:4005 GS=3.1MCM)	1. Construction of new WTW at Doma dam (InsCap=10,078m^3/day at least)
Niger	31.57	62.77	-9.20	1. Construction of new dam for Bida Scheme (Dam SN:2067 GS=3.2MCM)	
Ogun	30.17	159.77	-15.21	1. Construction of new dam for Ota Scheme (Dam SN:4014 GS=6.4MCM) 2. Construction of new dam for Ijebu-Ode/Yemoji Scheme (Dam SN:4018 GS=3.3MCM) 3. Construction of new dam for Ogere & Shagamu Scheme (Dam SN:2205 GS=20.6MCM)	1. Postponement of construction of the following WTWs (for demand upto 2030) 1) Yewa Regional-1 (WTW) (InsCap=100,000m^3/day) 2) Yewa Regional-2 (WTW) (InsCap=100,000m^3/day) 3) Apoje Regional-2 (WTW) (InsCap=200,000m3/day) 4) Mokoloki Regional Phase-2 (WTW) (InsCap=250,000m^3/day) 5) Mokoloki Regional Phase-3 (WTW) (InsCap=200,000m^3/day)
Oyo	43.49	205.58	-109.92	1. Constructon of proposed Odedele dam for Odedele/Ibadan Scheme (Dam SN:3501 GS=182MCM)	
Plateau	21.30	43.18	-13.33	1. Construction of new dam and change of water source of 13.33MCM at Yakubu Gowon/Jos Scheme to Barakin dam (Dam SN:4007 GS=20.1MCM)	1. Construction of new WTW at the new dam (Dam SN:4007) (InsCap=43,477m^3/day at least)
Zamfara	8.38	28.63	-10.59	1. Construction of new dam for Gusau Scheme (Dam SN:4008 GS=29.7MCM)	

Remarks
1) GS＝Gross storage volume
2) For the states that are not shown in the table, it is evaluated that the water source for the water purification plants whose volume of water source is more than 3MCM/year can be supplied with 90% yearly dependability.

Source: JICA Project Team

(6-2) Water Source for Irrigation Water Supply

As the results of the water balance study for the existing large irrigation schemes whose planned area is more than 500ha, it is evaluated that the irrigable area in terms of stable water supply with 80% yearly dependability is less than the planned area in some schemes. The evaluated irrigable area for these schemes is shown in Table 6-10. The irrigation development plan in Chapter 8 as well as surface water development plan in Chapter7 refers the evaluated results shown in the table.

Table 6-10 Evaluation of Existing Irrigation Schemes in Terms of Availability of Water Source

SN	HA	Irrigation Scheme	Planned Area (ha)	Developed Area (ha)	Evaluated Irrigable Area(ha)	Remarks
1	1	Jibiya	3,500	3,000	2,300	In case that municipal water supply is prioritized.
2	1	Zobe	8,200	60	2,000	In case that municipal water supply is prioritized.
6	1	Sabke	1,200	540	130	In case that municipal water supply is prioritized.
7	1	Ajiwa	1,900	500	0	In case that municipal water supply is prioritized.
14	2	Omu-Aran	1,300	400	0	
19	2	Oke Oyi	500	100	60	
20	2	Oloru	500	20	0	
22	2	Oro-Ago	500	80	10	
25	2	Agaie/ Lapai	1,000	20	1,000	It is assumed that new dam (Dam SN：2028) is installed.
27	2	Duku-Lade	2,000	200	1,200	It is assumed that new dam (Dam SN：2043) is installed.
29	2	Guzan	1,500	400	0	
34	2	Zara	500	50	0	
35	2	Tubo	620	100	600	
37	2	Manta	500	300	0	Inundated by construction of Zungel dam
38	2	Badeggi	830	830	830	It is assumed that new dam (Dam SN：2066) is installed.
47	3	Wase	500	100	90	
50	3	Bagal	5,700	10	1,600	
51	3	Balanga	4,400	500	3,800	In case that municipal water supply is prioritized.
52	3	Kaititingo	2,300	0	0	
57	4	Longkat	2,000	800	1,100	In case that municipal water supply is prioritized.
62	4	Awe	500	0	80	
63	4	Umogidi	1,500	0	660	
66	4	Bokkos	1,000	18	370	
77	5	Ejule Ojebe	2,000	25	1,100	
78	5	Ofarachi	1,000	10	520	
80	5	Ada-Rice	5,000	1,000	1,000	
81	5	Uzo Uwani	1,000	315	50	
82	6	Upper Ogun	2,000	10	600	
83	6	Ofiki(A)	2,000	24	60	
85	6	Sepeteri(A)	2,000	24	30	
87	6	Iwo	1,000	0	0	
88	6	Ilero	2,000	0	70	
89	6	Otta	1,000	340	0	
90	6	Eyinwa	1,000	300	10	
91	6	Oke-Odan	600	250	400	
93	6	Okuku	600	0	30	
94	6	Igbonla	1,500	130	130	
96	6	Oye	500	100	0	

SN	HA	Irrigation Scheme	Planned Area (ha)	Developed Area (ha)	Evaluated Irrigable Area(ha)	Remarks
99	7	Nkari	2,080	0	610	
100	7	Ijegu Yala	2,000	80	910	
102	7	Imo (Igwu and Ibu)	1,200	80	0	In case that municipal water supply is prioritized.
105	7	Isi-Uzo	500	71	360	
107	7	Igbere	1,300	250	440	
109	7	Adim Rice	1,000	545	340	
110	7	Idomi	1,000	100	530	
115	8	Kano River Phase II	40,000	203	15,000	In case that municipal water supply is prioritized.
120	8	Jere Bowl Rice	1,300	0	0	In case that municipal water supply is prioritized.
122	8	Michika	500	200	0	
124	8	Gari	4,100	2,200	300	In case that municipal water supply is prioritized.
126	8	Jakara	2,000	820	430	
127	8	Baguwai (Watari)	872	273	0	In case that municipal water supply is prioritized.
130	8	Dembo	700	60	0	In case that municipal water supply is prioritized.
131	8	Guzuguzu	530	530	0	In case that municipal water supply is prioritized.
132	8	Magaga	600	300	70	In case that municipal water supply is prioritized.
133	8	Bagauda	610	300	430	
140	8	Gwarzo	600	0	0	In case that municipal water supply is prioritized.

Remarks: For the irrigation schemes which are not shown in the table, it is evaluated that the stable water supply with 80% yearly dependability can be secured for the planned irrigation area. It should be noted that the irrigation schemes whose source is wetland area or Lake Chad are not evaluated by the water balance study.
Source: JICA Project Team

(6-3) Hydropower Generation by Significant Dams

On the basis of the simulated results by the water balance study for the water demand in 2030, the hydropower generation by the significant dams as well as large hydropower dams (Kainji, Jebba, Shiroro) is estimated. The results are shown in Table 6-11.

Table 6-11 Estimated Hydropower Generation by Significant Dams

	Dam	Install Capacity (MW)	Average Generated Energy (GWh/year)	80% yearly dependable Generated Energy (GWh/year)	Remarks
1	Gurara	30	45.9	36.2	It is assumed that the hydropower is generated by the release from dam except the transferred water to Abuja.
2	Oyan	9	24.9	15.2	It is assumed that all released water is used for hydropower generation.
3	Ikere George	6	21.9	16.7	It is assumed that all released water is used for hydropower generation.
4	Bakolori	3	13.2	11.8	It is assumed that all released water is used for hydropower generation.
5	Dadin Kowa	34	94.6	80.2	It is assumed that the hydropower is generated by the release from dam except the water volume directly supplied to municipal water supply from dam.
6	Tiga	6	26.1	19.8	It is assumed that all released water is used for hydropower generation.
7	Kiri	20	60.4	47.3	It is assumed that the hydropower is generated by the release from dam except the water volume directly supplied to irrigation scheme from dam.
8	Jibiya	3	0.7	0.3	It is assumed that all released water is used for hydropower generation.
9	Challawa Gorge	6	10.6	5.7	It is assumed that all released water is used for hydropower generation.
10	Zobe	3	1.9	0.9	It is assumed that all released water is used for hydropower generation.
11	Omi	2	5.9	4.5	It is assumed that all released water is used for hydropower generation.
12	Kashimbilla	40	216.0	206.2	It is assumed that the hydropower is generated by the release from dam except the water volume directly supplied to municipal water supply from dam.
13	Kainji	500	1,825.9	1,325.7	It is assumed that all released water is used for hydropower generation. It is also assumed that almost constant volume with 80% yearly dependability is released.
14	Jebba	540	2,026.0	1,601.0	It is assumed that all released water is used for hydropower generation. It is also assumed that almost constant volume with 80% yearly dependability is released.
15	Shiroro	550	1,408.4	1,177.2	It is assumed that all released water is used for hydropower generation. It is also assumed that almost constant volume with 80% yearly dependability is released.

Remarks:
1) It is assumed that overall efficiency is 0.7.
2) As for Oyan, Ikere Gorge, Bakolori, Dadin Kowa, Kiri, Kainji, Jebbea, Shiroro dams whose H-V-A relation is available for the present project, the fluctuation of water level is taken into account for estimating hydropower generation. For other dams, the head is approximated at 50% of the maximum water depth for estimating hydropower generation.

Source: JICA Project Team based on information from FMWR and FMP

(6-4) Excess Storage Volume in Significant Dams

It is clarified that there could be excess storage volume in some significant dams, even if the demand for irrigation and municipal water supply in 2030 is considered. The possible additional water supply volume with 90% yearly dependability as well as excess storage volume is shown in Table 6-12. The excess storage volume can be utilized for several different purposes such as irrigation, municipal water supply, enhancement of firm energy of hydropower generation, reduction of peak flood discharge and enhancement of river environment. It is necessary to discuss how to use the excess storage volume by stakeholders in each of hydrological area. It would be one of important topics during formulation of the Catchment Management Plan.

Table 6-12 Excess Storage Volume in Significant Dams

No	Dam	HA	Effective Storage Volume (MCM)	Excess Storage Volume (MCM)	Location to Evaluate Possible Additional Water supply Volume	Possible Additional Water Supply Volume with 90% yearly dependability (MCM/year)
1	Jibiya	1	121	0		0
2	Zobe	1	170	0		0
3	Goronyo & Bakolori	1	1,336	906	Wamako	216
4	Galma	2	141	91	Downstream of Galma dam	132
5	Aula	2	180	150	Downstream of Aula dam	156
6	Gurara	2	700	700	Downstream of Gurara dam	708
7	Omi	2	220	190	Downstream of Omi dam	144
8	Usuma	2	100	0		0
9	Dadin Kowa & Kiri	3	3,090	2,540	Downstream of Kiri dam	2,280
10	Kashimbilla	4	378	368	Downstream of Kashimbilla dam	1,680
11	Oyan & Ikere Gorge	6	830	365	Intake point of Akute in Lagos State	360
12	Tiga & Challawa Gorge	8	2,126	0		0
13	Watari	8	93	0		0
14	Gari	8	203	0		0
15	Alau	8	106	0		0

Source: JICA Project Team

(6-5) Remarks on Water Balance Study

The water balance study in the present project has been conducted by utilizing the currently available data and information on water use facilities as well as the estimated water quasi-natural flow. There are also many assumptions such as the setting of minimum stream flow requirement. All of these may affect the results of the water balance study. It should be noted that the results of the water balance study are based on those data, information and the assumptions.

It is recommended that the effort to refine the estimation of flow condition by improving hydrological observation and the data/information on water use facilities be continued, in order to proceed to the next step for implementation of the water resources project. The refined water balance study should be conducted when the individual project will be implemented.

6.4.4 Estimation of Risk Associated with Climate Change and Trans-boundary Water

(1) Risk related to Water Supply-Demand Balance Associated with Climate Change

In order to estimate the risk on water supply-demand balance associated with climate change, the water balance study with the runoff and water demand considering under the climate change scenario of Case-1 shown in 5.4.2 (3) The Case-1 considers only changes in air temperature and gives smaller runoff compared to Case-2.

As the results of the water balance study for the relatively large scale water purification plants whose abstraction volume is more than 3MCM/year under the climate change scenario of Case-1, it is expected that the safety level of water supply could be lower than 90% yearly dependability in some places, as shown in Table 6-13. There could be many intake points whose safety level is expected to be lower than 80% yearly dependability in HA-3 and 8. The impact of climate change on municipal water supply tends to be larger in these HAs.

As the results of the water balance study for the existing large irrigation schemes whose planned area is more than 500ha under the climate change scenario of Case-1, it is expected that the available irrigation area in terms of stable water supply with 80% yearly dependability could decrease in some irrigation schemes, as shown in Table 6-14. The significant reduction could be expected in HA-8, in which both irrigation and municipal water demand are large.

Although it is evaluated that there is the excess storage volume in Oyan and Ikere Gorge dams in the Ogun river basin in HA-6 in case of base climate condition, the excess volume becomes zero in case of climate change of Case-1, because of the significant reduction of runoff in the river basin and subsequently the lowered turn-over rate in these dams. Furthermore, it is executed that the safety level of municipal water supply could become lower than 90% yearly dependability in Osun river basin.

In HA-8, supplying stable water to Kano River Phase-2 with 40,000ha could become impossible. Furthermore, the available irrigation area in Hadejia Valley could become to about 3,000ha.

Table 6-13 Estimated Lowering on Safety Level for Municipal Water Supply by Climate Change Scenario of Case-1

HA	Number of Water Sources for Municipal Water Supply				
	More than 90% yearly dependability	80-90% yearly dependability	50-80% yearly dependability	Less than 50% yearly dependability	Total
1	5	4	1	0	10
2	9	5	1	0	15
3	8	0	1	2	11
4	10	0	0	0	10
5	6	0	0	0	6
6	19	5	1	0	25
7	7	5	0	0	12
8	8	3	4	0	15

Source: JICA Project Team

Table 6-14 Reduction of Irrigable Area in Terms of Stable Water Supply in Case of Climate Change Scenario of Case-1

HA	Ratio of Irrigable Area in case of climate change scenario of case-1 and that of base climate condition (%)
1	92
2	94
3	87
4	84
5	93
6	99
7	97
8	52

Remarks: Only the results for the large irrigation scheme whose planned area is more than 500ha are compiled.
Source: JICA Project Team

The hydropower generation by the significant dams as well as large hydropower dams (Kainji, Jebba, Shiroro) could be reduced to 60-90% of the base climate condition, in case of climate change scenario of Case-1, as shown in Table 6-15.

Table 6-15 Reduction of Hydropower Generation in Case of Climate Change Scenario of Case-1

	Dam	Install Capacity (MW)	Ratio of average hydropower generation in case of climate change scenario of case-1 and that of base climate condition (%)
1	Gurara	30	77
2	Oyan	9	73
3	Ikere George	6	81
4	Bakolori	3	78
5	Dadin Kowa	34	81
6	Tiga	6	73
7	Kiri	20	78
8	Jibiya	3	47
9	Challawa Gorge	6	63
10	Zobe	3	63
11	Omi	2	76
12	Kashimbilla	40	97
13	Kainji	500	87
14	Jebba	540	87
15	Shiroro	550	75

Source: JICA Project Team

(2) Risk related to Water Supply-Demand Balance Associated with Trans-boundary Water

As discussed in Chapter 5, about 24% of the total water resources potential in Nigeria relies on trans-boundary water. Because most of the trans-boundary water is the inflow through the Niger and Benue rivers, the impact of trans-boundary water would mainly appear along the main course of the Niger and Benue rivers.

There are large hydropower dams constructed along the main course of the Niger River. It is possible that hydropower generation by these dams be affected by the change in inflow from the upstream countries. Although it is difficult to predict the change in the inflow, the effect on the hydropower generation is estimated under the scenario that the average inflow would be reduced.

The scenarios are that only average inflow volume is reduced by 10, 30 and 50%, with the flow pattern unchanged with the past 40years (1970-2009) at Malanville in Benin. The water balance study with these scenarios is examined. The estimated hydropower generation at Kainji and Jebba dams is shown in Table 6-16. The reduction rate of generated energy is almost same as that of inflow to Nigeria when the reduction rate is small, however, the higher reduction rate the lower impact on generated power.

Table 6-16 Reduction of Hydropower Generation of Kainji and Jebba Dams due to Reduction of Inflow from Upstream Countries of Niger River

Dam	Reduction Rate of hydropower generation against base case (Last 40 yeras (1970-2009))		
	10% Reduction of average inflow	30% Reduction of average inflow	50% Reduction of average inflow
Kainji	-9%	-23%	-38%
Jebba	-6%	-18%	-30%

Source: JICA Project Team

In addition to the long-term regime change of inflow, sudden change in flow due to operation of dams in upstream countries should be taken care. In order to flexibly cope with the sudden change in flow condition, the real-time monitoring of flow condition as well as close communicant and information exchange with neighboring countries should be established.

CHAPTER 7 WATER SOURCES DEVELOPMENT PLAN

7.1 Groundwater Development Plan

7.1.1 Current Situation of Groundwater Development

(1) Merit of Groundwater Use in Nigeria

Merit of groundwater resources should be considered as mentioned below:

- Groundwater is stored in aquifer, which is distributed in every place in Nigeria.
- Groundwater can be used even in dry season. In this point, groundwater is superior to surface water and rain-harvesting water.
- Cost of groundwater development and usage is less expensive than that of surface water in case where amount of groundwater development is small. Therefore, groundwater is suitable for rural water supply and small town water supply, which cannot expect large investment.
- Generally, groundwater has better water quality than surface water and does not need high level treatment even for drinking.

On the other hand, groundwater has demerit below:

- Amount of groundwater flow is small compared with amount of groundwater stored in aquifer. Therefore groundwater level will decline regionally when groundwater is extracted more than replenishment (=groundwater recharge). As a result, environmental hazard such as land subsidence and sea water intrusion will take place.

(2) Characteristics of Borehole

<u>Yield of borehole</u>

Standards yield of boreholes is shown in Table 7-1.

Table 7-1 Potential Yield of Borehole

Aquifer type		Potential Yield
Sedimentary rock and unconsolidated sediment	Sand /gravel layer	20 to 500m^3/day
	Sandstone	Less than 20 to 500m^3/day
	Argillaceous rocks	Less than 20m^3/day
Basement Complex		Less than 20m^3/day

Source: JICA Project Team

<u>Length of borehole</u>

Relationship between aquifer type and borehole depth is shown in Table 7-2.

Table 7-2 Type of Aquifer and Depth of Borehole

Aquifer type		Aquifer distribution	Representative depth of borehole
Sedimentary rock and unconsolidated sediment	Sand and gravel	Aquifer is distributed shallow in alluvial area and deep in Tertiary area.	10m to 300m
	Sandstone	Sandstone aquifer is distributed following geological structure.	30m to 300m
	Argillaceous rock	Aquifer is formed in weathered and fractured zone near the ground surface.	30m to 50m
Basement Complex		Aquifer is formed in weathered and fractured zone near the ground surface.	30m to 50m

Source: JICA Project Team

<u>Operation rate of borehole</u>

According to survey by FMWR on water supply infrastructure in 2006, 37% of the existing boreholes are currently not used. Breakdown of hand pumps and motorized pump is main reason. User's organizations are in charge of maintenance of pumps for small town and rural water supply. However, most of the user's organizations are not functioning. As a result, many broken pumps are left non-operational without any repair.

7.1.2 Optimum Method of Groundwater Development

Optimum groundwater development by aquifer was examined based in groundwater recharge using borehole filed theory.

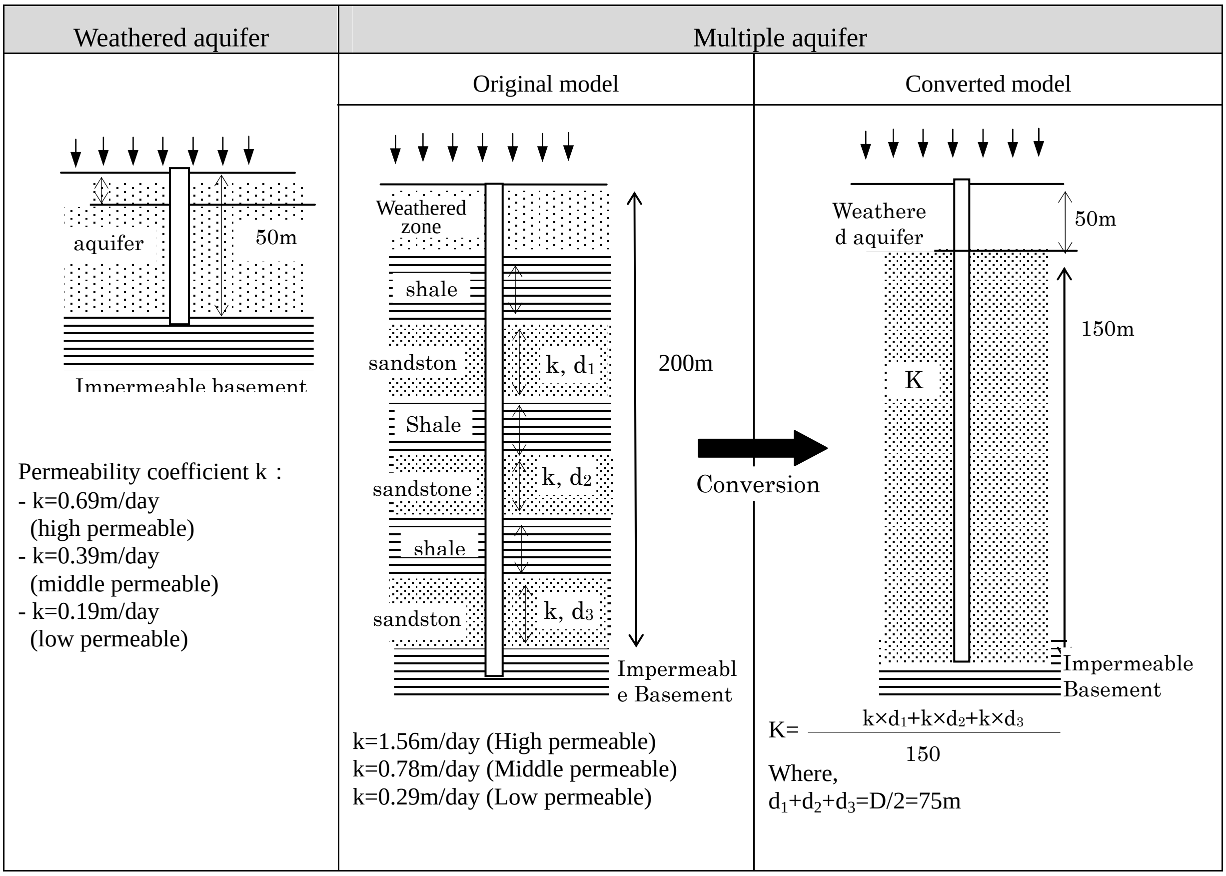
Aquifer of Nigeria is classified into two types as shown in Table 7-3

Table 7-3 Aquifer Type

Geology		Model
Basement rock	Weathered rock	Weathered aquifer
Sedimentary rock	Weathered rock	
	Sandstone within alternation of sandstone and shale	Multiple aquifer

Source: JICA Project Team

Representative hydrogeological parameters were selected for based on hydrogeological characteristics of weathered aquifer and multiple aquifer as shown in Figure 7-1 and Table 7-4.



Source: JICA Project Team

Figure 7-1 Aquifer Model

Amount of current groundwater development and number of the existing boreholes are taken into consideration in estimation of aquifer parameters. Amount of newly available groundwater was calculated for 6 aquifer types shown in Table 7-4, based on groundwater recharge and aquifer parameters, applying borehole field theory.

Table 7-4 Aquifer Model

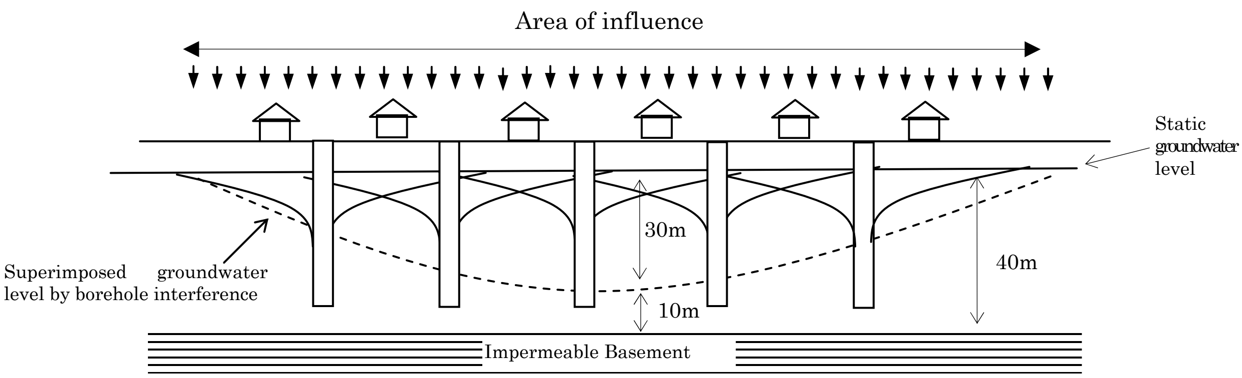
Model	Symbol		Aquifer type	Thickness of aquifer	Permeability coefficient (see 7-1)	Static groundwater level
Weathered aquifer	**W**eathered **H**igh permeability	WH	Weathered Basement rock and weathered part of the other type rocks	50m	0.69	GL-10m
	Weathered **M**iddle permeability	WM			0.39	
	Weathered **L**ow permeability	WL			0.19	
Multiple aquifer	**M**ultiple **H**igh permeability	MH	Sandstone or sandy formation within alternation of sandstone and shale	200m	1.56	GL-50m
	Multiple **M**iddle permeability	MM			0.78	
	Multiple **L**ow permeability	ML			0.39	

Source: JICA Project Team

Limit of pumping

Weathered aquifer: As shown in Figure 7-2, it is assumed that pumping limit happens when distance between impermeable basement rock and the lowest groundwater level is 10m by pumping. It means that draw-down of groundwater level of 30m is set as pumping limit.

Multiple aquifers: Draw-down of 50m is assumed as pumping limit.



Source：JICA Project Team

Figure 7-2 Conceptual Scheme of Pumping Limit of Weathered Aquifer

Available yield of borehole field is expressed by the formula in Table 7-5, which is approximated function of i) groundwater recharge, ii) number of boreholes, iii) distance between boreholes.

Optimum groundwater development plan was proposed using formula on Table 7-5, which was applied to groundwater recharge of 6 aquifers classified for entire Nigeria. Optimum groundwater development means that groundwater recharge will be pumped up efficiently within influence area, by optimum borehole distribution and yield of each borehole.

Table 7-5 Groundwater Development Potential

Aquifer type T: Transmissibity (m^2/day) K: Conductance (m/day) L: Aquifer thickness (m)			Formula to estimate sustainable yield of borehole field (m^3/day) • Number of boreholes in borehole field (N) • Groundwater recharge (P, mm/year) • Distance between boreholes (D, m)		Yield per Borehole (m^2/day)	
		T=K*L	One borehole	More than 2 boreholes	Average	Range
WH	**W**eathered **H**igh permeability	62	$Y=11.08\times T\times P^{0.06}$	$Y=T\times(0.74+0.43)\times N^{0.53}\times P^{0.25}\times D^{0.47})$	480	100-1,000
WM	**W**eathered **M**iddle permeability	31			380	300-500
WL	**W**eathered **L**ow permeability	16			150	100-300
MH	**M**ultiple **H**igh permeability	104	$Y=13.58\times T\times P^{0.05}$	$Y=T\times(0.81+1.20\times N^{0.42}\times P^{0.20}\times D^{0.37})$	990	700-1,500
MM	**M**ultiple **M**iddle permeability	58			560	500-900
ML	**M**ultiple **L**ow permeability	29			280	200-500

Source：JICA Project Team

7.1.3 Groundwater Development Plan by Aquifer

(1) Basic Policy

Basic policy of groundwater development is as follows:

- Groundwater development should be sustainable in view pint of water balance
- Groundwater development should be efficient in economic view point

Groundwater will be developed for water supply, private irrigation, livestock and aqua-culture. Policy for groundwater development for each water use sector is as follows:

(2) Municipal Water Supply

(2-1) Distribution of Water Demand

Groundwater will be developed in large scale for water supply sector than the other sectors. Therefore, groundwater development will be planned in detail for LGA by LGA based on groundwater demand of each LGA, and will be finally summed up by state.

(2-2) Concept of Groundwater Development

Concept of groundwater development is proposed as shown in Table7-6.

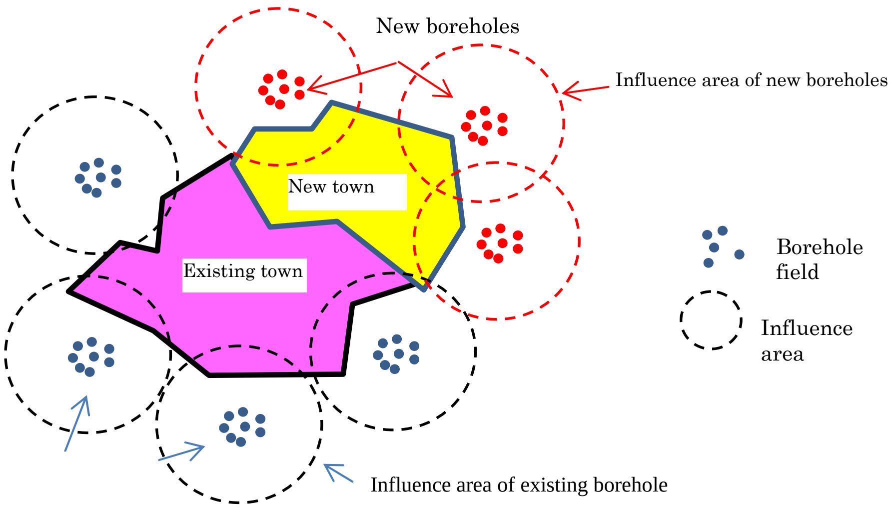
Table 7-6 Concept of Groundwater Development

Classification	Concept of groundwater development
Urban/Semi-urban/ Small town	Well fields will be constructed around urban/semi-urban/small town area, supplying water by independent water supply system with well field. See Figure 7-3.
Rural	Boreholes will be constructed individually for water supply for communities using hand-pumps and motorized pumps. Ratio between hand pumps and motorized pumps is estimated as 4:6. This ratio is assumed to be kept until year of 2030...

Source: JICA Project Team

Borehole field will be planned for each LGA, with the conceptual scheme shown in Figure 7-3. Design parameters by this Project are below:

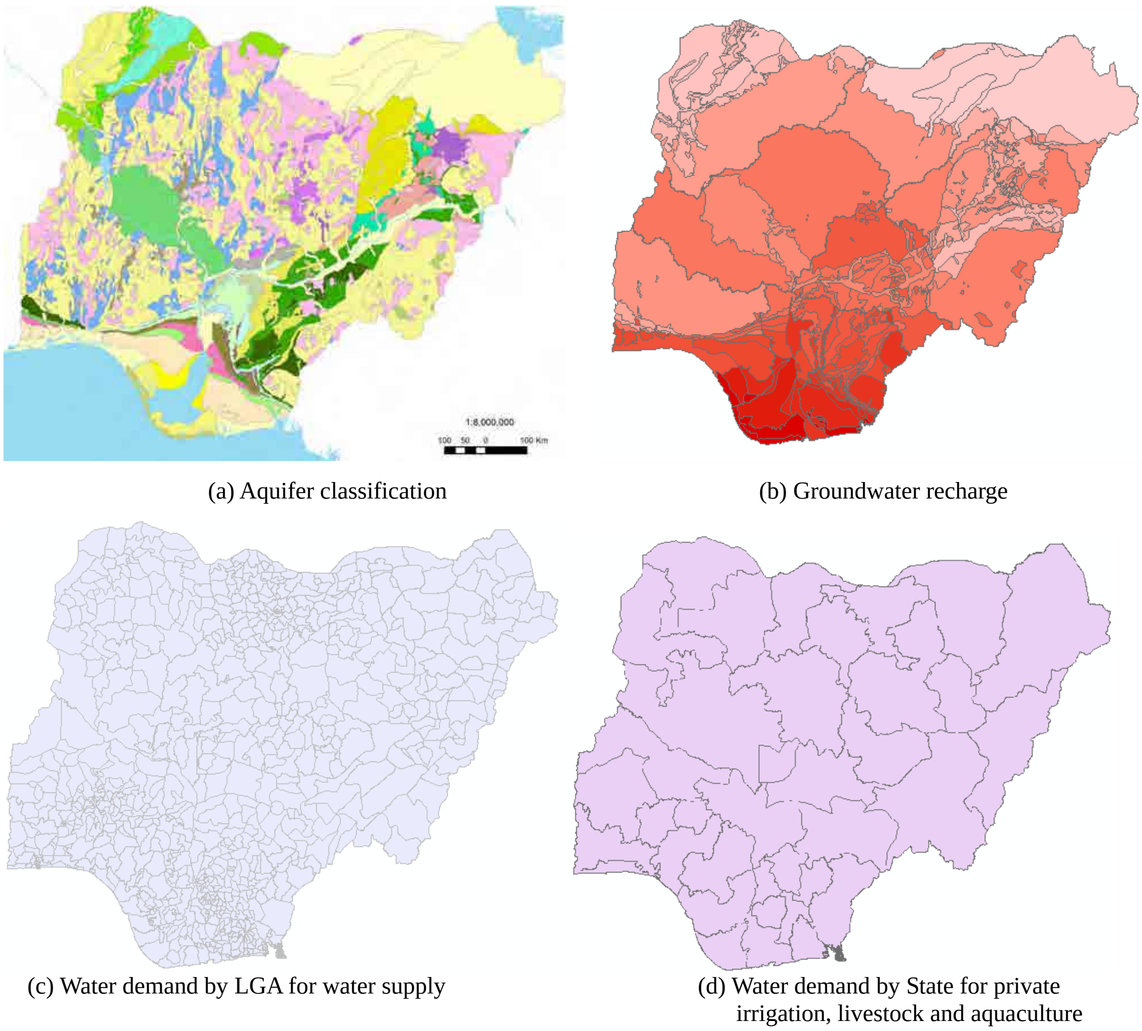
- Number of borehole fields by LGA
- Available yield from each borehole fields
- Number of boreholes in each borehole field



Source: JICA Project Team

Figure 7-3 Conceptual Scheme of Municipal Water Supply by Borehole Field

Factors to be considered in planning borehole field are shown in Figure 7-4.



Source: JICA Project Team

Figure 7-4 Content of Factors to be considered in Groundwater Development Plan

Available yield (Y) and number of boreholes (N) were estimated from three (3) factors: i) type of aquifer, ii) groundwater recharge (P) and iii) distance between boreholes (D), using relationship shown in Table 7-5 and Table 7-7.

Table 7-7 Relationship between Geological Formation and Aquifer Type

Geological formation	Aquifer type	Geological formation	Aquifer type
Alluvial Sediments	MH	Bassange Formation	WL
Meader belt, Back swamps, Water Swamps	MH	Nkporo Formation	WL
Abandoned Beach Ridge	MH	Agwu Formation	WH
Mangrove Swamp	MH	Taloka Formation	ML
Sombreiro Deltaic Formation	MH	Dukamaje Formation	WL
Chad Formation	MH	Rima Group	WL
Benin Formation	MH	Pindiga Formation	WL
Newer Basalt	WH	Lafia-Wukari Formation	MM
Older Basalt	WL	Nupe Formation	ML
Ogwashi-Asaba Formation	WM	Gundumi-Illo Formation	MM
Ilaro Formation	MH	Fika Formation	ML
Gwandu Formation	MM	Eze-Aku Formation	WM
Imo Group	WL	Yola-Bima-Yolde Formation	WM
Keri-Keri Formation	MM	Bima Formation	WM
Sokoto Formation	ML	Asu River Group	WL
Gombe Formation	WL	Young Granite	WM
Ajali Formation	MH	Older Granite	WM
Nsuka Formation	WL	Meta Sedimentary	WM
Abeokuta Formation	MM	Migmatite Gneiss	WM
Mamu Formation	WL	Cataclastic	WM

Source: JICA Project Team

(2-3) Condition of Borehole Field Planning

<u>Optimum Yield of Borehole Field</u>

As shown in Figure 7-3, borehole filed will expand with population growth of cities/towns. It should be noticed that number of boreholes can be set minimum in entire Nigeria by giving optimum yield to each borehole field, which depends on capacity of aquifer. This project proposed optimum yield of borehole fields by aquifer type. The result of analysis for optimum yield is shown in Table 7-8.

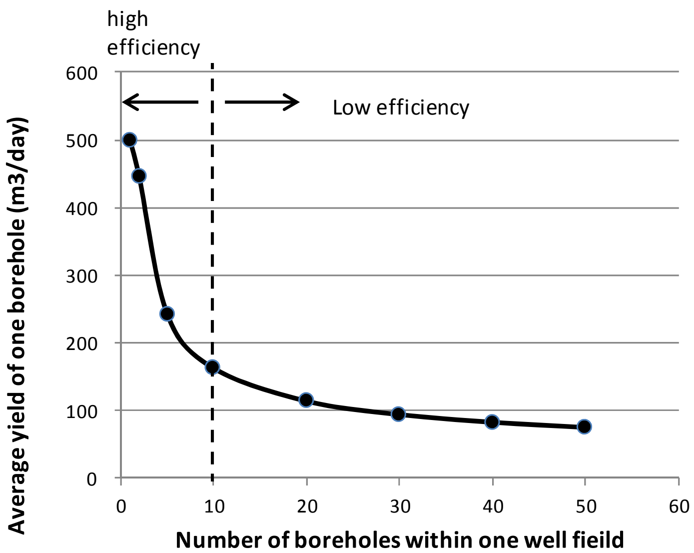
Table 7-8 Optimum Yield of Borehole Field

<table>
<tr><th rowspan="3">Aquifer type</th><th colspan="2">Urban/Semi-urban/Small town</th><th colspan="4">Rural*</th></tr>
<tr><th colspan="2">Motorized pump</th><th colspan="2">Motorized pump</th><th colspan="2">Hand pump</th></tr>
<tr><th>Optimum yield of boreholes field (m^3/day)</th><th>Population to-be-supplied (persons)</th><th>Optimum yield of boreholes field (m^3/day)</th><th>Population to-be-suppl ied (persons)</th><th>Independent borehole (m^3/day)</th><th>Population to-be-supplie d (persons)</th></tr>
<tr><td>WH</td><td>1,000</td><td>10,000</td><td rowspan="6">Less than 150</td><td rowspan="6">Less than 5,000</td><td rowspan="6">10</td><td rowspan="6">Less than 300</td></tr>
<tr><td>WM</td><td>500</td><td>5,000</td></tr>
<tr><td>WL</td><td>400</td><td>4,000</td></tr>
<tr><td>MH</td><td>1,500</td><td>15,000</td></tr>
<tr><td>MM</td><td>1,000</td><td>10,000</td></tr>
<tr><td>ML</td><td>900</td><td>9,000</td></tr>
</table>

Remarks
*: Optimum borehole yield for rural water supply will be decided not by aquifer capacity but by community population.
Source: JICA Project Team

Number of Boreholes by Borehole Field

As number of boreholes increases, available yield from each borehole will decrease as shown in Figure 7-5. Therefore, 10 boreholes should be max in each borehole filed for high efficiency in economical view point.



Source: JICA Project Team

Figure 7-5 Number of Boreholes and Yield from each Borehole in Borehole Filed

Limitation by Groundwater Recharge

For sustainable groundwater development, amount of groundwater development should be less than amount of groundwater recharge within each LGA. On the other hand, if groundwater development is larger than groundwater recharge within LGA, additional consideration is necessary.

Borehole Specification

Borehole specification is shown in Table 7-9. Borehole specification depends on aquifer type. Important point in specification is summarized below.

- Borehole length is set as 50m in the Basement Rock area.
- In the Sedimentary rock area, Borehole length will be between 50-600m depending on geological condition at place by place. However, in this Project, borehole length is set as 200m to deal the entire Nigeria by simplified and unified way in hydrogeological view point.
- Borehole diameter should be 6 inch for motorized pump and 4 inch for hand pump. However, in this Project 6 inch diameter is recommended even for hand pumps borehole. This is for future change of pump type from hand pump to motorized pump in rural water supply.
- Distance between boreholes in borehole filed is set as 200m.

Table 7-9 Borehole Specification

Aquifer type	Urban/Semi-urban/Small town		Rural			Note
	Motorized pump		Motorized pump	Hand pump	Borehole diameter (inch)	
	Borehole depth (m)	Borehole diameter (inch)	Borehole depth (m)	Borehole diameter (inch)		
WH	50	6	50	50	6	Distance Between boreholes in borehole filed is 200m
WM	50	6	50	50	6	
WL	50	6	50	50	6	
MH	200	6	200	50	6	
MM	200	6	200	50	6	
ML	200	6	200	50	6	

Source: JICA Project Team

(2-4) Borehole Construction Plan

Current Yield

For planning of new borehole construction, the current yield from existing boreholes must be known. The current yield from the existing boreholes by state is shown in Table 7-10.

Table 7-10 Current Yield from Existing Boreholes by State

State		Urban/ Semi-urban/ Small town	Rural		State		Urban/ Semi-urban/ Small town	Rural	
		Motorized pump	Motorized pump	Hand pump			Motorized pump	Motorized pump	Hand pump
		m^3/day	m^3/day	m^3/day			m^3/day	m^3/day	m^3/day
1	Abia	171,464	13,642	1,701	20	Katsina	75,731	19,524	13,748
2	Adamawa	9,349	1,259	10,115	21	Kebbi	54,890	12,529	6,385
3	Akwa Ibom	204,237	20,288	0	22	Kogi	78,468	11,562	2,190
4	Anambra	126,283	9,138	869	23	Kwara	63,444	10,686	4,952
5	Bauchi	131,820	15,272	3,893	24	Lagos	1,142,528	2,619	5,456
6	Bayelsa*1	3,027	5,748	0	25	Nasarawa	43,972	7,583	2,671
7	Benue	154,788	20,894	6,985	26	Niger	138,811	19,460	11,706
8	Borno	151,168	9,578	6,568	27	Ogun	231,094	14,301	1,056
9	Cross River	35,052	5,986	0	28	Ondo	157,154	20,936	3,405
10	Delta	170,787	16,368	1,788	29	Osun	121,265	30,226	2,867
11	Ebonyi	63,702	7,159	5,998	30	Oyo	305,109	37,604	7,644
12	Edo	247,183	8,773	915	31	Plateau	54,851	7,178	1,800
13	Ekiti	49,233	14,362	1,225	32	Rivers	328,610	20,916	5,184
14	Enugu*4	33,225	8,946	882	33	Sokoto	87,675	22,135	3,297
15	Gombe	36,092	615	7,137	34	Taraba	22,435	3,060	3,336
16	Imo	87,194	18,041	2,359	35	Yobe	70,622	8,335	4,571
17	Jigawa	216,661	0	41,319	36	Zamfara	124,408	18,098	6,231
18	Kaduna	171,991	44,063	10,654	37	FCT Abuja	18,489	90	2,322
19	Kano	443,575	18,706	20,664		Total	5,626,388	505,683	307,828

Source: JICA Project Team

Relationship between yield by rehabilitated boreholes and newly drilled borehole

Amount of groundwater by newly drilled boreholes will be estimated form relationship below, considering available yield by borehole rehabilitation

Amount of groundwater by newly drilled boreholes	=	Amount of groundwater to be developed by 2030	-	Amount of groundwater by rehabilitated boreholes

Table 7-11 Amount of Groundwater by Newly Drilled Boreholes and by Borehole Rehabilitation

	State	Amount of groundwater to be developed by 2030		Amount of groundwater by rehabilitated boreholes		Amount of groundwater by newly drilled boreholes		
		Urban/ Semi-urban/ Small town	Rural	Urban/ Semi-urban/ Small town	Rural	Urban/ Semi-urban/ Small town	Rural	
						Motorized pump	Motorized pump	Hand pump
		m^3/day	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day
1	Abia	234,836	30,910	73,485	6,576	161,351	14,600	9,734
2	Adamawa	176,499	64,336	3,435	2,007	173,064	37,397	24,931
3	Akwa Ibom	311,393	69,628	155,697	24,797	155,697	26,899	17,933
4	Anambra	134,954	49,824	56,736	4,496	78,218	27,197	18,131
5	Bauchi	300,186	109,555	112,291	16,326	187,895	55,937	37,291
6	Bayelsa	246,612	19,464	4,540	8,622	242,072	6,506	4,337
7	Benue	146,595	86,034	73,298	24,723	73,298	36,786	24,524
8	Borno	290,589	82,243	37,792	4,037	252,797	46,924	31,283
9	Cross River	121,148	63,719	60,574	31,859	60,574	19,116	12,744
10	Delta	465,063	59,466	232,531	27,234	232,531	19,339	12,893
11	Ebonyi	0	41,270	0	3,930	0	22,404	14,936
12	Edo	212,275	43,604	0	2,036	212,275	24,941	16,628
13	Ekiti	65,945	31,420	32,973	15,587	32,973	9,500	6,333
14	Enugu	377,139	48,300	22,150	6,552	354,988	25,049	16,699
15	Gombe	134,299	49,695	44,113	9,475	90,186	24,132	16,088
16	Imo	356,887	69,027	37,369	8,743	319,519	36,171	24,114
17	Jigawa	251,869	57,835	26,778	16,964	225,091	24,523	16,348
18	Kaduna	110,091	91,901	55,045	45,951	55,045	27,570	18,380
19	Kano	323,421	153,056	161,710	16,974	161,710	81,649	54,433
20	Katsina	416,521	103,700	39,013	17,140	377,509	51,936	34,624
21	Kebbi	201,880	68,542	64,437	22,203	137,443	27,803	18,535
22	Kogi	257,044	55,443	78,468	13,752	178,576	25,014	16,676
23	Kwara	129,600	28,500	54,045	13,321	75,555	9,107	6,071
24	Lagos	0	10,676	0	4,949	0	3,436	2,291
25	Nasarawa	94,527	31,785	47,263	13,051	47,263	11,241	7,494
26	Niger	191,784	65,360	88,748	19,926	103,036	27,260	18,174
27	Ogun	0	49,617	0	11,120	0	23,098	15,399
28	Ondo	154,922	61,726	77,461	24,341	77,461	22,431	14,954
29	Osun	78,834	48,011	39,417	24,006	39,417	14,403	9,602
30	Oyo	0	77,890	0	30,165	0	28,635	19,090
31	Plateau	173,722	67,490	54,851	8,978	118,870	35,107	23,405
32	Rivers	583,030	76,512	219,073	17,400	363,957	35,468	23,645
33	Sokoto	181,504	62,983	90,752	31,491	90,752	18,895	12,597
34	Taraba	143,180	51,001	5,609	1,599	137,571	29,641	19,761
35	Yobe	192,148	48,067	65,190	11,913	126,958	21,692	14,462
36	Zamfara	133,053	63,761	55,893	10,930	77,160	31,699	21,132
37	FCT Abuja	551,877	19,035	22,598	2,948	529,279	9,653	6,435
	Total	7,743,426	2,211,389	2,193,335	556,123	5,550,091	993,159	662,106

Source: JICA Project Team

<u>Borehole Drilling and Rehabilitation Plan</u>

Based on method explained above, optimum borehole construction plan was examined by LGA and finally arranged by State as shown in Table 7-12. Two matters below should be noticed.

- Number of newly drilled boreholes should be estimated considering water demand growth rate and borehole operation rate (80%).
- Amount of yield by rehabilitated boreholes should be less than 50% of total amount groundwater to be developed by 2030.

Table 7-12 Number of newly Drilled Borehole and Rehabilitated Boreholes to meet Water Demand of 2030

State		Number of newly drilled borehole							Number of rehabilitated borehole		
		Urban/Semi-urban/ Small town			Rural				Urban/Semi-urban/Small town	Rural	
		Motorized pump			Motorized pump			Hand pump	Motorized pump	Motorized pump	Hand pump
		200m	50m	total	200m	50m	total				
1	Abia	108	215	323	78	63	140	1,217	170	14	73
2	Adamawa	29	546	575	50	295	345	3,116	43	3	179
3	Akwa Ibom	133	45	178	215	34	249	2,242	214	34	0
4	Anambra	71	76	147	189	54	243	2,266	144	11	40
5	Bauchi	141	333	474	234	270	504	4,661	170	20	332
6	Bayelsa	208	0	208	56	0	56	542	32	59	0
7	Benue	16	218	234	23	326	349	3,066	71	18	620
8	Borno	353	303	656	311	106	418	3,910	172	11	165
9	Cross River	18	161	179	40	145	185	1,595	186	98	0
10	Delta	208	0	208	178	0	178	1,612	94	10	269
11	Ebonyi	0	0	0	4	203	206	1,867	0	4	180
12	Edo	145	234	379	139	95	234	2,078	0	0	204
13	Ekiti	0	101	101	0	88	88	792	25	11	123
14	Enugu	95	1,180	1,275	79	165	244	2,087	70	19	59
15	Gombe	33	525	558	53	169	221	2,011	419	8	873
16	Imo	212	243	455	226	98	324	3,014	233	49	102
17	Jigawa	317	210	527	176	49	225	2,044	147	0	1,697
18	Kaduna	2	168	170	1	246	248	2,298	105	71	897
19	Kano	26	542	568	115	596	711	6,804	281	15	886
20	Katsina	335	975	1,310	143	325	468	4,328	234	61	709
21	Kebbi	228	278	506	161	109	270	2,317	240	55	750
22	Kogi	95	374	469	79	154	233	2,085	127	19	219
23	Kwara	19	200	219	13	73	85	759	91	16	422
24	Lagos	0	0	0	33	0	33	286	0	1	335
25	Nasarawa	22	110	132	29	90	119	937	242	50	340
26	Niger	179	184	363	129	134	263	2,272	36	5	749
27	Ogun	0	0	0	154	73	226	1,925	0	12	77
28	Ondo	20	185	205	54	153	206	1,869	189	51	341
29	Osun	0	146	146	0	140	140	1,200	34	19	208
30	Oyo	2	89	91	6	251	258	2,386	0	28	510
31	Plateau	12	347	359	25	299	324	2,926	39	6	180
32	Rivers	322	0	322	309	0	309	2,956	111	8	346
33	Sokoto	246	539	785	150	45	195	1,580	294	89	409
34	Taraba	15	430	445	33	238	270	2,470	39	6	84
35	Yobe	183	99	282	183	20	203	1,808	511	61	422
36	Zamfara	39	337	376	64	194	258	2,408	37	6	280
37	FCT Abuja	25	1,397	1,422	10	74	84	804	80	1	284
Total		3,857	10,790	14,647	3,736	5,369	9,105	82,538	4,880	949	13,364

Source: JICA Project Team

Number of newly drilled boreholes for motorized pump is 15,361 for water supply of urban/semi-urban/small town, 9,105 for rural water supply. On the other hand, number of hand pumps is 82,538 for rural water supply.

(3) Private Irrigation, Livestock and Aquaculture

Method for groundwater development for private irrigation, livestock and aqua-culture is shown in Table 7-13. It is assumed that groundwater will be developed by not well field but single well in those sectors.

Table 7-13 Method of Groundwater Development

Classification	Method for groundwater development
Private irrigation	Groundwater development by single boreholes
Live stock	Groundwater development by shallow hand-dug well
Aquaculture	Groundwater development by single boreholes

Source: JICA Project Team

(3-1) Distribution of Water Demand

It is assumed that groundwater demand is distributed equally within State. Number of boreholes is estimated considering aquifer capacity within State. It means that many boreholes are necessary in low capacity aquifer, and on the contrary few boreholes are enough in high capacity aquifer.

(3-2) Available Yield by Aquifer

Available yield (Y) by aquifer is estimated using Table 7-14.

Table 7-14 Aquifer Type and Sustainable Yield

Aquifer type	Available yield (m^3/day)		
	Private irrigation	Live stock	Aqua culture
WH	100	10	100
WM	50	10	50
WL	10	10	10
MH	200	10	200
MM	100	10	100
ML	50	10	50

Source: JICA Project Team

(3-3) Borehole Drilling Plan

Based on the method explained above, borehole drilling plan was proposed as shown in Table 7-15.

Table 7-15 Number of Boreholes to Meet Water Demand in 2030 of Private Irrigation, Livestock and Aquaculture

No	State	Private irrigation	Live stock	Aqua -culture	No	State	Private irrigation	Live stock	Aqua -culture
1	Abia	371	69	192	20	Katsina	2,190	1,073	1,862
2	Adamawa	845	1,421	86	21	Kebbi	1,125	461	74
3	Akwa Ibom	186	92	83	22	Kogi	2,082	243	231
4	Anambra	308	160	120	23	Kwara	821	68	111
5	Bauchi	1,864	971	54	24	Lagos	42	83	61
6	Bayelsa	34	52	9	25	Nasarawa	898	158	196
7	Benue	2,279	61	81	26	Niger	1,859	518	228
8	Borno	1,146	2,015	27	27	Ogun	1,713	55	120
9	Cross River	1,346	14	1,837	28	Ondo	866	23	282
10	Delta	158	272	1,772	29	Osun	577	29	99
11	Ebonyi	1,440	226	30	30	Oyo	1,507	451	1,395
12	Edo	1,238	49	41	31	Plateau	1,419	868	2,367
13	Ekiti	353	17	218	32	Rivers	66	136	137
14	Enugu	1,145	66	29	33	Sokoto	1,701	2,217	1,026
15	Gombe	1,331	1,003	66	34	Taraba	1,556	343	48
16	Imo	154	55	15	35	Yobe	1,008	993	5
17	Jigawa	900	644	71	36	Zamfara	1,557	946	26
18	Kaduna	1,712	550	183	37	FCT Abuja	241	41	107
19	Kano	1,963	1,640	159		Total	40,001	18,084	13,445

Source: JICA Project Team

7.1.4 Issues on Groundwater Development and Management

Groundwater is mainly used for sources for water supply in Nigeria. Issues of groundwater development and management are described below:

(1) Groundwater Recharge

Groundwater recharge is small in the northern part of Nigeria due to little precipitation and high evapotranspiration. Therefore, it is desirable to promote groundwater recharge for active groundwater development. There is possibility that groundwater is recharged from river bed of large river in the northern part of Nigeria. Considering above situation, it should be promoted to construct recharge dams to increase groundwater recharge by controlling discharge from the recharge dams.

(2) Issue in Rural Water Supply

Low Successful Rate of Borehole

Groundwater is extracted for rural water supply in the Basement Complex area. Borehole successful rate is as low as 50-70%. Survey technique to select promising drilling points must be improved to raise successful rate.

Groundwater Contamination

Groundwater quality in Basement Complex is generally excellent. However, groundwater is sometimes contaminated with domestic waste water showing high Cl and NO_3 concentration because boreholes and dug wells are located in the center of communities.

(3) Issue in Urban Area

Lowering of Groundwater Level and Land Subsidence by Over Pumping

There is excellent aquifer that consists of sand formation in the coastal plain of the southern part of Nigeria. Metropolitan area such as Lagos and Port Harcourt are located in the coastal plain, where large amount of groundwater is being pumped up for industrial and municipal use. It is reported that groundwater level is lowering in those areas. The lowering of groundwater level affects many groundwater users and will bring about regional land subsidence. However, there is no monitoring data to judge occurrence of land subsidence.

Sea Water Intrusion

Sea-water intrusion into aquifer is taking place due to lowering of groundwater level in the coastal aquifers, which will cause saline groundwater of boreholes and shallow wells. Excellent aquifers of high permeable sand layer are distributed along the coastal line in southern part of Nigeria. Over pumping of large cities will cause lowering of groundwater level. It is reported that sea water intrusion is occurring in large city area in the southern part of Nigeria. NIHSA should monitor groundwater level and salt concentration of groundwater continuously to predict behavior of sea water intrusion for formulation n of effective countermeasures.

Groundwater Contamination

It is said that industrial waste water is injected into boreholes, which causes groundwater contamination in Logos Area.

(4) Salty Groundwater within Sedimentary Rocks in Benue Basin

There is shale layer with salty minerals within aquifer (Awe formation) in Benue area, so that groundwater of the aquifer shows high salt concentration. Countermeasures against it are necessary.

(5) Groundwater Contamination of Mining Area

Groundwater can be contaminated with harmful mining residue which was deposited inadequate way. As example of above situation, in Zamfara State, mining residue containing harmful metals was deposited on the bottom of mining pit. From bottom of the pit, the mining residue infiltrated into aquifer and contaminated groundwater causing serious health hazard of the residents.

(6) Groundwater Level Lowering and Drought

Pattern of groundwater fluctuation responding to precipitation is different at place by place. Fluctuation of groundwater level of some boreholes is sensitive to precipitation but others not.

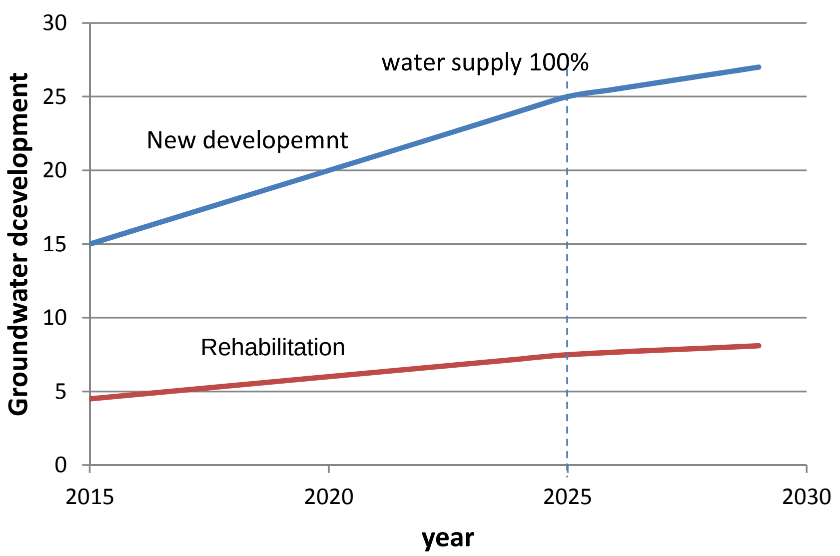
Therefore, it is important to know pattern of groundwater level fluctuation responding to precipitation by monitoring, which will give important information on vulnerability by drought disaster. This information will be used for formulation of countermeasure against drought.

(7) Shift from Hand Pump to Motorized Pump

It can be said that hand-pump, which is main instrument for current rural water supply, does not have enough capacity to utilize groundwater potential of Nigeria to full extent. On the other hand, motorized pump can utilized groundwater potential of Nigeria to full extent. Boreholes with groundwater production capacity of $10m^3$/day is available for hand pump operation. However, borehole needs capacity of $50\text{-}150m^3$/day for operation of motorized pump. Most of boreholes of Nigeria will have enough capacity for operation of motorized pump according to the existing record. Ratio of motorized pump and hand pump is assumed as 6:4 in this Project. This Project will promote usage of motorized pumps together with hand pumps for rural water supply.

7.1.5 Project Implementation Schedule

After the preparation period of in 2014, groundwater development will be implemented during 2015 to 2029 with the same rate, and will be completed in 2030. Conceptual scheme of groundwater development is shown in Figure 7-6.



Source：JICA Project Team

Figure 7-6 Conceptual Scheme of Groundwater Development by Step

Amount of groundwater development is different state by state. Number of rehabilitated boreholes and new drilled boreholes by year is shown in Table 7-16.

Table 7-16 Number of Rehabilitated Borehole by Year

State		Urban/ Semi-urban/ small town	Rural		State		Urban/ Semi-urban/ small town	Rural	
		Motorized pump	Motorized pump	Hand-pump			Motorized pump	Motorized pump	Hand-pump
1	Abia	11	1	5	20	Katsina	16	4	47
2	Adamawa	3	0	12	21	Kebbi	16	4	50
3	Akwa Ibom	14	2	0	22	Kogi	8	1	15
4	Anambra	10	1	3	23	Kwara	6	1	28
5	Bauchi	11	1	22	24	Lagos	0	0	22
6	Bayelsa	2	4	0	25	Nasarawa	16	3	23
7	Benue	5	1	41	26	Niger	2	0	50
8	Borno	11	1	11	27	Ogun	0	1	5
9	Cross River	12	7	0	28	Ondo	13	3	23
10	Delta	6	1	18	29	Osun	2	1	14
11	Ebonyi	0	0	12	30	Oyo	0	2	34
12	Edo	0	0	14	31	Plateau	3	0	12
13	Ekiti	2	1	8	32	Rivers	7	1	23
14	Enugu	5	1	4	33	Sokoto	20	6	27
15	Gombe	28	1	58	34	Taraba	3	0	6
16	Imo	16	3	7	35	Yobe	34	4	28
17	Jigawa	10	0	113	36	Zamfara	2	0	19
18	Kaduna	7	5	60	37	FCT Abuja	5	0	19
19	Kano	19	1	59	Total		325	62	892

Source: JICA Project Team

Table 7-17 Number of Newly Drilled Borehole by Year

State		Urban/Semi-urban/small town			Rural			
		Motorized pump			Motorized pump			Hand pump
		200m	50m	Total	200m	50m	Total	
1	Abia	7	14	22	5	4	9	81
2	Adamawa	2	36	38	3	20	23	208
3	Akwa Ibom	9	3	12	14	2	16	149
4	Anambra	5	5	10	13	4	17	151
5	Bauchi	9	22	32	16	18	34	311
6	Bayelsa	14	0	14	4	0	4	36
7	Benue	1	15	16	2	22	24	204
8	Borno	24	20	44	21	7	28	261
9	Cross River	1	11	12	3	10	13	106
10	Delta	14	0	14	12	0	12	107
11	Ebonyi	0	0	0	0	14	14	124
12	Edo	10	16	25	9	6	15	139
13	Ekiti	0	7	7	0	6	6	53
14	Enugu	6	79	85	5	11	16	139
15	Gombe	2	35	37	4	11	15	134
16	Imo	14	16	30	15	7	22	201
17	Jigawa	21	14	35	12	3	15	136
18	Kaduna	0	11	11	0	16	16	153
19	Kano	2	36	38	8	40	48	454
20	Katsina	22	65	88	10	22	32	289
21	Kebbi	15	19	34	11	7	18	154
22	Kogi	6	25	31	5	10	15	139
23	Kwara	1	13	15	1	5	6	51
24	Lagos	0	0	0	2	0	2	19
25	Nasarawa	1	7	10	2	6	8	62
26	Niger	12	12	24	9	9	18	151
27	Ogun	0	0	0	10	5	15	128
28	Ondo	1	12	14	4	10	14	125
29	Osun	0	10	16	0	9	9	80
30	Oyo	0	6	29	0	17	17	159
31	Plateau	1	23	26	2	20	22	195
32	Rivers	21	0	21	21	0	21	197
33	Sokoto	16	36	52	10	3	13	105
34	Taraba	1	29	31	2	16	18	165
35	Yobe	12	7	19	12	1	13	121
36	Zamfara	3	22	27	4	13	17	161
37	FCT Abuja	2	93	95	1	5	6	54
Total		255	719	1,014	252	359	611	5,502

Source: JICA Project Team

7.2 Surface Water Development Plan

7.2.1 Current Condition of Surface Water Development

(1) Related Policy and Plan

(1-1) Vision 20:2020

The Vision 20: 2020 as a national development plan does not directly state on water resources development and management. However, it can be said that the water resources development and management should support the achievement of the target for water supply, irrigation and hydropower etc.

(1-2) National Water Policy (2009)

According to the National Water Policy revised in 2009, the objectives and strategies for dams and water resources facilities are as follows.

Table 7-18 Objectives and Strategies for Dams and Water Resources Facilities in National Water Policy, 2009

	Contents
Objectives	− To ensure all year round availability of surface water for its different socio-economic and environmental uses through the construction of dams. − To ensure proper harnessing, protection and utilization of the surface water resources of the nation − To ensure that dams should have hydropower components where feasible
Strategies	− Ensuring construction, operation and maintenance of medium and large dams in accordance with recognized engineering standards − Ensuring the construction of medium and large dams in accordance with the National Water Resources Master Plan − Ensuring the inter-basin transfer of water from areas of surplus to areas of scarcity − Ensuring that the construction of Dams which are either trans-boundary/interstate in spread shall be the responsibility of the Federal Government − The operation and maintenance of Federal Government dams are to be done by the Federal Government

Source: National Water Policy, 2009

(1-3) Water Sector Roadmap (2011)

The Water Sector Roadmap formulated in 2011 targeted the followings.

- Mid-term (for MDG): Increase gross storage capacity from 34,000MCM to 35,500MCM
- Long-term (post MDG): No description

(2) Existing Surface Water Development Facilities

(2-1) Inventory of Existing Dams

In the present project, the inventory of existing dams has been prepared mainly on the basis of the following documents.

- FMWR: Nigeria Register of Dams, 1995.
- FMWR: Compendiums of Nigerian Dams, 2007.
- NIWRMC: Inventory of Water Infrastructure Project in Nigeria, Appendix II, 2010.

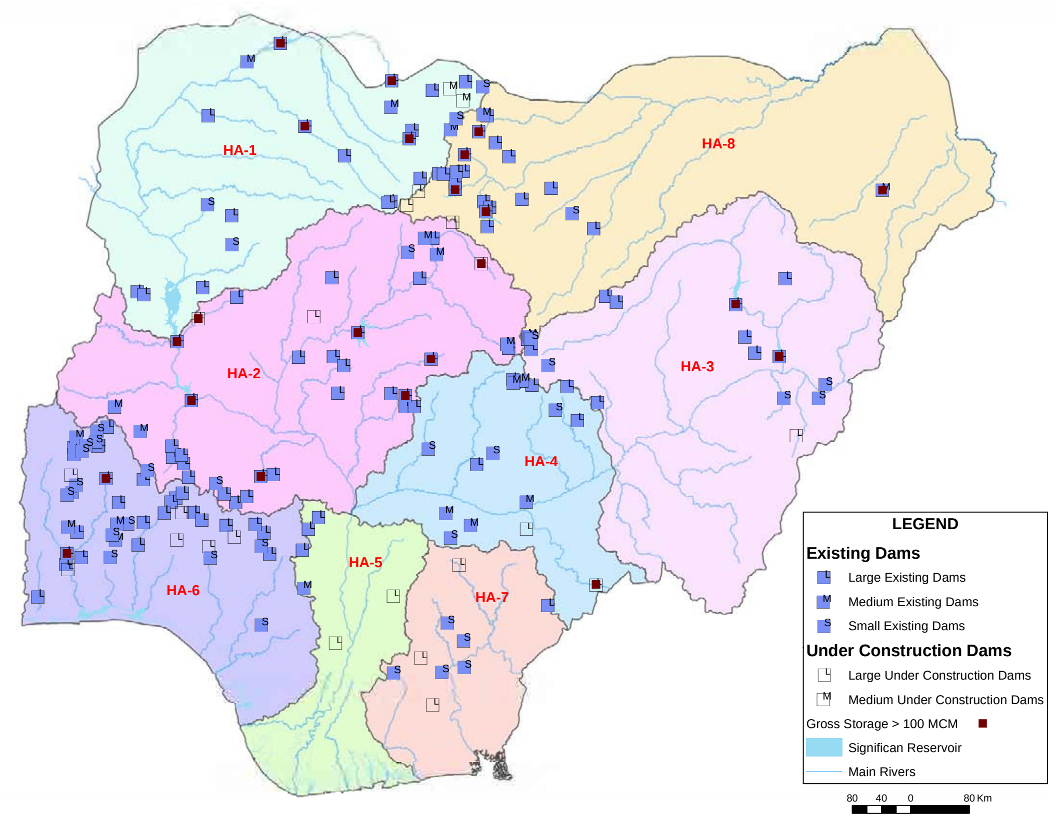
During the process of arranging the data, the dams that we cannot confirm their existence by satellite images and/or photographs and so on are categorized as unknown dams. The detail of inventory is described in Item (1), Section SR4.2.2, Volume-5 Supporting Report.

The total number of existing dams in Nigeria, which the project could confirm, is 171. The location of these dams is shown in Figure 7-7.

The total storage capacity is 37.4BCM. Among it, 25.8BCM is associated with large hydropower dams such as Kainji, Jebbe and Shiroro. The remaining storage of 11.6BCM is mainly used for irrigation and municipal water supply. The average effective storage is about 78% of the total storage capacity.

(2-2) Dams under Construction

According to Dam Department of FMWR, the number of dams under construction is about 30 and their total storage volume is 1.6BCM. It coincides with the incremental storage volume that is set at mid-term target in Water Sector Roadmap. The representative dams of which storage volume is large are Kashimbilla, Galma and Kontagora (Auna) dams. The location of dams under construction is shown in Figure 7-7.



Source: JICA Project Team

Figure 7-7 Location of Existing and Under-Construction Dams

(2-3) Survey on Management Status of Selected Existing Dams

The project selected 26 dams with large storage capacities and/or the major dams in HA-1 and 6 in which the draft catchment management plan is formulated, in order to study the current management status of each dam. The follow table summarizes the results.

Table 7-19 Summary of Survey on Management Status of Selected Existing Dams

Item		Status
Management status of operation data		Many important data has not been managed and recorded except for the part of the dam
Status of dam body, facilities and reservoir	The water quality of reservoir	Recognition for water quality is high.
	Sedimentation of reservoir	Recognition for sedimentation is high.
	The safety of the dam body	There are some problems of dam crack and the vegetation in many dams. Heavy damage in the arid HA-1 and HA-8 is found particularly
	Spillway	The structure of the spillway itself and related facilities seems to have been managed relatively well. However, the discharge capacity needs to be checked carefully.
	Administrative road	Some of the dam is in poor conditions.
Reservoir operation record		Supplying capacity for the dry season is determined by the storage of the rainy season, the storage operation is forced to operate difficultly. There is also a dam that does not recover to full water although the turnover rate is low.

Source: JICA Project Team

The detail of survey is described in Item (2), Section 4.2.2, Volume-5 Supporting Report.

(3) Related Mattes on Large Dams

There are two on-going large scale hydropower development projects by FMP as shown in Table 7-20.

Table 7-20 On-Going Large Scale Hydropower Development Projects by FMP

Project	Project Site	Outline
Manbilla HPS	Upper Donga River (HA3)	Max power: 3,050MW, Design Discharge:373m^3/s, Rated Head: 927m Dams: Nya dam (H=23m), Sumsum dam (H=70m), Nghn dam (H=75m), Api dam (H=150m)
Zungeru HPS	Middle Reach in Kaduna River (HA2)	Max power::700MW, Design Discharge: 220m^3/s, Rated Head: 92m Dam: Height 90m

Source: FMP

On the other hand, the discussion on the possibility of the construction of Dasin Hausa dam at around border between Nigeria and Cameroon has been starting. It is a multi-purpose water resources development project including hydropower, irrigation and inland water navigation, of which pre-feasibility study was conducted in 1982. In 2008, a feasibility study was conducted and economic evaluation was done except for irrigation component. The storage capacity and surface area of the dam is 16BCM and 1,530km^2, respectively. About 70% of the inundation area by the dam is located in the territory of Cameroon. It is said that there could be almost 100,000 people who are required to be resettled.

After the severe flood along the Benue River in 2012, the buffer function of Dasin Hausa dam against flood is attracted. The discussion between Nigeria and Cameroon Government on possibility of construction of Dasin Hausa dam has just started for exploring mutual benefit for both countries.

7.2.2 Problems and Issues on Surface Water Development

The problems and issues on surface water development are summarized in Table 7-21.

Table 7-21 Problems and Issues in Surface Water Development

Problem	Issue
Increasing Water Demand	The current (2010) population of 150 million in Nigeria is expected to reach to 250 million in 2030. It is the most fundamental and important issues in the water sector to secure the adequate volume of domestic water in accordance with the increasing population. According to the water demand projection, usage of surface water source will be increasing. It is necessary to secure enough surface water sources.
Unevenly Distributed Water Resources	The hydrological condition in Nigeria varies very much area by area, resulting in the unevenly distributed water resources. It is necessary to consider these unevenly distributed water resources for effective and sustainable water use.
Existing Dams without Keeping Original Functions	It is necessary to revive the dams of which operation and maintenance are very poor condition for preparing the expected increase in the water demand. There are the areas where the supply capacity by the existing dams has not yet been fully utilized. The unutilized storage capacity should be used effectively including conversion of purposes.
Non-Implementation of Water Resources Development proposed in the M/P1995	There are a lot of medium and small scale dams proposed in the M/P1995. However, almost all of them have not yet been implemented, although some other new dams are now under-construction. One of the reasons for the non-implementation could be the mismatching between the current demand (needs) and the dams. The validation of these proposed dams are required by examining the current water demand.

Source: JICA Project Team

7.2.3 Strategy on Surface Water Development

The strategy on surface water development is set based on the problems and issues as shown in Table 7-22.

Table 7-22 Strategy on Surface Water Development

Objective	Strategy
Effective Utilization of Existing Dams	Many of the existing dams do not keep their original functions, because of lack of proper operation and maintenance including management of information on reservoir operation. It is necessary to revive these dams urgently, for preparing the expected increase in the water demand. The followings are considered. ● Enhancement of dam management, including preparation of manual for dam management ● Rehabilitation of dams ● Enhancement of dam operation
Preparation of Sufficient Surface Water Source to Address Increasing Water Demand in Consideration of Unevenly Distributed Water Resources in the Country	The necessary water resources development would be proposed by utilizing the proposed dams in the M/P1995 as the potential dams as well as the other potential sites. ● By examining water balance for the potential dam sites, efficiency of each site is roughly evaluated. The priority for development should be given to the sites with higher efficiency. ● In the area where water resources is very limited and the future demand is expected to be more than the supply capacity of water source, the demand control such as reduction of the planned irrigation area and/or changing the crop should be considered as one of options for managing the available water, in order to avoid the conflict among water users. ● The integrated development with hydropower generation and irrigation components is proposed in order to promote self-reliant project.

Source: JICA Project Team

7.2.4 Concept of Rehabilitation of Existing Dams

It is necessary to enhance dam management including preparation of manual for dam management, in order to utilize the existing dams effectively. This is discussed in Section 9.3 of Chapter 9.

On the basis of the results of the survey on management status of selected existing dams, the direction of rehabilitation of the existing dams is as follows.

- Equipment for meteorological and hydrological observation as well as monitoring of inflow and outflow, which is necessary for proper operation, should be rehabilitated in early stage. The integrated usage of monitoring data of river flow by NIHSA and dam operation data by dam owner should be considered.
- Rehabilitation of dam body should be conducted when severe cracks on dam body are observed.

In order to implement the rehabilitation project, it is necessary to investigate in detail on the condition of individual dam including safety management survey such as equipment related to spillway, backup power for emergency case, equipment on for meteorological and hydrological mentoring, as well as dam body survey. It is proposed to implement urgently the capacity development project on dam management for FMWR and relevant agencies. During the capacity development activities, necessary survey such as safety management survey and dam body survey should be implemented as many as possible, so as to materialize the rehabilitation project. The significant dams which have more than 100MCM and other important dams should be prioritized.

According to the results of the survey on management status of selected existing dams, the following dams may be necessary to be rehabilitated among the significant dams; Goronyo, Jibiya, Zobe, Gari, Ruwan Kanya, Tiga and Watari.

7.2.5 Potential Sites for Surface Water Source Development

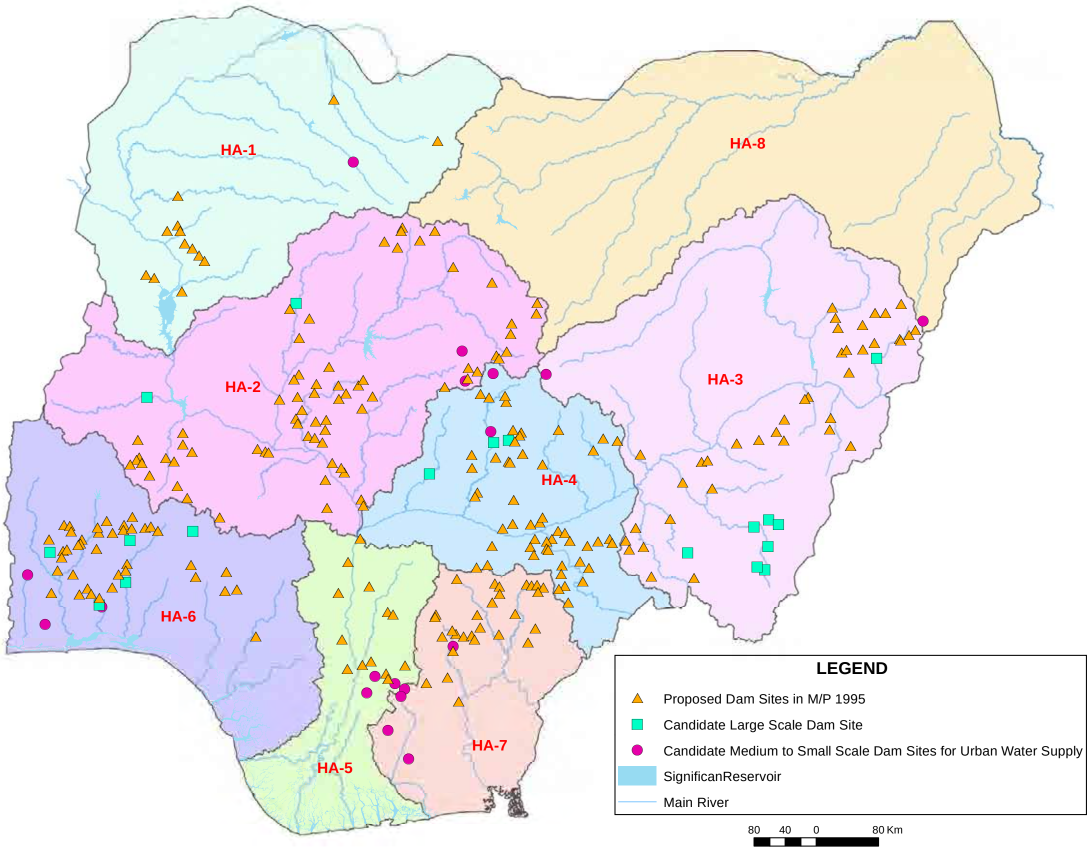
(1) Potential Sites

In addition to the proposed dam sites in the M/P1995, i) candidate sites for large scale dam, ii) candidate small to medium scale dams sites for municipal water supply, were examined and added as potential sites for surface water source development. The total number of the potential sites is 288 in total (refer to Table 7-23). The location of potential sites is shown in Figure 7-8.

Table 7-23 Potential Surface Water Source Development Sites

Type	Number	Total Storage Capacity (BCM)
Proposed dam sites in the M/P1995	252	7.35
Candidate sites for large scale dam	18	7.46
Candidate small to medium scale dam sites for municipal water supply	18	0.24

Source: JICA Project Team

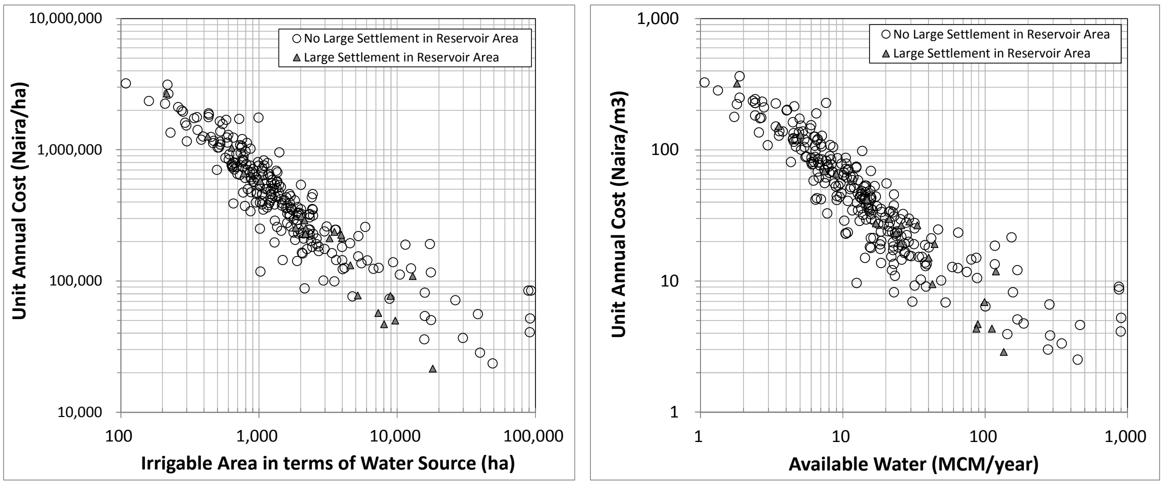


Source: JICA Project Team

Figure 7-8 Location of Potential Sites for Surface Water Development

(2) Efficiency of Potential Sites

As discussed in Chapter 6, the water balance study for each of potential dam sites has been conducted. As a result, a) irrigable area with 80% yearly dependability under the assumed copping pattern, b) available volume of municipal water supply with 90% yearly dependability, were estimated. The construction cost of each of potential dam was also roughly estimated. Using these results, a) annualized cost per 1ha of irrigation area and b) annualized cost per 1m^3 of water are calculated under the following assumptions; project duration =50years, annual operation & maintenance cost=0.5% of project cost and discount rate=10%. These indices represent efficiency of water source development. The smaller annualized cost means the more efficient development.



Source: JICA Project Team

Figure 7-9 Efficiency of Potential Sites for Surface Water Development

(3) Criteria of Selection of Sites

On the basis of needs by municipal water and irrigation development, the proposed dam sites are selected among the potential dam sites. The criteria of the selection are shown in Table 7-24 and 7-25.

Table 7-24 Criteria of Selection of Water Source for Municipal Water Supply

	Item	Criteria
1	Needs on Surface water	There are needs for surface water source nearby.
2	Socio-environmental impact	No large scale resettlement required.→To avoid the site where large town will be inundated by the dam construction.
3	Efficiency	Less costly site. In case of municipal water supply, demand site is already defined. So, possible selection would be limited.

Source: JICA Project Team

Table 7-25 Criteria of Selection of Water Source for Irrigation Development

	Item	Criteria
1	Availability of irrigation area in term of land	There is large available land area where water can be delivered basically by gravity from dam site.
2	Socio-environmental impact	No large scale resettlement required.→To avoid the site where large town will be inundated by the dam construction.
3	Efficiency	Less costly site.

Source: JICA Project Team

7.2.6 Proposed Projects

The proposed projects are shown in Table 7-26, in consideration of the strategy.

Table 7-26 Proposed Surface Water Development Project

Objective	Proposed Project	
Effective Utilization of Existing Dams	1-1	Capacity development of dam management
	1-2	Rehabilitation of equipment for proper operation of major dams
	1-3	Rehabilitation of deteriorated dams
Preparation of Sufficient Surface Water Source to Address Increasing Water Demand in Consideration of Unevenly Distributed Water Resources in the Country	2-1	Surface water development for municipal water supply
	2-2	Surface water development for irrigation development
	2-3	Integrated surface water development

Source: JICA Project Team

Project 1-1: Capacity Development of Dam Management

The direction of improvement of dam management is discussed in Section 9.3 in Chapter 9 as one of important elements of water resources management. This project is to enhance the capacity of dam department of FWMR, as well as dam owners such as RBDAs, SWB on dam management. The following activities in pilot areas would be included in the project. The duration of the project is proposed to be three years.

- Preparation of manuals on dam management
- Inspection of dam
- Installation of simple monitoring equipment, if necessary
- Meteorological and hydrological monitoring
- Survey on reservoir sedimentation
- Recording, storing and transferring dam operation monitoring data
- Assessment of function of dam including dam safety
- Study on dam operation rule
- Information sharing on dam operation data, information dissemination
- Promotion of optimum use of excess storage in dams by discussion with stakeholders

Project 1-2: Rehabilitation of Equipment for Proper Operation of Major Dams

This project is to rehabilitate the equipment for proper operation of dams such as meteorological, hydrological mentoring, monitoring for reservoir operation.

In order to secure the sustainability of the equipment, the reason why the damage of the equipment occurred would be examined. Then, maintenance plan of the equipment should also be prepared. The integrated usage of monitoring data of river flow by NIHSA and dam operation data by dam owner should be considered.

Project 1-3: Rehabilitation of Deteriorated Dams

This project is to rehabilitate deteriorated dam which may threaten the downstream area. The rehabilitation would be implemented case by case up to 2030.

In case of earthfill or rockfill dam, it is important to check if there is water leakage or not. Furthermore, the condition of cracks on dam body, erosion, caving should be carefully checked. All of these could cause the failure of dam. The detail conditions should be studied for individual dam and accordingly the countermeasure would be implemented.

Project 2-1: Surface Water Development for Municipal Water Supply

This project is to prepare stable water source for municipal water supply against the water source where the safety level is expected to be lower than 90% yearly dependability in 2030. On the basis of the results of water balance study shown in Chapter 6, the surface water source development projects shown in Table 7-27 are proposed. The total storage capacity of the proposed dams is 381MCM. The locations of the proposed sites are shown in Figure 7-11.

Table 7-27 Surface Water Development for Municipal Water Supply

No	Project	HA	State	Water Supply Scheme	SN	H (m)	GS (MCM)
1	Aba dam project	7	Abia	Aba Water Supply Scheme	4012	11	3.4
2	Mubi dam project	8	Adamawa	Mubi Water Supply Scheme	4013	22	6.0
3	Umuseke dam project	5	Anambra	Greater Awka Water Supply Scheme	4009	16	9.5
4	Ihiala dam project	5	Anambra	Ihiala Regional Water Supply Scheme	4010	11	3.4
5	Nnewi dam project	5	Anambra	Nnewi Regional Water Supply Scheme	4011	20	24.2
6	Yedseram diversion	8	Borno	Alau/Maiduguri Water Supply Scheme	Diversion weir		
7	Monaya/Ogoja dam project	7	Cross River	Ogoja Water Supply Scheme	2245	10	5.4
8	Ezillo dam project	7	Ebonyi	Ishielu/Ezzilo Water Supply Scheme	4016	20	2.3
9	Oji/Ajali dam project	5	Enugu	Ajali Water Supply Scheme	2185	20	16.9
10	Okigwe dam project	7	Imo	Okigwe Water Supply Scheme	4015	10	9.2
11	Owerri dam project	7	Imo	Owerri/Otamiri Water Supply Scheme	4002	16	3.9
12	Kwoi dam project	2	Kaduna	Kwoi Water Supply Scheme	4017	11	2.5
13	Kafanchan dam project	2	Kaduna	Kafanchan Water Supply Scheme	4003	11	3.1
14	Kachia dam project	2	Kaduna	Kachia Water Supply Scheme	4004	11	3.5
15	Faloku/Oyun dam project	2	Kwara	Oyun Water Supply Scheme	2023	19	18.9
16	Ibu dam project	6	Ogun	Otta Ikosi/Ogere/Shagamu Water Supply Scheme	2205	19	20.6
17	Kumpa/Keffei-Mada dam project	4	Nasarawa	Keffi/Mada Water Supply Scheme	4005	12	3.1
18	Emiziko/Bida dam project	2	Niger	Bida Water Supply Scheme	2067	15	3.2
19	Ota dam project	6	Ogun	Ota Water Supply Scheme	4014	16	6.4
20	Araromi Ake/ Ijebu-Ode-Yemoji dam project	6	Ogun	Ijebu-Ode/Yemoji Water Supply Scheme	4018	12	3.3
21	Barakin dam project	3	Plateau	Yakubu Gowon/Jos Water Supply Scheme	4007	26	20.1
22	Sakin Noma/Gusau dam project	1	Zamfara	Gusau Water Supply Scheme	4008	20	29.7
23	Odedele dam project	6	Oyo	Odedele/Ibadan Water Supply Scheme	3501	30	182.6

Remarks: SN=Serial number of dam, H=Height of dam, GS=Gross storage
Source: JICA Project Team

Project 2-2: Surface Water Development for Irrigation Development

This project is to secure necessary water volume for irrigation development, according to irrigation development plan proposed in the M/P2013. On the basis of the results of water balance study shown in Chapter 6, the surface water source development projects shown in Table 7-28 are proposed. The total storage capacity of the proposed dams is 969MCM. The locations of the proposed sites are shown in Figure 7-11.

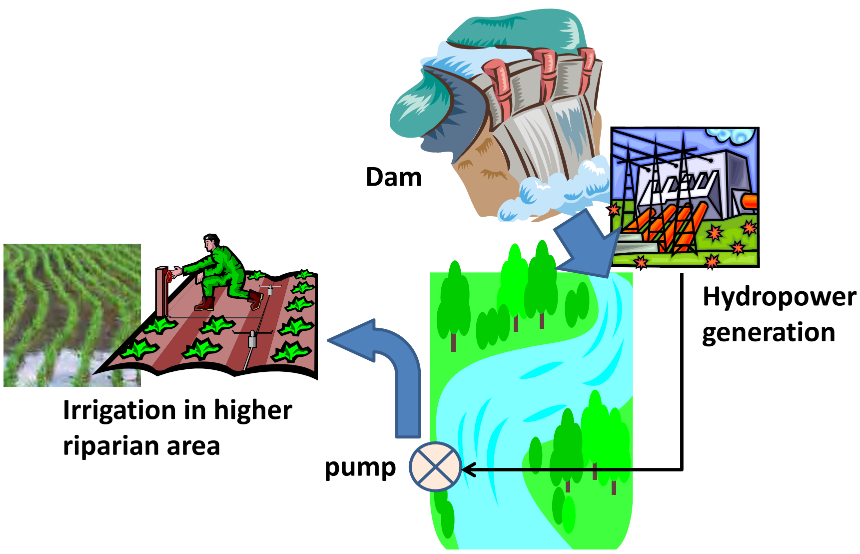
Table 7-28 Surface Water Development for Irrigation Development

No	Project	HA	State	Irrigation Scheme	SN	H (m)	GS (MCM)
1	Lade dam project	2	Kwara	Duke Lade irrigation scheme (1,200ha)	2043	25	29.5
2	Agaie dam project	2	Niger	Agaie/Lapai irrigation scheme (1,000ha)	2028	16	44.0
3	Mussa dam project	2	Niger	Badeggi irrigation scheme (830ha)	2066	17	13.2
4	Bakogi dam project	2	Niger	Bakogi irrigation scheme (2,000ha)	2069	17	48.7
5	Kasanu dam project	1	Kebbi	Newly proposed scheme 1,500ha	2009	18	21.0
6	Ukusu dam project	2	Niger	Newly proposed scheme 1,400ha	2039	14	11.5
7	Bado dam project	3	Plateau	Newly proposed scheme 2,200ha	2112	15	28.6
8	Mayo Ine dam project	3	Adamawa	Newly proposed scheme 9,000ha	2089	15	72.6
9	Aneri dam project	4	Benue	Newly proposed scheme 1,500ha	2139	12	14.2
10	Kereke dam project	4	Benue	Newly proposed scheme 2,000ha	2142	13	16.7
11	Dula dam project	4	Benue	Newly proposed scheme 2,000ha	2148	20	19.9
12	Obe dam project	5	Edo	Newly proposed scheme 4,100ha	2175	27	52.4
13	Okhuo dam project	6	Edo	Newly proposed scheme 1,500ha	2224	27	9.6
14	Ombi dam project	7	Benue	Newly proposed scheme 2,000ha	2229	19	24.1
15	Ogege dam project	7	Benue	Newly proposed scheme 1,000ha	2231	14	12.6
16	Abe dam project	7	Cross River	Newly proposed scheme 1,200ha	2237	13	13.0
17	Konshisha dam project	7	Benue	Newly proposed scheme 1,500ha	2240	18	16.0
18	Bejagira dam project	2	Niger	Newly proposed scheme 6,000ha	3008	21	30.0
19	Mayo Belwa dam project	3	Adamawa	Newly proposed scheme 18,000ha	2091	33	240.0
20	Muleng dam project	3	Adamawa	Newly proposed scheme 10,000ha	3012	41	113.0
21	Shemankar dam project	4	Plateau	Newly proposed scheme 16,000ha	2124	22	138.5

Remarks: SN=Serial number of dam, H=Height of dam, GS=Gross storage
Source: JICA Project Team

Project 2-3: Integrated Surface Water Development

This is an integrated project to combine hydropower generation and irrigation development. Necessary energy for pumping for supplying irrigation water is provided internally by the generated energy in the project so as to secure self-reliance and sustainability of the project (refer to Figure 7-10). Three project sites along the Benue River are proposed. The total storage volume of the proposed dams is 960MCM. The locations of the proposed dams are shown in Figure 7-11.



Source: JICA Project Team

Figure 7-10 Schematic Drawing on Integrated Surface Water Development

Table 7-29 Integrated Surface Water Development

No	Project	HA	State	Irrigation/Hydropower scheme	Dam SN	Dam Name	H (m)	GS (MCM)
1	Nasarawa Integrated Project	4	Nasarawa	New Irrigation scheme: 19,000ha Hydropower 4MW； Total generate energy 29GWh/year Required energy for irrigation 2GWh/year Excess energy 27GWh/year	3011	Ragwa	24	30
2	Taraba integrated project	3	Taraba	New Irrigation scheme: 45,000ha				
				Hydropower 7MW； Total generate energy 52GWh/year Required energy for irrigation 12GWh/year Excess energy 40GWh/year	3001	Baudeu	37	240
				Hydropower 2MW； Total generate energy 15GWh/year Required energy for irrigation 10GWh/year Excess energy 5GWh/year	3004	Kogin Baba	39	290
3	Donga-Suntai Integrated project	3	Taraba	New Irrigation scheme: 35,000ha Hydropower 9MW； Total generate energy 60GWh/year Required energy for irrigation 37GWh/year Excess energy 23GWh/year	3005	Kwossa	78	400

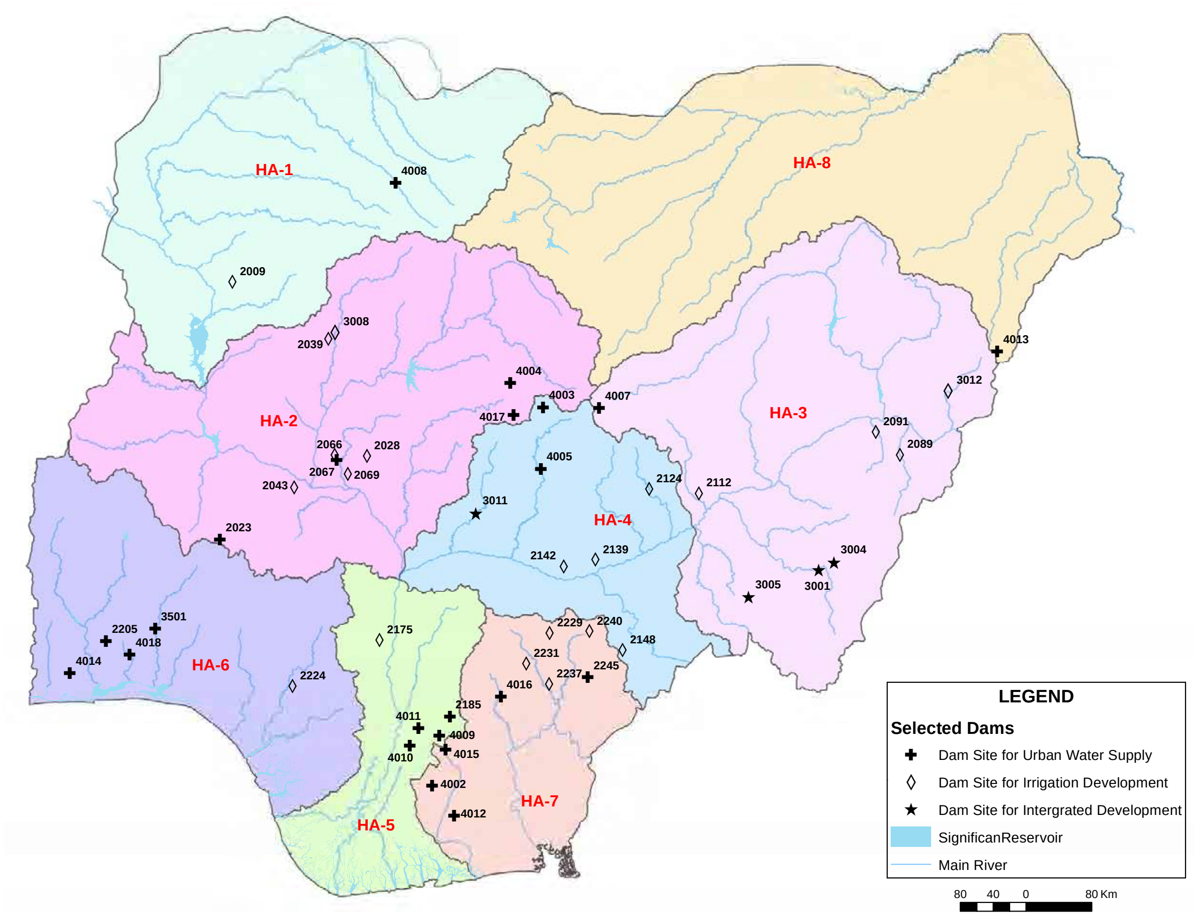
Remarks:
1) The size of dam is set so as to provide necessary water for hydropower generation for pumping as well as irrigation water supply with 1/5 safety level.
2) The capacity of hydropower equipment is set so as to maximize the net benefit (benefit-cost) under the following assumptions with keeping the necessary capacity for pumping of irrigation water.
Assumptions: a) Overall efficiency of hydropower generation=0.7, b) project cost of installation of hydropower equipment=2.53mil.US$/MW, c)Project duration=50year, d)Replacement of equipment=every 20year, e) O&M cost=0.5% of project cost /year, f) Discount rate=10%, and g)Selling price of electricity=0.05US$/kWh.
SN=Serial number of dam, H=Height of dam, GS=Gross storage
Source: JICA Project Team

It should be noted that the scale of dam and hydropower equipment are tentatively set at this moment. In the next step, the optimum scale and combination of component should be examined in detail. For reference, the potential of hydropower generation under the assumption that the maximum flow is annual average flow is presented in Table 7-30.

Table 7-30 Estimated Maximum Hydropower Generation in Integrated Surface Water Development Project

No	Project	Dam Size	Max Output (MW)	Max Generated Power (GWh/year)
1	Nasarawa Integrated Project	Proposed (Dam Height=24m)	11	54
		Max development (Dam Height=37m)	18	89
2	Taraba integrated project	3001: Proposed (Dam Height=37m)	38	167
		3001: Max development (Dam Height=37m)	38	167
		3002: Proposed (Dam Height=39m)	6	25
		3002: Max development (Dam Height=55m)	7	31
3	Donga-Suntai Integrated project	Proposed (Dam Height=78m)	16	75
		Max development (Dam Height=105m)	22	112

Source: JICA Project Team



Source: JICA Project Team

Figure 7-11 Selected Dam Sites for Surface Water Source Development

<u>**Remarks on Selected Dams Sites**</u>

The selection of the dam sites is based on the preliminary study during the formulation of the M/P2013 (see Figure 2-28). It should be noted that the proposed schemes are conceptual level, and thereby further detail study would be required for their implementation.

7.2.7 Possibility of Hydropower Generation in Surface Water Source Development Projects for Municipal Water Supply and Irrigation Development

The dam operation for the water source development projects for municipal water supply and irrigation development basically follows the requirement from municipal and irrigation water users. So, even if hydropower equipment is installed, its operation should follow the release based on the requirement by other water users. How much energy can be generated in these cases is roughly examined by utilizing the results of water balance study. It is assumed that the installed capacity of hydropower equipment is determined so as to maximize the net benefit (benefit-cost). Table 7-31 summarizes the assumed condition.

Table 7-31 Assumed Conditions

Assumed conditions
● Hydropower generation uses released flow for other water users ● Effective head is assumed to be constant with 50% of maximum water depth. ● Overall efficiency of hydropower generation=0.7 ● Project cost of installation of hydropower equipment=2.53mil.US$/MW ● Project duration=50year ● Replacement of equipment=every 20year ● O&M cost=0.5% of project cost /year ● Discount rate=10% ● Selling price of electricity=0.05US$/kWh.

Source: JICA Project Team

Table 7-32 shows the averaged generated energy for each of the proposed dam sites. The total installed capacity and generated energy could be 4.6MW and 30GWh/year, respectively. It is recommended that more detail study be conducted when each project will be implemented.

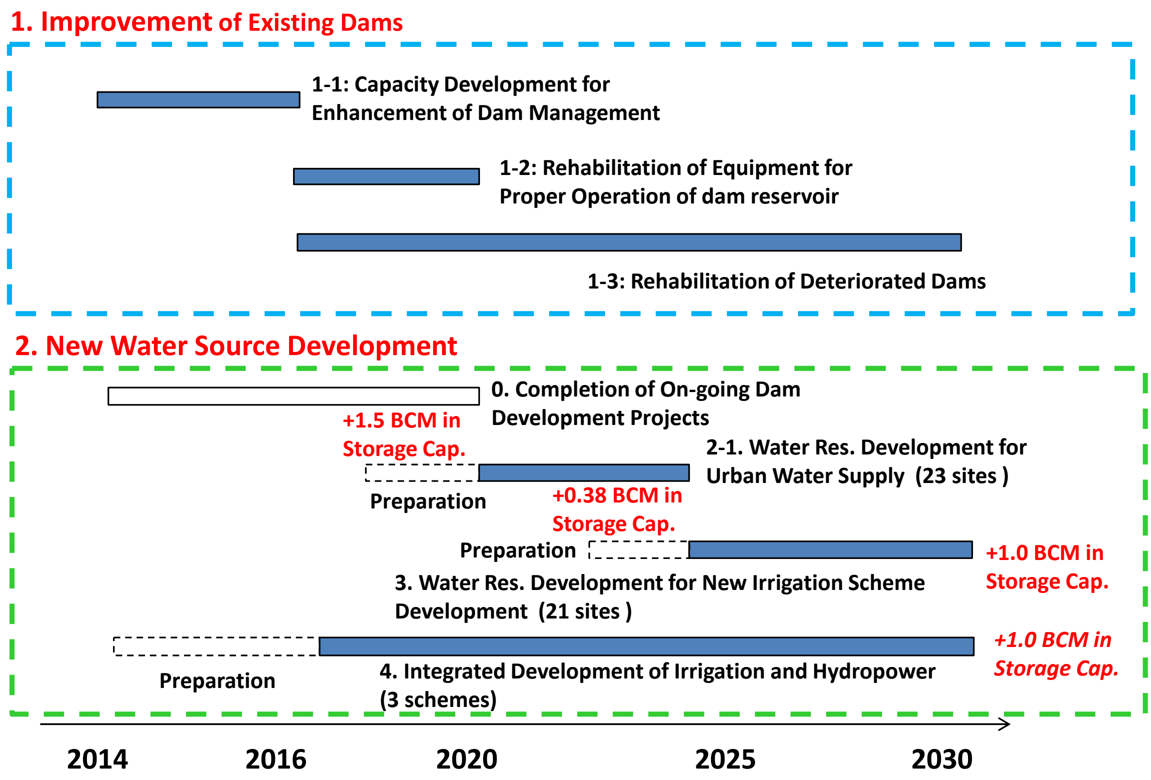
Table 7-32 Possibility of Hydropower Generation in Surface Water Source Development Projects for Municipal Water Supply and Irrigation Development

No	Surface Water Development for Municipal Water Supply	Capacity (MW)	Power (GWh /year)	No	Surface Water Development for Irrigation Development	Capacity (MW)	Power (GWh/ year)
1	Aba dam project	0.100	0.768	1	Lade dam project	0.025	0.161
2	Mubi dam project	0.000	0.000	2	Agaie dam project	0.030	0.202
3	Umuseke dam project	0.040	0.285	3	Mussa dam project	0.015	0.010
4	Ihiala dam project	0.130	0.954	4	Bakogi dam project	0.025	0.163
5	Nnewi dam project	0.090	0.756	5	Kasanu dam project	0.025	0.187
6	Yedseram diversion Project	0.000	0.000	6	Ukusu dam project	0.030	0.216
7	Monaya/Ogoja dam project	0.020	0.132	7	Bado dam project	0.040	0.280
8	Ezillo dam project	0.000	0.000	8	Mayo Ine dam project	0.200	1.447
9	Oji/Ajali dam project	0.090	0.761	9	Aneri dam project	0.030	0.206
10	Okigwe dam project	0.030	0.238	10	Kereke dam project	0.000	0.000
11	Owerri dam project	0.140	1.080	11	Dula dam project	0.000	0.000
12	Kwoi dam project	0.000	0.000	12	Obe dam project	0.000	0.000
13	Kafanchan dam project	0.020	0.158	13	Okhuo dam project	0.120	0.834
14	Kachia dam project	0.050	0.379	14	Ombi dam project	0.090	0.541
15	Faloku/Oyun dam project	0.000	0.000	15	Ogege dam project	0.040	0.262
16	Ibu dam project	0.035	0.244	16	Abe dam project	0.020	0.120
17	Kumpa/Keffei-Mada dam project	0.200	1.519	17	Konshisha dam project	0.040	0.237
18	Emiziko/Bida dam project	0.000	0.000	18	Bejagira dam project	0.300	2.147
19	Ota dam project	0.000	0.000	19	Mayo Belwa dam project	0.700	4.495
20	Araromi Ake/ Ijebu-Ode-Yemoji dam project	0.080	0.519	20	Muleng dam project	0.600	4.205
21	Barakin dam project	0.050	0.414	21	Shemankar dam project	0.400	0.003
22	Sakin Noma/Gusau dam project	0.070	0.580				
23	Odedele dam project	0.800	5.987				
	Total	1.945	14.774		Total	2.730	15.716

Remarks: The installed capacity is set at zero, if the install capacity becomes less than 0.01MW.
Source: JICA Project Team

7.2.8 Proposed Implementation Schedule

It is proposed that the surface water surface water source development be implemented step by step as shown in Figure 7-12.



Source: JICA Project Team

Figure 7-12 Proposed Implementation Schedule for Surface Water Source Development

7.3 Water Resources Conservation Plan

The conservation of water resources may be defined as the various types of activities to be executed by different stakeholders to conserve or protect the water quality and water quantity. Both water resources surface and groundwater must be targeted for conservation.

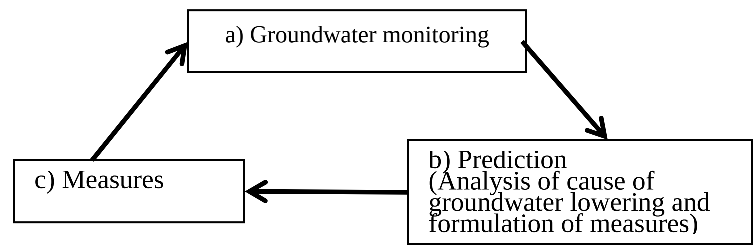
7.3.1 Groundwater Conservation

(1) Purpose and Importance of Groundwater Conservation

Groundwater must be conserved in terms of quantity and quality for sustainable groundwater usage. Groundwater management is indispensable for groundwater conservation.

Quantity conservation

When groundwater is extracted more than groundwater recharge, regional groundwater level lowering will occur, which will cause decrease in pumping yield or drying up of boreholes and land subsidence. To prevent such problems, cycle of a) monitoring, b) prediction and c) measures must be continuously implemented as show in Figure 7-13. NIWRMC and CMO should take responsibility of implementation of the cycle.



Source: JICA Project Team

Figure 7-13 Concept of Groundwater Management Comprising Monitoring, Prediction and Measures

Quality conservation

Groundwater will be contaminated when contaminated surface water infiltrate into aquifer. Moreover, when sea water has intruded into aquifer, groundwater will become salty. Type of groundwater contamination is shown in Table 7-33.

Table 7-33 Type of Groundwater Contamination and Countermeasures

Type of groundwater contamination		Cause	Measures
Man-made contamination	Sea water intrusion into aquifer	Over pumping	Legal control of pumping
	Infiltration of domestic and industrial waste into aquifer	• Lack of sewerage system • Low quality borehole construction work • Illegal dumping waste into borehole	• Improvement of sewerage system • Perfect sealing of borehole casing • Legal control of dumping
Contamination originated from geology	Groundwater contamination by harmful minerals in underground layer	• Shale with salty minerals • Harmful materials by mining activity	Identification of contaminated aquifer and prohibition of extraction from it

Source: JICA Project Team

(2)Method of Groundwater Management for Conservation

Method of groundwater management for conservation should be formulated place by place based on local hydrogeological characteristics and water use condition. However, standard method should be employed as basis of groundwater management for each case. It is proposed that groundwater management should be implemented by NIWRMC and NIHSA for entire Nigeria following the standard method as shown below.

(1) Hydrogeology and groundwater survey and analysis

- Survey on aquifer structure and characteristics
- Analysis of groundwater recharge
- Survey on current groundwater extraction
- Survey on groundwater hazard (groundwater level lowering, sea water intrusion, saline groundwater, groundwater contamination, impact of climate change)
- Survey on groundwater regulation to control groundwater extraction

⬇

(2) Water balance model

- Numerical model (aquifer distribution, groundwater recharge condition, groundwater pumping condition)

⬇

(3) Groundwater usage and development plan

- Analysis on current water supply and demand balance
- Forecasting future water demand and groundwater development plan
- Examination of feasibility of proposed groundwater development based on groundwater balance
- Examination of conjunction use of groundwater and surface water

⬇

(4) Groundwater Development based on National Water Resources Mater Plan and Catchment Management Plan year by year

⬇

(5) Groundwater management

- Monitoring of groundwater level and quality related to groundwater development
- Comparison of actual groundwater behavior and predicted one.
- Modification of groundwater development plan if necessary
- Implementation of groundwater regulation such as extraction control based on discussion and agreement among CMO and stakeholders.

Figure 7-14 Method for Groundwater Management and Development

Groundwater management plan should take into account of scale of target aquifer. Scale of aquifer can be classified as a) Large, b) Medium, c) Small, d) local, and management method should be decided corresponding to above classification as shown in Table 7-34.

Table 7-34 Groundwater Management Plan and Responsible Organization

<table>
<tr><th colspan="2">Scale of Area</th><th>Plan</th><th>Purpose of management</th><th>Responsible organization</th></tr>
<tr><td>a) Large</td><td>Multiple Catchment level</td><td>• National Water Resources MP
• CMP</td><td>Groundwater Basin Management</td><td rowspan="2">• NIWRMC
• CMO
• NIHSA</td></tr>
<tr><td>b) Medium</td><td>Catchment level</td><td rowspan="3">State Management Plan</td><td rowspan="2">• Allocation of groundwater extraction
• Allocation of borehole density
• Measures against groundwater hazard (sea-water intrusion, land subsidence, groundwater contamination)</td></tr>
<tr><td>c) Small</td><td>LGA level</td><td rowspan="2">• State Government
• LGA</td></tr>
<tr><td>d) Local</td><td>Community level</td><td>• Securing necessary yield for communities
• Setting adequate yields of individual borehole
• Setting enough distance among boreholes to prevent borehole interference
• Measures against groundwater contamination</td></tr>
</table>

Source: JICA Project Team

(3) Institutional Issue on Groundwater Management

Institutional improvement is necessary to resolve issues above. NIWRMC should implement activities below.

- Registration of boreholes
- Setting of permissible groundwater level
- Formulation of Groundwater management manual
- Information sharing among organizations in charge of groundwater management and groundwater users.
- Establishment of registration system of borehole drilling company

7.3.2 Conservation of Surface Water Source

(1) General

The surface water resources need to be conserved from point and non-point sources of pollution. Point sources of pollution are those generated from untreated domestic, industrial and mining wastewater and the leachate generated at the solid waste disposal sites. While non-point sources are those originated from agricultural lands and solid waste that are transported into the water courses by heavy rains. In addition, soil erosion is another important source of sediments that affect directly the surface water.

The point sources of pollution may be diminished by treating the wastewater before its discharging into the surface water. The non-point sources of pollution may be diminished by good practices in the field of agriculture.

As for soil erosion, a proper forest management and protection of critical zones such as steeped areas may work efficiently to decrease these phenomena.

Following is presented the problems/issues and recommendations for rivers and for dams/reservoirs.

(2) Issues on Conservation of Surface Water Source

The following table summarizes the issues in this field.

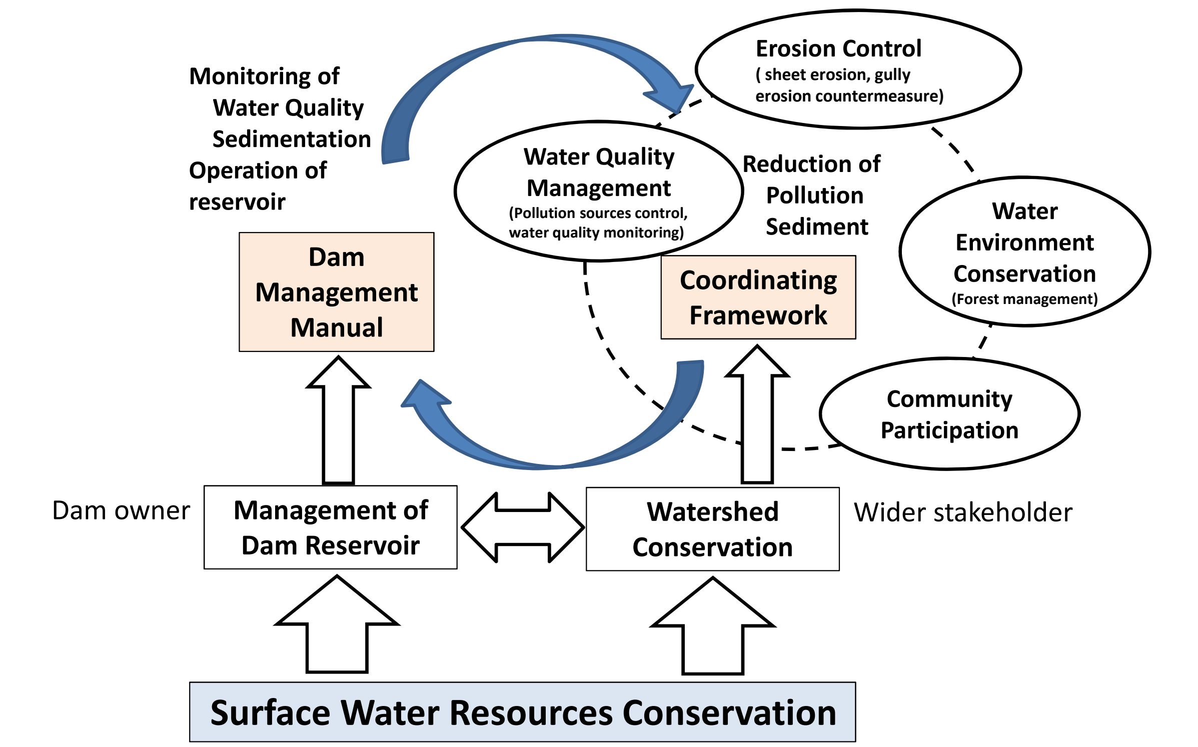
Table 7-35 Issues on Conservation of Surface Water Source

Important Issues	Recommendations
Point Sources of Pollution	
There is a poor enforcement of Laws, regulations and standards to control water pollution in the country	The enforcement of Laws, Regulations and Standards to control discharges of effluents (liquid & solid) into the environment needs to be improved.
Lack of awareness of the people on environmental issues, therefore not collaboration from them to avoid water pollution	Environmental education and awareness campaign on water resources protection from pollution must be implemented for primary & secondary schools and for the general public.
Lack of coordination or cooperation among relevant institutions for water pollution control	A memorandum of understanding should be promoted among FME, FMWR and State Governments to prioritize programs for water pollution control of water sources used as domestic source.
In the rural communities of Nigeria are very common the activities of mining at artisanal and small-scale levels. However, most of these activities do not follow good mining practices resulting in water pollution	A joint-work between NESREA, FMM and FMWR is proposed to assess the impact of mining activities into the water sources, in order to determine possible countermeasures.
Non-Point Sources of Pollution	
Fertilizer and pesticide cause water pollution in surface water and in aquaculture farming ponds	Proper use of fertilizer and pesticides is recommended to diminish pollution of water courses. Drainage of water from farm land should not be discharged into aquaculture farming pond due to its high impact on aquatic life.
In many urban cities of Nigeria can be observed illegal disposal of solid waste which are transported into rivers during heavy rain	Solid waste management needs to be improved in the country to avoid pollution of watercourses or water sources.
Soil Erosion	
The distribution of soil erosion site is sporadic; consequently, it is necessary to carry out a lot of small scale countermeasure in the country, however, often said because of lack of fund not sustainable.	Risk assessment in nationwide in order to prioritize the critical projects to be implemented
Currently, most of the erosion control has been done for the countermeasures in the area related to people's living condition such as keeping of transportation route, protecting of residential area and mitigating soil erosion into drainage. In Nigeria there is few attention to the watershed conservation in which it takes long time the result of countermeasure prevails.	• Environmental education and awareness campaign on water resources protection • Risk assessment in nationwide in order to prioritize the critical projects to be implemented among wide range of watershed size.
Dams/Reservoirs	
The presence of aquatic plants in dams and reservoir is of great concern that must be addressed. It is considered a nuisance since interfere in the normal operation of the dams. The introduction of nutrients such as P and N promotes the proliferation of this nuisance.	Aquatic plant control programme was implemented by FME for many dams until 2011. A continuation of that programme is under preparation by FME. It is proposed to make a joint-work between FME and FMWR for the recovery of affected dams by aquatic plants
Surveyed dams in this Study present problem of sedimentation and this has direct effect in their storage capacity.	Actions to control sedimentation effectively are necessary to be implemented such as: • Risk assessment in nationwide in order to prioritize the critical projects to be implemented among wide range of watershed size. • Economic comparison between dredging in reservoir and soil erosion countermeasures in each watershed

Source: JICA Project Team

(3) Proposed Mechanism for Conservation of Surface Water Source

Conservation of surface water resources would be implemented inside dams and reservoirs as well as in a watershed area (see Figure 7-15). Both activities are related each other. The former is a part of the dam management activities, and will thereby be proposed to be enhanced together with the measures for the recovering and upgrading function of the existing dams. This is mainly implemented by dam owners. On the other hand, the latter needs cooperation among wider range of stakeholders in a watershed, which deals with environment management, water quality management, erosion control and so.



Source: JICA Project Team

Figure 7-15 Framework of Conservation of Surface Water Source

(4) Responsibilities of Main Stakeholders in Proposed Mechanism for Conservation of Surface Water Source

The main activities that are identified to be done inside the Dam/Reservoirs and Watershed for conservation of surface water resources are presented in Table 7-36. Likewise, in the same table is shown the main stakeholders and their responsibilities. It is also proposed that NIWRMC be responsible for coordinating the activities by various stakeholders through formulation and implementation of Catchment Management Plan at each hydrological area.

The workable mechanism on the cooperation among stakeholders in a catchment level should be explored during the formulation of the draft Catchment Management Plan.

The details on dam management, water environmental management and erosion control are described in the following sections.

- Dam management: Section 9.3
- Water environmental management: Section 9.8
- Erosion control: Section 8.3.2

Table 7-36 Proposed Responsibility and Activities for Conservation of Surface Water Source

Surface Water Resources Conservation		dam owner (RBdA, SWB, etc)	RBdA	StateWater Board	FMWR (dams division)	FMWR (Water Quality & Sanitation division)	FMWR (Irrigation &drainage division)	NIWRMC	NIHSA	Ministry of Power	NIMET	NESREA	FME (Pollution Control and Environmental Health)	FME (EIA division)	FME (Forestry department)	FME (Flood & erosion control)	FME (Aquatic plant control program)	Federal/State Ministry of Health	States Ministry of Environment	Federal Ministry of Mines	Federal Ministry of Trade and Investment	Oil Spill Agency	National Orientation Agency	Farmer Association	Industrial Association	NGOs	Nigerian Citizens (community participation)
		Responsibility Assignment Matrix: M=Main Responsibility, S=Sub Responsibilities, d=Participation in discussions																									
Activities																											
1.	**Management of dam/Receiver**																										
1.1	Proper operation of water release	**M**	S	d	S			S	d	d																	
1.2	Observation of hydro-meteorological condition	**M**	S	d	d			d	S		S																
1.3	Monitoring of water quality and sedimentation	**M**	S	d	d	S		d	S																		
1.4	Removal of weeds	**M**	S	d	d		S										S										
1.5	dredging of sediment	**M**	S	d	S	d								d													
1.6	Inspection of physical-structure condition	**M**	S	d	S																						
1.7	Operation of hydropower station	**M**	S	d	d					S																	
2.	**Watershed Conservation**																										
2.1	Coordination of Watershed Conservation Activities	d	S	d	d	d	d	**M**	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d
2.2	Water Quality Monitoring (water source and drinking water)	d	S	S	d	**M**		d	S	d	d	d	d				d	S	d	d	d			d	d	d	d
2.3	Control of pollution sources (domestic, industrial, agriculture, mining, etc.)	d	d	d	d	d	d	d	d	d	d	**M**	S	d			d	d	S	S	d	d		d	d	d	d
2.4	Water Quality Monitoring (water environment)	d	d	d	d	**M**	d	d	d	d		**M**	d	d			d	d	d	d	d			d	d	d	d
2.5	Erosion control	d	S	d	d	d	d	d	d	d		d	d		S	**M**			S	d				d		d	d
2.6	Weeds Control on Rivers and Channels (excluding navigation)	d	S	d	d	d	d	d				d					**S**		M					d		d	d
2.7	Water environment conservation (forest management)	d	d	d	d			d		d					**M**	d			S	d				d		d	d
2.8	Environmental education & awareness campaign	d	d	d	d	d		d	d			d	d		d	d	d	d	**M**	d			S	d	d	d	d

Source: JICA Project Team

CHAPTER 8 WATER RESOURCES SUB-SECTOR DEVELOPMENT PLAN

8.1 Water Supply and Sanitation Development Plan

8.1.1 Basic Concept

Existing water supply facilities in Nigeria have not been utilized as designed as is clear from low production efficiency or operating ratio of the facilities, such as 45.2% of surface water (water treatment works production-based) and 54.3% of groundwater (borehole number-based). The Project concludes this fact has mainly caused low water supply coverage of 51.4% at national level, which was estimated in the Project. In fact, improvement of production efficiency or operating ratio of existing facilities and ensuring its sustainability by appropriate operation and maintenance are keys to boosting water supply coverage.

In order to correspond to increase in future water demand, the Project plans to improve low production efficiency of existing facilities using surface water in the short term and operating ratio of existing facilities using groundwater in the entire period, and furthermore to develop new facilities to be required additionally.

Water Supply development plan consists of the following two major components.

- Rehabilitation scheme of existing facilities
- New construction scheme of facilities (including expansion)

In consideration of sector policies and strategies, water resources potential and water balance between demand and supply in each Hydrological Area (HA), contents of existing State development plans and present water supply services, ongoing projects and plans, the Project will make the sector development plan based on the current status and more practical as much as possible.

8.1.2 National Plans, Sector-Related Policies and Strategies

(1) National Development Policy

Water supply and sanitation sector is one of the nation's highest priorities for national development from the fact that “Nigeria Vision 20:2020”, a national development policy cites “Provision of Sustainable Access to Potable Water and Basic Sanitation” as a fundamental subject in the section “Guaranteeing the Well-being and Productivity of the People” as one of three-pronged strategies.
Table 8-1 shows priorities in the Water and Sanitation sector to be carried out strategically, specified in Vision 20:2020.

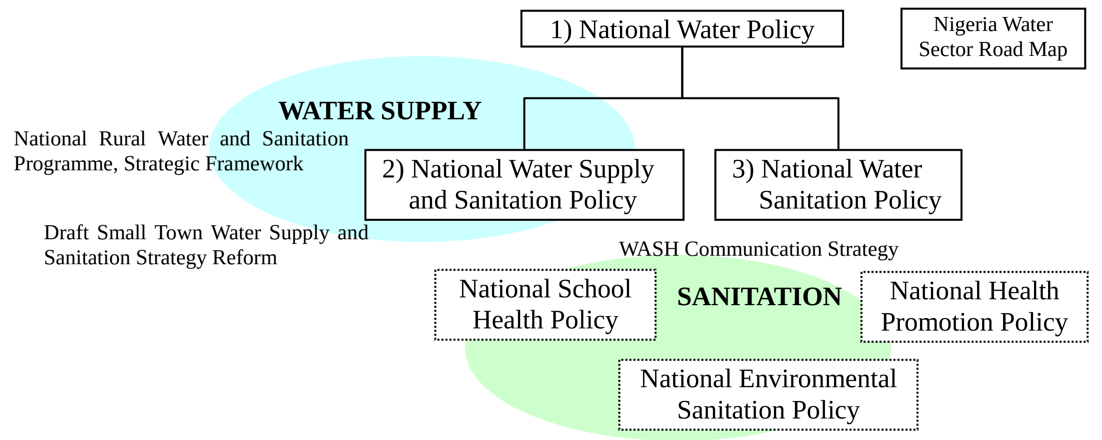
Table 8-1 Strategic Priorities in the Water Supply and Sanitation Sector by Vision 20:2020

- Encouraging Community Participation, Private Sector Participation and Public Private Partnership in the provision of water supply and sanitation schemes and services, so as to empower water supply agencies (both private and public) to operate on a commercial basis, by developing and promoting the market, through the provision of incentives.
- Developing integrated best practices programmes and manuals of management, operation and maintenance for Urban, Small Town and Rural water and sanitation supply schemes and services.
- Rehabilitating, constructing and modernizing existing water supply and sanitation schemes, distribution networks and facilities for optimal operation, so as to meet the increase in demand owing to population growth. Also encouraging the use of alternative energy sources, such as solar, wind and other renewable energy sources to power pumps and other facilities for water supply and sanitation schemes and services
- Ensuring performance monitoring and evaluation programmes for sanitation undertakings such as re-introduction and strengthening of sanitary inspection units and sanitary inspectors at all levels.
- Embarking on effective and sustained public awareness campaigns to reduce, recycle and re-use solid waste. In addition, encourage community participation, PSP and PPP in the provision of sanitation schemes and services.
- Ensuring local manufacturing capacity for basic water supply and sanitation equipment and control devices, a special grant will be provided to the National Water Resources Institute to establish a National Training Network (NTN), and building the capacity of environmental scientists on sound environmental management practices.
- Incorporating extensive pollution control and waste management programmes such as the provision of sewage treatment plants for some major cities.
- Compliance, monitoring and enforcement of appropriate standards towards creating changes in attitudes. In addition, effectively coordinating the implementation of environmental programmes for the control of environmental degradation, pollution, sustainable use and conservation of natural resources.
- Enlightening the citizenry and corporate organizations on ways and methods to go green, in order to reduce waste and pollution.

Source: Vision 20:2020

(2) Sector-Related Policies, Strategies and Documents

Figure 8-1 shows association chart of principal policies, strategies and documents relevant to the water and sanitation sector, and Table 8-2 shows three key policies of the Federal Ministry of Water Resources (FMWR).



Source: JICA Project Team

Figure 8-1 Association Chart of Sector-Related Policies, Strategies and Documents

Table 8-2 Water and Sanitation Sector-Related Key Policies

1) National Water Policy, 2009 / Revised (2000, 2004/Revised)
The national policy document on the whole Water Sector, in which all policies on sub sectors including water supply and sanitation under the jurisdiction of FMWR are specified. **Objectives: (Water supply and sanitation sub sector)** To increase service coverage for water supply and sanitation nationwide to meet the level of socio-economic demand of the nation in the sector through, - New projects designed carefully to meet the real demand of the population avoiding over sizing - Combating leakage and losses - Reducing unaccounted for water (UfW) **Strategies: (Water supply and sanitation sub sector)** - Establish a data management system on water supply and sanitation, including information on expansion of schemes and extension of distribution networks, rehabilitation and modernization of existing schemes - Prevent wasteful water use and control water leakages through special awareness campaigns and standards set for the water supply and sanitation providers - Promote universal metering of water consumption in existing projects and enforce it in new projects of urban and small town supply systems - Carry out programmes to combat illegal connections - Carry out programmes to reduce commercial losses on private, industrial and administrative consumption - Promote social marketing of water saving devices - Establish a national water quality reference laboratory - Encourage private and community ownership of water supply and sanitation facilities - Encourage local manufacture of water supply and sanitation equipment and treatment chemicals - Strengthen water supply and sanitation training institutions - Grant operational autonomy to water supply and sanitation agencies - Capital investment, operation and maintenance, rehabilitation and reinvestment will be the responsibilities of States and Local Governments - Enhance national capacity in the operation and management of water supply and sanitation undertaking - Ensure good quality standards (including WHO standards for water quality) are maintained by water supply undertakings - Monitor the performance of the sector for sound policy adjustment and development for water supply and sanitation
2) National Water Supply and Sanitation Policy, 2000
The national policy document on water supply and sanitation was formulated in 2000 and a number of measures have been attempted by sector reform. The policy is expected to be updated. **Objectives:** To provide sufficient potable water and adequate sanitation to all Nigerians in an affordable and sustainable way through participatory investment by the three tiers of government, the private sector and beneficiary.

(Though target of service coverage of water supply and sanitation is 60% in 2003, 80% in 207 and 100% in 2011, they were not achieved.)

Basic Principles:

- Decentralization
- Community Participation and Ownership
- Cost Sharing
- Autonomous Management
- Water as a Economic Good
- Water Quality Management
- Private Sector Participation
- Subsidy for the Poor

Components:

- Increase service coverage for water supply and sanitation nationwide to meet the level of socio-economic demand of the nation in the sector
- Ensure good water quality standards are maintained by water supply undertakings
- Ensure affordability of water supply and sanitation services for the citizens
- Guarantee affordable access for the poor to basic human need level of water supply and sanitation services
- Enhance national capacity in the operation and management of water supply and sanitation undertaking
- Private water supply and wastewater services (where feasible) with adequate protection for the poor
- Monitor the performance of the sector for sound policy adjustment and development for water supply and sanitation
- Legislations, regulations and standards for water supply and sanitation
- Reform of the water supply and sanitation sector to attain and maintain internationally acceptable standards

3) National Water Sanitation Policy, 2004

The national policy document emphasizing on water sanitation, since the National Water Supply and Sanitation Policy formulated in 2000 has emphasized on water supply.

Objectives：

All Nigerians have access to adequate, affordable and sustainable sanitation through the active participation of federal, state and local governments, NGOs, development partners, private sector, communities, households and individuals.

(Though target of sanitation coverage is 65% in 2010, 80% in 2015, 90% in 2020 and 100% in 2025, current coverage has not achieved the target.)

Basic Principles:

- Sanitation as Priority
- Hygiene Practice
- Political Will
- Environmental Impact of Sanitation Facilities
- Integrated Approach
- Gender Responsiveness
- Equity and Poverty Reduction
- Sustainable, Appropriate and Affordable Options
- Private Sector Participation
- NGO Participation
- Demand Responsiveness
- Legislation
- Ownership and Responsibilities
- Social Acceptance
- Building on Existing Practices
- Funding
- Monitoring and Evaluation
- Research and Development

Strategies:

- Advocacy
- Mobilization
- Capacity Building
- Community Ownership and Management
- Service Delivery
- Participatory Approach
- Monitoring and Evaluation
- Legislation

Source: National Water Policy, 2009 / Revised (2000, 2004/Revised)
National Water Supply and Sanitation Policy, 2000
National Water Sanitation Policy, 2004

8.1.3 Current Status of Water Supply and Sanitation

(1) Nationwide Water Supply and Sanitation Coverage

Water supply and sanitation coverage published in late years vary in existing policies, studies and documents, as shown in Table 8-3. According to the Water Sector Roadmap 2011, the Federal Ministry of Water Resources (FMWR) accepted the coverage calculated by WHO/UNICEF Joint Monitoring Programme (JMP) in 2008 as the latest coverage.

The JMP 2008 calculated the coverage through regression analysis of the results of National Demographic and Health Surveys (NDHSs) in 1990, 1999 and 2003 regarded as a relatively accurate survey and also review of the coverage calculated by another JMP in 2006. Moreover, in consideration of little gap between it and the latest coverage of NDHS in 2008, the coverage accepted by the FMWR can be reasonable.

However, in view of actual usage and operation of facilities such as defective function due to inadequate operation and maintenance, partial or intermittent supply and also active private water vending, we should remember that the coverage may not necessarily present a realistic picture of water supply and sanitation situation on the ground.

Other surveys, such as Core Welfare Indicators Questionnaire Survey (CWIQS) in 2006, National Water Supply and Sanitation Baseline Survey (NWSSBS) in 2006 and Multiple Indicator Cluster Survey (MICS) in 2007, resulted in variety of coverage possibly due to differences of survey methods including data collection and sample number, and also definition of indicators.

The Project utilizes the results of Core Welfare Indicators Questionnaire Survey (CWIQ), 2006 for water demand projection, because it shows water supply coverage by water supply category at the state level, and its nationwide coverages do not differ much from JMP, 2008

As a result of summation of population served by Local Government Area (LGA), nationwide water supply coverage estimated by the Project becomes 56.2%, and 72.2% for urban and 39.9% for rural (51.3% for semi-urban/small-town), as baseline values of the Project.

As for Sanitation, the Project applies the results of National Demographic and Health Survey (NDHS) as baseline values of the Project, because it shows sanitation coverage at the state level.

Table 8-3 Recent Water Supply and Sanitation Coverages and Estimate by the Project

Coverage (%)		1990 JMP	2000 NWSSP	2006 JMP	2006 CWIQS	2006 NWSSBS	2007 MICS	2008 NDHS	**2008 JMP**	**2011 JICA-M/P**
Water	Urban	80.0	48.0	65.0	73.4	69.3	75.7	75.0	**75.0**	**72.2**
	Rural	34.0	39.0	30.0	40.0	49.9	37.4	45.0	**42.0**	**39.9**
	National	50.0	-	47.0	51.4	54.3	49.1	56.0	**58.0**	**56.2**
Sanitat.	Urban	33.0	-	35.0	77.0	85.2	70.0	31.0	**36.0**	**31.0**
	Rural	22.0	-	25.0	47.6	59.6	31.0	25.0	**28.0**	**25.0**
	National	26.0	-	30.0	57.6	65.6	42.9	27.0	**32.0**	**27.0**

Source:
JMP: Joint Monitoring Programme (WHO and UNICEF)
NWSSP: National Water Supply and Sanitation Policy (FMWR)
CWIQS: Core Welfare Indicators Questionnaire Survey (National Bureau of Statistics: NBS)
NWSSBS: National Water Supply and Sanitation Baseline Survey (FMWR)
MICS: Multiple Indicator Cluster Survey (National Bureau of Statistics: NBS)
NDHS: National Demographic and Health Survey (National Population Commission: NPC)

(2) Government Institutions on the Water Supply and Sanitation Sector

In principle, responsibilities on project implementation, operation and maintenance of water provision are divided into three tiers of government in Nigeria, such as the Federal, the States and the Local Governments. But, it has been pointed out that they have institutional problems, poor coordination, limited funding, lack of capacity, and also that implementation by many authorities and duplication of services cause disorder and insufficiency.

Table 8-4 shows involvement of government institutions and community organizations by water supply categorized into urban, semi-urban / small town and rural (see Section 4-2-2 (1-2)) which are based on population size. But, it differs depending on state, and it is difficult to categorize actual water supply simply according to settlement type based on population size because of a mixture of water supply on the ground.

The whole water and sanitation sector in the federal level is under the jurisdiction of the Federal Ministry of Water Resources (FMWR), and the Department of Water Supply below the Ministry is composed of several units for urban water supply, semi-urban / small town water supply, rural water supply and others. Besides, the Department of Water Quality Control and Sanitation is in charge of water quality management, and sanitation in semi-urban / small town and rural communities.

Table 8-4 Government Institutions and Responsibilities on the Water Sector

Tier	Organization	Settlement Category			Remarks
		Urban	S.U./S.T.	Rural	
Federal	Federal Min. of Water Resources (FMWR)	✓	✓	✓	overall responsibility
State	State Water Authority (SWA)	✓	✓	✓ *	* if any in some state
	Small Town Water Supply and Sanitation Agency (STWSSA)		✓		If any by STWSS project
	State Min. of Water Resources (SMWR)			✓	in some states
	Rural Water Supply and Sanitation Agency (RUWASSA) or WATSAN Project		✓ *	✓	* point source motorized pump system or small piped facilities
Local Government	Local Government Area (LGA) Council		(✓)	✓	If capable, mostly lack of capacity
Community (O&M)	Water Consumers Association (WCA)		✓		if any by STWSS project
	WATSAN Committee or WASHCOM (conventional)		(✓)	✓	if any, but low sustainability

Source: JICA Project Team

Furthermore, a large number of the ministries and organizations have been engaged on sanitation, such as the Federal Ministry of Environment (FMEn) for especially environmental sanitation, water pollution and sewerage through Environmental Protection Agency , the Federal Ministry of Health (FMH) for drinking water quality, water and sanitation related diseases through the Department of Public Health, the Federal Ministry of Education (FMEd) for school sanitation, the Federal Ministry of Women's Affairs (FMWA), and also the Ministry of Youth Development. At the state level, related state ministries are responsible for implementation, and Small Town Water Supply and Sanitation Agency (STWSSA) and Rural Water Supply and Sanitation Agency (RUWASSA) are in charge of community sanitation under State Ministries of Water Resources. Also, sanitation related section of LGA and committee in community are involved.

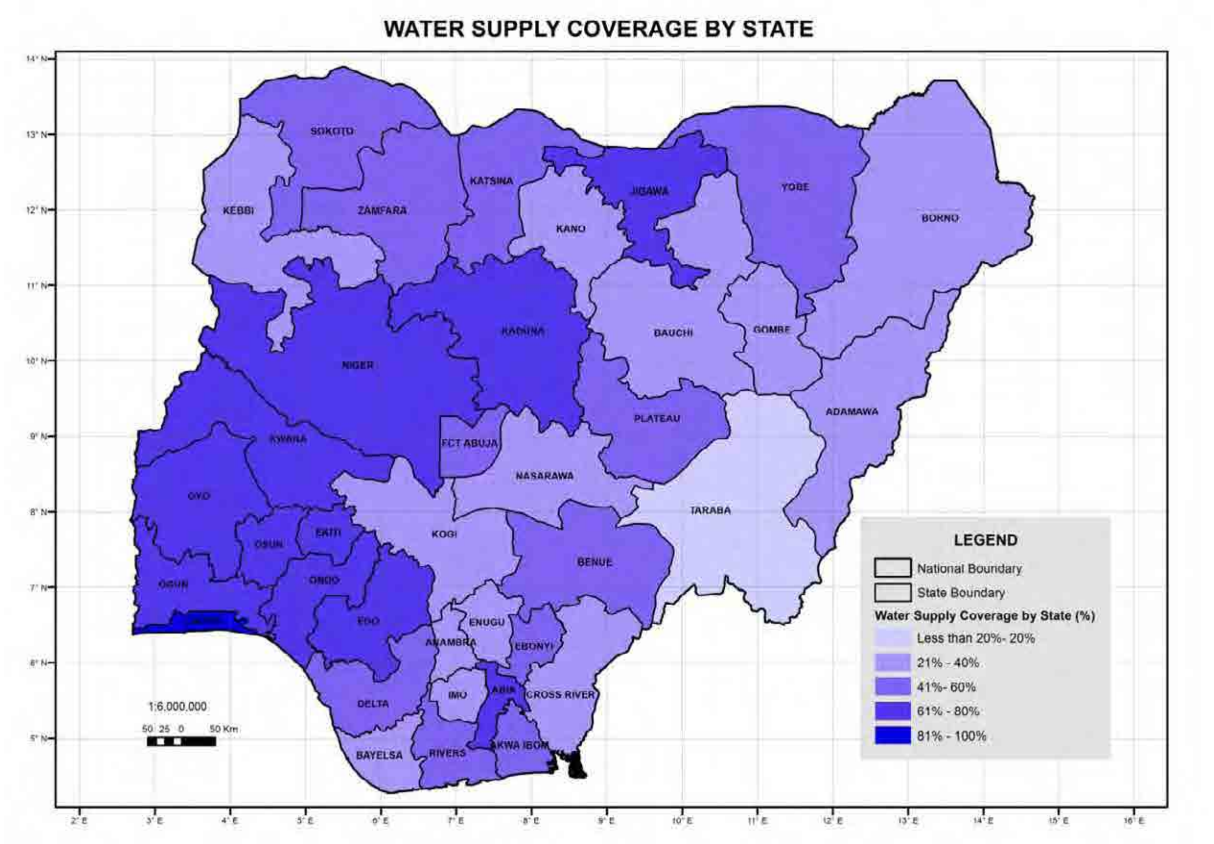
(3) Current Status of Water Supply

Nationwide water supply coverage is described in the above 8.1.3 (1), but Table 8-5 and Figure 8-2 show water supply coverage by settlement type at the state level, sourced from Core Welfare Indicators Questionnaire Survey (CWIQS), 2006. The coverage by state is utilized for water demand projection in the Project.

Table 8-5 Water Supply Coverage by State in 2006 (%)

	State	Urban	Semi-Urban	Rural	Overall
1	Abia	94.8	22.6	52.5	63.6
2	Adamawa	34.9	18.5	23.6	26.7
3	Akwa Ibom	81.4	58.8	37.9	43.5
4	Anambra	39.4	27.6	26.3	30.8
5	Bauchi	78.1	44.6	25.0	33.8
6	Bayelsa	1.9	1.8	31.1	29.6
7	Benue	65.6	61.8	39.0	43.4
8	Borno	44.1	61.7	29.1	34.4
9	Cross River	66.2	36.5	13.7	31.1
10	Delta	61.1	26.6	39.1	46.1
11	Ebonyi	65.1	49.7	37.1	43.8
12	Edo	90.0	71.4	28.6	60.2
13	Ekiti	70.4	61.7	52.1	61.9
14	Enugu	33.2	13.2	26.4	28.9
15	Gombe	39.1	35.7	22.0	23.9
16	Imo	59.0	28.0	36.4	38.5
17	Jigawa	76.8	74.2	63.5	64.0
18	Kaduna	90.9	62.3	62.7	71.4
19	Kano	59.4	67.8	34.1	40.0
20	Katsina	62.6	30.0	38.1	42.9
21	Kebbi	58.9	43.5	34.4	38.7
22	Kogi	51.9	32.5	31.4	36.9
23	Kwara	81.9	54.6	60.3	71.4
24	Lagos	89.3	66.2	51.0	86.6
25	Nasarawa	67.2	49.1	38.6	38.6
26	Niger	81.7	72.1	54.0	62.6
27	Ogun	87.6	76.0	38.7	65.1
28	Ondo	83.5	60.6	44.7	62.0
29	Osun	81.2	81.1	66.9	71.6
30	Oyo	85.4	74.9	66.5	77.4
31	Plateau	81.9	33.8	19.1	43.3
32	Rivers	68.4	48.6	44.2	48.6
33	Sokoto	81.4	57.3	45.5	51.7
34	Taraba	31.8	18.1	16.9	19.2
35	Yobe	50.4	42.5	36.5	42.4
36	Zamfara	71.9	71.9	44.7	47.6
37	FCT Abuja	49.4	31.5	35.8	42.2
	Nationwide	**73.4**	-	**40.0**	**51.4**

Source: Core Welfare Indicators Questionnaire Survey (CWIQS), 2006



Source: Core Welfare Indicators Questionnaire Survey (CWIQS), 2006. Represented graphically by JICA Project Team

Figure 8-2 Water Supply Coverage by State

(3-1) Urban Water Supply

Urban water supply corresponds to water supply for more than 20,000 populations to be served, for example, in not only the Abuja Federal Capital Territory (FCT) and 36 state capitals but also local high-populated cities.

Water supply services have been actually done by the State Water Agency (SWA) named commonly as State Water Board or Corporation, established by each State including FCT Abuja. Water is normally abstracted from river or dam as a water source and distributed after treatment, but some cities rely on groundwater. Water service level is typical house or yard connections but some public standpipes. As a whole, most of facilities and equipment have been deteriorated and actually operated below the designed capacity due to aging and inadequate maintenance. And, asbestos pipes had been heavily used for main reticulation, and unaccounted for water (UfW) is very high because of loss and illegal connection. Furthermore, intermittent water supply has been frequent due to unreliable power supply, so the operational cost increased by using generators for sustainable water supply has been a significant problem. To make up for inadequate water supply by government authorities, ironically, overvalued water selling by private water vendors is popular nationwide, and many households or private estates own boreholes.

Although state water agencies (SWAs) should be financially independent in principle with water tariff collection from water consumers, unmetered tariff system, low priced water and high non- revenue water (NRW) have caused insufficient operating revenue. Consequently, they have had structural problems on habitual reliance on subsidies from state governments.

(3-2) Semi-urban and Small Town Water Supply

Semi-urban and small town water supply corresponds to water supply for between 5,000 and 20,000 populations to be served. There are nationwide a great number of semi-urban and small towns positioned between urban and rural categories, in which a lot of people reside, 45% estimated in water demand projection of the Project.

In the past before 2000, most of water supply services in semi-urban or small towns were provided virtually as a social service without needed tariff collection by state water agencies, state governments and so on. Accordingly, it caused often no sustainability of services because inadequate operation and maintenance, lack of funds and poor ownership. Water is normally abstracted from groundwater and pumped up to elevated tank by motorized pump, and then distributed by gravity to end-consumers through standpipes or house/yard connections.

Against such a background, water supply services were categorized including semi-urban and small town water supply by the National Water Supply and Sanitation Policy, 2000 and meanwhile, Small Town Water Supply and Sanitation Projects (STWSSP) have been implemented as a pilot project in some states with assistances of World Bank and European Union. Under these projects, Small Town Water Supply and Sanitation Agencies (STWSSA) were established in the states for improvement of water supply in semi-urban and small towns, and as well, Water Consumer Association (WCA) for community-based operation and maintenance with tariff collection.

However, in a number of semi-urban and small towns except the above assisted by STWSSP, water supply services has been still provided by several government authorities, such as State Water Agencies (SWAs), Rural Water Supply and Sanitation Agencies (RUWASSA), Local Government Area (LGA) Councils, MDG Project and so on, and sometimes with duplication. Actually, existing facilities and equipment in these small towns have been not operated and maintained appropriately, and not rehabilitated and finally left neglected because of lack of funds and other various reasons.

(3-3) Rural Water Supply

Rural water supply corresponds to water supply for less than 5,000 populations to be served, generally rural villages.

Local Government Area (LGA) Councils are in charge of rural water supply in principle, but actually not capable to implement projects and operate and maintain facilities due to lack of human resources, funds, equipment and skills, except a few LGA councils. To make up for the inadequate capacity of LGA councils, Rural Water Supply and Sanitation Agencies (RUWASSAs) or Water and Sanitation (WATSAN) Projects under state governments and the State Ministry of Water Resources have taken the place of them. Water supply facilities are typically boreholes equipped with handpump, but some small piped water supply facilities using motorized pump and elevated tank are also popular nationwide.

Community-based organization has usually a responsibility of daily operation and maintenance, such as Water and Sanitation (WATSAN) Committee or Water, Sanitation and Hygiene Committee (WASHCOM), but regular collection of usage fees to cope with the cost of operation and maintenance is rare, so RUWASSA or state ministry have supported communities financially and technically. However, facilities have been often left neglected because the support is not distributed due to lack of funds and other various reasons.

(4) Operational Situation of Public Water Supply Facilities

Common composition of public water supply facilities in Nigeria are generally as shown in Table 8-6, categorized by water supply type based on population size, but these facilities exist often in parallel in urban, semi-urban and small town. Furthermore, a number of household and private estate have or share own water source nationwide, and most of them are facilities rely on groundwater such as borehole equipped with handpump or small motorized pump.

Table 8-6 Common Composition of Public Water Supply Facilities

Water Supply Type		Main Water Source	Common Composition of Facilities
1	Urban	Surface Water mainly but also groundwater	Water treatment works, pump and booster, pipeline, house/yard connections and standpipes.
2	Semi-Urban or Small Town	Groundwater mainly but also surface water or distribution from urban water facilities	Chlorination if needed, motorized pump, reservoir, pipeline, standpipes, and house/yard connections.
3	Rural	Groundwater	Handpump, 250m radius, 250-500 beneficiaries per point. And also, small piped facilities with motorized pump, elevated tank, and standpipes.

Source: JICA Project Team

To see the general picture of existing public water supply facilities, National Water Supply and Sanitation Baseline Survey, 2006 by the Federal Ministry of Water Resources (FMWR) is only useful to count of water supply facilities using groundwater and its operating situation (simply, functioning or not), but not useful to find quantitative operating situation and also information about water supply facilities using surface water. Water supply authorities of states do not have quantitative data of existing water supply facilities using groundwater, too.

The Project sees the picture of water supply facilities using groundwater through estimation by the number of facilities and their operating ratio, because existing information and interview to relevant authorities cannot lead to accurate outcome and also because of a great number of facilities around the county. Meanwhile, the Project analyzes water supply facilities using surface water in term of capacity of water treatment works.

(4-1) Operating Ratio (Production Efficiency) of Water Supply Facilities by Water Source Type

Regardless of scale of existing water supply facilities, most of them nationwide have been deteriorated because of aging and inadequate maintenance, so ratio of actual water supply to designed capacity (raw water or treated water), called operating ratio (production efficiency), were estimated at 68.0% of the facilities using surface water and 57.0% of the facilities using groundwater at the national level in M/P1995 (refer to Table 8-7). In addition, erratic power supply has made water supply intermittent if it relies on commercial power for treatment and pumping.

Table 8-7 Production Efficiency (Operating Ratio) of Water Supply Facilities in M/P1995

Zone		NW	NE	CW	CE	SW	SE	National
a)	Designed Supply ($10^6 m^3$)							
	Surface Water Facilities	90	110	210	90	330	80	910
	Groundwater Facilities	40	90	30	20	160	120	460
b)	Actual Supply 1995 ($10^6 m^3$)							
	Surface Water Facilities	70	60	150	40	240	60	620
	Groundwater Facilities	20	60	20	10	80	70	260
c)	Operating Ratio (b/a) （%）							
	Surface Water Facilities	78	55	71	44	73	75	**68**
	Groundwater Facilities	50	67	67	50	50	58	**57**

Source: M/P1995, JICA

Borehole inventory survey by the Federal Ministry of Water Resources (FMWR) in 2006 found updated operating ratio was 63.0% at the national level, and this proves little improvement in utilization of facilities when compared with the above for facilities using groundwater in 1995.

Meanwhile, the facilities using surface water corresponding to mainly urban water supply facilities have been rehabilitated and expanded with international assistance such as World Bank and African Development Bank, but improvement in utilization of facilities is in progress in some states where the projects are confined to.

The Project estimates operating ratios of water supply facilities using surface water and groundwater respectively and gathers information of ongoing and planned rehabilitation projects, in order to reflect them into water supply development plan in the M/P2013.

(4-2) Water Supply Facilities using Surface Water

Public water supply facilities using surface water including subsurface water are generally operated and maintained by State Water Agencies (SWA) and distribute water to mainly urban, semi-urban and small town after treatment of water taken from dam, river or stream. Water treatment works has typically conventional process with rapid filtration if large scale of production; but some are package plants if small scale; in addition, a few mobile treatment plants exist in Kano State. As a result of study by the Project, these treatment works and plants exist in major cities or their outskirts throughout the country but Akwa Ibom, Cross River, Delta and Rivers states located in the southern delta area. The reasons may include abundance of groundwater and higher cost of water treatment due to contamination of surface water, high turbidity and high salinity. Meanwhile, the Project did not verify any water supply facilities using surface water in Yobe State located in the northern area.

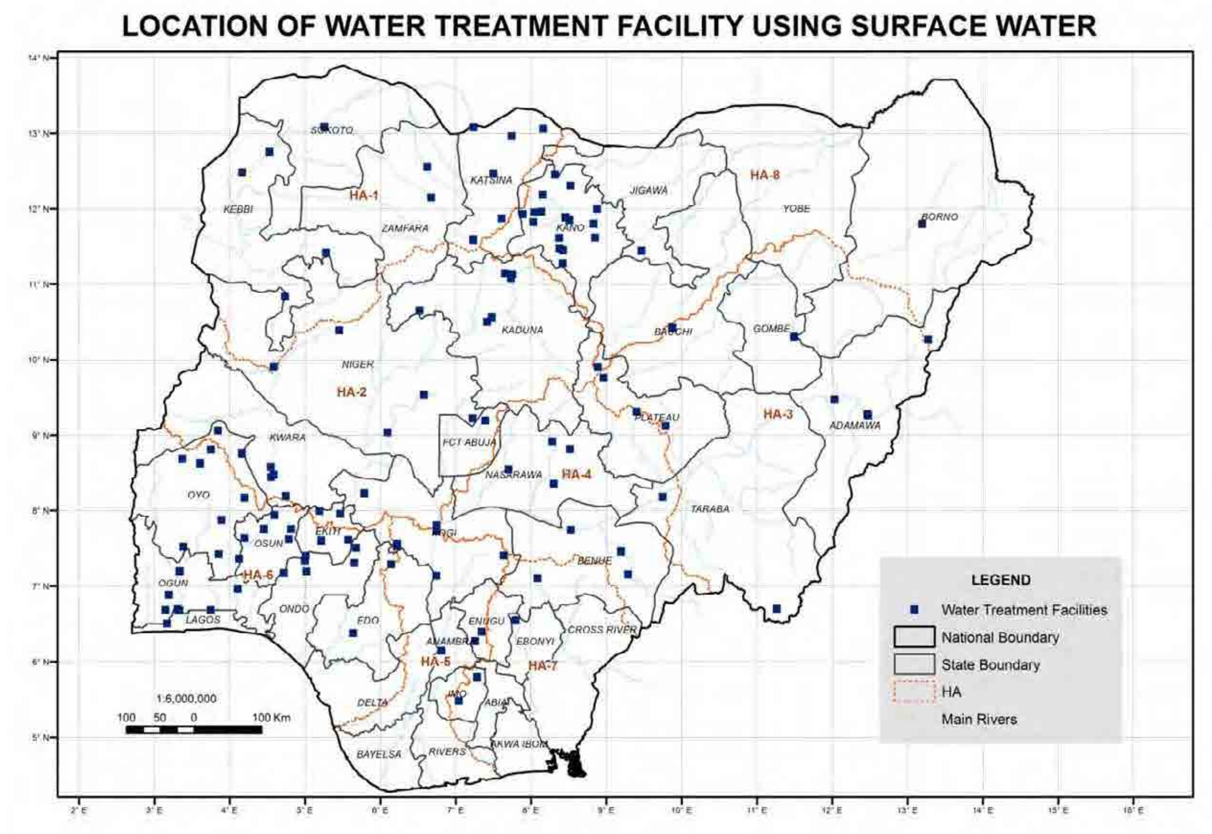
Table 8-8 shows summary of existing public water supply facilities using surface or subsurface water, mostly treatment facilities verified by the Project (refer to details in Section SR5.1.1, Volume-5,Supporting Report), and then Figure 8-3 shows their locations. To a greater or lesser, more than 240 treatment facilities or equivalent of surface or subsurface water exist in Nigeria, and the proportion of actual production to designed capacity, that is, nationwide production efficiency is 45.2% in terms of water production through treatment. This shows us inefficiency of facility operation at least, and the inefficiency has been not necessarily attributable to planned operation but erratic power supply, aging of facilities and equipment, malfunction of equipment such as pump due to inadequate maintenance, and also supposedly oversize design by excess estimate of water demand.

Moreover, some treatment facilities were constructed 50 years ago, in addition, reservoirs and pipelines (asbestos material in heavy usage) were also constructed during the same period. In consideration of expected lifetime, the Project will deal with the possibility of drastic measures such as rehabilitation and replacement.

Table 8-8 Existing Water Treatment Facility of Surface Water

No	State	Number of Water Treatment Facility※1			Capacity/Production (LCD)※2		
		Surface	Subsurface	Total	Design	Present	Efficiency
1	Abia	1	0	1	53.0	10.6	20.0
2	Adamawa	4	9	13	86.0	24.5	28.5
3	Akwa Ibom	0	0	0	0	0.0	-
4	Anambra	3	0	3	46.0	0.0	0.0
5	Bauchi	2	0	2	50.0	36.5	73.0
6	Bayelsa	0	0	0	0.0	0.0	-
7	Benue	17	0	17	42.2	9.0	21.3
8	Borno	1	3	4	70.0	31.5	45.0
9	Cross River	8	0	8	144.2	38.6	26.8
10	Delta	0	0	0	0.0	0.0	-
11	Ebonyi	1	0	1	25.4	10.9	43.1
12	Edo	3	0	3	20.0	8.6	43.0
13	Ekiti	5	0	5	186.2	67.4	36.2
14	Enugu	1	0	1	77.0	23.1	30.0
15	Gombe	1	1	2	51.0	45.5	89.2
16	Imo	2	0	2	105.0	22.5	21.4
17	Jigawa	2	0	2	14.6	7.2	49.5
18	Kaduna	10	0	10	366.3	176.8	48.3
19	Kano	17	2	19	319.6	180.8	56.6
20	Katsina	8	0	8	169.4	43.3	25.6
21	Kebbi	4	0	4	87.8	51.5	58.7
22	Kogi	10	0	10	40.2	17.0	42.3
23	Kwara	7	0	6	157.5	119.3	75.7
24	Lagos	3	0	3	541.0	344.4	63.7
25	Nasarawa	5	0	5	70.9	15.3	21.6
26	Niger	11	0	11	182.2	103.8	57.0
27	Ogun	16	0	16	178.5	70.4	39.4
28	Ondo	8	0	8	34.9	10.9	31.2
29	Osun	45	0	45	242.5	38.8	16.0
30	Oyo	14	0	11	251.0	34.9	13.9
31	Plateau	4	0	4	130.5	56.3	43.1
32	Rivers	0	0	0	0.0	0.0	-
33	Sokoto	3	0	3	184.5	114.0	61.8
34	Taraba	2	3	5	24.2	6.0	25.0
35	Yobe	0	0	0	0.0	0	-
36	Zamfara	4	0	4	48.4	28.3	58.5
37	FCT Abuja	2	0	2	240.0	168.0	70.0
	Nationwide	**225**	**18**	**243**	**4,239.8**	**1,915.8**	**45.2**

*1: As of 2010. Simplified treatment facilities and chlorination only are included.
*2: As of 2012.
Source: JICA Project Team



Notes: Except for the facilities using subsurface and locations unknown, 130 facilities are shown here
Source: JICA Project Team

Figure 8-3 Location of Existing Water Treatment Facility of Surface Water

(4-3) Water Supply Facilities using Groundwater

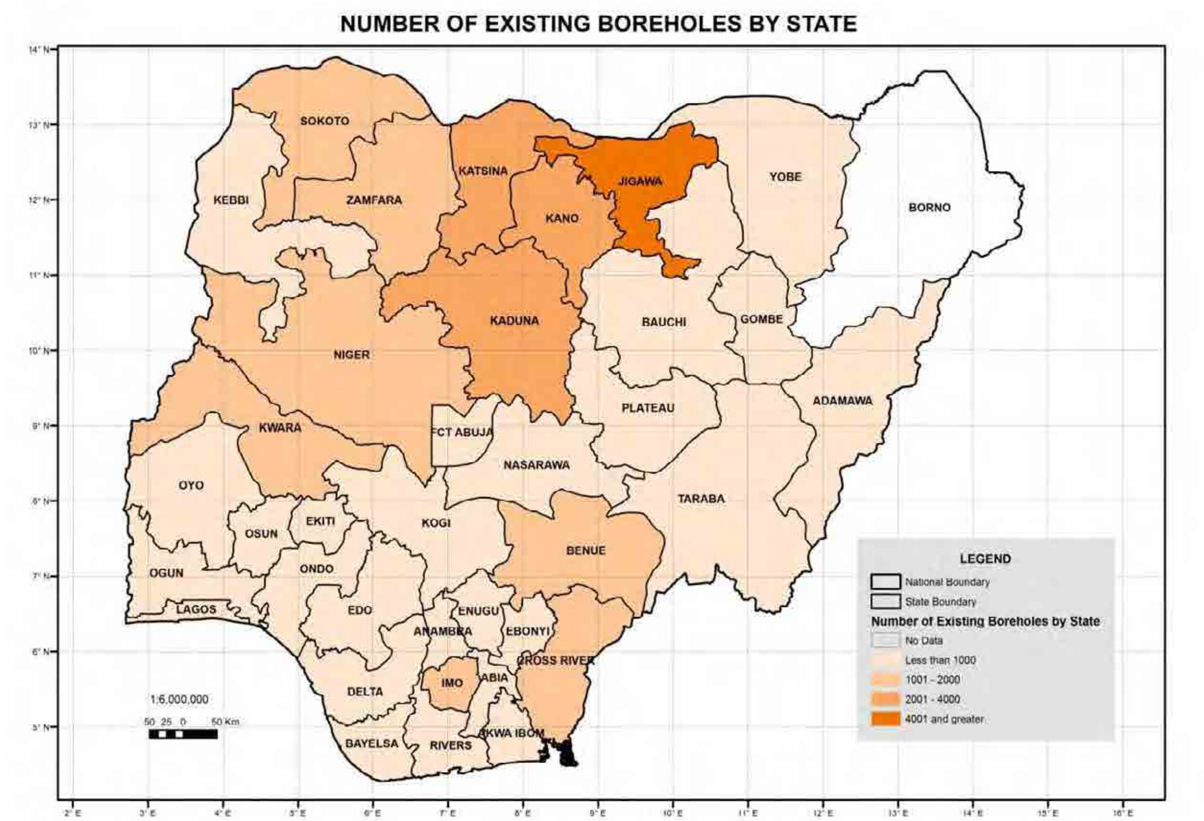
Public water supply facilities using groundwater (i.e. borehole) exist throughout the country regardless of their scale. In urban water supply, some facilities rely totally on groundwater such as Jalingo, the capital of Taraba State, but in most cases they exist as secondary or supplementary water facilities for water supply facilities using surface water. Meanwhile, groundwater is definitely a main source for semi-urban, small town and rural water supply facilities, usually equipped with handpump or motorized pump. And, the Project regards spring water as groundwater, which is a minority source in some states.

Table 8-9 shows the number and operating ratio of existing boreholes by state through detail check and summarization of raw data of the National Water Supply and Sanitation Baseline Survey (NWSSBS), 2006 by FMWR. As a result, the total number of boreholes is about 38,000 excluding Borno State, and nationwide operating ratio is 54.3%. Figure 8-4 and 8-5 show graphically the number of boreholes and operating ratio by state respectively.

Table 8-9 Number and Operating Ratio of Existing Boreholes by State in 2006

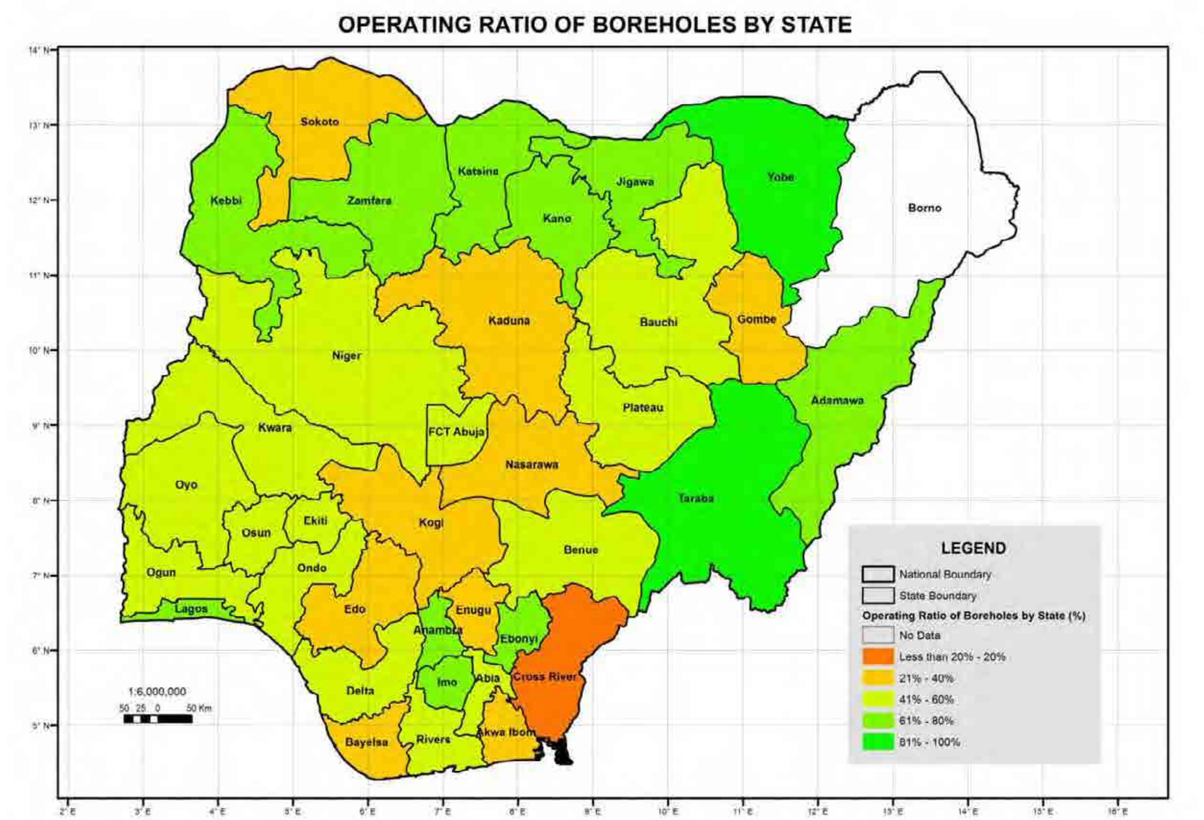
	State	Handpump			Motorized Pump			Total		
		No.	Function	(%)	No.	Function	(%)	No.	Function	(%)
1	Abia	153	58	37.9	610	359	58.9	763	417	54.7
2	Adamawa	649	439	67.6	157	87	55.4	806	526	65.3
3	Akwa Ibom*1	0	0	0	633	218	34.4	633	218	34.4
4	Anambra	68	24	35.3	496	371	74.8	564	395	70.0
5	Bauchi	603	341	56.6	199	60	30.2	802	401	50.0
6	Bayelsa*1	0	0	0	149	54	36.2	149	54	36.2
7	Benue	969	433	44.7	110	43	39.1	1,079	476	44.1
8	Borno*3	-	-	-	-	-	-	-	-	-
9	Cross River*1	0	0	0	1,151	92	8.0	1,151	92	8.0
10	Delta	447	190	42.5	175	69	39.4	622	259	41.6
11	Ebonyi	769	611	79.5	16	14	87.5	785	625	79.6
12	Edo*2	295	93	31.5	0	0	0	295	93	31.5
13	Ekiti	253	122	48.2	82	31	37.8	335	153	45.7
14	Enugu*4	147	34	23.1	132	63	47.7	279	97	34.8
15	Gombe	61	17	27.9	556	119	21.4	617	136	22.0
16	Imo	270	217	80.4	754	518	68.7	1,024	735	71.8
17	Jigawa	5,537	3,909	70.6	574	403	70.2	6,111	4,312	70.6
18	Kaduna	1,440	602	41.8	734	67	9.1	2,174	669	30.8
19	Kano	2,952	1,798	60.9	417	266	63.8	3,369	2,064	61.3
20	Katsina	2,083	1,410	67.7	827	550	66.5	2,910	1,960	67.4
21	Kebbi	245	186	75.9	226	121	53.5	471	307	65.2
22	Kogi	438	176	40.2	266	81	30.5	704	257	36.5
23	Kwara	913	477	52.2	212	110	51.9	1,125	587	52.2
24	Lagos	61	40	65.6	667	407	61.0	728	447	61.4
25	Nasarawa	245	94	38.4	195	66	33.8	440	160	36.4
26	Niger	1,650	848	51.4	116	68	58.6	1,766	916	51.9
27	Ogun	82	22	26.8	489	296	60.5	571	318	55.7
28	Ondo	418	165	39.5	489	232	47.4	907	397	43.8
29	Osun	389	144	37.0	367	165	45.0	756	309	40.9
30	Oyo	606	388	64.0	280	148	52.9	886	536	60.5
31	Plateau	360	165	45.8	48	14	29.2	408	179	43.9
32	Rivers*2	864	352	40.7	0	0	0	864	352	40.7
33	Sokoto	692	174	25.1	600	215	35.8	1,292	389	30.1
34	Taraba	347	304	87.6	80	74	92.5	427	378	88.5
35	Yobe	173	153	88.4	349	338	96.8	522	491	94.1
36	Zamfara	903	604	66.9	131	48	36.6	1,034	652	63.1
37	FCT Abuja	388	158	40.7	134	69	51.5	522	227	43.5
	Nationwide	**25,470**	**14,748**	**57.9**	**12,421**	**5,836**	**47.0**	**37,891**	**20,584**	**54.3**

*1 No handpumps exist, but it's not known exactly why.
*2 No motorized pumps exist, but it's not known exactly why.
*3 No results due to security deterioration in the survey period.
*4 The unknown 128 boreholes are counted as handpump borehole.
*5 Spring water is not included, but a very little if any.
Source: National Water Supply and Sanitation Baseline Survey (NWSSBS), 2006. Reanalyzed by JICA Project Team



Source: National Water Supply and Sanitation Baseline Survey (NWSSBS), 2006. Reanalyzed and represented graphically by JICA Project Team

Figure 8-4 Number of Existing Boreholes by State



Source: National Water Supply and Sanitation Baseline Survey (NWSSBS), 2006. Reanalyzed and represented graphically by JICA Project Team

Figure 8-5 Operating Ratio of Existing Boreholes by State

(5) Current Status of Sanitation

Sanitary facilities in Nigeria are typically flush toilet connected to sewerage system, flush toilet with septic tank and ventilation improved pit latrine. If not any sanitary facilities, people relieve themselves under unsanitary or primitive conditions.

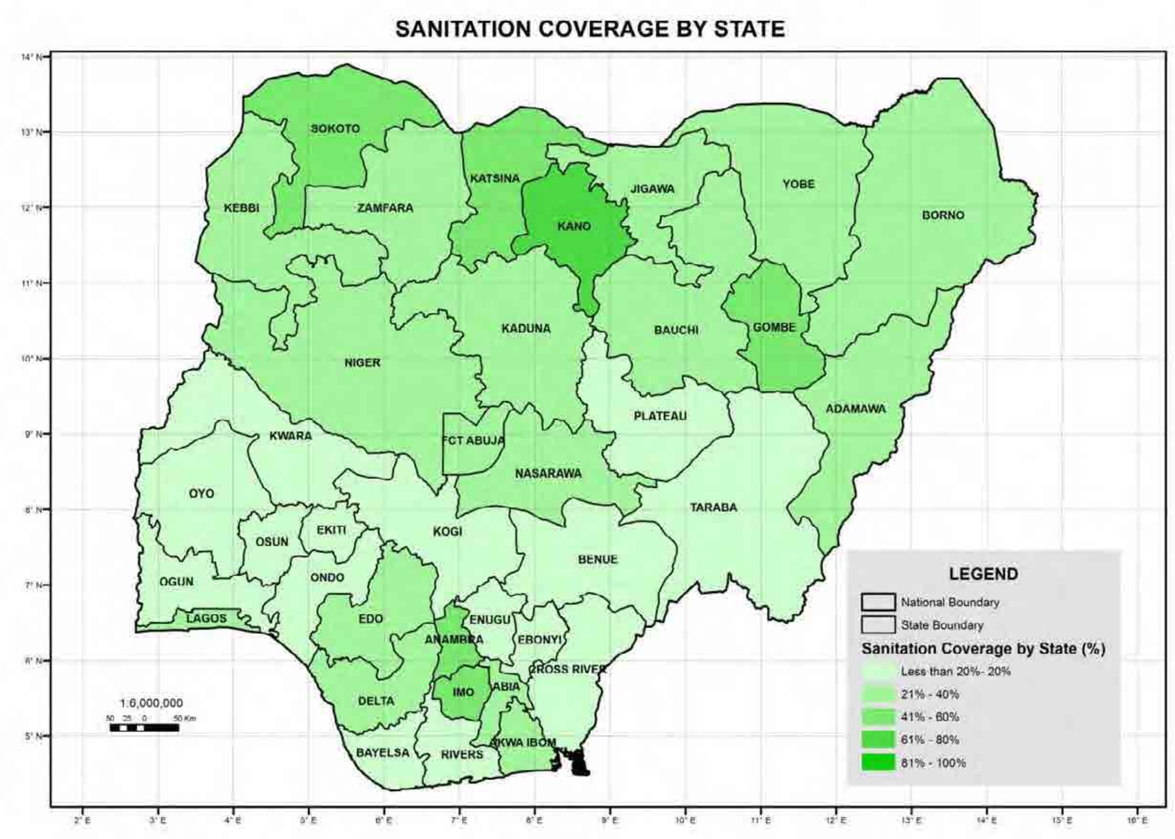
Nationwide sanitation coverage is described in the above Section 8.1.3 (1), but Table 8-10 shows both sanitation coverage and sewerage coverage at the state level, sourced from National Demographic and Health Survey (NDHS), 2008 and Multiple Indicator Cluster Survey (MICS), 2007. Figure 8-6 shows graphically sanitation coverage by state.

Sewerage systems with proper treatment exist only in a part of major metropolis such as Abuja and Lagos, others probably have not proper treatment even if sewerage networks exist there.

Table 8-10 Sanitation and Sewerage Coverage by State (%)

	State	Sanitation (NDHS,2008)	Sewerage (MICS,2007)
1	Abia	39.0	0.3
2	Adamawa	21.0	0.3
3	Akwa Ibom	39.0	0.0
4	Anambra	43.0	12.6
5	Bauchi	22.0	0.2
6	Bayelsa	6.0	0.0
7	Benue	15.0	2.8
8	Borno	26.0	3.3
9	Cross River	10.0	0.9
10	Delta	22.0	0.5
11	Ebonyi	13.0	4.9
12	Edo	30.0	10.0
13	Ekiti	17.0	2.0
14	Enugu	19.0	5.1
15	Gombe	45.0	0.7
16	Imo	53.0	12.9
17	Jigawa	22.0	1.3
18	Kaduna	29.0	3.6
19	Kano	63.0	1.1
20	Katsina	47.0	0.2
21	Kebbi	38.0	1.5
22	Kogi	16.0	6.6
23	Kwara	10.0	6.8
24	Lagos	24.0	17.3
25	Nasarawa	38.0	3.6
26	Niger	23.0	3.5
27	Ogun	13.0	4.3
28	Ondo	15.0	2.5
29	Osun	13.0	0.0
30	Oyo	7.0	4.2
31	Plateau	14.0	1.3
32	Rivers	20.0	5.4
33	Sokoto	57.0	0.7
34	Taraba	10.0	0.4
35	Yobe	27.0	0.5
36	Zamfara	28.0	0.2
37	FCT Abuja	38.0	17.6
	Nationwide	**27.0**	**3.9**

Source: National Demographic and Health Survey (NDHS), 2008
Multiple Indicator Cluster Survey (MICS), 2007



Source: National Demographic and Health Survey (NDHS), 2008. Represented graphically by JICA Project Team

Figure 8-6 Sanitation Coverage by State

8.1.4 Basic Conditions of Development Planning

In view of the above current status, the Project will make a water supply and sanitation development plan based on the following design criteria.

(1) Water Supply

As mentioned in basic concept of Section 8.1.1, water supply development plan is composed of the following two major components:

- Rehabilitation of existing facilities
- New construction of facilities (including expansion)

(1-1) Per Capita Consumption

As mentioned in Section 3.2.2, the National Water Supply and Sanitation Policy, 2000 defines standard per capita consumption according to category of water supply and settlement type based on population size, as shown in Table 8-11.

The Project conforms to this standard per capita consumption for sector development plan as well as basic conditions for water demand projection.

Table 8-11 Per Capita Consumption by Water Supply Category

	Water Supply Type	Per Capita Consumption (lit/cap/day)
1	Urban	120
2	Semi-Urban / Small Town	60
3	Rural	30

Source: National Water Supply and Sanitation Policy, 2000, FMWR

(1-2) Designed Capacity and Yield of Water Sources

To make up a development plan of water supply against future growing water demand, capacity or yield of water source should be specified. For water supply facilities using surface water, water demand within available capacity of water source corresponds to designed capacity by considering surface water potential. Meanwhile, for water supply facilities using groundwater, designed yield is subject to hydrological features and pumping capacity.

(1-3) Rehabilitation Scheme of Existing Facilities

As to existing water supply facilities using surface water, the Project assumes that all the facilities have production efficiency at across-the-board 45.2% in 2010, the baseline year of the Project, which were obtained from nationwide efficiency of 2012, and also that the efficiency will be recovered to 80% by 2020 through rehabilitation and sustained until 2030. This water volume to be recovered by rehabilitation scheme becomes required development in both hydrological balance and facility planning.

On the other hand, as to existing water supply facilities using groundwater, out of groundwater development as remaining balance of total required water development after deduction of surface water development, the volume to be rehabilitated to the maximum extent possible is reactivated through rehabilitation scheme, based on Table 7-11 in Section 7.1.3, which varies from state to state. This water volume to be reactivated by rehabilitation scheme becomes required development in both hydrological balance and facility planning.

(1-4) New Construction Scheme of Facilities

As to the water supply facilities using surface water to be newly constructed, the Project assumes that water development is 80% of design capacity, as production efficiency, of newly planned water treatment works and sustained until 2030 in hydrological balance. Water development in facility planning is full design capacity of newly planned water treatment works.

On the other hand, as to the water supply facilities using groundwater to be newly constructed, the remaining balance of groundwater development after deduction of groundwater development by rehabilitation scheme is covered by newly construction in hydrological balance. Water development in facility planning is 125% (inverse of production efficiency at 80%) of water development in hydrological balance.

Table 8-12 Calculation of Required Development by Type of Water Source

<table>
<tr><th colspan="2">Scheme</th><th>Development in Hydrological Balance</th><th>Development in Facility Planning</th></tr>
<tr><td rowspan="2">Rehabilitation</td><td>Surface</td><td>Recovered production of existing facilities to 80%</td><td>Recovered production of existing facilities to 80%</td></tr>
<tr><td>G.W</td><td>Maximum volume to be rehabilitated, based on Table 7-11 in Section 7.1.3.</td><td>Maximum volume to be rehabilitated, based on Table 7-11 in Section 7.1.3.</td></tr>
<tr><td rowspan="2">New Construction</td><td>Surface</td><td>80% of capacity of newly planned water treatment works</td><td>100% of capacity of newly planned water treatment works</td></tr>
<tr><td>G.W</td><td>Remaining balance of groundwater development after deduction of groundwater development by rehabilitation scheme</td><td>Multiplication of 125% (inverse of production efficiency at 80%) to remaining balance of groundwater development after deduction of groundwater development by rehabilitation scheme</td></tr>
</table>

Source: JICA Project Team

(1-5) Composition of Water Supply Facilities

The Project standardizes composition of water supply facilities by the categories mentioned in Table 8-13.
However, urban settlement and semi-urban / small town settlement are conveniently combined together because they cannot be distributed by category of water source.

Table 8-13 Composition of Water Supply Facilities in Development Plan of M/P2013

<table>
<tr><th>Category-1</th><th>Category-2</th><th>Category-3</th><th>Composition of Water Supply Facilities (Standard)</th></tr>
<tr><td rowspan="4">Rehabilitation or New Construction</td><td rowspan="2">Urban and Semi-Urban / Small Town</td><td>Surface W.</td><td>Water treatment works – Pumping main – Reservoir – Distribution – House connection and public standpipe</td></tr>
<tr><td>Groundwater</td><td>Borehole equipped with motorized pump – Pumping main – Reservoir - House connection and/or public standpipe</td></tr>
<tr><td rowspan="2">Rural</td><td rowspan="2">Groundwater</td><td>Borehole equipped with motorized pump – Reservoir - public standpipe</td></tr>
<tr><td>Borehole equipped with handpump</td></tr>
</table>

Source: JICA Project Team

(2) Sanitation

(2-1) Sanitation Service Level

The National Water Sanitation Policy, 2004 defines standard sanitation service level guaranteed for all citizens according to settlement category based on population as well as water supply, as shown in Table 8-14.

The Project conforms to this standard sanitation level for sector development plan.

Table 8-14 Standard Sanitation Service Level

Category of Sanitation		Population	Service Level (at least)	Remarks
Urban	Urban	20,000 <	Pour-Flush Toilet	each household, using suitable and affordable water conveyance systems
	Semi-Urban / Small Town	5,000 - 20,000	SanPlat Latrine or equivalent	each household, improved latrine slab and superstructure harmonizing with surroundings
Rural		< 5,000	Upgraded Pit Latrine	each household, reduction of flies and odour, etc.

Source: National Water Sanitation Policy, 2004, FMWR

(2-2) Components of Sanitation Development Plan

Sanitation development projects are shown in Table 8-15.

Construction of domestic toilet or latrine is not regarded as public development because of privately-owned facility, but the Project calculates necessary development resulted from population forecasted by the Project and household size of each state sourced from Annual Abstract of Statistics (2009, National Bureau of Statistics), provided a toilet or latrine per household.

As a public sanitation development project, the Project plans construction of public toilets at public facilities such as market and bus terminal in order to improve urban sanitary environment nationwide.

In terms of reduction of pollution load, the Project proposes disposal process of septage from individual septic tanks to final disposal facility and site through collection and transport as a common process of septage management in urban settlement, and also sewerage system in a part of urban settlement in some states at 50% sewerage coverage in household basis. For selection of the target areas of the sewerage system, in consideration of higher capital and operating costs, the Project sorts out the states of which average household income is more than 50,000 Naira per month. The target areas are Benin in Edo state, Lagos Central in Lagos state, Osogbo in Osun state, Ibadan in Oyo state and Abuja Municipal Area Council in FCT Abuja.

Furthermore, the Project plans hygiene promotion and education to be implemented by ministries, agencies or LGA, particularly in semi-urban, small town and rural areas. Community led total sanitation (CLTS) should be adopted nationwide in rural area.

Table 8-15 Components of Sanitation Development Plan

Project	Settlement Category	Description
Public toilet	Urban	in Market, bus terminal, etc. 4 places per 20,000 persons
	Semi Urban / Small Town	in Market, bus terminal, etc. 2 places per 20,000 persons
Final disposal facility/site	Urban	Disposal of septage/sludge collected and transported from septic tanks
Sewerage system	Urban	Sewerage treatment plant, sewer
Hygiene promotion	Semi Urban / Small Town	Conventional hygiene promotion and education
	Rural	Community-Led Total Sanitation Approach

Source: JICA Project Team

8.1.5 Water Supply and Sanitation Development Plans

(1) Water Supply Development Plan

To meet the future water demand projected in Section 4.2, the Project calculates nationwide water supply development for both hydrological balance and facility planning in the target year 2030, as shown in Table 8-16 and 8-17.

Both water supply development target demand growth for 20 years from 2011 to 2030 because baseline year of water demand projection is 2010. But water supply development plan targets demand growth from 2015 to 2030, which is also ground for project cost estimation. Assuming development projects have been implemented at the development pace expected by the M/P2013 from 2011 to 2014, water supply development by both rehabilitation and new construction projects proposed in the M/P2013 is 12,620 million liter per day (MLD) in hydrological balance and 14,880 MLD in facility planning.

Figure 8-7 shows nationwide demand and supply graph in water development plan in facility planning.

State-wise water development plans are described in Section SR5.1.2, Volume-5, Supporting Report.

Table 8-16 Water Supply Development Plan for Hydrological Balance

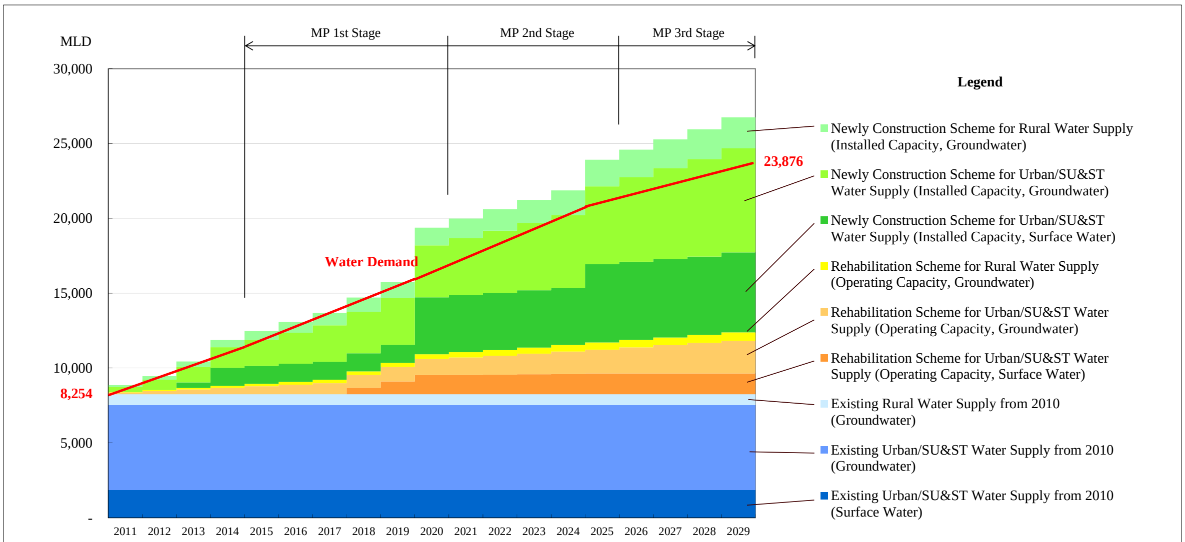
Scheme	Category	Existing Capacity (2010)	Pre-MP Period (2011-2014)	MP Period (2015-2030)	**Grand Total (2030)**
Rehabilitation	Urban, SU/ST (SW)	1,870	-	1,388	**3,257**
	Urban, SU/ST (GW)	5,667	425	1,761	**7,852**
	Rural (GW)	718	126	430	**1,274**
	Sub-Total	**8,254**	**551**	**3,578**	**12,383**
Newly Construction	Urban, SU/ST (SW)		964	3,317	**4,280**
	Urban, SU/ST (GW)		1,109	4,449	**5,558**
	Rural (GW)		379	1,276	**1,655**
	Sub-Total		**2,452**	**9,041**	**11,493**
Grand Total	**(MLD)**	**8,254**	**3,003**	**12,620**	**23,876**

Source: JICA Project Team

Table 8-17 Water Supply Development Plan for Facility Planning (Installed Capacity)

Scheme	Category	Existing Capacity (2010)	Pre-MP Period (2011-2014)	MP Period (2015-2030)	**Grand Total (2030)**
Rehabilitation	Urban, SU/ST (SW)	1,870	-	1,388	**3,257**
	Urban, SU/ST (GW)	5,667	425	1,761	**7,852**
	Rural (GW)	718	126	430	**1,274**
	Sub-Total	**8,254**	**551**	**3,578**	**12,383**
Newly Construction	Urban, SU/ST (SW)		1,204	4,146	**5,350**
	Urban, SU/ST (GW)		1,386	5,561	**6,947**
	Rural (GW)		474	1,595	**2,069**
	Sub-Total		**3,065**	**11,302**	**14,367**
Grand Total	**(MLD)**	**8,254**	**3,616**	**14,880**	**26,750**

Source: JICA Project Team



Source: JICA Project Team

Figure 8-7 Demand and Supply in Water Supply Development Plan for Facility Planning

(2) Sanitation Development Plan

Based on current sanitation coverage as of baseline year 2010, mentioned in Section 8.1.3(5), the Project formulates sanitation development plan to meet demand in the target year 2030, which sanitation coverage should reach 100%. But sanitation development plan targets demand growth from 2015 to 2030, which is also ground for project cost estimation. Assuming development projects have been implemented at the development pace expected by the M/P2013 from 2011 to 2014, sanitation development by the projects proposed in the M/P2013 are shown in Table 8-18.

Table 8-18 Sanitation Development Plan (2015-2030)

Project	Settlement Category	Required Development
Public toilet	Urban	8,564 places
	Semi Urban / Small Town	11,762 places
Final septage disposal facility/site	Urban	For 9,325,745 households
Sewerage system	Urban	For 876,758 households (Treatment : 473,266m3/day)
Hygiene promotion	Semi Urban / Small Town	For 16,650,716 households
	Rural	For 13,406,807 households

Source: JICA Project Team

As mentioned above, sanitation development plan includes projects for septage disposal and sewerage, but formulation of the following master plans is necessary to promote realization of the projects.

- National Master Plan on Sanitation (including septage management)
- National Master Plan on Sewerage Development (for major urban areas)

On the other hand, the Project estimates required development of domestic sanitation facilities (toilet or latrine) at 36.8 million totally in the target period of sanitation development plan from 2015 to 2030, as shown in Table 8-19.

State-wise sanitation development plans and required development of domestic sanitation facilities are described in Section SR5.1.3, Volume-5, Supporting Report.

Table 8-19 Required Development of Domestic Sanitation Facilities

(x1,000)	Settlement	Existing (2010)	Pre-MP Period (2011-2014)	MP Period (2015-2030)	**Grand Total (2030)**
Population	Urban	7,018	6,105	29,614	**42,736**
	Semi-Urban/Small-Town	20,649	16,827	79,971	**117,447**
	Rural	16,812	13,997	66,823	**97,632**
	Sub-Total	44,479	36,928	176,407	**257,815**
Household	Urban	1,511	1,396	6,739	**9,646**
	Semi-Urban/Small-Town	3,989	3,510	16,651	**24,149**
	Rural	3,149	2,813	13,407	**19,369**
	Sub-Total	8,649	7,719	36,796	**53,164**

Source: JICA Project Team

8.1.6 Operation and Maintenance Plan

(1) Current Status of Operation and Maintenance

As mentioned above, water supply facilities are categorized into urban, semi-urban and small town, and rural based on population size of settlement, so not only composition of facilities but also system and current status of operation and maintenance differ.

(1-1) Urban Water Supply

State water agencies (SWAs) are in charge of water supply services in urban settlement such as Abuja, state capitals, other urban cities and LGA seats. Common status of these water supply services includes, more or less, inefficiency and high non-revenue water, for example, operation below design capacity, aged deterioration, poor maintenance, insufficient monitoring, water leakage, inadequate collection of water tariff (i.e. low cost recovery), and low water tariff and so on. These situations have led World Bank to give financial support to relevant agencies through the National Urban Water Sector Reform Programme (NUWSRP), in which French Development Agency (AFD) is also involved.

Besides, various conditions to be deal with exist, such as measures against private water vendors and low income households.

(1-2) Semi-Urban and Small Town Water Supply

In spite of smaller scale than urban water supply, a variety of problems and issues on operation and maintenance exist in semi-urban and small town water supply, and therefore time, effort and care are imperative. Although daily operation and maintenance has been commonly done by not government agencies or LGA but community organization, a great number of existing water supply facilities have not been operated and maintained appropriately and have resulted in being out of service and neglected in the wake of failure or malfunction of facility and equipment. This situation has caused low operational ratio of water supply using groundwater. To deal with its fact, small town water supply and sanitation projects, which aim to secure sustainability based on community ownership enhanced by various social intervention, have been implemented after 2000 in some states with assistance provided by World Bank and European Union, together with establishment of Small Town Water Supply and Sanitation Agency (STWSSA) in each target state and also with institutional arrangement.

(1-3) Rural Water Supply

Rural water supply is mainly borehole equipped with handpump or small scale facilities equipped with motorized pump, and community based organization such as WASHCOM and WATSAN committee is responsible for daily operation and maintenance. However, regular collection of usage charge for maintenance is not done everywhere, consequently, most LGA and RUWASSA have given financial and technical support when failure or malfunction of facility and equipment occurs. In case of not enough support, facility and equipment are to be neglected. This situation has caused low operational ratio of water supply using groundwater. So rural water supply projects assisted by Unicef, JICA, other donors and NGOs have included various social intervention such as community awareness raising and capacity development to deal with the issues.

(1-4) Sanitation

Low sanitation coverage in Nigeria shows many households have relied on unsanitary facility or primitive way, and sewerage system is not common at all except a part of urban area in Abuja and Lagos cities. Domestic toilet equipped with septic tank and pit latrine are common in most of urban areas, semi-urban areas and small towns, but there is no appropriate disposal system of septage. Poor coordination among relevant bodies on sanitation including federal ministries/agencies, state ministries/agencies and LGA has been pointed out, but they has recently set forward coordination with assistance of international donors.

(2) Recommendation on Appropriate Operation and Maintenance System

(2-1) Urban Water Supply

In order to secure high production efficiency and operating ratio of water supply facilities, state water agencies (SWAs) need to establish framework of appropriate monitoring, operation and maintenance. So, various measures should be taken for adequate budget allocation, appropriate personnel distribution and capacity development for operation and maintenance as well as properly-set water tariff and non-revenue water reduction. In addition, measures against low income households and ingenuity should be considered such as reduced water tariff by cross subsidy, community participation and job creation. And relevant bodies should aim to realize safe water supply without dealing negatively in private water vendors.

(2-2) Semi-Urban and Small Town Water Supply

State water agencies (SWAs) or small town water supply and sanitation agencies (STWSSAs) in some states are typically responsible for operation and maintenance, and they need to make sure of efficient and reasonable operation and maintenance of water supply together with community in semi-urban areas and small towns where will be inhabited area of future growing population. So, various measures should be taken for cost-cutting efforts, adoption of appropriate technology, community participation, empowerment and awareness raising, job creation, strengthening of monitoring and so on. To this end, STWSSA should be established nationwide in each state and developed in capacity, and existing small town and sanitation projects should be monitored and evaluated to improve system and strength implementation framework.

(2-3) Rural Water Supply

Appropriate institutional framework and distribution system are necessary so that operation and maintenance functions properly. For this, various measures should be taken for community awareness raising, capacity development of community based organization, LGA and RUWASSA, and rapid deployment. And, cooperation with private suppliers should be expanded to secure supply chain of spare parts in rural areas.

(2-4) Sanitation

Particularly in rural areas where people habitually have relied on unsanitary facility or primitive way, Community Led Total Sanitation (CLTS) should be promoted to boost sanitation coverage and reduce water-borne diseases. In urban areas and semi-urban areas and small towns if necessary, in order to establish appropriate process of septage disposal and also sewerage system, various measures should be taken for capacity development of implementing bodies, establishment of institutional framework, adoption and transfer of appropriate technology. Moreover, operation and maintenance based on beneficiaries-pay principle should be built up with awareness raising on sanitation through hygiene promotion and education to beneficiaries.

8.2 Irrigation and Drainage Development Plan

8.2.1 Current Condition of Operation and Maintenance in Irrigation Scheme

The operation and management of public irrigation schemes is mainly in charge of RBDAs and state, a part of farmer group in the scheme has been supporting the maintenance of irrigation facilities. However the irrigation infrastructure are dilapidated in most of the irrigation schemes with many pumps in need of repair/replacement and conveyance structures damaged or deteriorated, weed infested and silted up. The causes of deterioration are as follows;

- **Management capacity of RBDAs**: Many of the public small schemes in the south of the country are effectively operational whilst some of the public large schemes are still active but operating at low level capacity and low cropping intensities.
- **Irrigation Infrastructure**: Gravity irrigation system is effective compared with equipped irrigation system because of low operation and maintenance cost and few trouble with equipment. However a lot of public irrigation schemes have been using pump and suffer from deterioration, breakdown, repair/replacement of pumps and high cost of fuel. Also the farmers have not been able to adapt to the sprinkler system. The conveyance structures damaged or deteriorated, weed infested and silted up.
- **Inadequate water delivery:** Water delivery to secondary canal from main canal is mostly carried out through the cross regulators and the manual sluice gate type. Flow into secondary canals can be measured by using rating curves however; measuring gauges to determine water depth for measurement are missing or unreadable where they exist. Thus there are no records of actual flow into the canal systems. Also the farmers have not been able to adapt to the sprinkler system.
- **Water Users Associations (WUAs)**: The Water Users Associations (WUAs) rarely exist in most of the schemes, they are neither not effective nor active. The farmers believe that the water charge paid should cover the maintenance, thus farmer's motivation to participate or collaborate is low in the maintenance work on scheme.
- **Cost-Recovery**: The water charge paid in most of public irrigation schemes is generally from 500 to 3000 Niara/ha・season. The water charges are too low to meet the cost of water delivery. The inadequate pricing is responsible for the cycle of poor services leading to lack of willingness to pay by the user.
- **Equipment**: The equipment in use of the schemes is two main categories namely, one is water delivery equipment, and the another is agricultural equipment and machinery. The water delivery equipment mainly comprises pumps of various capacities used for water abstraction at the water source. Most of the pumps were purchased during the 1980s, and these spare parts are now no longer available. Most of the agricultural equipment and machinery are not being operated due to low maintenance such as a tractor, combined rice harvesters, and rice mill, etc. There are very few maintenance personnel working on schemes. Workshop at all RBDAs were run down, and poorly equipped and staffed. Spare parts were rarely stocked and records not kept.

8.2.2 Basic Policy for Development

(1) Basic Policy

The promotion of irrigation sector should be schemed in accordance with national development policy, regional feature such as climate, hydrology, terrain and habitant, economical efficiency, and situation of existing public irrigation scheme.

(2) Development policies

Development Policies of irrigation sector are follows and development will be extended step by step according to priority.

- To complete early on-going public irrigation schemes,
- To implement rehabilitation and expansion on public irrigation schemes which FMWR identifies as high priority,

- To develop new water resource for high priority public irrigation schemes,
- To utilize existing dams for public irrigation schemes and expand its system developed area,
- To develop new proposed irrigated farmland, and
- To formulate effective structure for operation and maintenance to run schemes.

(3) Category of Public Irrigation Scheme

The existing and proposed public irrigation schemes are categorized as follows;

Table 8-20 Category of Public Irrigation Scheme

No.	Category	Description
1.	Existing Irrigation Scheme	Scheme which is existing before the M/P2013
1.1	Completion with No Extension Scheme	Scheme which has already completed or suspended, and which has no extension plan in future.
1.2	Ongoing Scheme	Scheme which has been on-going and has a sure plan to implement in future.
1.3	Extension Scheme	Scheme which is recommended to expand planned irrigation area more
2.	New Irrigation Scheme	New Scheme which is proposed after the M/P2013
2.1	Supplementary Irrigation Scheme	Scheme which comprises of land reclamation and supplementary irrigation. Scheme is specified in HA-5 and HA-7 owning much precipitation.
2.2	Dam Irrigation Scheme	Scheme which has irrigation dam considered in the M/P1995 and the M/P2013 in order to assure full-year irrigated farmland.
2.3	Integrated Development Scheme	Scheme which is extensively developed by multipurpose dam, utilizing water and hydropower deriving from that dam

Source: JICA Project Team

8.2.3 Development Plan

(1) Completion with No Extension Scheme

Out of existing public irrigation scheme of 301 sites, there are 177 schemes which has already completed or suspended, and which has no extension plan in future. Subject to the proposed cropping pattern and safety level for water supply (1/5 years safety level), future irrigation area is evaluated by irrigation scheme. In case of insufficient water volume from water resources in general against planned irrigation areas or limitation utilizing to irrigation water due to prioritize to domestic water supply in future. As a result, system developed area 43,403ha developed so far by FMWR is evaluated at 38,018ha due to lack of water potential against water demand for irrigation.

Table 8-21 Project List (1.1 Completion with No Extension Scheme)

HA	Number of Scheme			System Developed area(ha)			Planned Irrigation Area(ha)			Future Irrigation Area (ha)
	L	M	Total	L	M	Total	L	M	Total	
1	3	12	15	23,700	1,241	24,941	26,900	1,950	28,850	24,441
2	14	35	49	2,603	1,725	4,328	15,500	4,018	19,518	3,048
3	7	4	11	560	355	915	12,250	820	13,070	905
4	6	6	12	607	270	877	6,500	850	7,350	877
5	5	3	8	625	270	895	7,000	320	7,320	630
6	8	14	26	1,234	995	2,229	10,100	2,445	12,545	1,449
7	9	15	24	351	1,899	2,250	11,145	2,969	14,114	2,250
8	14	22	36	5,300	1,668	6,968	18,210	3,730	21,940	4,418
Total	66	111	177	34,980	8,423	43,403	107,605	17,102	124,707	38,018

Note) L: Large Scale Scheme, M: Medium and Small Scale Scheme

・Future irrigation area means irrigable area subject to the proposed cropping pattern and safety level for water supply (1/5 years safety level), and Future irrigation area is identified with system developed area due to no expansion plan.

Source: JICA Project Team

(2) Ongoing Scheme

There are 32 sites of on-going irrigation scheme implemented by FMWR in the country, and those schemes should be completed early. According to evaluation based on surface water potential, number of irrigation scheme become 9 sites of which future irrigation area evaluated fall below planned irrigation area.

Table 8-22 Project List (1.2 Ongoing Scheme)

No	HA	Class	Name of Scheme	State	System Developed Area (ha)	Planed Irrigation Area (ha)	Future irrigation Area (ha)
1	1	L	Jibiya	Katsina	3,000	3,500	2,300
2	1	L	Zobe	Katsina	60	8,200	2,000
3	1	L	Middle Rima Valley	Sokoto	1,188	5,000	5,000
4	1	L	Sabke	Katsina	540	1,200	130
5	2	L	Kampe/Omi	Kogi	1,000	4,000	4,000
6	2	L	Duku-Lade *1)	Kwara	200	2,000	1,200
7	3	L	Dadin Kowa	Gombe	250	6,660	6,660
8	3	L	Lower Taraba (Gassol)	Taraba	30	3,000	3,000
9	3	L	Chouchi	Adamawa	0	1,200	1,200
10	4	L	Longkat	Plateau	800	2,000	1,100
11	5	L	Lower Anambra	Anambra	3,850	5,000	5,000
12	5	L	Isampou Rice	Delta	110	1,280	1,280
13	5	L	Peremabiri Rice	Bayelsa	348	1,280	1,280
14	5	L	Kolo Rice	Bayelsa	140	1,300	1,300
15	5	L	Ejule Ojebe	Kogi	25	2,000	1,100
16	5	L	Ada-Rice	Enugu	1,000	5,000	1,000
17	6	L	Middle Ogun (I.G)	Oyo	750	12,000	12,000
18	6	L	Lower Ogun (Mokoloki)	Ogun	500	12,000	12,000
19	7	L	Abakaliki/ Iwa	Ebonyi	1,000	1,000	1,000
20	7	L	Imo (Igwu and Ibu)	Imo	80	1,200	0
21	8	L	Kano River Phase I	Kano	16,000	22,000	22,000
22	8	L	Hadejia Valley	Jigawa	5,255	12,500	12,500
23	8	L	Bagwai (Watari)	Kano	273	872	0
24	1	M	Zauro Polder	Kebbi	100	100	(100)
25	1	M	Shagari	Sokoto	220	220	(220)
26	3	M	Waya	Bauchi	30	250	(250)
27	5	M	Ukhun/ Erah	Edo	50	250	(250)
28	5	M	Anyama-Ogbia	Rivers	24	180	(180)
29	5	M	Kpong	Rivers	89	100	(100)
30	6	M	Owiwi	Ogun	45	302	(302)
31	6	M	Itoikin	Lagos	141	315	(315)
32	8	M	Galala	Bauchi	72	130	(130)
Total					37,170	116,039	98,897

Note) L: Large Scale Scheme, M: Medium and Small Scale Scheme

- Future irrigation area means irrigable area subject to the proposed cropping pattern and safety level for water supply (1/5 years safety level)
- Value of ( ) in column of future irrigation areas evaluated are judged to be possible to expand FMWR planned areas despite water balance evaluation was not implemented by individual scheme about medium and small scale scheme which is difficult to specify the detailed location.

*1) It is possible to irrigate farmland up to 1,200ha, constructing new dam (No.2043 Lade Dam).

Source: JICA Project Team

Reference : 1) FMWR budget document 2) Utilization of Natural Resources Fund for Water Resources and Agricultural Development, FMWR, FMARD

(3) Extension Scheme

According to Proposed Master Plan for Irrigation and Dam Development for 2009-2020 (FMAWR), numbers of irrigation scheme for only rehabilitation and for expansion with partial rehabilitation are 37 sites and 45 sites respectively. According to the surface water potential evaluation, almost the scheme for rehabilitation only have plenty amount of water, and then it is possible to expand the system development area up to the planned irrigation areas. To expand the irrigated farmlands it is recommended to expand the development to 37 schemes not only that rehabilitation but the planned irrigation areas.

Meanwhile some existing schemes were abandoned or were not expanded up to planned irrigation area, although existing dam has actually abundant water. On these schemes it is possible to realize economical development due to needless new dam construction. Therefore in the point of view of utilization of existing dam, it is recommended to expand the system development area up to the planned irrigation areas at the additional five schemes such Swashi Valley, Kontagora, Bagoma, Tubo, and Sendam (1).

Table 8-23 Project List (1.3 Extension Scheme)

No	HA	Class	Name of Scheme	State	Level of Development		System Developed Area (ha)	Planed Irrigation Area (ha)	Future irrigation Area (ha)
1	1	L	Kalmalo	Sokoto	R	E	400	800	800
2	1	L	Gafara	Niger	R	E	150	500	500
3	1	L	Wurno	Sokoto	R	E	700	1,500	1,500
4	1	L	Kware	Sokoto	R	E	300	800	800
5	1	L	Swashi Valley *1)	Niger		E	200	2,900	2,900
6	2	L	Tungan Kowa	Niger	R	E	800	800	800
7	2	L	Agaie/ Lapai *2)	Niger	R	E	20	1,000	1,000
8	2	L	Badeggi *3)	Niger	R	E	830	830	830
9	2	L	Tada Shonga	Kwara		E	435	4,100	4,100
10	2	L	Kangimi	Kaduna	R	E	1,200	1,600	1,600
11	2	L	E.Lapai	Niger		E	100	2,000	2,000
12	2	L	Bakogi *4)	Niger		E	100	2,000	2,000
13	2	L	Galma	Kaduna		E	55	610	610
14	2	L	Kontagora *5)	Niger		E	250	2,000	2,000
15	2	L	Bagoma *6)	Niger		E	50	500	500
16	2	L	Tubo *7)	Kaduna		E	100	620	600
17	3	L	Lake Geriyo	Adamawa	R	E	320	4,000	4,000
18	3	L	Balanga	Gombe	R	E	500	4,400	3,800
19	4	L	Dep	Nasarawa	R	E	300	2,000	2,000
20	4	L	Katsina-Ala	Benue	R	E	200	2,000	2,000
21	4	L	Makurdi	Benue	R	E	200	1,000	1,000
22	4	L	Doma	Nasarawa		E	1,600	2,037	2,037
23	4	L	Awe	Nasarawa		E	0	500	80
24	4	L	Oguma	Kogi		E	100	1,000	1,000
25	4	L	Jato-Aka	Benue		E	20	1,000	1,000
26	4	L	Shendam(1) *8)	Plateau		E	500	1,000	1,000
27	5	L	Ilush-Ega	Edo		E	3,000	5,000	5,000
28	6	L	Iwo	Osun		E	0	1,000	0
29	6	L	Ilero	Oyo		E	0	2,000	70
30	6	L	Asa	Oyo	R	E	0	500	500
31	6	L	Okuku	Osun	R	E	0	600	30
32	6	L	Owena	Ondo		E	500	500	500
33	6	L	Esa Oke Dam	Osun	R	E	800	800	800
34	6	L	New Erinle	Osun	R	E	500	500	500
35	7	L	Ekoi	Akwa Ibom	R	E	80	500	500
36	7	L	Adim Rice	Cross River	R	E	545	1,000	340
37	7	L	Igbere	Abia		E	250	1,300	440
38	7	L	Mbiabet	Akwa Ibom	R	E	100	500	500
39	8	L	Kano River Phase II	Kano	R	E	203	40,000	15,000
40	8	L	Daya	Borno	R	E	960	960	960
41	8	L	Gashua	Borno		E	100	2,000	<2,000>
42	8	L	Baga Polder	Borno		E	2,000	20,000	[2,000]
43	8	L	South Chad	Borno	R	E	22,000	67,000	[22,000]
44	8	L	Jere Bowl Rice	Borno		E	0	1,300	0
45	8	L	Katagum	Bauchi		E	50	700	<700>
46	8	L	Yobe	Borno		E	637	2,820	<2,820>
47	8	L	Guzuguzu	Kano	R	E	530	530	0
48	8	L	Magaga	Kano	R	E	300	600	70
49	1	M	Kwakwazo	Sokoto	R	E	250	250	(250)
50	1	M	Argungu/ Tabarau	Kebbi	R	E	100	100	(100)
51	2	M	Ero	Ekiti	R	E	200	200	(200)
52	2	M	Edozhigi	Niger	R	E	100	100	(100)
53	2	M	Odugbo	Kogi	R	E	100	150	(150)
54	2	M	Chanchanga	Niger	R	E	302	302	(302)
55	2	M	Agaie	Niger	R	E	76	76	(76)
56	2	M	Papiri	Niger	R	E	80	80	(80)
57	2	M	Loguma	Niger	R	E	100	125	(125)
58	2	M	Tamani	Niger	R	E	10	10	(10)
59	2	M	Bangi	Niger	R	E	50	50	(50)
60	2	M	Galama	Kaduna	R	E	300	300	(300)
61	2	M	Toroko	Niger	R	E	80	80	(80)
62	2	M	Tafa/ Jere	Kaduna		E	52	355	(355)

No	HA	Class	Name of Scheme	State	Level of Development		System Developed Area (ha)	Planed Irrigation Area (ha)	Future irrigation Area (ha)
63	2	M	Birnin Gwari	Kaduna	R	E	200	430	(430)
64	2	M	Kogun	Kaduna	R	E	150	400	(400)
65	3	M	Dwan	Adamawa	R	E	200	200	(200)
66	3	M	Dasin Hausa	Adamawa	R	E	200	200	(200)
67	3	M	Mayo	Adamawa	R	E	50	50	(50)
68	4	M	Loko	Nasarawa	R	E	50	50	(50)
69	4	M	Allam	Benue	R	E	50	50	(50)
70	4	M	Sabon Gida	Nasarawa	R	E	200	200	(200)
71	4	M	Bassa	Nasarawa	R	E	50	50	(50)
72	4	M	Rutu	Nasarawa	R	E	50	50	(50)
73	5	M	Ogboji	Anambra	R	E	100	130	(130)
74	5	M	Otuokpoti	Rivers		E	50	100	(100)
75	5	M	Enugu abor Ufuwa	Enugu	R	E	350	350	(350)
76	6	M	Oogi	Osun	R	E	0	400	(400)
77	6	M	Ipetu-Ijesha	Osun	R	E	0	250	(250)
78	6	M	Orile Owu	Osun	R	E	100	100	(100)
79	6	M	Old Erinle Dam	Osun	R	E	150	150	(150)
80	6	M	Ikere-Ogbese	Ekiti		E	32	32	(32)
81	7	M	Ogoja	Cross River	R	E	125	125	(125)
82	7	M	Bende	Abia	R	E	150	300	(300)
83	7	M	Igwu-Ohafia	Abia	R	E	160	300	(300)
84	7	M	Nung Obong	Akwa Ibom	R	E	100	200	(200)
85	7	M	Owutu	Abia	R	E	280	480	(480)
86	7	M	Oniong Nung Nden	Akwa Ibom	R	E	177	400	(400)
87	7	M	Obubra	Cross River		E	315	315	(315)
88	7	M	Ihitti-Uboma	Imo	R	E	200	310	(310)
89	7	M	Ezeiyieku Esu	Ebonyi		E	0	200	(200)
90	7	M	Ezillo Farm	Ebonyi	R	E	150	150	(150)
91	7	M	Ozara Okangwu	Ebonyi		E	0	300	(300)
92	7	M	Item-Ikwo	Enugu	R	E	100	300	(300)
Total							47,524	200,357	103,937

Note) L: Large Scale Scheme, M: Medium and Small Scale Scheme
In Level of development, R: Rehabilitation, E: Expansion

・Future irrigation area means irrigable area subject to the proposed cropping pattern and safety level for water supply (1/5 years safety level)
・Value of ( ) in column of future irrigation areas evaluated are judged to be possible to expand FMWR planned areas despite water balance evaluation was not implemented by individual scheme about medium and small scale scheme which is difficult to specify the detailed location.
・Value of < > in column of future irrigation areas are judged to be possible to expand FMWR planned areas. Because water resources in the areas is from large scale swamp reserving water flow.
・Value of [ ] in column of future irrigation areas are judged that the scheme development scale is limited up to existing system developed area, considering recently reducing chad lake water resources.

*1) It is possible to irrigate farmland up to 2,900ha, utilizing existing dam (No.12 Swashi Dam).
*2) It is possible to irrigate farmland up to 1,000ha, constructing new dam (No.2028 Agaie Dam).
*3)It is possible to irrigate farmland up to 830ha, constructing new dam (No.2066 Mussa Dam).
*4) It is possible to irrigate farmland up to 2,000ha, constructing new dam (No.2069 Bakogi Dam).
*5)It is possible to irrigate farmland up to 2,000ha, utilizing existing dam (No.1014 Kontagora Dam).
*6) It is possible to irrigate farmland up to 500ha, utilizing existing dam (No.19 Bagoma Dam).
*7)It is possible to irrigate farmland up to 600ha, utilizing existing dam (No.145 Kerawa Dam).
*8)It is possible to irrigate farmland up to 1,000ha, utilizing existing dam (No.54 Shendam Dam).

Source: JICA Project Team

Reference： 1)Baseline studies for National Water Resources Draft Final Report, ENPLAN, 2009
2) Masterplan for Irrigation and Dam Development for 2009- 2020, FMAWR

(4) Supplementary Irrigation Scheme

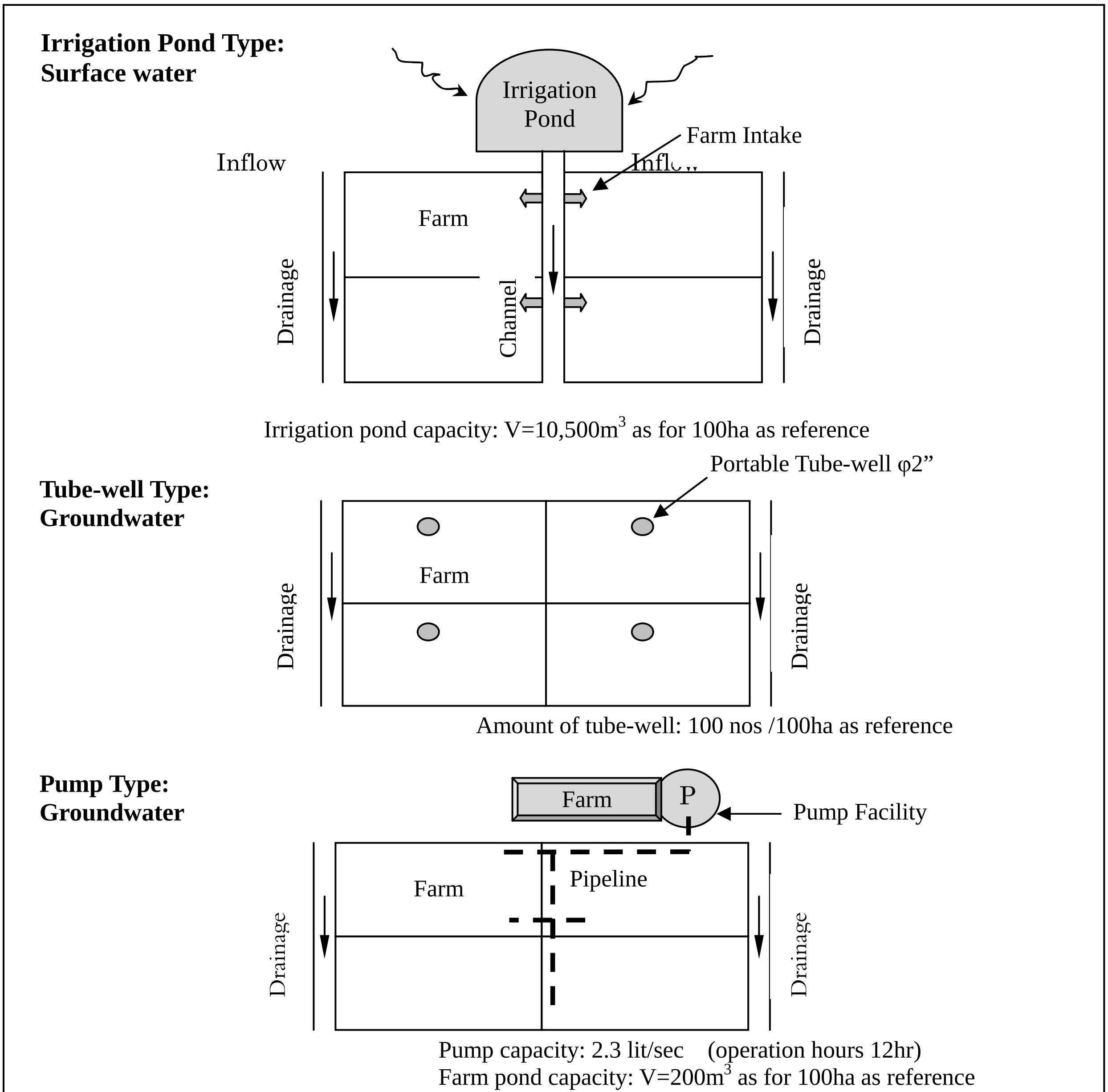
Economical irrigation development is possible utilizing regional characteristics of HA-5 and HA-7. The southern regions locate at tropical rainforest climate zone and then rain-fed rice cultivation has been active. However, it is necessary enough water in the initial stage of rice cultivation and then it is desire to keep the supplemental water resources for unstable rainfall condition in this season. Accordingly, land reclamation and supplementary irrigation facilities are planned utilizing farm ponds and groundwater. In this case, irrigation water is for only rainy season because of small scale of water resources. However, it is convinced to increase rice yield due to irrigation effectively. The cost of development method minimizes comparing with other development menu, also this method is applied as small scale irrigation scheme by state government. Possible available farmlands in HA-5 and HA-7 are vast. In case terrain is flat and soil is suitable to rice cultivation in the area, this development method is easily applied to all over the place.

New development areas are 19,000 ha for HA-5 and 29,000 ha for HA-7 corresponding to the irrigation areas omitted at the dam selection stage mentioned below paragraph (5).

Table 8-24 Project List (2.1 Supplementary Irrigation Scheme)

No	HA	Class	Name of Scheme	State	System Developed Area (ha)	Planed Irrigation Area (ha)	Future Irrigation Area (ha)
1	5	Sup	HA-5 Supplementary Irrigation Scheme	Anambra, Bayelsa, Delta, Edo, Enugu, Kogi, Rivers	0	19,000	19,000
2	7	Sup	HA-7 Supplementary Irrigation Scheme	Abia, Abalaliki Iwa, Akwa Ibom, Benue, Cross River, Ebony, Enugu, Imo, Ukum	0	29,000	29,000

Note) Sup: Supplementary Irrigation Scheme
Source: JICA Project Team



Source: JICA Project Team

Figure 8-8 Schematic sketch of Supplementary Irrigation Scheme

(5) Dam Irrigation Scheme

Nigerian agriculture depend on rain-fed cultivation nationwide, however it is imperative to enhance irrigated agriculture emphatically for national food security. Possible merit expected from irrigation in the case of converting rain-fed cultivation into irrigated one include 1) yield improvement by avoiding drought damages, 2) extension of cropping period from only wet season to throughout the year.

New proposed irrigation scheme development is planned possible to irrigate through a whole year at the downstream of dam, which water resources to be groups of dam projected in the M/P1995 and dams newly proposed. Location of dam will be selected considering economy, possibility of suitable irrigation area at downstream of dam, dam efficiency, avoidance of competition among water supply and the existing irrigation scheme, and possibility of resettlement. The sites of new proposed irrigation schemes owing to dam are 17 sites.

Table 8-25 Project List (2.2 Dam Irrigation Scheme)

No	HA	Class	Name of Scheme	Number of Dam	Name of Dam	Gross Capacity (MCM)	Planned Irrigation Area (ha)
1	1	103	Kebbi	2009	Kasanu	21	1,500
2	2	20804	Niger	2039	Ukusu	12	1,400
3	2	20804	Niger	3008	Bajegira	30	6,000
4	3	316	Adamawa	2089	Mayo Ine	73	9,000
5	3	312	Adamawa	2091	Mayo Belwa	240	18,000
6	3	304	Plateau	2112	Bado	29	2,200
7	3	318	Adamawa	3012	Muleng	113	10,000
8	4	410	Plateau	2124	Shemankar	139	16,000
9	4	407	Benue	2139	Aneri	14	1,500
10	4	405	Benue	2142	Kereke	17	2,000
11	4	406_i	Benue	2148	Dula	20	2,000
12	5	50403	Edo	2175	Obe	52	4,100
13	6	614	Edo	2224	Okhuo	10	1,500
14	7	704043	Benue	2229	Ombi	24	2,000
15	7	704043	Benue	2231	Ogege	13	1,000
16	7	704043	Cross River	2237	Abe	13	1,200
17	7	704042	Benue	2240	Konshisha	16	1,500
					Total	836	80,900

Source: JICA Project Team

(6) Integrated Development Scheme

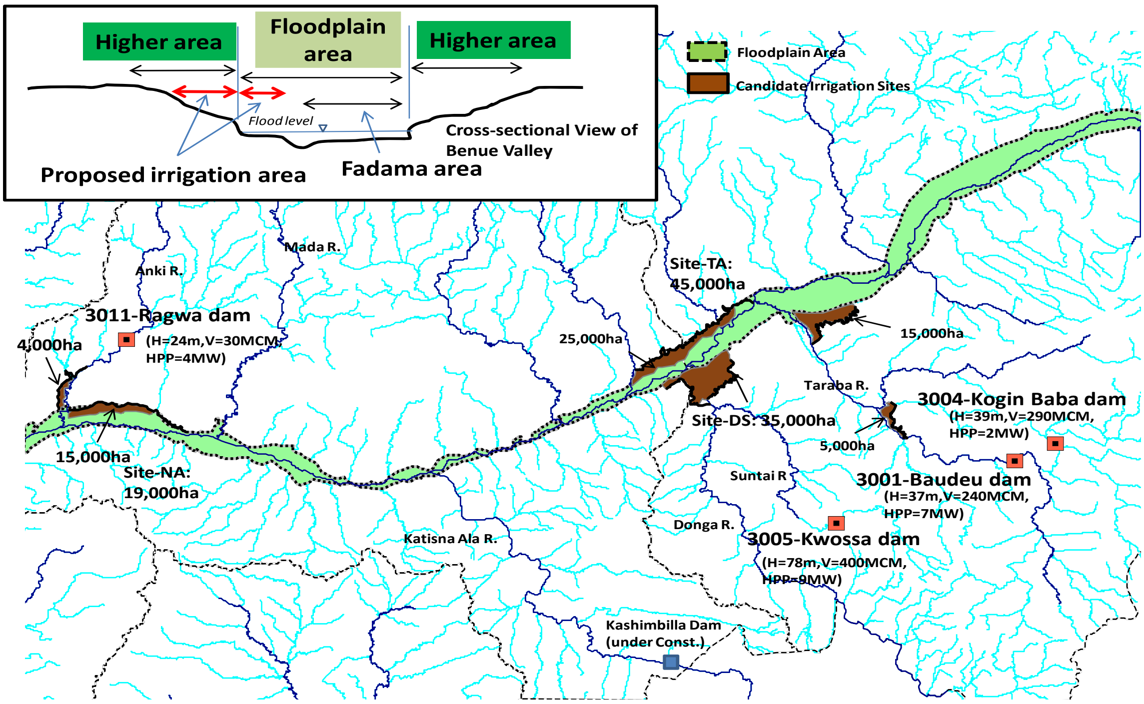
The long term target of irrigation sector in Nigeria is to convert irrigable potential area of 3.14 million hectares lying in this country to irrigated farmland. Herein it is a plan developing large scale irrigation scheme including pump operation which utilize electricity created by the hydraulic power generation in the multi-purpose medium and large scale dams constructed in the branch river of Benue River.

This development system takes long implementation period to complete the dam construction. Therefore, considering easiness and cheapness of management and maintenance and immediate effectively, private small scale irrigated farming should de preceded as a group in the irrigation development area. At the time keeping water resources after completion of late dam construction the public irrigation scheme is transferred.

Table 8-26 Project List (2.3 Integrated Development Scheme)

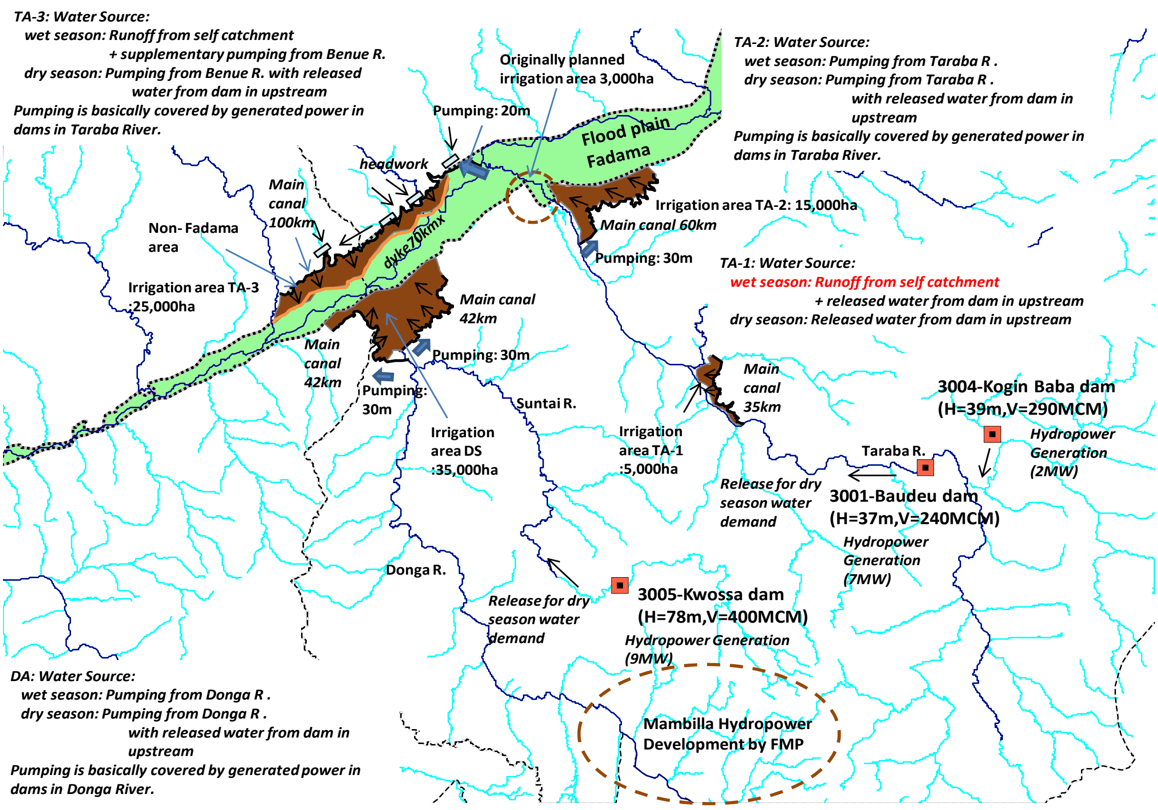
No	HA	Name	New Proposed Dam	Planned Irrigation Area (ha)
1	3	Donga-Suntai Integrated Scheme	Kwossa Dam(3005) H=78m V=400 MCM P=9MW	35,000
2	3, 4	Taraba Integrated Scheme	Baudeu Dam(3001) H=37m V=240MCM P=7MW Kogin Baba Dam(3004) H=39m V=290MCM P=2MW	HA-3: 5,000 + 7,500 + 25,000 = 37,500 HA-4: 7,500
3	4	Nasarawa Integrated Scheme	Ragwa Dam(3011) H= 24m V=30 MCM P=4MW	4,000+15,000= 19,000
			Total	99,000

H: Dam Height, V: Dam Capacity
Source: JICA Project Team



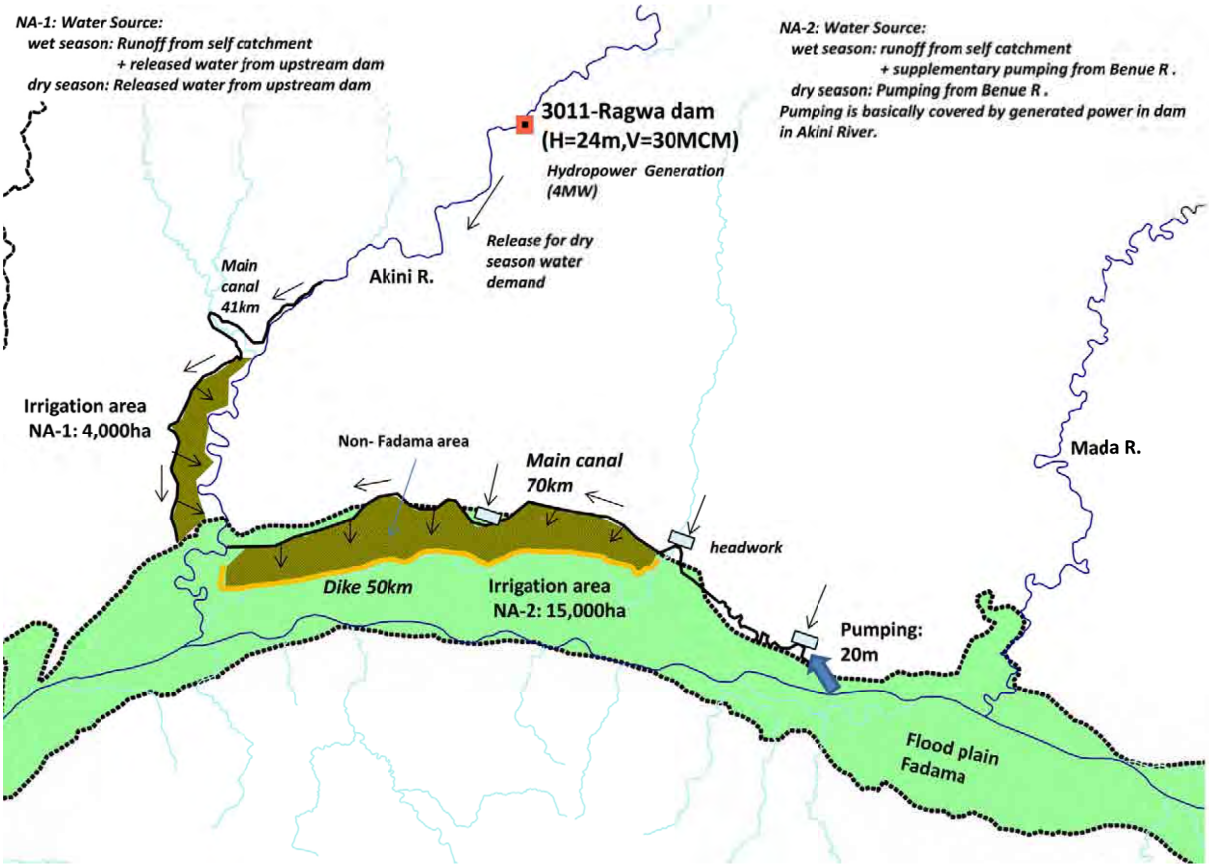
Source: JICA Project Team

Figure 8-9 Integrated Development Location Map



Source: JICA Project Team

Figure 8-10 Integrated Development (Donga-Suntai and Taraba)



Source: JICA Project Team

Figure 8-11 Integrated Development (Nasarawa)

(7) Planned Irrigation Area by Hydrological Area

Future irrigation area on existing public irrigation scheme and planned irrigation area on new proposed public irrigation scheme are shown as follows (refer to Figure 8-11 - 8-18).

Table 8-27 Planned Irrigation Area as of 2030

	HA-1	HA-2	HA-3	HA-4	HA-5	HA-6	HA-7	HA-8	Total
Existing Irrigation Scheme	41,041	26,946	20,265	12,494	17,700	29,398	8,410	84,598	240,852
1.1	24,441	3,048	905	877	630	1,449	2,250	4,418	38,018
1.2	9,750	5,200	11,110	1,100	11,490	24,617	1,000	34,630	98,897
1.3	6,850	18,698	8,250	10,517	5,580	3,332	5,160	45,550	103,937
New Irrigation Scheme	1,500	7,400	111,700	48,000	23,100	1,500	34,700	0	227,900
2.1	0	0	0	0	19,000	0	29,000	0	48,000
2.2	1,500	7,400	39,200	21,500	4,100	1,500	5,700	0	80,900
2.3	0	0	72,500	26,500	0	0	0	0	99,000
Total	42,541	34,346	131,965	60,494	40,800	30,898	43,110	84,598	468,752

Name of Scheme :
- 1.1 : Completion with No Extension Scheme
- 1.2 : Ongoing Scheme
- 1.3 : Extension Scheme
- 2.1 : Supplementary Irrigation Scheme
- 2.2 : Dam Irrigation Scheme
- 2.3 : Integrated Development Scheme

Source: JICA Project Team

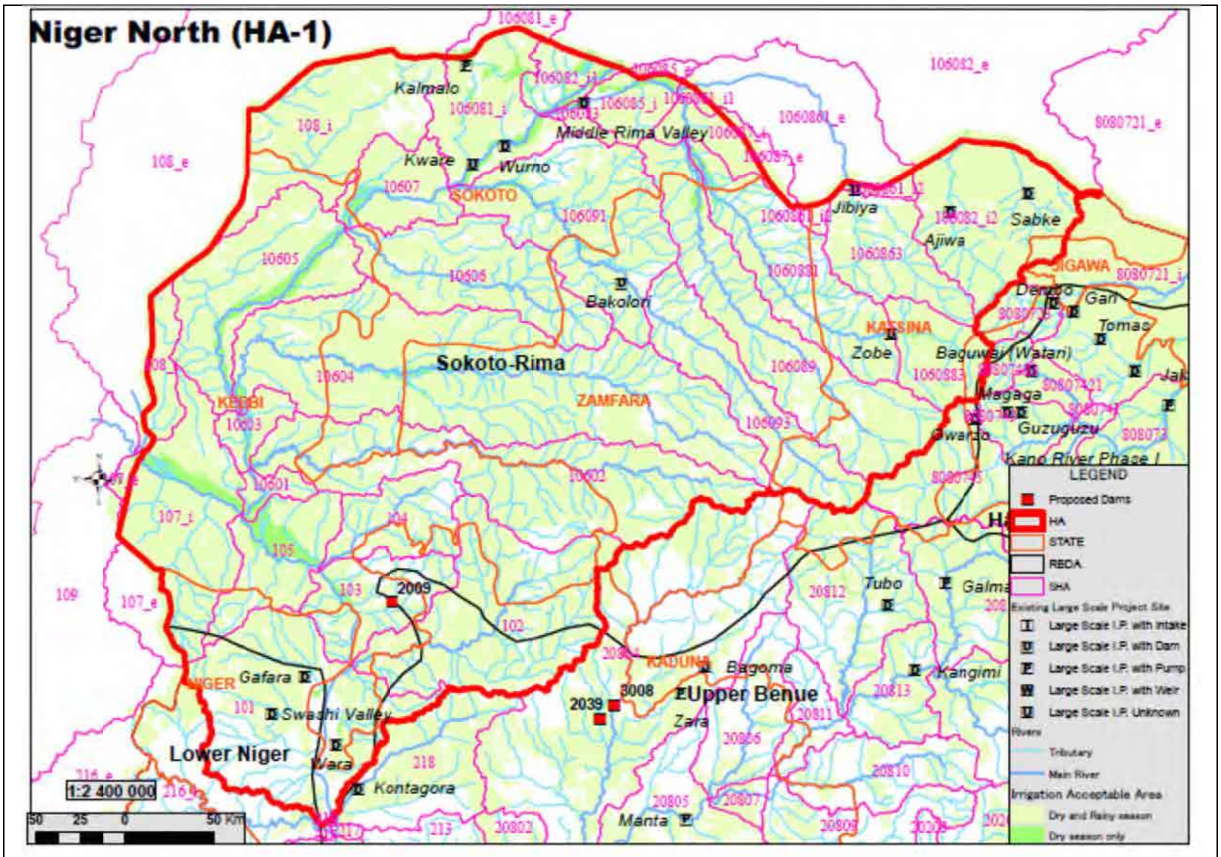
(8) Planned Irrigation Area on Term

The trend of above-cited irrigation area on term, which are corresponded with the Implementation Schedule after-mentioned Chapter-10, are shown as follows (refer to Figure 10-4).

Table 8-28 Planned Irrigation Area on Term

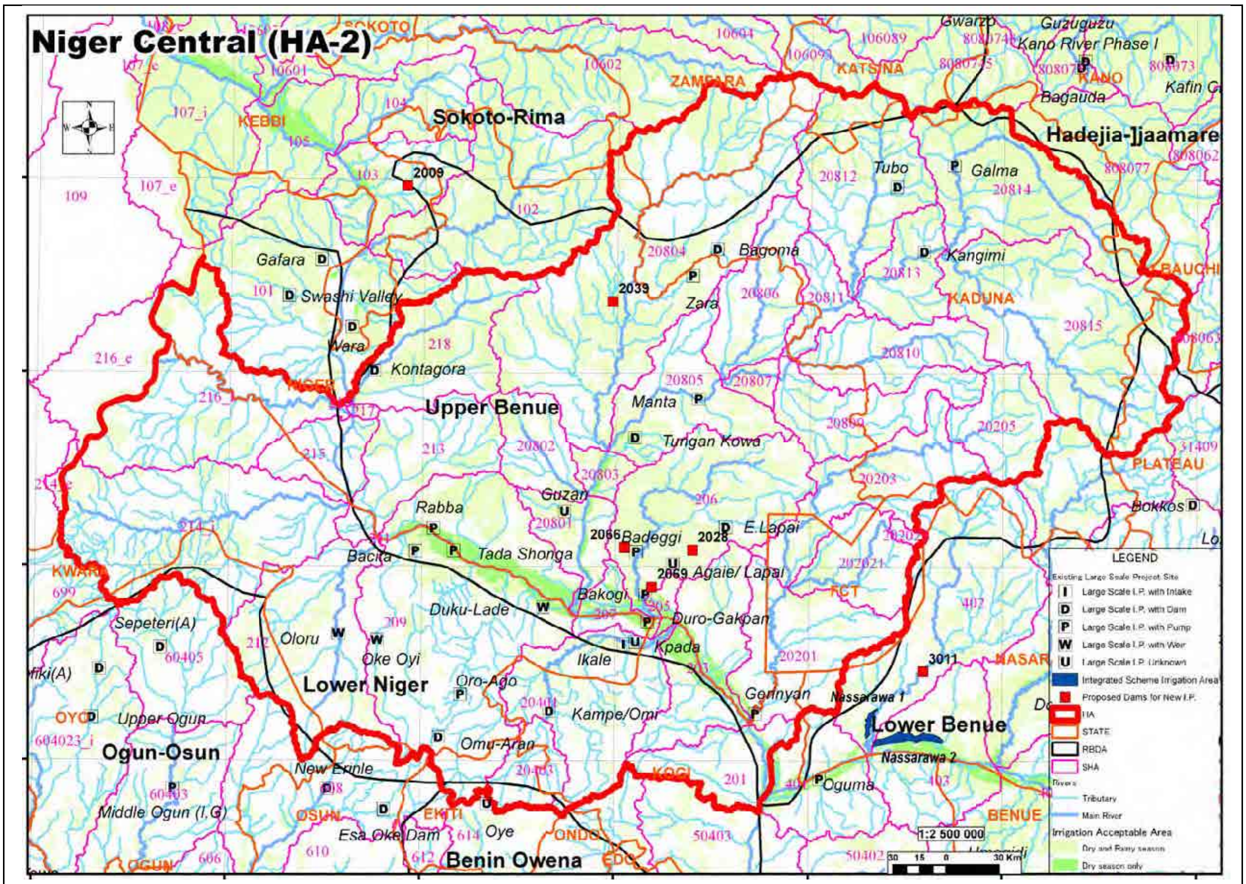
	Short term (2020)	Middle term (2025)	Long term (2030)
Existing Irrigation Scheme	164,617	221,426	240,852
1.1	38,018	38,018	38,018
1.2	73,602	98,897	98,897
1.3	52,997	84,511	103,937
New Irrigation Scheme	24,000	67,000	227,900
2.1	24000	48000	48,000
2.2	0	0	80,900
2.3	0	19000	99,000
Total	188,617	288,426	468,752

Name of Scheme：
1.1 : Completion with No Extension Scheme
1.2 : Ongoing Scheme
1.3 : Extension Scheme
2.1 : Supplementary Irrigation Scheme
2.2 : Dam Irrigation Scheme
2.3 : Integrated Development Scheme
Source: JICA Project Team



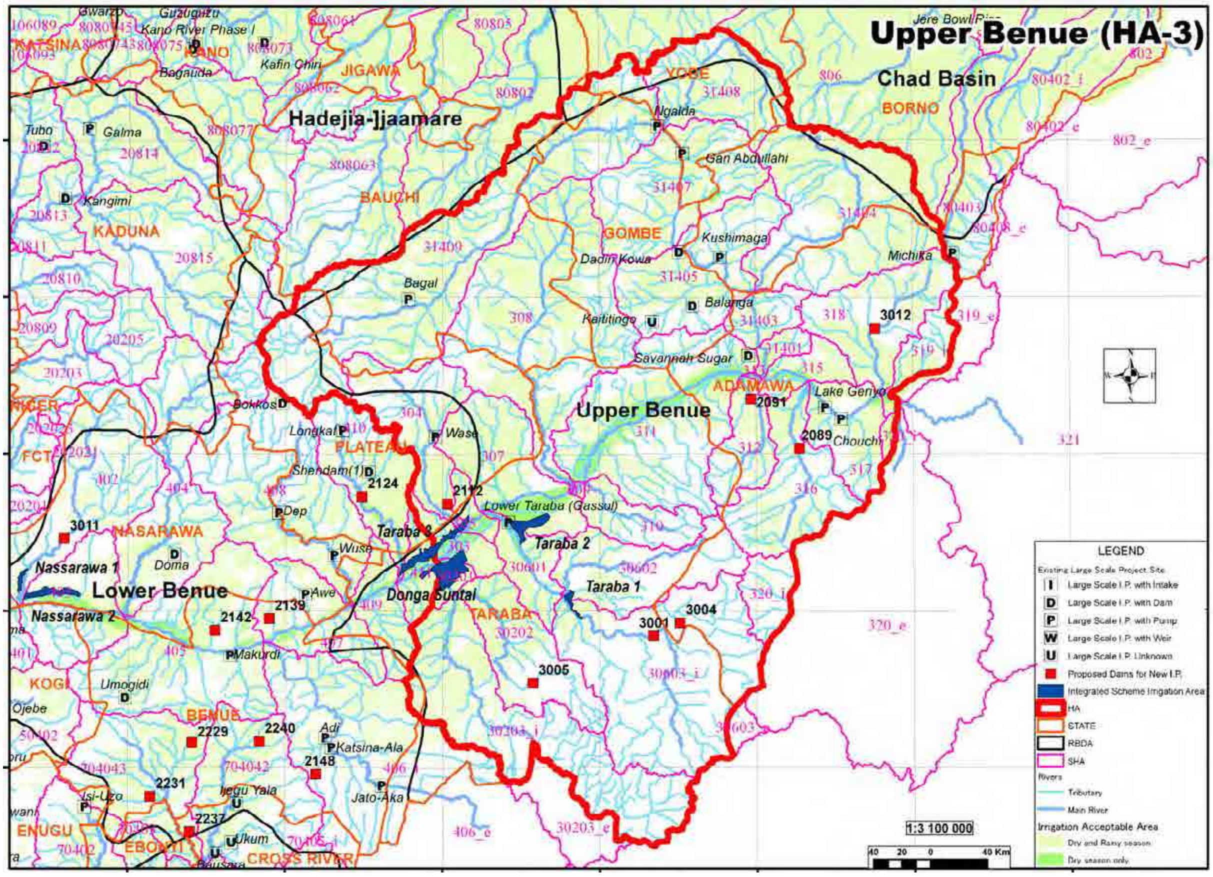
Source: JICA Project Team

Figure 8-12 Irrigation Development Plan (HA-1)



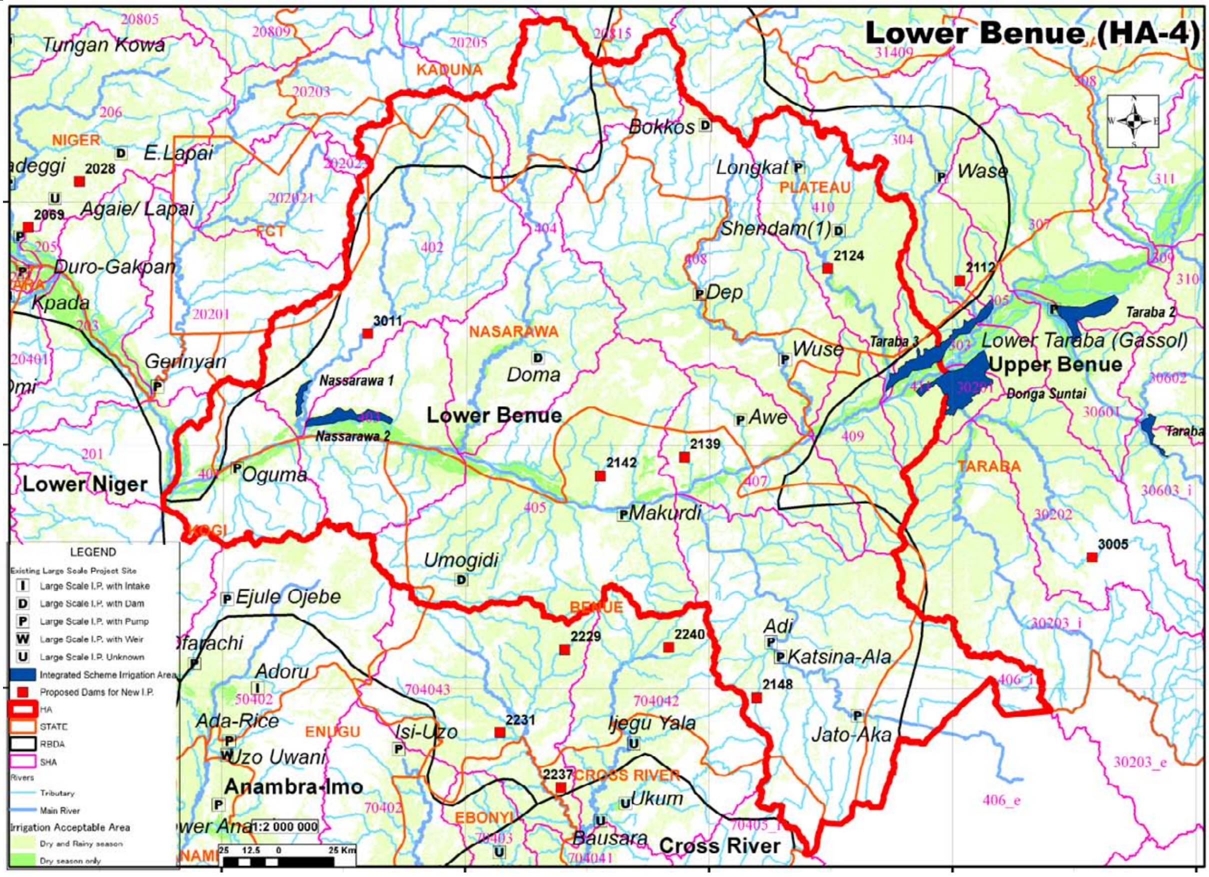
Source: JICA Project Team

Figure 8-13 Irrigation Development Plan (HA-2)



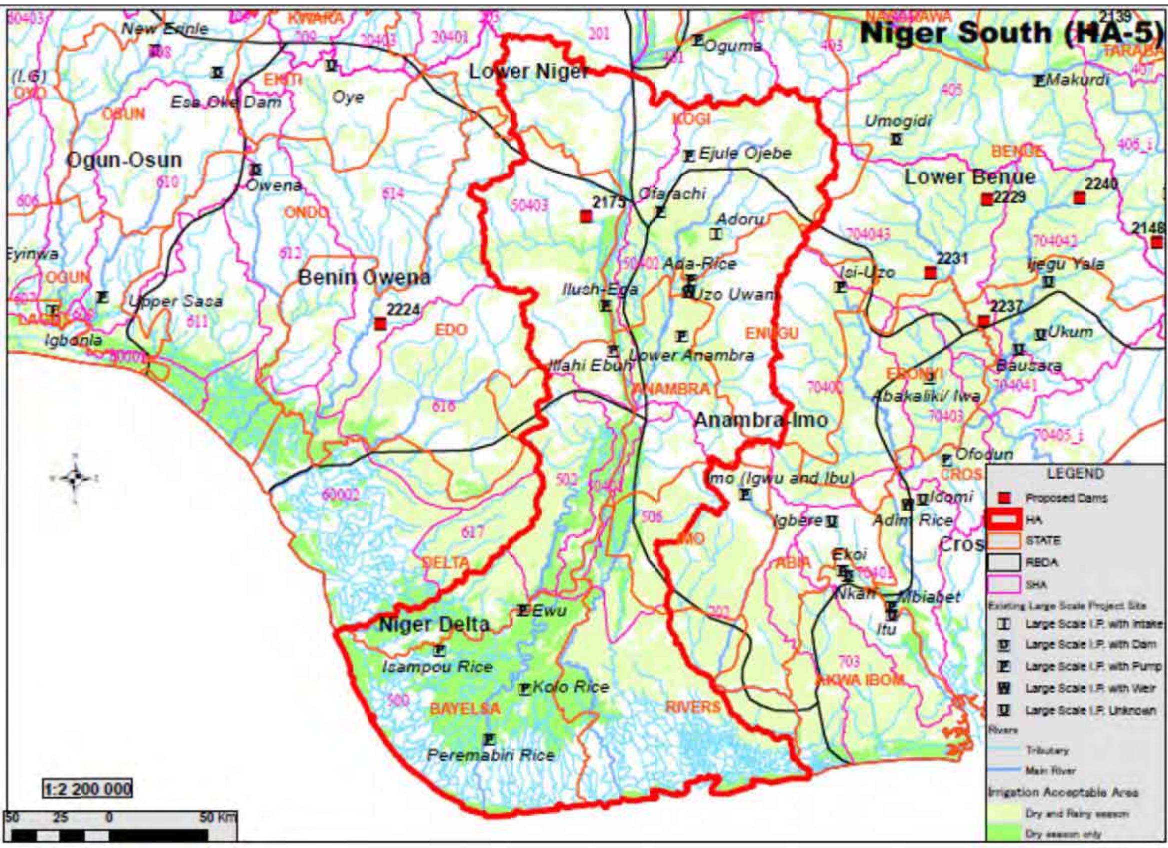
Source: JICA Project Team

Figure 8-14 Irrigation Development Plan (HA-3)



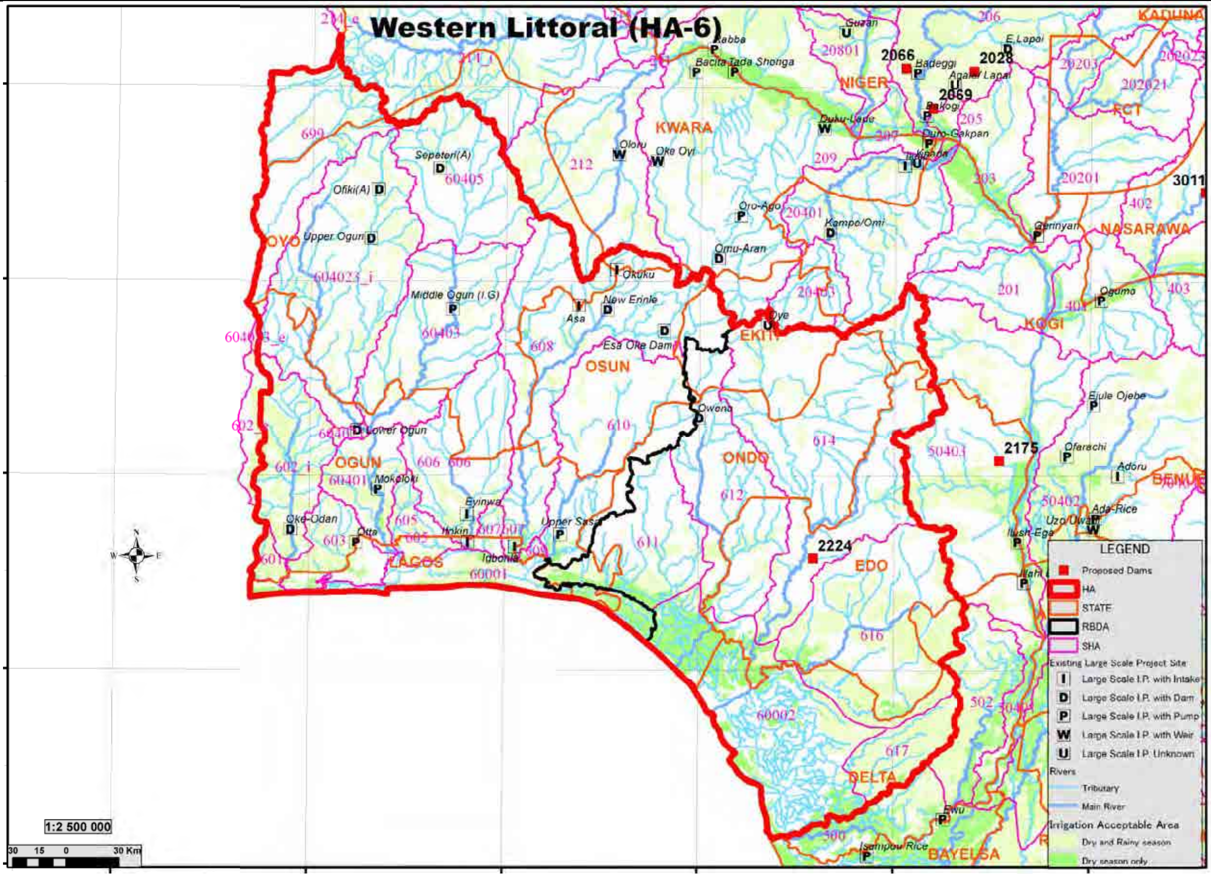
Source: JICA Project Team

Figure 8-15 Irrigation Development Plan (HA-4)



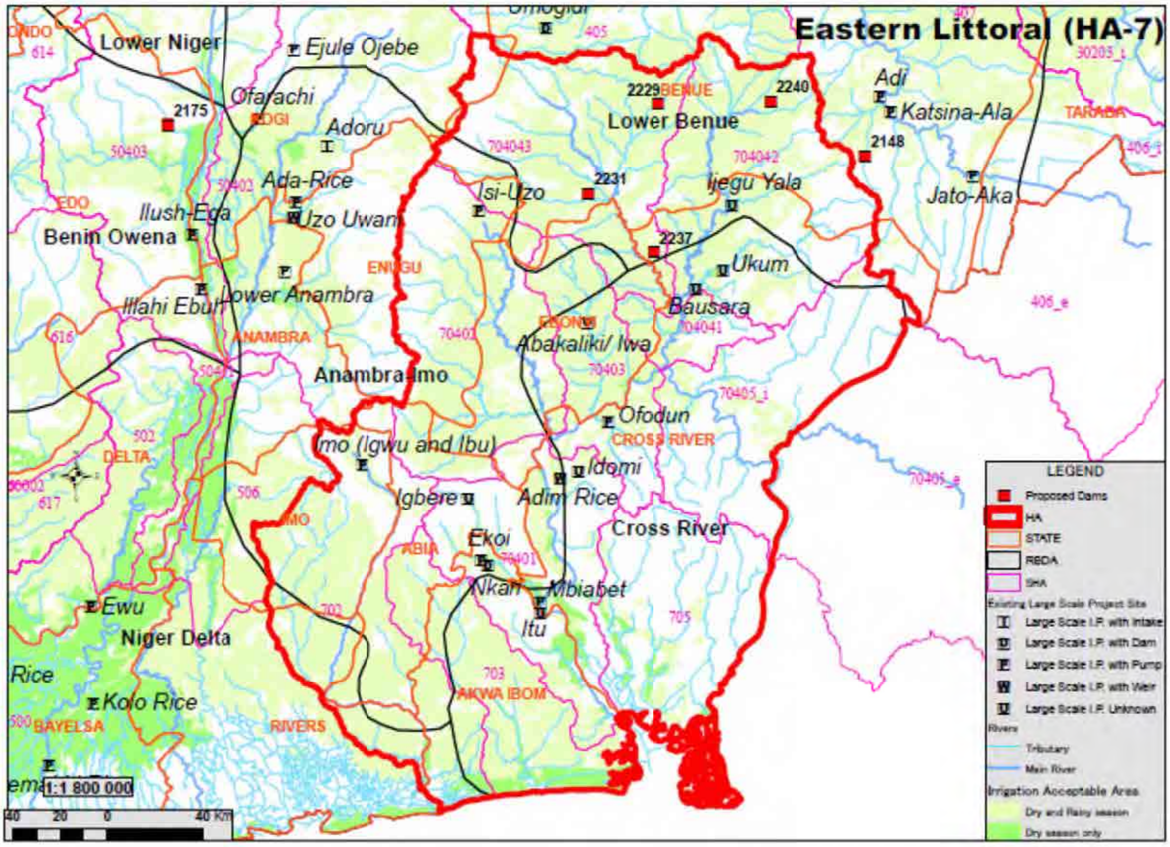
Source: JICA Project Team

Figure 8-16 Irrigation Development Plan (HA-5)



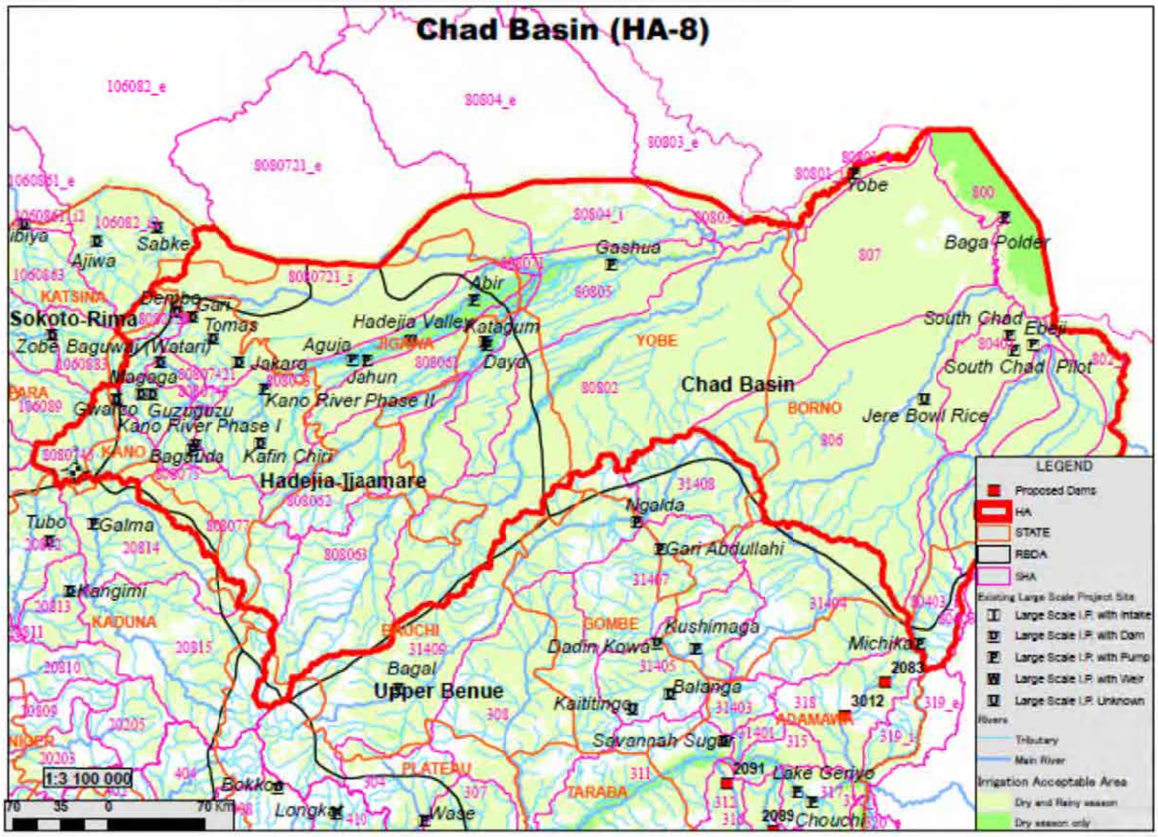
Source: JICA Project Team

Figure 8-17 Irrigation Development Plan (HA-6)



Source: JICA Project Team

Figure 8-18 Irrigation Development Plan (HA-7)



Source: JICA Project Team

Figure 8-19 Irrigation Development Plan (HA-8)

8.2.4 Formulation for Effective Running Public Irrigation Scheme

RBDAs and local government mainly operate, maintain and manage the public irrigation schemes. However, the irrigation schemes have a lot of problems such as low ability of operation, maintenance and management of RBDAs, constraint of budget, troubles and aging of irrigation facilities, inadequate water arrangement, farmer’s unwillingness to participation to irrigation association, collection of water charge and cost recovery, poor arrangement of irrigation and agriculture equipment and the rest. The followings are very important to operate and maintain smoothly.

1) Strengthening of RBDAs administrative ability and maintenance and management, Improvement of technology for staff;

   Smooth operation of scheme prevails to other areas as success model.

2) Institutional strengthening of water use association and enlightenment of farmer’s participation conscious;

   Enlighten farmers through introduction of success area and workshop. Sense of community is uprised through consultation of water use plan between RBDAs and water use association as representative of farmers.

3) Procurement of fund for adequate operation due to increase of water charge

   Procurement of fund eye to raise up to meet economically the adequate price of water for grade-up water supply services to get farmer’s confidence. Furthermore, it is necessary to take budgetary steps for supplement of balance among water charge collected on the scheme and the cost required for operation, maintenance and management.

4) Alteration of irrigation system, strengthening of rehabilitation, improvement and maintenance and management of facilities

   Irrigation system will be alternated to gravity irrigation system depending on location condition. RBDAs mainly conduct rehabilitation and improvement of facilities, but participation of water use association and farmers are conspired for maintenance and management of facilities.

5) Adequate water delivery and formulation of effective monitoring system

   Adequate water delivery is carried out through monitoring and evaluation on check gate operation, etc. Also it is necessary that capacity building of RBDAs staff in charge of water delivery and farmers.

6）Implementation for arrangement and renewal of equipment

   It is necessary to take budgetary steps to overhaul and renew equipment. Also, strengthening of ability for maintenance staff is conspired.

8.3 Recommendation to Other Sub-Sectors

8.3.1 Hydropower Generation

Hydropower generation is a technology to convert the energy of falling or flowing water into electricity. The structure of hydropower stations is relatively simple and thus easier to install than thermal power stations, which require large-scale plant facilities. However, some cautions are needed, as hydroelectric plants often turn out not to be economically feasible in locations where the hydraulic head and stream flow are insufficient. Also, it is important to properly maintain the turbines, which are driven by a stream of water and thus are prone to breakage caused by debris in the water.

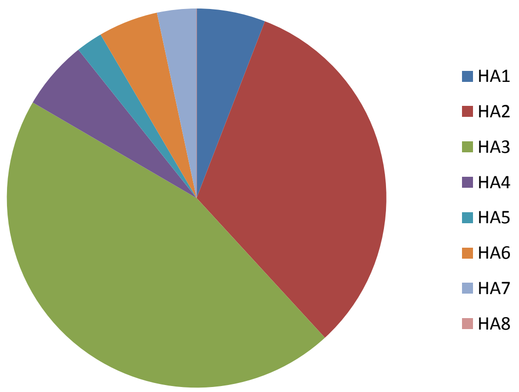
Considering the large environmental and social impacts of constructing a large-scale hydroelectric station, as well as the lack of suitable dam sites with large enough capacities, a more practical choice for the proposed dam sites would be to install small hydropower stations that are driven by water used primarily for irrigation purposes.

In regards to the large-scale hydroelectric dam development projects being planned by Nigeria's Federal Ministry of Power (FMP), it is important for FMWR as the administrator of the river environment to provide FMP appropriate guidance on a continuing basis such as, for instance, teaching them to check the existence of low-flow sections and, if necessary, discharge water to secure the predetermined minimum flow level.

(1) Evaluation of Hydroelectric Potential (of Irrigation Waterways)

We estimated the hydroelectric potential of each dam site based on the flow regime and dam height of each site, which were identified by our survey, to examine the possible introduction of hydroelectric stations, and sorted out the approximate results as follows. HA-2 and HA-3 have large potentials, as these areas are blessed with good stream flows and topographical advantages.

HA	Annual Output (MWh)
HA-1	69,722
HA-2	383,971
HA-3	537,402
HA-4	69,929
HA-5	26,900
HA-6	60,359
HA-7	39,934
HA-8	0
Total	1,188,217



Source: JICA Project Team

Figure 8-20 Hydroelectric Potential in HAs

(2) Considering the Installation of Low-Head Hydroelectric Stations

While dam-type hydroelectric stations have the advantage of relatively large output, they also have shortcomings such as high construction cost and large impact on the river environment. Low-head hydropower is drawing attention recently as a promising solution to such obstacles, as it generates electricity mostly by the use of river current without relying on a large head and therefore can minimize the alteration of the river environment.

Shown below are examples of low-head hydroelectric stations in Japan, the heads of which range from 3 to 9 meters. The Shichika Yosui Station is a turbine facility installed in an irrigation canal constructed for agricultural purposes. Some of the sites under the agricultural scheme of this Study may be suitable for this type of hydropower station.

River: Shichika Yousui
Effective head: 5.45m
Max. water use: 15.00m^3/s
Max. output: 630kW
Annual output: 4,011MWh

Source: Website of Tedori River Shichika Yousui Land Improvement District
http://www.shichika.or.jp/work/plant.html

Shichika Yousui Hydropower Station (Owner: Ishikawa Prefecture)

River: Aga River
Effective head: 9.00m
Max. water use: 45.00m^3/s
Max. output: 3,300kW
Annual output: 17,036MWh

Source: Website of Fukushima Prefectural Enterprise Bureau
http://www.pref.fukushima.jp/development/denki/main1.html

Oya Hydropower Station (Ower: Tosei Kogyo)

River: Kizu River
Effective head: 3.30m
Max. water use: 27.80m^3/s
Max. output: 710kW
Annual output: unknown

Source: Website of Izumiji Tourism Association
http://www.kizu.ed.jp/kyoui/izumijikanko/

Souraku Hydropower Station (Kansai Electric Power Co.)

Figure 8-21 Examples of Low-Head Hydroelectric Stations in Japan

The above stations use large amounts of water to compensate the low heads, which means that this type of hydropower station does not function well in locations without abundant stream flow. Also, constructing a power station in areas with large river flow requires due consideration, as it involves some difficult works, such as building a cofferdam, etc.

Installing a power generation facility concurrently with the construction of an irrigation canal, as was the case with the Shichika Yousui, is a very rational approach, as it does not require large-scale cofferdam work. For this reason, we recommend that the future irrigation canal projects under the agricultural scheme with large stream flows should actively incorporate low-head hydropower. We presume that there are many potential sites, as low-head hydropower stations are not so much constricted by topographical features.

(3) Necessity of Trial Installation

The most important aspect of the maintenance of hydroelectric facilities is the removal of dust from the equipment, as it takes in water directly from the river, which naturally contains dust and debris that need to be removed properly. While the intake gates of dam-type hydropower stations are usually situated lower than the river surface, those of low-head stations are at about the same level as the river, which makes it easier for the debris floating on the river surface to flow into the turbines, causing breakage. For this reason, it is desirable to install a turbine in a relatively small river or canal on a pilot basis to test and check the actual output and removal of debris before full-scale installation.

8.3.2 Flood and Erosion Control

(1) River and Floodplain Features in Nigeria

Major rivers in Nigeria flow through wide floodplain in a flat valley usually confined by hard terraces. The flow regime is quite seasonal because of the semi-arid or sub-tropical climate and its watershed size. Such characteristics are similar to those of the Nile valley, where traditional floodplain irrigation was popular for agriculture. Also in Nigeria there remained such traditional floodplain irrigation called Fadama along the Niger and Benue and its tributaries. It is understood that in Nigeria it reflects the Nile river civilization through the migration of the Hausa.

Due to the above said river characteristics; the irrigation on floodplain was comparatively easy to make use of river water by minimum structure, so that large scale mechanical irrigation system was not so developed until recently. This indicates a clear contract to the other areas such as the Mesopotamia and the Asian Monsoon in which large scale hydraulic irrigation and strong governance were required earlier.

In Nigeria, labor intensive irrigation has remained until recently due to the above background, and also local governance (government establishment) has only short history. Resultantly, in terms of river water usage as irrigation, engineering approach with large scale structure has not been so developed in local level while water use and land protection are depending on quite local needs in general.

The inland waterway transportation in Nigeria started as the European business in eighteenth century. It is assumed that cities in southeast region were developed recently mainly depending on a few kinds of trading between the European and the inland areas. This background is quite different from that of the Northern area.

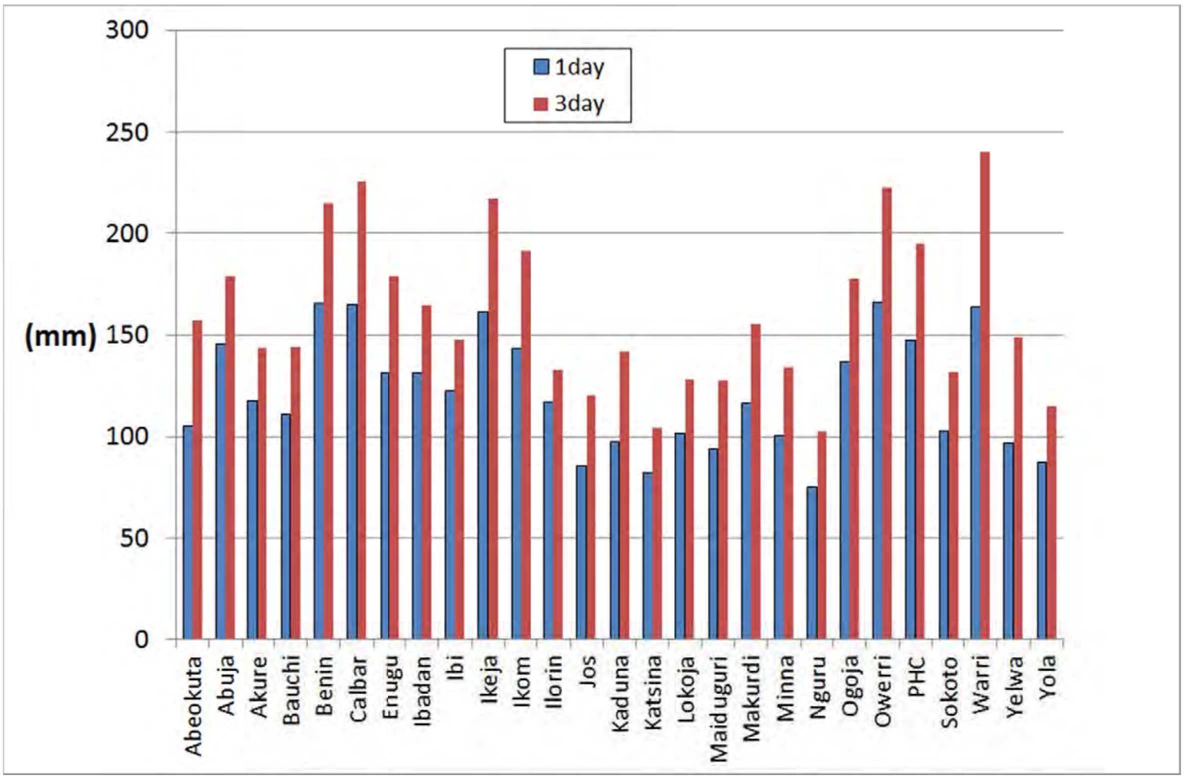
In many countries as well as Nigeria, the relation between the river and people has a long history; however, one of the special things in Nigeria is the comparatively short history of the Government involvement in the river management.

(2) Issues

(2-1) Flood Damage

The flooding in Nigeria is mainly composed of seasonal riverine flooding and flash flood by heavy rainfall. The seasonal flooding occurs in natural rivers such as the Niger, the Imo, the Anambra rivers. The flash flood is often recognized in Nigeria as inundation by rainfall –runoff in urban area. In the delta area in the South there are inundation caused by high tide or high water in rivers.
Fig. 8-19 shows the probable daily and 3 days rainfall amount of NIMET station based on the past 30 years. In the station in the coastal area the probable daily rainfall is over 150mm, while in the middle belt area the amount has a certain variation.

There is few document which compiled the past flood disaster in Nigeria. The information on flood disaster is scattered among various materials and newspaper. Table 8-29 shows some major flood disasters which caused a lot of victims. Some of the reported flood disaster events by media are Sokoto State flood in September 2010, Ibadan State flood in August 2011 and Lagos flood in July 2011. The former 2 floods events were caused by excessive overflow from dam or reservoir to result into flooding in the downstream reach, and the latter was the inundation event in urban lowland area near the coast.



Source: JICA Project Team

Figure 8-22 Probable Rainfall for 10 Years Return Period in NIMET Stations

Table 8-29 Past Major Flood Disasters in Nigeria

Year/Month	State (City) / River Name	Description of Cause and Damage
1980	Oyo(Ibadan) / Ogunpa R.	274.1mm rainfall in 12 hours, 100 people died and 50,000 people homeless.
1988 August	Kano	Bagauda dam failure, destroying 18,000 houses and leaving 200,000 and 23 people dead.
1999 September	Kaduna / Kaduna and Niger R.	Killed 39 people, Submerged hundreds villages, affected 300,000 people. 23 people were killed.
2010 September 8th	Sokoto, Kebbi / Sokoto , Rima R.	Heavy rainfall and Goronyo dam release.
2011 August	Oyo(Ibadan)	120 people killed.
2011 July	Lagos, Ogun, Oyo	25 people killed. Relentless rainfall on July 10 (Sunday).
2012 August-October	33 States, especially Kogi, Adamawa and Delta / Benue, Niger R.	363 people dead, 2.2 million people were displaced, damaged several thousand ha of cropland and destroyed houses and personal properties.

Source: JICA Project Team

In 2012 from July to October, Nigeria experienced historical flood along the Benue and the Niger rivers. The flood traveled in those rivers for more than 1 month and affected the urban areas along the rivers. According to NIMET information[1], the flood magnitude was the worst in 80 years on record, whose causes were the inflow from Niger due to a lot of rainfall in the country and the runoff from in and outside of Nigeria due to rainfall in July. Totally 33 states among 36 states were affected by the flood. Especially 14 states were seriously affected. The number of affected people is 7.7 million during July and October. The number of victim is 33 and the 18 thousand were injured and 618 thousands of houses/building were damaged.

(2-2) Erosion

As frequently described in many documents, the topography of Nigeria is composed of high land of Pre-Cambrian basement complex and low elevated area along the Niger-Benue river system. The former is extensive erosion surface and the latter is the flattened valley infilled with Cretaceous and later sediments (fluvial). In other words, the boundary between the erosion surface of basement complex and the sediment along the rivers is terrace with cliff which was created by fluvial action when the sea level was higher than the present. The present terrace with cliff has potential to be eroded

[1] NIMET, 2012 Nigeria Climate Review

by river flow or slope failure as well as gully erosion and foot spring, to extend outerward.

The flat erosion surface of basement complex develops gully erosion if rainfall intensity is high and the land has little vegetation.

The gully erosion in Nigeria has been paid attention to since the British colonial era in 19th century. Among the sites, the Agulu-Nanka site[2] [3] in Anambra State was one of the largest (approx. 1,100km^2) and some countermeasures have been applied being a symbol in terms of Nigerian gully erosion.

Gully erosion, since its scale is large, can be paid attention to, however, it should be certain that several factors are involved in the development of such large gully. In Agulu-Nanka site, it is reported that the road construction passing the stream source made considerable change on rainwater drainage system, resulting into the rill development as well as the gully, and produced inverse effect on the road itself[4]. The man-made activities to cause gully erosion in the Southeastern in Nigeria are construction of infrastructure such as road, quarry, cultivation, footpath, grazing and high population density.

FME conducted the study on Land Degradation Mapping and Assessment for the Prevention and Control of Potential Erosion Hazard in Nigeria in 2010 in order to assess the land condition in terms of land degradation. The main output was the mapping of nationwide land degradation condition, separated into 99 sheets (scale 1:250,000). Table 8-30 shows the area of land degradation for each HA.

Table 8-30 Land Degradation Area evaluated by FME

HA	Area(km2)	HA	Area(km2)
1	8,904	5	411
2	21,664	6	10
3	3,140	7	1,140
4	86	8	4,822

Source：JICA Project Team

(3) Current Situation of Sector

(3-1) Policy on Flood and Erosion Control (National and State)

When the Federal Ministry of Environment was created, the role on erosion control and flood control of the Federal Ministry of Water Resources was transferred to FME with its department. Consequently the countermeasures of erosion and flood control which was proposed in the M/P1995 has been mostly implemented by FME as the materialization of the National Policy on the Environment in 1998.

a) National Policy on the Environment (1998)

The National Policy on the Environment (1998), there are over 2,000 sites of active gully erosion to be controlled properly. The policy states that the following interventions are necessary.

For flooding it will be necessary to

- Enforce compliance with planning/urban laws/edicts
- Build embankments and levees along rivers and coastline prone flood
- Establish rainstorm early warning system
- Establish and monitor weather stations, river and tidal gauges
- Ensure appropriate management of dams
- Ensure proper maintenance of existing urban drainage channels
- Enforce environmental sanitation laws in towns and cities

For soil and coastal erosion it will be necessary to

- Prepare and implement a comprehensive national policy on soil and coastal erosion and flood control
- Formulate and enforce regulations for soil and water conservation especially in erosion-prone areas
- Carry out national watershed delineation and characterization for use as basis for development

[2] Egboka, Okpoko, Gully erosion in the Agulu-Nanka region of Anambra State, Nigeria, Proceedings of the Harare Symposium, July 1984, pp.335-347

[3] Floyd, B., Soil Erosion and Deterioration in Eastern Nigeria, Nig. Geogr. J. 8(1965), pp33-43

[4] Enuvie G. Akpokodje, Akaha C. Tse, Nnamdi Ekeocha , Gully Erosion Geohazards In Southeastern Nigeria and Management Implicatioons , Scientia Africana, Vol. 9 (No.1), March, 2010, pp 20-36

of an aggressive management and enforcement program to protect and maintain the quality of the nation's land water and coastal resources and implement the programs

- Prepare periodic master plan on the management of soil and coastline erosion and flood, and advise the Federal Government on the financial requirements for the implementation of such plans
- Carry out feasibility and scientific studies on soil erosion and related flood problems for the design of appropriate integrated remedial control measures
- Carry out public enlightenment campaigns on environmental degradation arising from poor land and water management practices
- Provide and promote training on environmental issues as they relate to flood, erosion, land degradation and water conservation
- Promote integrated ecosystem management with other agencies connected with agriculture, land use, soil and water conservation, rural development and coastal resources management including environmentally sound recreational use
- Strengthen national capacity through personal development, provision of training facilities and research on combating climate-related ecological problems
- Strengthen capacity of the Environmental Management Support System (EMSS) for Remote Sensing data gathering. GIS facilities and development of disaster environment data bank
- Support agro-forestry and integrated Coastal Zone Management
- Encourage planting fallow and abandoned farmland using soil enriching species
- Promote conservation farming and use of organic fertilizer and soil conditioners.
- Establish viable contingency plans for tackling socio-economic and other problems resulting from coastal and other erosional disasters.

(3-2) Institutional Arrangement on Flood and Erosion Control

The present institutional arrangement on flood and erosion control is shown in Table 8-31. In reality, most and major activities of these sectors are implemented by Federal Ministry of Environment and State governments as urban environment improvement administration. FMWR is in charge of release of dam under her jurisdiction and flood/erosion control in related to her large scale irrigation projects.

Table 8-31 Present Institutional Arrangement on Flood Control and Erosion Control

Institution		Flood Control	Erosion Control
Federal Ministry of Environment	Main Ministry	Development and operation of Flood Early Warning for local area	Implementation of nationwide program on erosion control as a part of watershed management Implementation of structure measures in some local areas
Federal Ministry of Water Resources	Main Ministry	Operation of multi-purpose dam	
	RBDA	Implementation of structure measures mainly related to agricultural facility	Implementation of structure measures mainly related to agricultural facility
	NIHSA	Hydrological Monitoring	
State Governments	Environmental Management section	Implementation of structure measures	Implementation of structure measures

Source: JICA Project Team

(3-3) On-going Projects List

The major projects of flood and erosion control in Nigeria are currently Nigerian Erosion/ Watershed Management Project (NEWMAP) and Web based Flood Early Warning System (FEWS) led by FMEnv.

Nigerian Erosion/ Watershed Management Project (NEWMAP)

The overall objective of the Nigeria Erosion and Watershed Management Project (NEWMAP) is to support participating states and local governments to reduce vulnerability to erosion financed by World Bank. The relevant Federal Governments are FMF, FME and FMARD.

This is to be achieved by applying a comprehensive watershed management approach and by selecting and implementing affective engineering/ecological solutions for selected erosion sites. The project will focus on nine states[5], namely Anambra, Abia, Imo, Enugu, Ebonyi and Kaduna, Kano Ogun. The project includes two major components of investments in targeted areas and institutional development and establishment of information systems for erosion management and watershed planning. The total financing is said to be 508 million US$.

The FME in Collaboration with other partner agencies has set up this Web based Flood Early Warning System (FEWS) to monitor various locations in the country for Flood Signs, and Issue alerts to minimize loss of lives and property. The FEWS is setup to cater for urban areas and for River basins, and Reservoirs such as Dams.

Forecast data is provided on this website for various cities in the country. The Forecast includes Rainfall, Temperature, Humidity, Atmospheric Pressure and more.

Also the FME has started the satellite-based flood monitoring system and the community-based FEWS with support of UNDP and other relevant organizations.

The structure measures of those sectors have been implemented by environmental sections in State governments. Each project is separated and small scale one such as lining and dredging in natural stream, drainage works on slope, vegetation planting and revetment works in coastal area.

(4) Contribution of FMWR for flood and erosion control sector in Nigeria

The sectors of flood control and erosion control are mainly implemented by FMEnv and State governments as a part of urban environmental improvement. FMWR used to take these sectors before, however, these sectors were transferred to FMEnv at present. Consequently the sectors within FMWR have not been active only with relevant activities of irrigation projects.

However in recent years, especially after the 2012 flood in Nigeria, the Government of Nigeria is stepping forward nation-wide disaster management on flood. NIMET and NISHA (FMWR) expressed the need of further enhancement on exchange of hydrological information. NIHSA is eager to take responsibility for flood forecasting (rainfall-runoff relation in Nigeria) along major river system.

The flood control sector in Nigeria has been materialized in three tiers such as Federal, State and Local governments with frameworks on environmental management and disaster management. FMWR has nation-wide hydrological monitoring network and jurisdiction of a lot of dams. In this sense, FMWR should be involved in management of floodplain along the major rivers, especially for the downstream reaches of her multipurpose dams. At the same time, the hydrological monitoring system of FMWR should be improved to monitor more short term phenomenon such as floods. Moreover, FMWR should extensively do flood risk evaluation for the area of floodplain along the major rivers in which irrigation project is/will be implemented or urbanization has been/will be progressed.

Regarding the erosion control in Nigeria, some State governments as implementing body express their desires on proper budget allocation from the Federal Government and technical support from Federal agencies in terms of hydrological analysis. NIHSA of FMWR can contribute to this aspect through hydrological monitoring.

Table 8-32 Prioritized Activities for Flood Control Sector in FMWR

Objective	To enhance the land use of floodplain having high potential for large and small scale irrigation and to improve the future land use to respond flood in riverine areas
Major Activities of FMWR	1. Construction and maintenance of flood control facilities in relevant to large scale irrigation (Main Ministry and RBDA) 2. Regulation of release from multipurpose dam (Main Ministry and RBDA) 3. Consolidation of hydrological monitoring for flood (NIHSA) 4. Flood risk evaluation in floodplain (NIHSA) 5. Dissemination of the above information to State government, NEMA, FMARD, FMEnv, NIWA, etc.

Source: JICA Project Team

[5] This Day(Newspaper) 2012 March 09

Government in charge		State Government / FME			FMWR
Category/Type		Urban Drainage	Flood Control in Lowland (ex. Niger Delta)	Flood Control in Riverine Area (ex. Along the Niger, the Benue)	Flood Control in Floodplain (ex. For irrigation)
Current Measures	Structural Measures	Channelization Dredging Dike } Project by Environmental Sector			Project related to Irrigation Project by RBDA
	Non-structural Measures	Flood Early Warning by FME			Hydrological Monitoring
Proposed Measures	Structural Measures	Channelization Dredging Dike } Project by Environmental Sector		Planning/Design by NIHSA	Project related to Irrigation Project by RBDA
	Non-structural Measures	Flood Early Warning by FME Proper application of landuse control		Enhancement of Flood Monitering, Flood Early Warning , Flood Risk Mapping by NIHSA	
Project Site			Lagos and Delta areas	Lokoja, Yola, Makurdi, Kaduna, Abeokuta, Ibadan, etc.	Niger R., Benue R. Sokoto-Rima R. Kaduna R.

Source: JICA Project Team

Figure 8-23 Technical Field on Management of Floodplain for FMWR

(5) Proposed Actions for FMWR

Action 1: Flood risk evaluation in floodplain

Background

The flood in 2012 caused historical high water in the major rivers such as the Benue and the Niger rivers and raised nation-wide concerns on flood in the future. The FMWR as well as NIHSA have a lot of dams in the major rivers and the hydrological monitoring network. They are expected to collaborate with NIMET and to implement flood forecasting in the downstream of her dams.

Contents of the Action

- Designation of floodplain rivers as well as sections to be managed
- Selection of floodplain sections for which flood risk is evaluated
- Basic Survey and Analysis (River cross section survey, flood modeling and flood monitoring)
- Evaluation of flood risk area

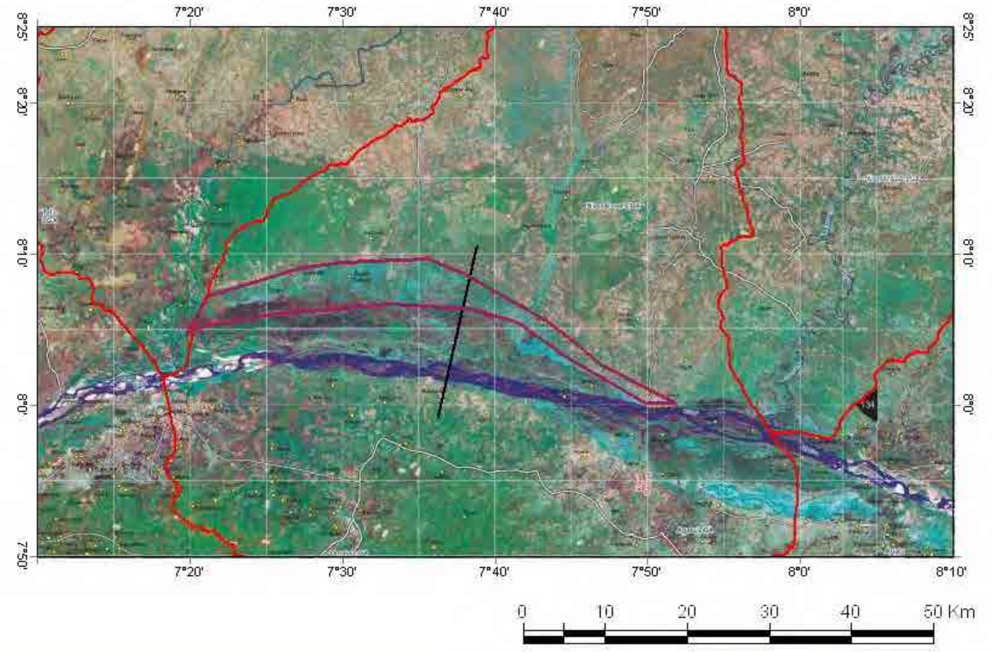
Usage of the Output

- Dissemination of information on flood to irrigation farmers in the designated floodplains
- Reference to floodplain development in the future
- Disaster management and land use planning in urban area along the floodplains

Action 2: Flood control for proposed irrigation project in the Benue river floodplain

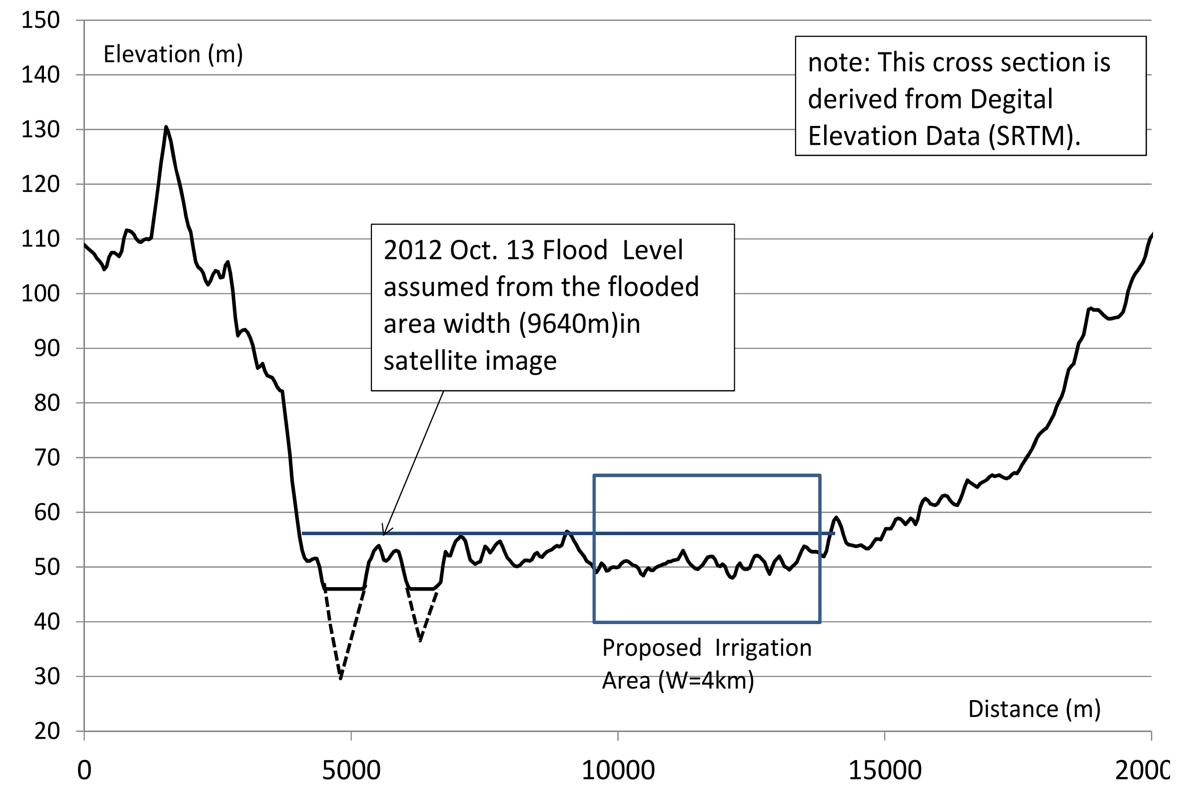
In the future plan of irrigation sector, there are 2 large scale irrigation projects in the Benue river floodplain. The project areas of those proposed projects are the right bank of the Benue river, where there is high flood potential in rainy seasons.

Figure 8-24 shows the location of a proposed large irrigation project in the lower reach of the Benue river. Figure 8-25 shows a typical cross section profile. The cross section profile is generated from SRTM3 whose accuracy in terms of elevation is supposed to be several meters. In the floodplain a natural levee is recognized. The proposed project area was inundated during the 2012 flood, so that a certain kind of flood control facility is needed in order to protect the irrigation area such as dike on the natural levee. FMWR will make use of the output of the Project 1 and will be able to make flood control plan for the large scale irrigation project.



Source: JICA Project Team（remark：The black line in the figure is the cross section line of the following figure.）

Figure 8-24 Location of Proposed Large Scale Irrigation in the downstream of the Benue River



Source: JICA Project Team

Figure 8-25 Cross Section of the Benue River in the Proposed Large Scale Irrigation Project

8.3.3 Inland Navigation

(1) Existing policy, strategy and plans

The Federal Government of Nigeria prepared Draft National Transport Policy in August 2010. The policy said as the Nigerian Transport System in perspective as follows,

The evolution of modern transport system in Nigeria can be categorized into two distinct phases. These are:

a) The colonial period which marked the origin of modern transport system.

The networks of rail, water and road developed then were geared essentially to meet the exportation of cash crops, such as groundnuts, cocoa, cotton and palm products and to the importation of cheap, mass produced consumption goods. These early transport systems were planned in the most economic way possible, as typified in sub-standard road and rail alignments and a sub base, which later proved inadequate to accommodate heavy vehicles.

b) The post-colonial period/attainment of independence.

With a re-orientation of goals, transport became one of the instruments of unification of the country and an important tool for social and economic development. The development of petroleum resources from the 1950's had significant impact on the nation's social and economic growth, putting increasing demands on the transport system.

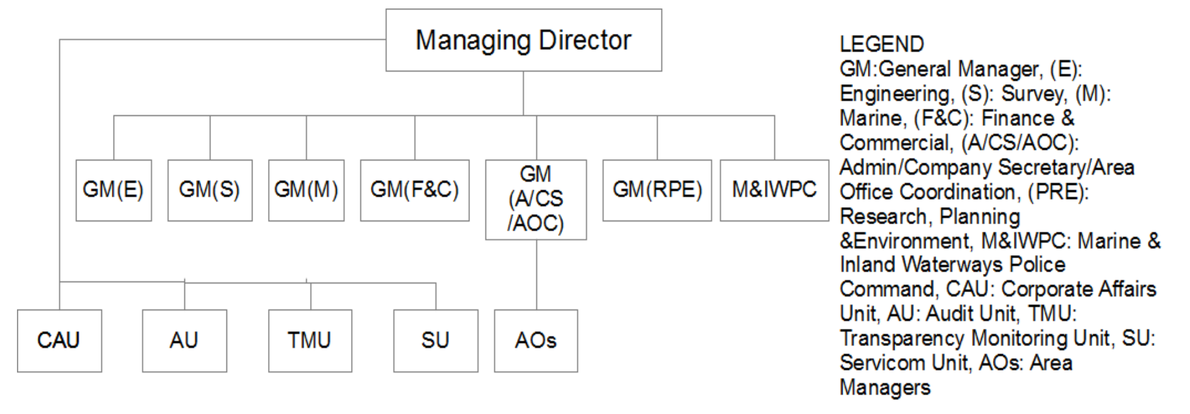
Goods and passenger movements in Nigeria are performed mainly by road, with the railway and inland waterways playing significant, but less important roles. International freight movement is principally by sea while air transportation is the main passenger carrier.

An efficient coastal and inland waterway system will relieve pressure on the country's rail and road transport infrastructure as bulk goods can be transported over long distances at very low rates. The energy demand of the Waterways is low and the negative effect on the environment is minimal. The use of the waterways for transportation should therefore be encouraged as a matter of principle.

(2) Existing condition

The Nigerian inland waterways are a major natural resource, traversing 20 out of the 36 states. The areas adjacent to the major rivers represent the nation's important agricultural wetlands. Agricultural products from the middle belt and particularly from Makurdi, and Lafia areas can be transported to Onitsha and Port Harcourt through the waterways.

The National Inland Waterways Authority (NIWA) was established by Decree No. 13 of 1997. The Decree vests in NIWA the power of exclusive management, direction and control on the Nigerian inland waterways. The organization chart is shown in Figure 8-26. This power is exercised on Nigeria's 3000 km navigable waterways from the Nigeria/Niger and Nigeria/Cameroon borders to the Atlantic Ocean. Nigeria is blessed with a river configuration very suitable for North-South movement of people and goods.



source： JICA Project Team

Figure 8-26 Organization Chart of NIWA [6]

The inland waterways of Nigeria comprise of the main river system (Rivers Niger and Benue which form a confluence at Lokoja), creeks, lagoons, lakes and intra-coastal waters. They are declared by the 1997 degree as Federal navigable waterways.

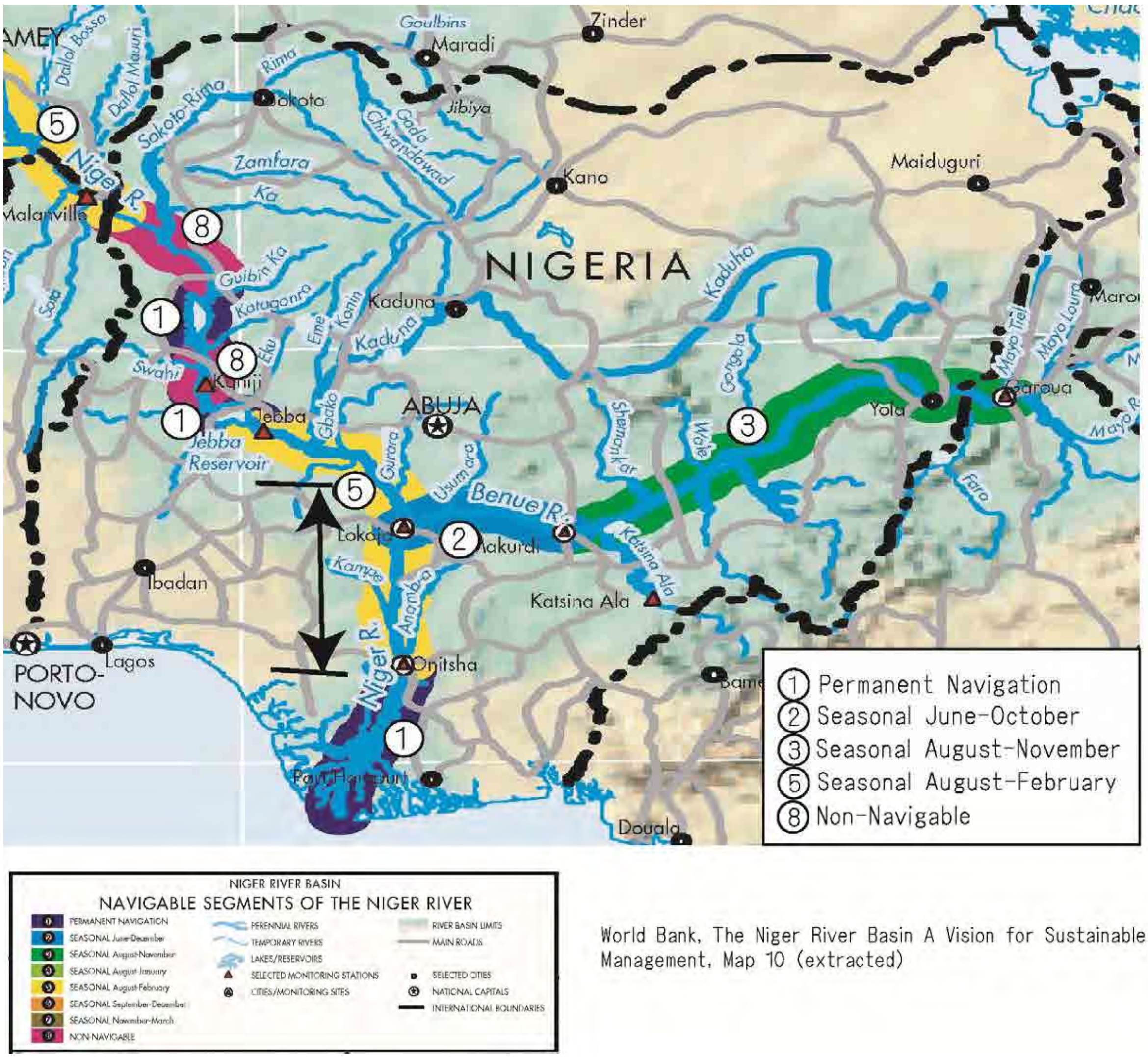
Basically all navigable waterways shall be under the exclusive management, direction and control of NIWA. The right of land usage for improvement of navigability and provision of infrastructure shall

[6] NIWA's Charter of Service Compact(SERVICOM)

cover areas on both banks of the waterways which would submerged in a flood of 100 years return period. In case of waterways with steep banks where such flood have no overbank flow, the right of way shall include the areas of land along the waterways measured 100 meter perpendicular from the edge of the channel.

According to WB (2005), in Nigeria, the overall navigable network in the coastal lagoons and river branches of the Niger Delta is more than 6,000 km; half of that network is part of the Niger and Benue network. Along the length of the Niger, navigation is possible for large flatbottomed boats upstream to Onitsha (1,127 km from the ocean) throughout the entire year, and even farther upstream to Jebba (1,448 km) from August to February. Lake Kainji is navigable for 130 km. The Benue is navigable to Makurdi from June to December, and to Garoua in Cameroon from August to November.

The Kainji Dam and the Jebba Dam have a navigation lock facility according to an observation by Google Earth.



source： World Bank

（The arrow in this figure is the dredged section in 2009-2012. Some legends were improved by JICA Project Team.）

Figure 8-27 Navigable Route in Niger and Benue Rivers in Nigeria

Attempts have been made to dredge the Lower River Niger in 1958 and in 1978. In 1996, the Federal Military Government approved the dredging project, covering 572 kilometers from Warri in Delta State to Baro in Niger State. The approved dredging project just started in 2009 and finished in 2012 as capital dredging.

The depth and width of the Lower Niger River after the dredging exercise shall be dredged to achieve a trapezoidal configuration;

Depth below chart datum - 2.5m
Bottom Width - 60.0m
Top Width at line CD - 100.0m

The dredging Chart Datum (CD) is a measurement benchmark of the waterline established during pre-project execution period (low waters) between the months of February and March.

(3) Identified issues and problems

Despite its advantages, the use of this transport mode has diminished particularly over the past three decades due to physical, investment and operational constraints, notably:

- High rate of sediment build up along the channel.
- Physical obstruction (wrecks, rock outcrop etc.).
- Poor government investment in infrastructure development
- inadequate river Port infrastructure
- poor landward connection to River Ports
- poor communication and navigational aids

(4) Direction of improvement

Government recognizes the great potentials and benefits of the inland waterways and is resolve to address the outlined constraints to enable the country fully exploit and enjoy this mode of transport. It is therefore the objective of government to develop the inland and coastal waterways with private sector participation.

In order to achieve this objective government will:[7]

- Eliminate the physical constraints to navigation in the country's waterways;
- Promote pricing policies that will shift traffic to the inland waterways;
- Restructure the National Inland Waterways Authority (NIWA) (which is charged with the responsibility of managing the waterways) to give ample opportunity for private sector participation in the management and operation of the waterways;
- Encourage indigenous involvement in the development of the inland waterway as a mode of transportation; and
- Establish an Inland Waterways Safety Inspectorate to curtail the high incidents of major and minor accidents. The potential dangers posed by poorly maintained vessels and incompetent operators will also be checked in addition to stricter endorsement of existing navigational and safety rules. Proper licensing and inspection procedure will be adopted and appropriate sanctions imposed on those who infringe safety rules and procedure. Commercial river crafts will be properly inspected.

According to NIWA, the Study on Inland Waterway Masterplan and Bankable Feasibility was conducted by FMT on 2011. The report was submitted from FMT to the Federal Executive Council for review. The report contains some concession issues and public-private partnership projects.

(5) Role of FMWR

FMWR owns and manages dams which may affect flow regimes along navigable river sections in the country. Furthermore, FMWR has to provide necessary information for disaster management in cities along rivers as well as for management of large scale irrigation area in the floodplain which is under jurisdiction of NIWA. It is necessary to consider effects of floodplain management on inland navigation. The followings are proposed to be implemented by FMWR.

- Sharing information on hydrological data and hydraulic parameters with NIWA;
- Sharing information on cross-sectional shape of floodplain area in navigable river sections; and
- Considering the effect of large scale irrigation development in floodplain on inland navigation.

[7] Federal Government of Nigeria, Draft National Transport Policy, P.17

8.3.4 Inland Fishery

(1) Fishery sector policies

Fishery division has launched the following policies in order to promote inland fishery in Nigerian Fisheries Master Plan 1998 (draft).

- Developing and modernizing measures of fishery production, processing, storage, marketing and conservation of resources,
- Improving living standard of fishery communities,
- Enhancing researches on fisheries,
- Consolidating research facilities and developing human resources,
- Prompting private enterprises to participate in and invest to fisheries,
- Organizing viable fisheries cooperatives throughout the country,
- Providing subsidies for purchasing fishing gears,
- Promoting fishermen’s access to public financing organizations,
- Implementing model projects for country-wide diffusion of fish farming techniques,
- Consolidating legal frameworks on fisheries,
- Improving fishery processing techniques and adding higher values to fishery products,
- Collecting information on development of fishrie4s subsector.

(2) Recommendations

Inland fishery basically competes with irrigation sector in terms of water use. However, it is recommendable to apply fish farming in the field of irrigation in such ways as fish farming in dams and reservoirs for agricultural purpose. In particular, it will be possible for local people to create opportunities of subsidiary income sources without competing with water use by agriculture only if they introduce fish farming on the surface of lowland rice fields in such a way as observed in Japan and in China. In this case, they can utilize abattoirs’ wastes and livestock droppings. In this way, as development frame of fisheries sub-sector and that of irrigation, agriculture and livestock sub-sectors are closely related each other, it is advisable to closely hold consultation among these sub-sectors for developing their activities by effectively utilizing water resources.

8.3.5 Livestock

(1) Policies of Livestock

Livestock division has launched the following policies in order to promote livestock industry in National Agriculture and Food Security Strategy 2010-2020.

- Accelerating participation of private sector in livestock industry making use of loans provided by “Nigeria Agricultural Cooperative and Rural Development Bank (NACRDB)” so as to establish larger-scaled livestock industry,
- Providing animal feeds, vaccination, livestock medicines, information and resources (loans) so that private management of livestock husbandry can be stabilized and quality and quantity of product supply can be maintained,
- Hatcheries of poultry should be consolidated throughout the country under the collaboration between public and private sectors. Besides, technical research should be promoted for realizing economical hatchery enterprises.
- Promoting dairy industry so as to produce milk for domestic consumption and for exports and
- Increasing highly productive grassland and cropping area under fodder crops through the liaison between public and private sectors so as to increase the production of forage crops and hay.

(2) Recommendations

The above policies do not include water resources development and management for promoting livestock industry. In practice, however, animal water at lakes, ponds, rivers, reservoirs, canals etc is indispensable for livestock maintenance including water spots for seasonal transhumant activities. Also, commercial livestock sub-sector may need means of water supply exclusively provided for livestock. Thus, livestock and irrigation sectors should closely be related mutually, it is necessary to produce efficient use of water resources through communication, coordination and collaboration between them.

CHAPTER 9 WATER RESOURCES MANAGEMENT PLAN

9.1 General

This section discusses the objectives and strategy of Water Resource Management. Then, the framework of water resources monitoring is discussed as the monitoring of the quantity and quality of water resources is important to manage many items, clarifying water resources monitoring in accordance with the administrator or management items of water resources management.

9.1.1 Objective and Strategy of Water Resources Management

Water Resources Management Plan shows the methodology how Water Resources Management is implemented based on the following Strategies:

(1) Objectives of Water Resources Management

The objective of water resources management is to provide the water services based on 3S&2E (Sufficiency, Safety, Sustainability, Efficiency and Equitability) to the water users who expect "Effective Use of Water", "Mitigation of Flood Damage" and "Conservation of Water Quality", by using the facilities and operation systems installed on the basis of Water Resources Development Plan. The Water Resources Management Plan compiles the methods to achieve the objectives

(2) Strategy of Water Resources Management

Water resources management is implemented based on the following strategies.

- **Strategy-1: Organization and Institution for Water Resources Management**

  As results of the analysis of current organization and institution for water resources development and management, it is clarified that improvement and strengthening of current organization and institution are necessary. This topic is discussed in Section 9.2. This section proposes fourteen (14) action plans according to four (4) policies for improvement and strengthening of organization and institution. Namely, 1) Cooperative Institutional Arrangement, 2) Participatory Management Administration, 3) Fair Regulatory Institutional Framework, 4) Decentralization and Coordination.

- **Strategy-2: Operation and Maintenance for Provision of Water Services**

  Provision of proper water services is most important item of water resources management. The M/P2013 proposes proper operation and maintenance regarding water resources development facilities such as dam, well, water supply facility and irrigation facility. Chapter 8 proposes operation and maintenance for water supply facility (Section 8.1.6) and for irrigation facility (Section 8.2.3). In this Chapter 9, Section 9.3 proposes proper operation and maintenance for water source development facilities (dam and well) and discusses the routine process of Monitoring - Prediction (Judgment) - Operation for operation and maintenance. Regarding dam's O&M, 1) Enhancement of Dam Management, 2) Improvement of Dam & Reservoir Operation and 3) Dam Safety Management are proposed. Regarding Well's O&M, 1) Aquifer Management, 2) Operation and Management of Borehole Facilities, 3) Pumping Capacity of Boreholes and 4) Borehole Construction system are proposed.

  Regarding this strategy, Hydrological Monitoring (Section 9.4), Water Resources Data and Information Database (Section 9.5), Management of Flood Plain (Section 9.6), Consideration of Risk Associated with Climate Change and Trans-boundary Water (Section 9.7) and Water Environment Management (Section 9.8) are discussed in detail.

- **Strategy-3: Allocation and Regulation of Water Resources Quantity and Quality**

  Allocation and regulation are important mandate of NIWRMC newly established. It is necessary to establish necessary institutions and systems required for licensing and regulation of water intake for new users. This topic is discussed in Section 9.9. This Section carries out analysis of current situation and framework related to water allocation and regulation, and proposes four (4) projects: namely, 1) CMP Formulation Project, 2) Capacity Development Project for Water License and Regulation, 3) Catchment Management Promotion Project and 4) Project for Preparation of Water Pricing Guideline.

- **Strategy-4: Facilitation and Improvement for Water Resources Management**

  This plan includes action plans to support and improve human resources and technology for water resources development / utilization / management, and also to promote effectively water projects. Regarding this strategy, Public Relations on Water Resources (Section 9.10), Public-Private Partnership (Section 9.11), Human Resources Development (Section 9.12) and Monitoring and Evaluation (Section 9.13) are discussed in detail.

In order to achieve proper water resources management, in the M/P2013, it is proposed to consider the improvement plan and method analyzing the current issues relating to management items shown in Figure 9-1.

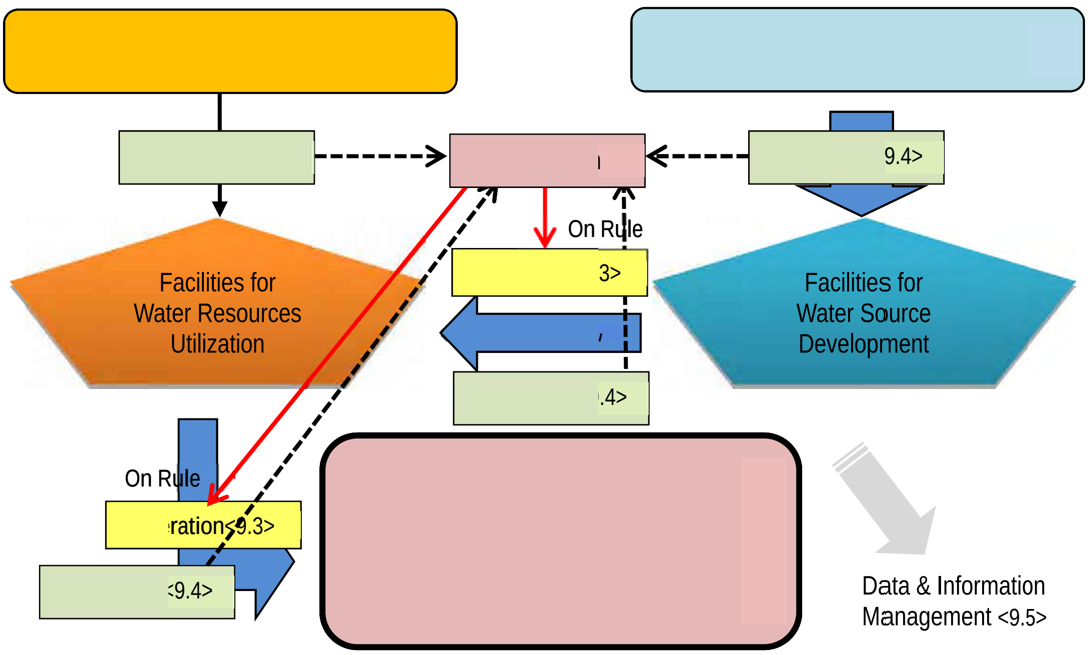
Objectives of Water Resources Management

Targets of Water Resources Management in Nigeria, i.e. “Effective Use of Water Resources”, “Mitigation of Flood and Sediment Disaster” and “Conservation of Water Quality” will be achieved on the basis of “Sufficiency, Efficiency, Equitability, Safety and Sustainability”.

Strategy-1 Organization and Institution for Water Resources Management

Management Item: 9.2 Organization and Institution for Public Water Services

Strategy-2 Operation and Maintenance for Provision of Water Services



Management Item:
9.3 Operation and Maintenance for Water Resources Development Facilities
9.4 Hydrological Monitoring
9.5 Data and Information Management
9.6 Management of Floodplain
9.7 Consideration of Risk Associated with Climate Change and Trans-boundary Water
9.8Water Environment Management

Strategy-3 Allocation and Regulation of Water Resources Quantity and Quality

Management Item: 9.9 Water Allocation and Regulation

Strategy-4 Facilitation and Improvement for Water Resources Management

Management Item:
9.10 Public Relations
9.11 Public-Private Partnership (PPP)
9.12 Manpower Development and Capacity Building
9.13 Monitoring and Evaluation

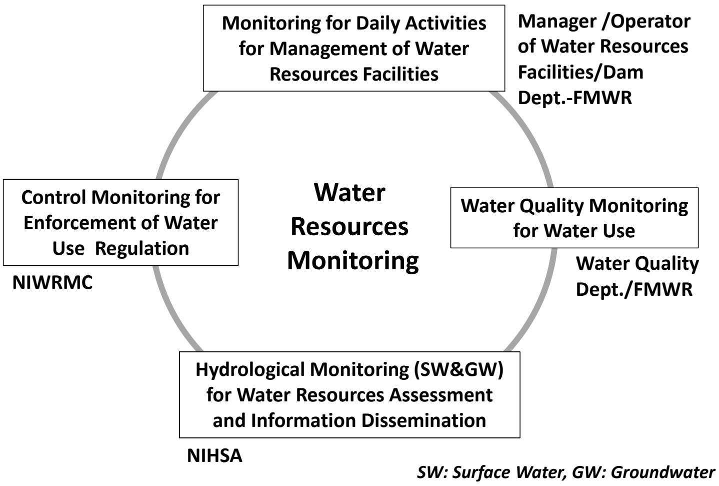
Source: JICA Project Team

Figure 9-1 Targets of Water Resources Management

9.1.2 Framework of Water Resources Monitoring

The water resources monitoring is one of fundamental elements for water resources management. The water resources monitoring is not limited to the hydrological monitoring, but covers other important aspects for proper management of water resources. The water resources monitoring includes the following four major components (see Figure 9-2), and these components are related and support each other.

- Hydrological Monitoring for Water Resources Assessment and Information Dissemination
- Water Quality Monitoring for Water Use
- Monitoring for Daily Activities for Management of Water Resources Facilities
- Control Monitoring for Enforcement of Water Regulation



Source: JICA Project Team

Figure 9-2 Four Major Components for Water Resources Monitoring

(1) Hydrological Monitoring for Water Resources Assessment and Information Dissemination

This is the most fundamental component in water resources monitoring, which includes surface and groundwater monitoring in rivers, water bodies and aquifer. Main objective is to grasp the hydrological condition in the management area. Based on the observed hydrological data, assessment of water resources can be conducted. The results of assessment may be used for water resources planning, design. The monitoring data should be used for the hydrological services which may include analysis of flood and drought situation. The processed hydrological data including the result of analysis for flood and drought should be disseminated to other stakeholders related to water resources.

Currently, the responsible organization of the hydrological monitoring for water resources assessment and dissemination is NIHSA. In the section 9.4 of this chapter, the current condition and direction of improvement on the hydrological monitoring by NIHSA are further discussed.

(2) Water Quality Monitoring for Water Use

It is necessary to monitor water quality of water source for safe water supply. Although the management including enforcement of pollution source is under jurisdiction of NESREA, it is necessary for water resources administrator itself to monitor water quality of water source to be utilized and the monitored information should be shared by stakeholders. The water quality and sanitation department of FMWR is responsible for monitoring water quality for water use. The existing condition and future direction of improvement of the water quality monitoring is discussed in Section 9.9.

(3) Monitoring for Daily Activities for Management of Water Resources Facilities

The water resources facilities such as storage dams, water headwork and boreholes are the water source facilities to distribute water for water users such as irrigation and municipal water. The managers of such water source facilities are responsible to its proper operation. RBDAs who manage the Federal dams are the typical managers of the water source facilities.

In order to utilize the facilities efficiently and effectively, the manager must monitor the operation of the facilities for implementing their daily activities including the decision making for the operation. The monitoring sometimes may include meteorological and hydrological information of the related areas. The monitored data should be shared to other stakeholders. The reporting on water use to the regulator of water, which controls the water allocation in the management area, is obligatory for maintaining the license for water use.

The current condition of the monitoring for daily activities for management of water resources facilities, represented by the monitoring of reservoir operation, is described in Section 9.3.

(4) Control Monitoring for Enforcement of Water Regulation

The regulator of water is to control the water allocation, thus regulating the water uses by various water users. The water regulator shall receive the report on the water use. The report is a kind of summary on self-monitoring by the manager of water resources facilities. To check the reported contents, the control monitoring by the regulator of water is required.

Currently, the responsible organization of the water regulation is NIWRMC. However, the actual activities for the control monitoring by NIWRMC has not yet been implemented, because its establishment law is still waiting the final approval of the president. It can be said that there is no control of water by regulator of water in Nigeria at this moment. There is only practical water allocation by the managers of water resources facilities such as RBDAs.

This situation and direction of improvement of water allocation and regulation by NIWRMC is discussed in Section 9.8 of this chapter.

(5) Management of Water-related Data and Information

The data management of water resources is related to all four components and their information sharing. The direction of establishing proper data management is discussed in Section 9.5 of this Chapter.

9.2 Organization and Institution for Public Water Services

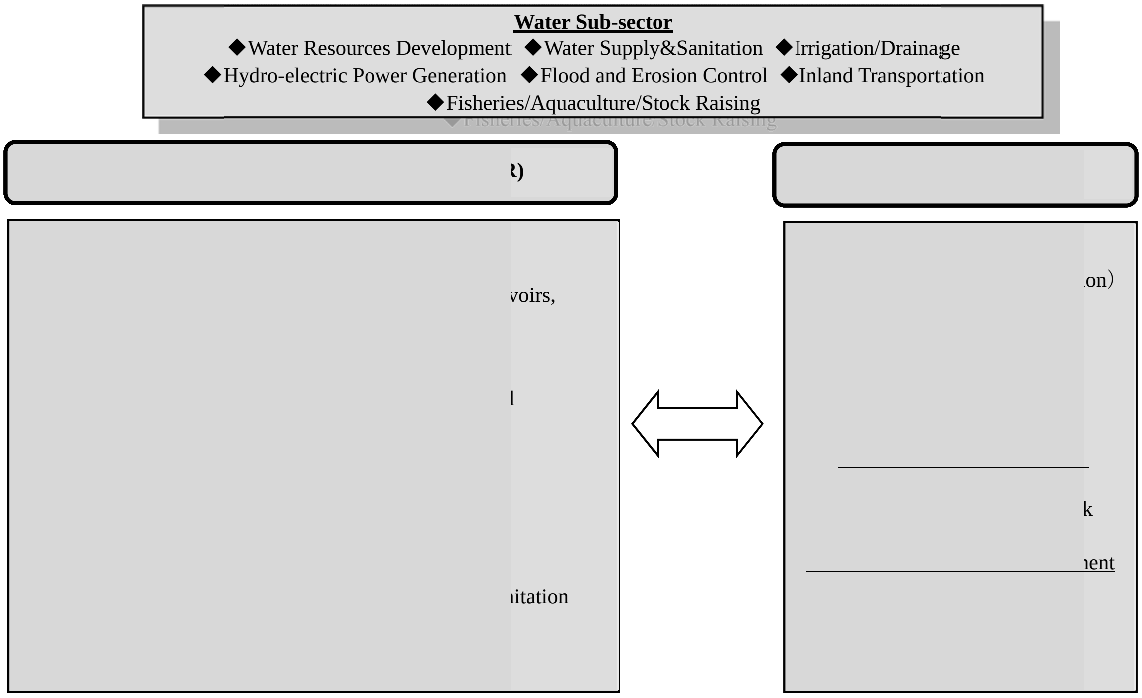
9.2.1 Current Situation

The current institutional situation in water resources sector in Nigeria was discussed in Section 1.3, Chapter 1. Notwithstanding the great achievements posted by FMWR in the past years, FMWR has many institutional challenges and problems as stated below.

(1) Overview of Institutional Responsibilities in Water Sector

Powers and functions of the institutions in water sector in Nigeria are enormously diversified and complicated. Of the various water sub-sectors, FMWR is responsible mainly for water resources development (surface and groundwater), water supply and sanitation, and irrigation and drainage. Other water sub-sectors such as hydro-electric power generation, flood and erosion control, inland transportation, fisheries/aquaculture/stock raising and mining are undertaken by Federal Ministries of Powers (FMP), Environment (FMEnv), Transport (FMT), Agriculture and Rural Development (FMA&RD), and Mining and Steel Development (FMM&SD) respectively.

The overall institutional framework in water resources sector in Nigeria is illustrated below.



Source: JICA Project Team

Figure 9-3 Overall Institutional Framework of Water Resources Management in Nigeria

Under the present institutional arrangement in water sector where the powers and functions are overlapped or duplicated in different institutions, the severity and significance of the institutional problem has become increasingly evident. For instance, Federal Ministry of Environment (FMEnv) is responsible for setting up policies on water quality, sanitation and pollution control including water quality standards and guidelines. On the other hand, in the same water sub-sector, the Department of Water Supply of FMWR is responsible for the execution of policies and guidelines, monitoring and coordination of water supply programs nationwide. In addition, the Department of Water Quality Control and Sanitation of FMWR is separately responsible for safe water supply through water quality control, water sanitation technology and monitoring and evaluation. Taking hydropower generation sector as another example, Federal Ministry of Power (FMP) and the Nigerian Power Holding Company (NPHC) work together for the development and operation of federal dams to be designed for hydro-electric generation purpose. On the other hand, the Department of Dams and Reservoir Operation which is one of the operational departments of FMWR is asked to undertake the responsibilities for nation’s dam development policies, planning, design, execution and maintenance of dams. It must be noted that the most dams and associated structure including hydropower facility on rivers constructed by FMWR and RBDAs are designed for portable water supply, supply for irrigation water, fisheries, and livestock, and for multipurpose use as well. Concerning flood control, FMEnv is mainly responsible for flood control nationwide. However, FMWR is individually responsible for construction and operation of dams and reservoirs not only for the purpose of storing water for various economic uses but for flood control purpose. There are some other institutions who work in the sector related to flood and erosion control – such as NIHSA, NIMET, etc. As a result, many institutions have difficulties in ensuring cooperation and coordination in the course of water resources management, and thus call for an adequate and closer cooperation and coordination among the institutions.

In addition to the federal institutions, the state and local governments are also individually responsible for the water resources development and management at respective status. Namely, FMWR shall take nationwide responsibilities for overseeing protection, use, development, conservation and management of water resources. On the other hand, the state governments such as State Ministry of Water Resources, Environment or Rural Development are in charge of overall management in water resources sector at the state level. However, their water resources development and management are also confronted with many challenges and problems. For instance, in the water supply and sanitation field, a major problem is a weak institutional and regulatory framework for managing the activities of the State Water Agencies such as the State Water Boards or Corporations, Small Towns Water Supply, and Sanitation Agency (STWSSA) , Rural Water Supply and Sanitation Agencies (RUWASSA), etc., leading to inconsistency and fragmentation in the management of water resources at the state and local levels.

(2) Challenges and Problems

Institutional challenges and problems are summarized below.

1) Overlapping and Duplication of Powers and Functions

FMWR has power relating to grant licenses for water abstractions and allocation. At the same time, RBDAs and the Nigerian Inland Waterways Authority which is an agency of FMT are given overlapping responsibilities for matters relating to water resources management such as issuance of water licenses, etc. The same phenomena are observed for matters relating to roles of collecting and storing hydrological data, water quality control, etc. in some institutions. So, it is hopeful that the National Water Resources Bill which is now under preparation will address all matters relating to overlapping or conflicts of the mandates based on clear and coherent regulations.

2) Lack of Adequate Cooperation and Coordination among Institutions

Bureaucratic approach or top-down approach in management especially in the federal institutions which has resulted in absence of adequate cooperation and coordination among the institutions is one of the real causes of the problem of inefficient and unreliable implementation of projects and programs. This situation calls for facilitation of a dialogue such as regular meetings among the institutions for accomplishing smooth running of the institutional structure of FMWR.

3) Absence of Management at Basin and Catchment Level

The National Water Policy (Draft) indicates that the Water Decree No. 101 of 1993 does not adequately meet present water resources management challenges and requirements, and shows clearly that water resources management shall be done in an integrated manner with strong involvement of beneficiaries in all aspect of development and management of water resources. It continues to saying that river basin organizations have to be developed in the eight (8) hydrological zones of Nigeria as the most appropriate unit in which management at basin and catchment level can be done in these zones. In the light of the aforesaid Policy document, it is important to strengthen a participatory management where all stakeholders such as the government, private sector, population, etc. are participated in water resources development and management.

4) Weak Regulatory Framework for Managing Water Resources

Planning, management and regulation in the river basins with integrated and participatory approach is a central principle for IWRM. NIWRMC which was established in 2007 as a regulatory body is strongly expected to play an important role in effectively carrying out the requirements of IWRM. On the other hand, it appears that RBDAs are not water resources management bodies. They are implementing agencies for the federal government with particular focus on water supply for irrigation. However, as already discussed, the delay in assenting to the NIWRMC Bill becomes a major constraint in executing all the functions of NIWRMC.

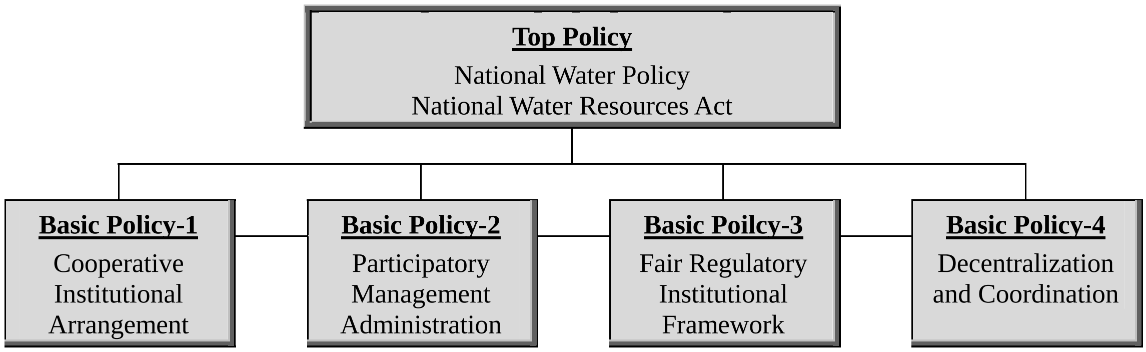
9.2.2 Suggestion

(1) Objectives of Development and Strengthening Institutional Framework

The specific objective of institutional development and strengthening is to carry out water resources management based on IWRM approach with an aim to efficiently and effectively execute the projects and programs contained in the M/P2013.

(2) Basic Policy

To accomplish the above-mentioned objective, we strongly suggest the following basic policies for institutional development and strengthening, as illustrated in Figure 9-4.



Source: JICA Project Team

Figure 9-4 Basic Policies for Institutional Development/Strengthening

Basic Policy-1: Cooperative Institutional Arrangement

FMWR has been collaborating with other federal institutions that are associated with water resources activities such as FMEnv, FMA&RD, FMP, FMT, etc. In addition, the institutional arrangement is such that three tiers of government, Federal, States and LGAs are involved. Under such institutional framework, lack of cooperation and collaboration among the institutions had prevented from carrying out their tasks efficiently and effectively.

In the light of this situation, from long-term viewpoint, it is desirable to consider institutional rearrangement taking into account the national water resources policy, strategies and legislation contained in the National Water Policy and the National Water Resources Act (Bill). However, FMWR is required, as a first and prioritized action, to take steps to promote a robust cooperative institutional arrangement. It must be noted that the national water resources bill that is still in process is expected to serve as the legal basis for this step. It is also important that the Department of Planning, Research and Statistics of FMWR will act as focal point for any activities that are concerned with this step.

Basic Policy-2: Participatory Management Administration

A bureaucratic or top-down approach in water resources management prevents the people from active participation in water resources development and management. As a result, for instance, there were such projects in water supply and sanitation sector that did not meet the users' needs and purpose. It is therefore important to change the approach of water resources management from top-down to bottom-up approach where all stakeholders including governments (federal, states and LGAs), have understanding and cooperation among all stakeholders, considering end-users of water in investment, maintenance and rehabilitation of water infrastructure including its financial burden. It is further important, to promote awareness of participation of people and other stakeholders in water issues that affect people' lives such as water, sanitation, gender and so on. CMOs, State and LGAs are expected to play important roles for this purpose.

Basic Policy-3: Fair Regulatory Institutional Framework

It must be emphasized that IWRM calls for a fair regulatory framework with the principles of planning, management and regulation at the river basin level as the most appropriate unit of water resources management. Particularly, it must be highlighted that of the various powers and function for water regulatory bodies, management and regulation on issuing licenses for water abstractions and allocation is one of the key functions. NIWRMC and its subsidiary CMOs are required to deliver adequately these powers and functions in collaboration with other relevant river basin institutions such as NIHSA, NWRI and RBDAs, etc. Capacity development for the staff who is involved in these activities as Regulators is highly required.

Basic Policy-4: Decentralization and Coordination

The merits for transferring the powers and function of FMWR to the State and LGA levels are considered below.

- It is expected to increase the benefits to the beneficiaries such as the people and communities as the development and management of water infrastructure are to be implemented to match the capacity as well as willingness and wish of the communities
- It is also expected to facilitate an efficient and effective institutional structure in water resources sector in Nigeria as a whole, as it must provide clear and rational definitions of roles and responsibility for each ministry and agency and the relationship of sector institutions.

In order to promote smooth decentralization, FMWR shall consider the followings:

- FMWR - an apex organ of the government at federal level in water resources sector shall continue to deliver the nationwide responsibilities for overseeing the protection, use, development, conservation and management of water resources in Nigeria.
- Development, operation and maintenance of water infrastructures in the area of Trans-Boundary River or in such areas as affects more than one state shall be managed directly by FMWR.
- It is desirable in the future that the state and local governments including state water agencies will have more autonomy for the implementation of projects and programs in water supply and sanitation sector in order to boost efficiency, performance and sustainability. FMWR is expected to provide the states or LGAs with various assistances and support in order to achieve the goals and objective that are articulated in the policies and strategies of each state government, especially for achievement of MDGs. Assistance and support by FMWR shall include development of policy and strategy and capacity buildings thereof, and financial assistance to state governments, especially to the major ESA (External Support Agencies) supported projects and programs which will be carried out in line with the national strategies.
- With respect to the development and operation of public irrigation systems, as a goal to be achieved from middle to long term, transfer of powers and function from the existing institutions to new irrigation management authorities needs to be considered. However, the matter at hand for most RBDAs is to launch activities that will help improvement of operational and managerial capacity including strengthening of financial sustainability.
- Transfer of powers and functions of FMWR to the state or LGA levels must be evolved in a phased manner where possible, taking into account the administrative, technical and financial capabilities of receiving institutions.

(3) Action Plan

Based on the basic policies mentioned above, the Project suggests the action plans as shown in Table 9-1. It must be noted that no distinguished differences among the action plans in terms of priority for implementation are identified. It implies that it is believed to be ideal to take up all action plans at the same time as earlier as possible in the course of the M/P2013. However, in reality, taking into consideration disparity or different constraints that for each institution, it is advisable as a realistic approach to launch available activities according to plan. It must be also noted that the prioritized target group for the action plan is mostly FMWR including its parastatals and agencies.

Table 9-1 Action Plan for Institutional Development and Strengthening

No.	Activities	Leading Institutions
	【BASIC POLICY - 1】COOPERATIVE INSTITUTIONAL ARRANGEMENT	
1.1	【Challenge/Problem】 Incompletion of National Water Policy 【Activity】 ● Completion, Approval, Publication and Dissemination of National Water Policy to replace Water Decree No.101 of 1993	NCWR/Dept. of PRS/ NIWRMC/RBDAs
1.2	【Challenge/Problem】 Incompletion of National Water Resources Act 【Activity】 ● Completion, Approval and Promulgation of National Water Resources Act ● Based on National Water Resources Act, review and revision of relevant laws and regulations to manage the nation’s water resources	NCWR/Dept. of PRS/ NIWRMC/RBDA
1.3	【Challenge/Problem】 Lack of Collaboration among Institutions among Relevant Institutions 【Activity】 ● Enlargement and evolvement of collaborative arrangement among relevant institutions in water sector through promotion of periodic meeting among key stakeholders to address common issues for water resources management	NCWR/Dept. of PRS/ NIWRMC/RBDAs
1.4	【Challenge/Problem】 Improvement of Data and Information Management System on Water Resources 【Activity】 ● Establishment of institutional framework to share hydrological data etc. among relevant institutions ● Development and Improvement of institutional framework for Integrated Monitoring and Evaluation System	NCWR/Dept. of PRS/ NIWRMC/RBDAs/ NIHSA/FMEvn/ NIMET/State MDAs
1.5	【Challenge/Problem】 Development of Institutional Framework for Implementation of Comprehensive Projects and Works which call for Integration of Various Sectors 【Activity】 ● Creation of task forces under FMWR for specific national comprehensive projects and programs	NCWR/Dept. of PRS/ NIWRMC/RBDAs/ NWRI/NIHSA/Federal Ministries Concerned
	【BASIC POLICY - 2】PARTICIPATORY MANAGEMENT ADMINISTRATION	
2.1	【Challenge/Problem】 Promotion of Public Awareness and Social Mobilization for Participatory Management of Water Resources 【Activity】 ● Organization of nationwide survey on public opinion and reaction on water issues, and formulation of data-base on survey results for preparing better awareness programs, etc. ● Organization of workshops and seminars to incorporate people’s awareness for water conservation and management	NIWRMC/COMs/ RBDAs/NIHSA/ State MDAs/CBOs
2.2	【Challenge/Problem】 Inadequate Catchment Management 【Activity】 ● Creation of comprehensive institutional framework involving all stakeholders for implementation of adequate Catchment Management Plan ● Promotion of Collaboration among partner government and other organizations through closer dialogue and greater interaction of CMOs with other basin organizations (CMCC, etc.)	NIWRMC/COMs/ RBDAs/NIHSA/ State MDAs/CBOs
2.3	【Challenge/Problem】 Mainstreaming of Water Related Issues such as Health, Gender, Poverty, Human Rights, etc. 【Activity】 ● Assistance and support for educative campaign and other tools and policies on water, sanitation, gender, empowerment, etc. in collaboration with relevant institutions (Federal Ministries of Health, Women Affairs, etc.)	PR Unit/ Gender and Human RightsUnit/ Dept. of PRS/ NIWRMC/NWRI/ State MDAs
	【BASIC POLICY - 3】FAIR REGULATORY INSTITUTIONAL FRAMEWORK	
3.1	【Challenge/Problem】 Weak Legal Regulatory Framework (Legal Backing) 【Activity】 ● Completion of legislative process and enactment of NIWRMC Bill as a primary basis of legal regulatory framework ● Review and revision of relevant laws and regulations including powers to grant licenses for water abstractions and allocation (RBDA Act, NIWA Act, Mineral Act, etc.)	NCWR/ Dept. of PRS/ NIWRMC/RBDAs/ FMT/FMM&SD

3.2	【Challenge/Problem】 Weak Regulatory Framework (Powers and Functions of NIWRMC) 【Activity】 ● Establishment of operational procedures for effective regulatory framework of NIWRMC and CMOs considering Catchment Management Plan in collaboration with other relevant basin institutions such as NIHSA, RBDAs, NWRI, etc.	NIWRMC/ CMOs/RBDAs/NIHSA/NWRI/ Dept. of PRS/ State MDAs
3.3	【Challenge/Problem】 Weak Regulatory Framework (Institutional and Human Resources Capacity Building and Enhancement) 【Activity】 ● Strengthening of institutional capacity of NIWRMC and CMOs based on needs assessment and development for capacity building ● Undertaking of recruitment, education and training for the staff (leader, technical and managerial staff, etc.) for IWRM in the basin	NIWRMC/CMOs/ Dept. of HR/ Dept. of PRS/ NIHSA/RBDAs/NWRI
	【BASIC POLICY - 4】DECENTRALIZATION AND COORDINATION	
4.1	【Challenge/Problem】 Improvement of Sustainability and Performance in Water Supply and Sanitation Sector considering Decentralization to State Agencies and LGAs 【Activity】 ● Encouragement of State Agencies (Water Boards, STWSSA, RUWASSA, etc.) and LGAs to boost efficiency of projects and programs through provision of technical assistance and support from federal institutions ● Preparation and dissemination of national technical guidelines and manuals etc. to ensure good quality standards in water supply and sanitation undertakings by states and LGAs ● Assistance and support for development of institutional arrangement at state level on PPP promotion in the Sector in consultation with concerned federal institutions	NCWRI/Dept. of PRS/ PPP Unit/NWRI RBDAs/NIWRMC/ State MDAs/ICRC/NESREA
4.2	【Challenge/Problem】 Optimization of Function of RBDAs in Irrigation and Drainage Sector 【Activity】 ● Improvement in operation and management of RBDAs (budget, water charges system, auditing on operation, etc.) ● Promotion of collaboration between RBDAs and the stakeholders such as farmers, Water User Association, etc. with respect to water resources for irrigation and agriculture development ● Updating of RBDAs functions in consistence with national policy documents such as National Water Policy	NCWR/RBDAs/ NIWRMC/ Dept. of PRS/PPP Unit/ ICRC
4.3	【Challenge/Problem】 Inadequate Skilled and Experienced Technical Staff 【Activity】 ● Establishment of National Water Resources Capacity Building Network (NWRCBNet) in various states of the country under the coordination of NWRI ● Capacity development for PPP capacity at various level of government to cope with inadequate funding of the water sector due to lack of private sector participation	NWRI/ Dept. of HR/ Dept. PRS/ PPP Unit/ State MDAs/ICRC

[Note]
NCWR: National Council on Water Resources/Dept. of PRS: Department of Planning, Research and Statistics of FMWR/NIWRMC: Nigeria Integrated Water Resources Management Commission of FMWR/RBDAs: River Basin Development Authorities of FMWR/NIHSA: Nigeria Hydrological Services Agency of FMWR/FMEvn: Federal Ministry of Environment/NIMET: Nigeria Meteorological Agency of FMEnv/State MDAs: State Ministries and Agencies /CMOs: Catchment Management Offices of NIWRMC/CBOs: Community-Based Organizations/PR Unit: Press and Public Relations Unit of FMWR/Gender and Human Rights Unit: Gender and Human Rights Unit of FMWR/NWRI: National Water Resources Institute of FMWR/ICRC: Infrastructure Concessionaire Regulatory Commission/PPP Unit: Water Sector Reform and PPP Unit of FMWR/CMCC: Catchment Management Coordinating Committee/LGA: Local Government Authorities or Areas/NESREA: National Environmental Standards and Regulations Enforcement Agency of FMEnv/NIWA: National Inland Waterways Authority of FMT/STWSSA: Small Town Water Supply and Sanitation Agencies/RUWASSA: Rural Water Supply and Sanitation Agencies
Source: JICA Project Team

9.3 Operation and Maintenance for Water Resources Development Facilities

9.3.1 Surface Water Development Facilities

(1) Current Situation

Dams and reservoirs are important facilities for the development of surface water resources. However, they do not automatically start functioning at 100% capacity upon construction and completion, as dams and reservoirs are civil engineering structures, which can function fully only with proper operations and maintenance after their completion. In other words, we must first recognize the fact that they are "civil engineering structures, which cannot function as intended without proper daily management." "Study on the present conditions of the dams" and the analysis of the results thereof under this Project revealed that almost all dams and reservoirs in Nigeria needed improvement toward more "proper operations, maintenance, and management." Consequently, the Project makes suggestions for "Enhancement of dam management", "Operations of dams and reservoirs" and "Dam safety management".

(2) Suggestion

(2-1) Enhancement of Dam Management

Dams serve diverse purposes, including flood control, water supply, irrigation, and power generation. Regardless of the purpose, dams need to be managed with respect to the following basic aspects:

- Dam structures and facilities
- Reservoirs
- Reservoir water level control (high water/low water-level operations)

Table 9-2 Configuration of Dam Management

Contents	Item	Dam management situation in Nigeria
The management of the facility of the dam body	Dam body, Administrative road, Discharge facilities, Water intake facilities, Private power generation facilities	Almost management has not been done. Kainji, Jebba, and Shiroro dam and some other dams have been managed, but it is still not completed.
Management of dam reservoir	Sedimentation; Water quality; Lakeshore	Almost management has not been done
Controlling and operation of the dam reservoir	Reservoir observation and recording; inflow observation and recording; other hydrological observation and recording; recording of gate operation; Transmission of information to downstream	Except Kainji, Jebba, and Shiroro dam, most of dams have not been managed and recorded.

Source: JICA Project Team

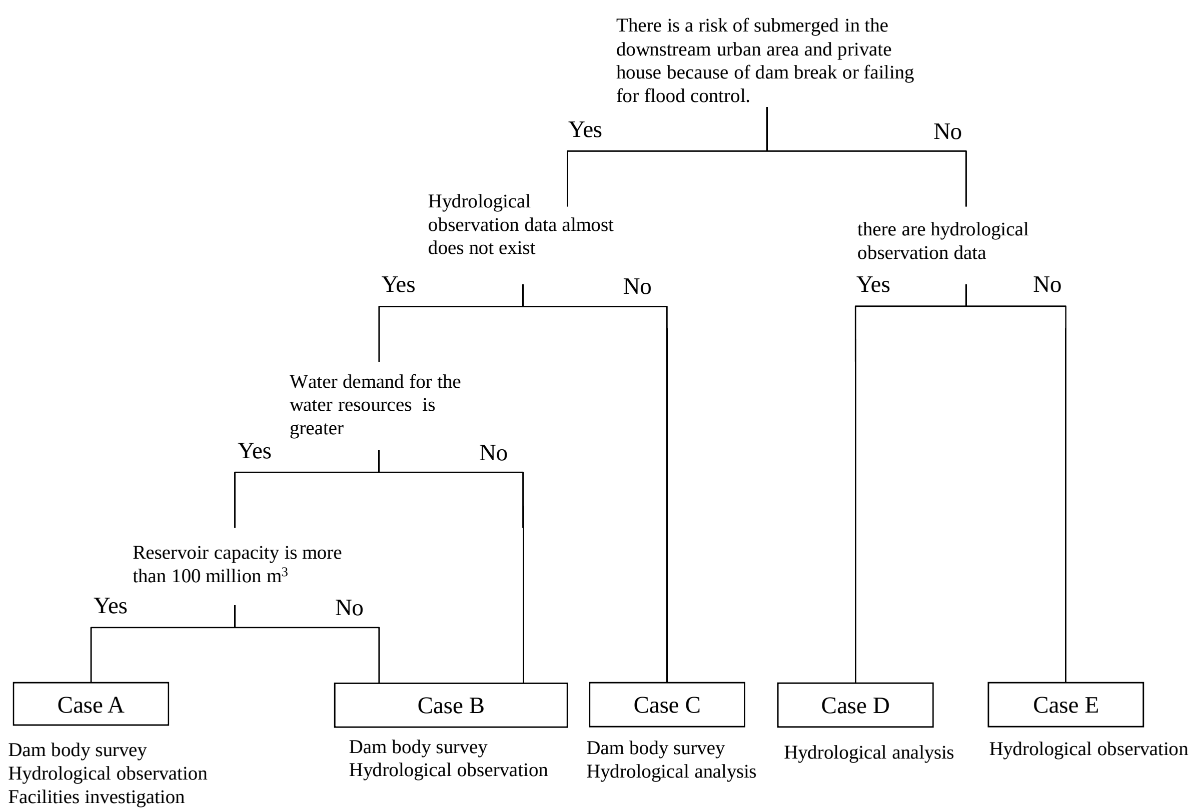
Principally speaking, organizational structures and facilities that allow prompt and proper implementation of the above management activities must be in place at the same time when the dams are completed. As the management statuses of the existing dams are extremely poor, the Project proposes to improve the management system starting with high priority dams by following the workflow shown in Table 9-3 and Figure 9-5.

As each dam has no manual for operation and maintenance. (It means that nobody knows how to operate and maintain the dam.) Also, the Project proposes that all the dams must prepare "Dam Management Manual" and manage properly the daily operation and maintenance according to the manual. The items written in "Dam Management Manual (Draft)" are as shown in Table 9-4.

Table 9-3 Necessary Survey for Dam Management

Case	Necessary Survey& Investigation	Explanation
A	- Dam Body Survey - Hydrological Observation - Facility Investigation	As the dam (Large scale and important for water resources development) has a risk of dam break or failing and no hydrological observation data, it is recommendable to implement immediately "Dam Body Survey", "Hydrological Observation" and "Facility Investigation"
B	- Dam Body Survey - Hydrological Observation	As the dam is smaller scale than Case-A, it is recommendable for the moment to "Dam Body Survey" and "Hydrological Observation" to confirm dam safety and accumulate hydrological data.
C	- Dam Body Survey - Hydrological Analysis	As the dam has risk of dam break or failing, immediately start "Dam Body Survey". Also it is recommendable to make a "Hydrological Analysis" by using accumulated hydrological data, for optimum dam operation.
D	- Hydrological Analysis	As the dam has accumulated hydrological data and a few risk of dam break or failing, it is recommendable to make a "Hydrological Analysis" for optimum dam operation.
E	- Hydrological Observation	Dam has no hydrological observation data. Immediately start "Hydrological observation"

Source: JICA Project Team



Source: JICA Project Team

Figure 9-5 Study Flowchart of Priority for Improving Ripeness of Dam Management

Table 9-4 Items written in Dam Management Manual (Draft)

Major items	Small items	Contents	Remarks
Definition of the dam managerial responsibilities	Division of roles of dam administrative staff	Stipulating the positions and responsibility of dam administrative staff (division of roles, responsibilities)	Responsibilities (division of roles and responsibilities) shall be assumed for each state in normal, flood, abnormal, emergency and inspection.
Controlling and operation of the dam reservoir	Hydrological observation	Defining the types of hydrological data and its contents that should be managed in dam. Furthermore, measurement frequency and responding in case of failure.	Determine the compiling style of hydrological data. Unifying the style on all dam in Nigeria
	Hydrological record	Defining the types of hydrological data, its contents and measurement frequency that should be recorded in dam	Determine the compiling style of hydrological data and dam body information. Unifying the style on all dam in Nigeria
	Operation record of valve and gate	Defining the recording method of the operation of valve and gate	Determine the recording style of gate opening. Unifying the style on all dam in Nigeria.
	Dam operation rules (Flood control) (Supplemental irrigation)	Defining the operation rules of reservoir in rain season and dry season	Stipulating the operation rules like the ones as a case study shown in Kainji, Jebba and Shiroro Dam.
	Means for transmitting information to the downstream	Defining the communication method and content to the downstream residents and related organizations during discharge, emergency and abnormal of dam	
Dam body facility	Observation and recording of dam body information	Defining the type of measurement data of leakage and deformation, measurement frequency, the recording method for verifying the safety of the dam body	Determining the compiling style of data. Unifying the style on all dam in Nigeria
	Inspection, maintenance	Defining the item and frequency for inspection and maintenance the content of dam body and accessory equipment.	Determining the record style of content for inspection and maintenance. Unifying the style on all dam in Nigeria Here, the content of the inspection and maintenance including dam body, managing road, gate, electrical equipment and all relative facilities.
Dam reservoir	Water quality	Defining the types of water quality data and its contents that should be managed in dam.	Determining the compiling style of data. Unifying the style on all dam in Nigeria
	Sedimentation	Defining the method and frequency of measuring the sediment yield in dam	Determining the compiling style of data. Unifying the style on all dam in Nigeria
	Lakeshore	Defining the item and frequency for inspection and maintenance the content to the reservoir shore	Determining the record style of content for inspection and maintenance. Unifying the style on all dam in Nigeria

Source: JICA Project Team

(2-2) Operations of Dams and Reservoirs

It cannot be said that dams in Nigeria are managed properly to supply water for irrigation and municipal uses. Clearly defined rules for operating the dams and reservoirs to supply water for water users are mostly nonexistent. The amount of water needed for irrigation and municipal uses is supposed to fluctuate greatly depending on the present demand of each sector. If, for instance, the population of the service area had reached only 50% of the prediction, the water supply volume (or the reservoir capacity) would only need to be half the planned volume (or capacity).

Conventionally, water from a dam is supplied to users in the form of water rights. Each water user applies for water rights by submitting a rationale for the calculation of present water demand to the river administrator, who, upon rigorously examining the rationale, will appropriate a certain amount of water to the applicant user by granting him water rights. The water user will then send a daily request to the dam administrator to supply a certain amount of water within his water rights volume. Upon receiving the request, the dam administrator will determine the supply volume of the day by taking comprehensively into account the day's river flow and reservoir levels, as well as the future river flow predictions, and manipulate the dam to release an appropriate volume of water. Normally, dams during low water regimes are managed by repeating this procedure daily.

If the Project tried to apply a similar low-water management method to the dams in Nigeria, the Project would encounter various problems including the following:

- First of all, water (agricultural and municipal) users cannot determine how much water they currently need, nor does anyone know exactly who is responsible for determining the water demand. In addition, a method to precisely calculate how much water to release from the dam has not been established.
- Even if requests were issued by the users, the dam administrators would not have the means to calculate how much water to supply based on the downstream flow condition, etc., as evidenced by the fact that the inflows, outflows, and reservoir levels are currently not measured by most of the dams.
- It is not clear as to who should take the initiative in coordinating the interests of different users when a dam reservoir has more than one user or when adjusting supply volumes from multiple dams (RBDAs and state-owned) within a basin. This is especially the case during dry river regimes.
- For successful low-water management, it is essential to collect and analyze a wide range of hydrological data, which also relates to the proper management of water resource data and information. However, when the data administrator is not the same person as the dam administrator, it is not clear who is responsible for conducting hydrological analysis, as well as how and through what channels the information is conveyed and disseminated.
- Most of the dams do not have decently-functioning hydrological equipment, nor do they repair the equipment if it breaks down. In addition, most of them do not properly measure the discharge volume for each user.

Described below are the points to be improved by the water users (the demand side) and the dam administrators (the supply side that manipulates the valve). Table 9-5 shows the future directions to be taken for improving these water resource facilities. As indicated in the Table, these issues relate not only to "the relation between dam administrators and water users" but also to "organizations and systems," "management of water resource data/information," and "agencies related to water rights," with whom issues need to be discussed and coordinated widely. In the future, it is important to involve these stakeholders in discussions to actively discuss and deeply explore how to operate the water resource facilities in ways appropriate for the legal and administrative systems of Nigeria.

Table 9-5 Directions for Future Improvement of Water Resource Facility Operations

Theme	Current Problems	Future Directions for Improvement
Relation between water users and dam administrators	In determining the water supply volume, consultation and coordination between dam administrators and water users are needed on a daily basis.	Dam administrators and water users need to make a conscious effort to have close daily communication and establish a system to allow such communication.
Water rights	The water rights volume of each user needs to be managed properly.	Careful discussions are needed for determining various issues regarding water rights, including the granting thereof, as water rights are important factors in water supply control.
Coordinating agency	When multiple dam administrators and water users are involved, it is not clear as to who should take the initiative in coordinating different interests.	In light of the legal and administrative systems of Nigeria, it should be discussed as to which river administrator, such as the Ministry of Land, Infrastructure, Transport and Tourism in case of Japan, should act as the coordinator.
Hydrological data management	No system has been established to measure, manage, and convey hydrological data. Also, it is not clear which agency is responsible for administering such data.	As collection, analysis, and transmission of hydrological data are essential for low-water management, it should be discussed as to how to establish a new water resource information management system based on the problems of the current system.
Dam measuring equipment	Dam measuring instruments, which are important hydrological management tools, are not functioning.	Hydrological equipment of each dam needs to be rehabilitated.

Source: JICA Project Team

(2-3) Dam Safety Management

1) Safety Management of Dam Structures

Most of the dams in Nigeria are earth-fill dams. In ensuring the safety of fill dams, the Project need to pay the greatest attention to piping, which is caused by deformation of or damage in the dam structures. As pointed out in the results of the subcontracted survey, cracks or shrubs that could cause cracks were found in many dams. Also, seepage is measured at almost no dams. In order to ensure safety, the structures of the above-mentioned high-priority dams need to be investigated.

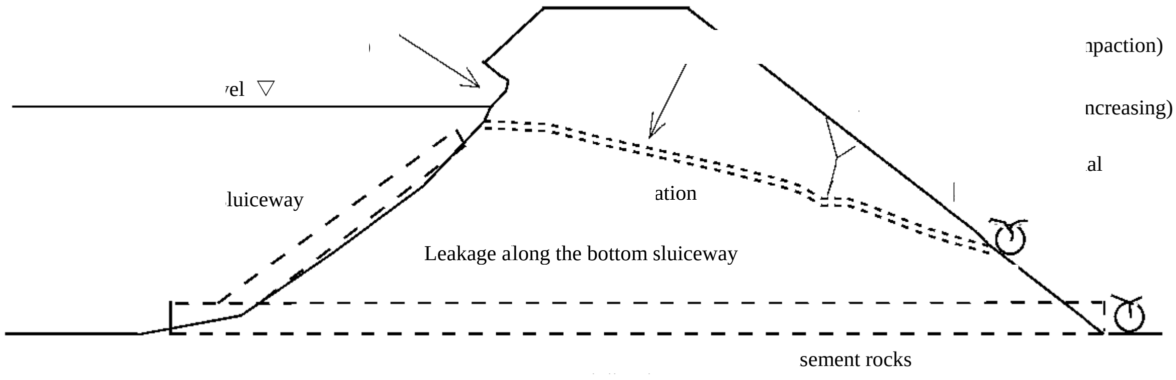
High-priority management works are as follows:

- Measure seepage.
- Remove (crack-causing) shrubs.
- Check the upstream side of dam structure.

Cracks, etc. should be repaired after examining the safety status and determining the appropriate corrective measures. It is also important to point out that a transportation means (an administrative vehicle) for patrolling and managing the dam structures will be needed, as many of the dams in Nigeria have long crests. In addition to dam structures, the following dam-related facilities will need safety management.

According to the results of the subcontracted survey, no major problem seems to exist in discharge facilities such as spillway gates and control devices. Maintenance work on these facilities seems to be conducted more or less periodically because failure to discharge water due to broken spillway gates could lead to serious consequences. However, broken and unrepaired hydrologic instruments, which do not directly affect the safety of dam structures, were found in many dams.

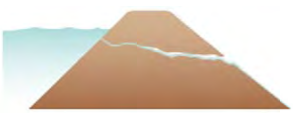
In view of the above, safety management of these facilities, including spillway facilities, backup power systems for outages, and hydrologic equipment, need to be studied extensively along with that of dam structures, especially with regard to high-priority dams.



Source: JICA Project Team

Figure 9-6 About Safety of Earth Dam Body

Table 9-6 Sound Diagnosis for Earth Dam

	Leakage from the dam body	Cave-in and cracks in the dam body	Cross-sectional deformation
Schematic diagram			
Causes and features	Leakage from the dam body usually come from banking part of dam body, the boundary between dam body and the foundation ground or on both sides ground, as well as facilities of crossing the dam body such as spillways and bottom gutter. Of these, the capability of piping is high if leakage occurs at local.	Cause leakage piping is often caused by crack	Damaged of the upstream slope protection works by the waves; dam body is weakened due to downstream surface erosion as slope erosion, rainwater and water leakage
Criterion of improvement in Japan	When the amount of leakage from the dam body is more than 60 liters per minute per 100m crest length at high water level When reservoir level in certain cases, the amount of leakage is increased by more than 10% during a month	When the deformed by the area ratio is more than 5% compared to the initial cross section of dam body	when lacking stability in steep slope

Note: "Causes and features" and "criteria for improvement" are based on actual cases in Japan.
Source: JICA Project Team

Table 9-7 Required Safety Management Facilities other than Dam Body

Item		Main facilities
Outlet facilities	Outlet facilities	Spillway, Gate
	Intake works	Intake tower, Valve、Diffuser
Facilities management support	Operation control device	Control device, gate indicator
	Electrical equipment	Electrical substation equipment, Power generation facilities, Load equipment(Lighting, power equipment)
	Observation facilities	Rain-gage, Water level indicator, Evapotranspiration amount
	Communication equipment	Radio equipment, Wired equipment, Internet
Incidental equipment	Dam administration office, etc.	Housing management, garage, patrol vehicle, Dormitory
	Power generation facilities	Waterwheel, generator, Power transmission facility, etc.

Source: JICA Project Team

2) Safety Management of Reservoirs

The Project could not obtain data regarding yearly sedimentation or hydrological observation. It is likely that periodic measurements are not taken at these dams. According to the personnel of each dam the Project interviewed, their greatest concerns were aquatic grass and hyacinth followed by sedimentation. Aquatic grass, etc. are probably caused by eutrophication of reservoir water, against which various measures need to be implemented to improve both stored and inflow waters. At any rate, it is important to measure and accumulate data on the water quality of dam lakes, as they provide important information for examining possible improvement measures.

Measurement of sedimentation, etc. tends to be costly, as reservoir areas of Nigerian dams are especially large. Nevertheless, it is important to keep record of yearly sedimentation rates and accumulate data through simplification by, for example: 1) taking measurements not every year but only after major floods, or 2) taking measurements only at topographically characteristic points to reduce the number of survey lines. Such accumulation of data will enable long-term forecasts of sedimentation and provide vital information for examining possible solutions. In managing the safety of dam reservoirs, it is important to take and keep record of water quality and sedimentation on a continuous and consistent basis.

3) Safety Management of Dam Reservoir Operation

A dam reservoir operation is an operation to control the volume of water released from a dam through its discharge facilities. There are two types of discharge control.

High water operation: Performing flood control, to protect the downstream region from flood damage

Low-water operation: Controlling the mount of inflow and discharge during non-flood period, irrigation supply, and while performing the operation to recover reservoir level quickly if possible

As described in the earlier section that examined the reservoir operation records of Shiroro and Kainji Dams, dams in Nigeria tend to give priority to storing (replenishing) water during rainy season, as they need to do so in order to supply water during dry season. This is more or less inevitable because they have the responsibility to store enough water in preparation for the long dry season. In their current low-water-level operation, they are opening and closing valves by relying on intuitive judgment without regard to the yearly flow regime, which is not desirable. Ideally, it is important to maintain a proper reservoir water level by controlling discharge in coordination with the discharge operation of other dams while forecasting the yearly flow regime to a certain degree.

For implementing such advanced high-water/low-water operations as described above, effective operation manuals, which are supported by the analysis of long-term actual data, need to be established (as part of the above-mentioned dam management manuals to be drafted in the future). However, none of the dams studied by the subcontracted survey have operation manuals that provide specific instructions as to how to control discharge during the high-water and low-water periods. The urgent task at hand is to draft such dam operation manuals (as part of the above-mentioned dam management manuals), for which, needless to say, long-term data on reservoir water level, inflow, precipitation, and outflow, as well as those of existing dams nearby, if any, are indispensable.

However, as far as the results of the subcontracted survey are concerned, most of the dams, except for the three major hydropower dams, either do not have accumulated data, or have data that lack accuracy, which, in either case, hardly stands up to a long-term analysis. Unless the situation is rectified, it will never be possible to establish much-needed dam operation manuals. Therefore, it is evident that they need to start immediately taking and keeping data in preparation for the establishment of dam management manuals in the future.

Items that especially need to be measured and recorded are listed in Table 9-8. It cannot be emphasized enough that the most important aspect of dam safety management is to take and record measurements accurately and diligently on a daily basis upon fully understanding the importance of the above listed data.

Table 9-8 Important Data in Dam Reservoir Operation and Management

Item	Contents
Reservoir water level	Basic data for the calculation of discharge volume, and it is indispensable to validate reservoir operation. Even if it is not automatic measurement, administrator has the ability to measure from a target visually at every morning, and impossible to missing data.
Inflow	Inflow can be calculated primarily backwards from the reservoir water level and discharge volume, especially measurement equipment is not required. In other words, no inflow data is a manifestation that either or both the reservoir water level and discharge volume is not measured.
Discharge volume	On discharge volume, not only discharge of power generation water and discharge of irrigation, it is also necessary of " total discharge volume", including the amount discharged from the crest Since each discharge volume obtained from the relationship of the degree of opening (valve) and reservoir water level, it is better to take a record of opening (valve) gate daily basically Because the amount of inflow cannot be determined if there is no "total discharge volume", it should be made to measure the "total discharge volume".
Discharge characteristics	Characteristics of discharge irrigation valve and crest gate (The discharged formula from the amount of gate opening and the reservoir water level) In this re-commissioned study, it has been carried out, but is still not complete.
Reservoir water level ~capacity curve	When calculating the inflow, the reservoir level must be converted into the amount of storage, the curve will require at that time. In this re-commissioned study, it has been carried out, but is still not complete.

Source: JICA Project Team

9.3.2 Groundwater Development Facilities

(1) Current Situation

From the analysis on operation and maintenance of facilities for groundwater use, items below were made clear and need improvement.

<u>Aquifer management</u>

Over pumping and groundwater contamination is taking place due to inadequate aquifer management

<u>Operation and maintenance of borehole facilities</u>

Borehole operation rate is low due to poor operation and management of boreholes facilities.

<u>Pumping capacity of boreholes</u>

Capacity of boreholes is not fully utilized due to use of hand pumps whose capacity is only $10m^2$/day.

<u>Borehole construction system</u>

There are so many organizations which take responsibility of borehole construction project for rural water supply that project implementation is inefficient due to poor coordination among the organizations.

(2) Suggestion

(2-1) Aquifer Management

Issues of groundwater management and development are summarized in Table 9-9.

Table 9-9 Hydrogeological Conditions

Combination of Climate and hydrogeology	Area[Note)]	Aquifer scale	Available yield of boreholes	Issues in management and development	
				Cause	Cause
Large precipitation-sedimentary rock	South	Large	Large	・ Over pumping ・Drain	・Land subsidence ・Sea water intrusion ・Groundwater contamination
Large precipitation-basement rock	South	Small	Small	Drought	Water shortage in dry season
Small precipitation-Sedimentary rock	North	Large	Large	Over pumping	Regional groundwater level lowering
Small precipitation-Basement rock	North	Small	Small	Drought	Water shortage in dry season

Note) Middle belt area has intermediate characteristics of both north and south
Source: JICA Project Team

To solve issues above, groundwater monitoring and the pumping control based on the result of the monitoring is necessary. Groundwater monitoring is mentioned in detail in Section 9.4.2.

(2-2) Operation and Maintenance of Borehole Facilities

There are around 57,000 boreholes currently in Nigeria, and most of those boreholes are for water supply of rural and small urban/town. Most of boreholes are operated and managed by communities. However, only one fifth of the entire rural communities in Nigeria might have special organizations for operation and maintenance of water supply facilities. As a result, boreholes were left non-operational without any repair after hand pump were broken, even though it is simple breakdown. Such situation is repeated again and again. Proposal for improvement for the issues are as below:

- Adequate selection of prioritized community for borehole construction
- Hygiene and sanitation education for communities
- Establishment of system for water fee collection
- Strengthening of supporting system for LGA
- Provision for spear part

(2-3) Pumping Capacity of borehole

There are many boreholes for rural water supply. Boreholes are installed with hand pumps. Pumping capacity of hand pump is as small as 10m3/day. Therefore, huge amount of boreholes must be drilled from now on to meet future groundwater demand by boreholes with hand pumps. It needs huge amount of investment. If hand pump is changed to motorized pump, pumping capacity of borehole will be considerably increased as proportional to aquifer capacity. It is necessary to use full capacity of aquifer by shifting pump type from hand pump to motorized pump to meet future groundwater demand.

(2-4) Borehole Construction System

Many organizations implement borehole construction for rural water supply. They are State Ministry, RUIWASSA, RBDA, MDG Office and others. They implement their projects without coordination with the other organizations. Consequently, inefficiency of their projects is pointed out. Issues below should be examined for better implementation of the projects.

- It should be abolished that many organizations implement borehole construction for rural water supply independently. Implementation agency should be unified to one organization, State RUWASSA.
- Implementation agency will formulate long term plan for borehole construction for efficient project implementation.

For more efficient groundwater development, matters below should be examined.

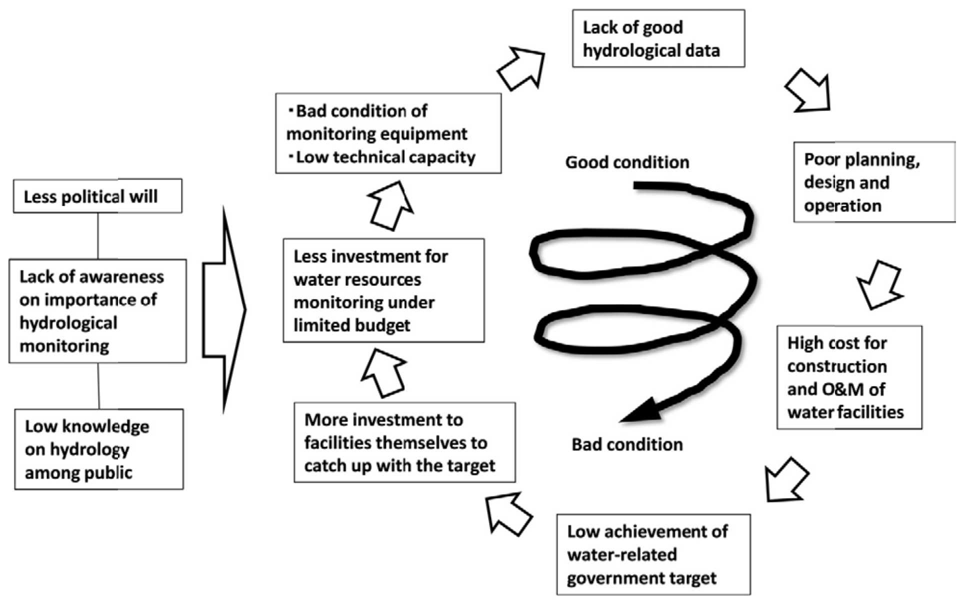
- To improve technical and institutional capacity of State Agency.
- To strengthen capacity and function of State Agency as main responsible organization for rural water supply.
- To improve capacity of private drilling companies under direction of State Agency.
- To make cooperation with Federal Organization such as NIWRCM and NIHSA for establishment of i) registration system of private borehole companies and ii) technical transfer system for new groundwater development.

9.4 Hydrological Monitoring

In the present section, hydrological monitoring for water resources assessment and information dissemination is discussed among water resources monitoring.

Nigeria Hydrological Service Agency (NIHSA) is the responsible agency for hydrological monitoring in Nigeria, which was established in 2010. The functions of NIHSA are as follows according to the law[1] establishing it.

- Advise the Federal and States Governments on all aspects of hydrology.
- Project, prepare and interpret Government policy in the field of hydrology.
- Work with the meteorological services to issue forecasts for floods.
- Promote hydrological services in agriculture draught and desertification activities.
- Provide hydrological services in operational hydrology and water resources activities.
- Collect process and disseminate all hydrological data and information within and outside Nigeria.
- Keep in safe custody all hydrological records in the Agency's archive.
- Ensure uniform standards of observation of all hydrological phenomena in Nigeria.
- Ensure that international standards and best practices in hydrological operations are maintained.
- Train, conduct and undertake research particularly in the field of surface and groundwater hydrology and other related areas of hydrology.
- Provide consultancy services to the public on hydrology.
- Monitor hydrology components of the environment including ground water pollution through industrial, commercial and agricultural activities.
- Establish stations for hydrological observation.
- Carry out river training activities to improve conveyance of water in river channels including monitoring of sediment road.
- Carry out geo-physical investigations for siting groundwater development projects, dam foundation and saline water intrusion.



The lack of good hydrological data can bring about the costly water facilities due to uncertainty in hydrological condition, and thus can be one of causes for low achievement of water-related government target. The low achievement of the target may bring about less investment for hydrological mentoring under limited budget, because of necessity of more budgets for water facilities themselves. The less investment makes the condition of the hydrological monitoring worse. Then, this negative chain would continue, making the situation worse and worse. The lack of awareness on importance of hydrological monitoring may accelerate the negative spiral.

Source: JICA Project Team

Figure 9-7 Negative Spiral of Hydrological Monitoring

[1] NIHSA Act, 2010.

Through the workshop for problem analysis in NIHSA as well as cooperation work with NIHSA, JICA Project Team recognized that there could be a negative spiral on hydrological monitoring as shown in Figure 9-7. How to change the negative spiral to the positive one will be one of important issues in the hydrological monitoring.

9.4.1 Hydrological Monitoring for Surface Water

(1) Current Situation

As a result of assessing the activities as well as the available hydrological data in NIHSA, the following problems and issues have been identified.

Table 9-10 Problems and Issues on Hydrological Monitoring for Surface Water

Problems	Issues
Sustainability of observation stations	− Almost half of the Type-1and 2 stations have been either non-functional or vandalized. The duration of the non-functional time of the observation will lose the opportunity for estimating flow condition during it forever. These stations should be rehabilitated as soon as possible so that missing duration will be minimal. Also, the observation by manual reading by a gauge keeper should be accompanied as a back-up, in order to continue the observation even if the automatic device is damaged.
Incomplete inventory of monitoring station	− Information of location of stations is sometimes not accurate. It may make the water resources assessment confused. The complete inventory should be prepared as soon as possible.
No rating curve for many stations	− Many stations do not have rating curve, especially for the newly established stations with data logger. − Rating curve for the station at low lying area may have influence of backwater. It causes strange discharge in low water condition. If such strange data are identified, they are not used for the assessment of water resources in the present project. − It is necessary to establish good rating curve for future usage of these data.
Lack of long-term observation data	− Duration of available observation data is short in many stations (less than 10years). − The number of stations which have daily and monthly discharge data rapidly reduced after 1990. − It is difficult to retrieve the historical data. For better water resources assessment, the data with good quality should be accumulated from now on, re-activating the currently existing network and enhancing the network.
Duplicated Information/ Inconsistency of discharge data	− Different data sources sometimes show different discharge. − Discharges observed in neighboring stations are sometimes inconsistent each other (For example, discharge in downstream station is too much lower than that in upstream station). − As the responsible agency for hydrological data, NIHSA has to check these data and qualified data should be stored as quality-assured data.

Source: JICA Project Team

(2) Suggestion

(2-1) Strategy on Improvement of Surface Water Monitoring

Considering the identified problems and issues, the strategy on improvement of surface water monitoring is set as shown in Table 9-11.

Table 9-11 Strategy on Improvement of Surface Water Monitoring

Item	Strategy
Classification and layout planning of monitoring stations based on primary purpose and importance	− The monitoring should have clear objective for those usage. Accordingly, methodology of observation, necessary quality of data, timing of data reading/transferring etc. would be decided. − Layout plan is prepared by categorizing the observation stations into i) primary stations, ii) secondary stations, and iii) tertiary stations. − The budget for establishing, operating and maintaining the monitoring stations are limited. The priority stations should be kept in good condition in order to keep continuous long-term observation, even in the limited budget condition.
Securing sustainability of stations	− Collaboration with local people as a gauge keeper should be introduced as a back -up observation system even if automatic device is introduced when establishing, rehabilitating the stations. − Any other possible measures to secure the sustainability should be considered.
Establishing and maintaining good rating curve	− The rating curve should be prepared urgently and be updated periodically. − The establishment of the rating curve should start from the priority stations. − The discharge measurement during flood events should be conducted. − The capacity development for discharge measurement and preparing the rating curve are also important.
Simultaneous observation on hydrological and meteorological data	− The responsible organization for meteorological data is NIMET in Nigeria. However, the number of their synoptic stations managed by NIMET is very limited, which may not be enough for proper hydrological service combined with hydrological data. − It is recommended that the key meteorological data such as precipitation be monitored simultaneously at the same place where hydrological station is set. It will supplement to the data provided by NIMET. The data exchange mechanism between NIMET and NIHSA should also be considered in future.
Simultaneous observation with sediment and water quality	− From the viewpoints of management of rivers and floodplains, the simultaneous monitoring with water quantity and sediment transport should be conducted when periodical discharge measurement at primary stations is executed, in order to grasp the overall dynamics of sediment and water quality. NIHSA is responsible for sediment measurement, whereas water quality and sanitation dept. of FMWR is responsible for water quality measurement.
Establishment of quality assurance mechanism	− NIHSA should establish the proper mechanism of data management such as collecting, processing, storing and disseminating. Necessary capacity development should also be considered.
Developing capacity for hydrological modeling	− The hydrological modeling can supplement to the observed data for water resources assessment. During the process of the modeling, the quality checking of the observed data are also available. − To disseminate the information related to hydrology such as flood warning, long-term predication of surface flow condition is a fundamental hydrological service. The hydrological modeling is necessary tool for it − NIHSA should develop the capability of the hydrological modeling.
Establishing collaborating mechanism on water resources monitoring	− Although NIHSA's primary responsibility is the monitoring for water resources assessment, the contribution to the activities on water resources monitoring is also necessary hydrological service. The collaborating mechanism to the other organizations such as RBDAs, NIWRMC and water quality dept. of FMWR should be established. − The reservoir operation data should be integrated to surface water monitoring data.
Information and Education Campaign on Hydrological Monitoring	− Importance of hydrological data should be recognized and understood by public. − Information and education campaign related to hydrology should be conducted by NIHSA staff. It will eventually support the proper water resources monitoring.

Source: JICA Project Team

(2-2) Proposed Projects

On the basis of the strategy shown in the above (2), the following projects are proposed to be implemented by NIHSA.

Project-1: Improvement of Surface Water Monitoring Network

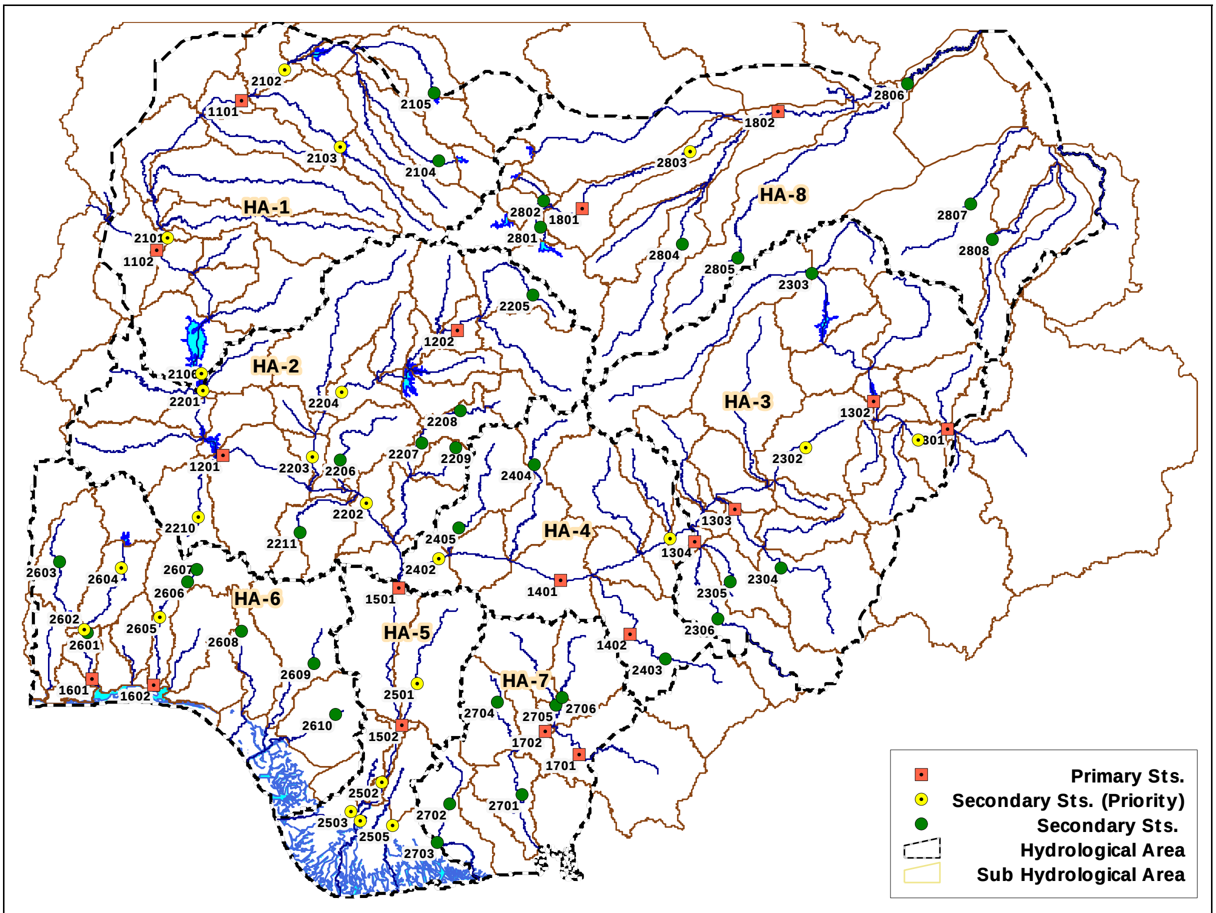
The monitoring network on surface water is setup step by step. Considering the existing Niger-Hycos network, the monitoring stations are categorized into four types. The main objectives and fundamental specifications ate summarized in Table 9-12.

Table 9-12 Classification, Main Objectives and Fundamental Specifications on Surface Water Monitoring Satiations

Type	Objectives	Criteria and number of stations	Fundamental specifications				
			Method of water level observation	Method of data transfer, frequency	Manual observation and gauge reader	Meteorological observation	Sediment and water quality
Primary	To evaluate overall water movement across the country	The most important locations in HA (one to a few stations in HA)* Total num.=18	Pressure gauge	DCP, Frequency of data transfer= hourly	Yes	Built in DCP	Together with discharge measurement
Priority Secondary	To enhance water management within HA and flood management	Important locations for water management*, especially with past experience of flood disaster Total num.=22	Pressure gauge	DCP, Frequency of data transfer= hourly	Yes	Built in DCP	No
Secondary	To enhance water management within HA	Important locations for water management* Total num.=35	Pressure gauge	Short term(2020): Recorded by logger, Collected once a month Mid-long term(2030)：DCP, Frequency of data transfer= hourly	Yes	Short term (2020): No Mid-long term(2030)：Built in DCP	No
Tertiary	To assess water resources potential in long term	At least one station in a SHA Total num.=93	Staff gauge (manual reading)	Collected once a month	Yes	No	No

Remarks: *There are cases that the existing Niger-Hycos stations are utilized.
DCP=Data Collection Platform (Generic data collection and transfer system with satellite-based data transfer)
Source: JICA Project Team

These monitoring stations are basically different from the monitoring of inflow and outflow of reservoir by dam owners. When dams exist at important points for water management, the monitoring stations would be located at appropriated locations at downstream reach of the dam. The locations of the monitoring stations are tentatively set by discussion with NIHSA as shown in Figure 9-8. It should be noted that the detail location would be confirmed by field survey.



Source: JICA Project Team

Figure 9-8 Proposed Surface Water Monitoring Stations

The scenario of the improvement is proposed as follows.

Phase-1 (Urgent) (2014-2016)

- Rehabilitation of the existing Niger-Hycos network
- Setting-up of primary stations
- Integrated management of data for Niger-Hycos and primary stations
- Setting-up of discharge measurement devices for each HA
- Establishment of rating curve for primary stations
- Grasping sediment load at primary stations

Phase-2 (2017-2020)

- Setting-up of secondary stations and their integration to primary station network
- Integrated management of data for primary and secondary stations and operation data of major dams
- Rehabilitation of tertiary stations if there are existing stations
- Expansion of discharge measurement devices for each HA
- Refinement of rating curve for primary stations
- Establishment of rating curve for secondary stations
- Grasping sediment load at primary stations

Phase-3 (2021-2030)

- Introduction of DCP to non-priority secondary stations
- Setting-up of tertiary stations
- Establishment of rating curve for tertiary stations
- Refinement of rating curve for primary and secondary stations
- Grasping sediment load at primary stations
- Renewal of monitoring equipment, maintenance of equipment

Necessary equipment with its quantity, items for observation and maintenance are presented in Table 9-13.

Table 9-13 Necessary Equipment with Its Quantity, Items for Observation and Maintenance for Surface Water Monitoring

No	Equipment (including installation)	Total Qty (2013-2030)
1	Manual Stuff Gauge	243
2	DCP	115
3	Data Loggers & Bubble Sensor	35
4	Current Meters	32
5	ADCP	32
6	Sediment Samplers	32
7	Leveling Equipment	32
	Observation and Maintenance	
	1) Allowance for Gauge Reader 2) Maintenance of DCP and logger Sts. 3) Discharge & Sediment Measurement (Primary Sts.) (Once/month) 4) Discharge Measurement (Secondary Sts.) (Once/2months) 5) Discharge Measurement (Tertiary Sts.) (Once/3months)	

Remarks: Renewal of equipment by each 10year is considered.
Source: JICA Project Team

Project-2: Enhancement of Data Management Capacity in NIHSA

This project is to enhance the data management of hydrological monitoring. It is proposed to be implemented in two phases.

Phase-1 is proposed to be implemented in three years (2014-2016) to enhance the capacity of the following items in a pilot area.

- Preparation of manual for data management
- Preparation of database for hydrological monitoring
- Collection and storing hydrological data including integration of hydrological monitoring data and dam operation data
- Quality management of hydrological data
- Preparation and improvement of rating curves as well as discharge measurement
- Introduction of hydrological modeling as one of checking process of quality of hydrological data
- Dissemination of hydrological information

In Phase-2, the activities conducted in Phase-1 will be expanded continuously by NIHSA with more proactive manner. This is to promote active usage of hydrological data. The project duration would be 14 years in 2107-2030.

- Revision of database for hydrological monitoring data
- Collection and storing hydrological data including integration of hydrological monitoring data and dam operation data
- Improvement of rating curves as well as discharge measurement
- Executing hydrological modeling and evaluation of water resources
- Dissemination of hydrological information

Project-3: Establishment of Hydrological Modeling Center within NIHSA

In order to make use of hydrological monitoring data and assure high quality of those data, it is proposed that Nigerian Government establish Hydrological Modeling Center within NIHSA.

The objective of the Hydrological Modeling Center is to enhance the proper usage of hydrological information and to materialize the best mixture between monitored hydrological information and hydrological modeling activity, and more over based on that, to disseminate the selected hydrological information.

The project implementation period shall be set to be about 3 years as the most urgent project for the establishment of Hydrological Modeling Center and the consolidation of the related activities. The following capacity development project is proposed.

1) Flood Runoff Modeling and Support for Integration of Flood Early Warning System

a. Site investigation of flood condition

In the communities locating along the major rivers such as the Niger and Benue rivers in which they recently suffered from flood damage, the site investigation will be conducted by interviewing to local people about the past flooding conditions (inundation depth, duration time, damage). The work will be done together with NIHSA officials, SEMA and communities. Especially NIHSA officials must confirm the local flood conditions for their flood analysis.

b. Sensitization for communities on significance of hydrological monitoring

In the site where the hydrological stations exist or new stations will be installed in the proposed project (provisionally called “Surface water monitoring network implementation project”) , gauge readers shall observe and record water-level as well as the automatic recording by equipment. In the practical scene of water-level monitoring for flood early warning issue, the people who are advised to evacuate must understanding the meaning of the announced water-level by NIHSA. In order to do this, NIHSA officials, SEMA and communities shall collaborate to sensitize the significance of the water-level monitoring.

c. Flood runoff modeling

For the discharge of the major rivers such as the Niger and the Benue rivers, some flood runoff mathematical model shall be prepared. The rainfall data is obtained from NIHSA and NIMET ground observation data and if necessary, from generally available satellite-origin rainfall data. After the comparison among several runoff models, the past flood hydrograph, for example in Lokoja, shall be tried to reproduce. After that the correlation between the hydrological stations is studied, referring to available rainfall forecast information, the applicability of the flood forecast system shall be studied.

d. Flood inundation modeling

For the major rivers such as the Niger and the Benue rivers, flood inundation model shall be prepared to evaluate the flood extents for several flood magnitudes. For the areas along those major rivers in which they suffered from flood damage recently, getting detailed topography and information in urban area, the flood risk shall be evaluated.

e. Support to integration of flood early warning system

It is worth the output of the flood runoff model and the flood inundation model prepared by NIHSA be integrated into the present flood early warning system. FMWR shall discuss with the relevant organization about this issue and make efforts to be involved in the implementation of flood early warning system.

2) Long-term Rainfall-runoff Model/Hydrological Cycle Modeling and Improvement of Estimation of Water Resources

a. Long-term rainfall-runoff model

- To learn about concept of monthly basis long-term rainfall-runoff model
- To learn how to prepare input data for the model such as precipitation
- To conduct model calibration
- To evaluate water resources by utilizing the output of the model
- To predict runoff condition by giving predicted meteorological conditions
- To understand limitation of the model

b. Hydrological cycle modeling

- To lean about concept of hydrological cycle modeling which integrates surface water and groundwater
- To learn how to prepare input data for the model such as precipitation

- To conduct model calibration for the pilot area where enough data for model calibration exists
- To evaluate water resources by utilizing the output of the model
- To predict runoff condition by giving predicted meteorological conditions
- To sort out necessary items to expand the model to the entire country as well as to understand limitation of the model

Necessary equipment with its quantity, items for observation and maintenance are presented in Table 9-14.

Table 9-14 Necessary Equipment with Its Quantity, Items for Observation and Maintenance for Hydrological Modeling Center Project

No	**Equipment**	Total Qty (2014-2030)
1	Web Server	4
2	Personal Computer	40
3	Printer	20
4	GIS Software License	10
5	Hydrological/Hydraulic Simulation Software License	10
6	Vehicle for Field Survey	6
	Observation and Maintenance	Qty. per year
1	Office Rental	L.S.
2	Fee for Data Transfer through Satellite	L.S.
3	GIS Software License Maintenance	10
4	Hydrological/Hydraulic Simulation Software Maintenance	10
5	Survey for River Section	L.S.
6	Web Programming	L.S.

Remarks: Renewal of equipment by each 10year is considered.
Source: JICA Project Team

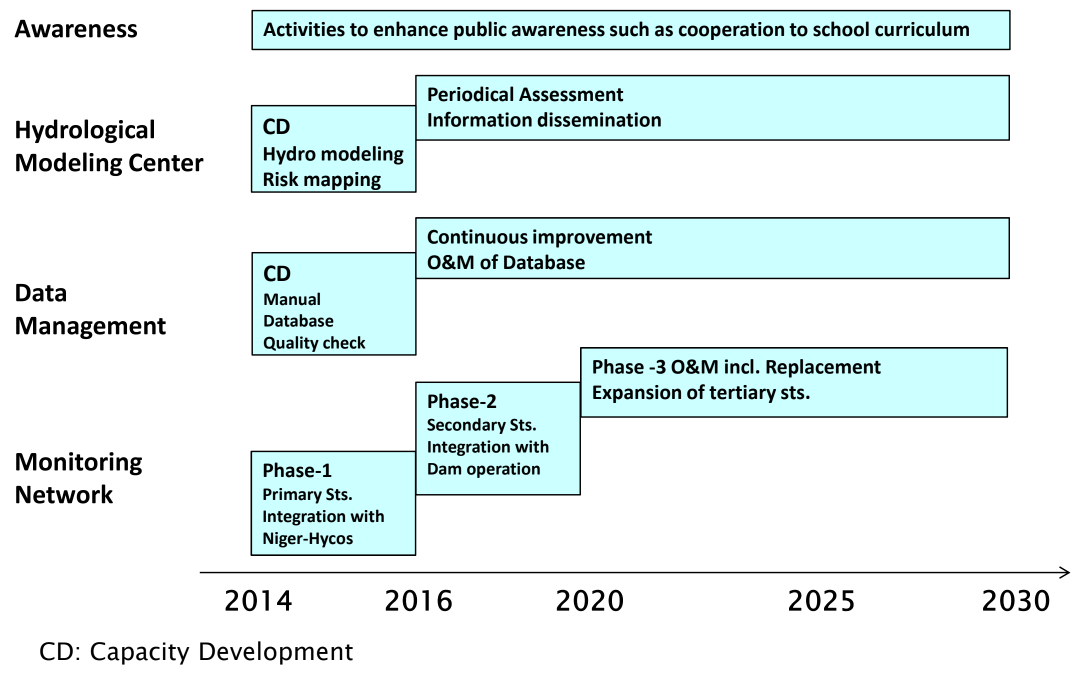
Project-4: Enhancement of Awareness on Importance of Hydrological Monitoring

This project is to promote awareness on importance of hydrological monitoring by NIHSA staffs.

The activities by NIHSA would be widely disseminated to public through periodical seminars and workshops. Furthermore, lectures at school curricula and so on by NIHSA staffs are promoted. These should be expanded to base flow work in NIHSA.

Proposed Implementation Schedule

It is proposed that the projects be implemented step by step as shown in Figure 9-9.



Source: JICA Project Team

Figure 9-9 Proposed Implementation Schedule on Improvement of Surface Water Monitoring

9.4.2 Hydrological Monitoring for Groundwater

(1) Current Situation

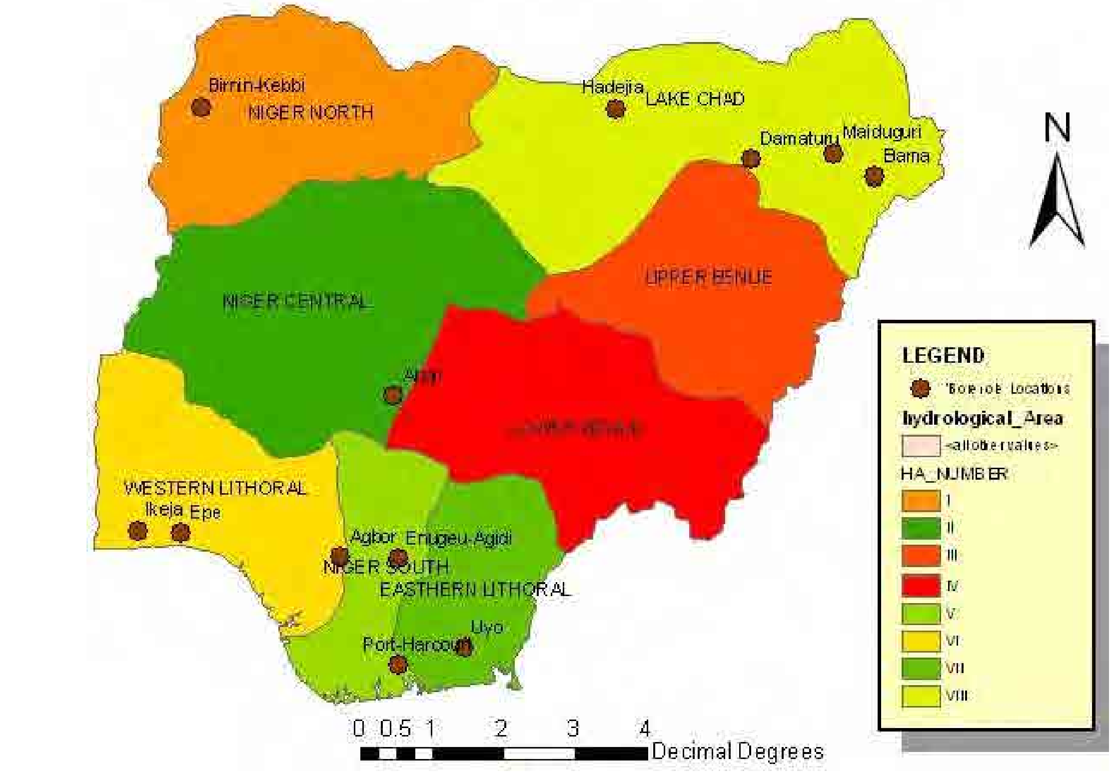
NIHSA is in charge of groundwater monitoring NIHSA in in charge of survey and assessment on groundwater monitoring and development based on the result of the monitoring.

(1-1) Monitoring of groundwater of Borehole

NIHSA has installed groundwater automatic recorders into 11 boreholes and is implementing groundwater level observation. These boreholes are drilled in sedimentary rock areas with borehole depth of 80 to 100m observing confined groundwater level. The purpose of monitoring is to know the groundwater fluctuation in aquifers that are the main water sources for urban water supply. Data accumulation is still not enough to analyze the tendency of long term groundwater fluctuation. It is expected that this monitoring should continue and new monitoring boreholes should also be established.

(1-2) Current Condition and Issues on Monitoring of Groundwater Level of Deep Borehole of NIHSA

Accumulation of observation data is not enough in the 11 monitoring wells, so that long term trend of groundwater level fluctuation has not yet been analyzed so far. It is expected that NIHSA continues the monitoring to accumulate observation data and install additional monitoring wells.



Source：NIHSA

Figure 9-10 Groundwater Monitoring Site of NIHSA

(2) Suggestion

NIHSA is in charge of groundwater monitoring in Federal level. Responsibility of NIHSA should be made clear to strengthen its institutional and technical capacity, and they should implement technical transfer to State Agencies such as Water Board/Corporation and RUWASSA that develop groundwater.

(2-1) Clarification of Purpose and method of monitoring

Monitoring activities will be made more efficient by clarification of monitoring purpose and method. Purpose of monitoring is defined as below:

- To assess groundwater development potentials
- To judge whether groundwater environmental problems is taking place or not, and to examine its cause and measures against it.

Content of the above two types of monitoring is explained below.

Assessment for groundwater development Potential

Fluctuation of groundwater level will be observed for a long period of time to assess groundwater development potential. The result for the monitoring will be analyzed with meteorological data to estimate groundwater recharge (see Table 9-15).

Table 9-15 Monitoring for Assessment of Groundwater Recharge

Monitoring points		Monitoring method/ period
Basement rock area	Monitoring points should be scattered at wide area. Groundwater monitoring should be continued in 30 monitoring sites that were established in HA-1 and HA-6 by the Project.	**Monitoring method** Monitoring by automatic recorder is desirable. However, maintenance of recorder in remote area is difficult. So in principle observers should patrol monitoring point regularly to collect data. **Monitoring period** Twice a month
Sedimentary rock area	Same as above.	

Source: JICA Project Team

The JICA Project Team established 30 monitoring sites in HA-1 and HA-6 to implement groundwater monitoring until July 2013, and then handed over the monitoring sites and monitoring works to NIHSA. It is expected that NIHSA will continue the monitoring work even after completion of the Project and expand monitoring points throughout Nigeria.

Groundwater environmental problem

Groundwater environmental problem will be caused by lowering of groundwater level by over pumping. Groundwater environmental problem and monitoring method is shown in Table 9-16.

Table 9-16 Groundwater Environmental Problem and Monitoring Method

Monitoring points		Monitoring method/period
Over pumping	Serious Over pumping is likely to take place where huge amount of groundwater is being extracted from excellent aquifer in sedimentary rock area. Groundwater monitoring should be implemented in borehole field used for urban water supply.	Monitoring method Groundwater level monitoring by automatic recorder Motoring period Continuous observation
Land subsidence	Land subsidence is likely to take place by consolidation of soft clay of Quaternary aquifer area. Large pumping and thick soft clay will cause land subsidence more serious. There is high possibility that land subsidence is taking place by over pumping in large cities along the coast in southern part of Nigeria. Monitoring should be implemented in above area.	Monitoring method 1. Levering survey 2. Observation well for land subsidence 3. Groundwater level monitoring at above sites Soil investigation bellow should be implemented together with monitoring above 4. Soil investigation on layer structure between sand aquifer and soft clay 5. Soil investigation on consolidation parameter of soft clay Monitoring period Continuous observation
Sea water intrusion	Sea water will proceed toward inland area to intrude into aquifer. This will be caused by lowering of groundwater level due to over pumping. Sea water will flow into boreholes to contaminate groundwater.	Monitoring method 1. Groundwater level monitoring by automatic recorder 2. Monitoring of salt concentration of groundwater Geological survey below should be implemented together with monitoring above Motoring period 1. Geological survey in layer structure on sand aquifer and clay layer (Aquitard)

Source: JICA Project Team

Groundwater environmental problem in Table 9-16, over-pumping will take place in the northern part of Nigeria, and land subsidence and sea water intrusion will take place in the southern part of Nigeria. NIHSA is performing groundwater monitoring in above areas. However, their monitoring work needs improvement in quality and quantity. Large cities along Guinea Gulf is using groundwater as main water sources, where it is pointed out that sea water intrusion into boreholes is taking place. Groundwater monitoring work should be strengthened as urgent necessity. Problems mentioned above, over-pumping, sea water intrusion and land subsidence, is environmental problems especially in sedimentary rock area. In that area, it is useful to newly drill deep monitoring boreholes of depth of 300 to 600m to survey geological structure of deep part of the ground for new groundwater development and resolutions of environmental problems.

(2-2) Clarification of responsibility of related organization and strengthening of institutional and technical capacity

NIHSA is in charge of groundwater monitoring in the Federal level. NIHSA should implement technical transfer to NIWRMC and State Agencies such as Water Board/Corporation and RUWASSA. For this purpose, their responsibility must be clarified and institutional and technical capacity of them must be improved.

NIHSA

NIHSA should make data-base by collecting data on borehole drilling and geophysical survey from State Agencies in charge of borehole construction. They will assess groundwater development potential to identify adequate amount of groundwater to be developed. When a risk in groundwater environment was detected through groundwater monitoring, they will analyze and examine measures against it.

NIWRMC

NIWRMC is expected to issue i) water right for groundwater development and ii) borehole registration based on result of assessment of groundwater development. Moreover, NIWRMC will propose measures against groundwater environmental problems such as pumping control, based on result of monitoring/ analysis/ prediction by NIHSA.

State agencies

State agencies are in charge of groundwater development for water supply for urban and rural area. However, they do not implement groundwater monitoring and cannot assess and manage groundwater resources. This is implemented by NIHSA and NIWRMC. However, NIHSA and NIWRMC have limit in terms of budget and manpower, and they cannot cover the entire Nigeria of 37 States by their monitoring network with high accuracy. Therefore, it is expected that State Agency should implement groundwater monitoring, receiving technical transfer from NIHSA and NIWRMC, to make effective use of the monitoring result for groundwater development and management in cooperation with NIHSA and NIWRMC.

9.5 Data and Information Management

9.5.1 Current Situation

Though analysis such as statistical analysis etc., hydrological observation data give us precious data for sustainable development, such as figure of rainfall runoff, design condition of the river structures, river structure's operation rules.

In order to acquire precious data, it is necessary to observe hydrological phenomenon in consistent manner for very long term. Therefore, it is very important to manage observation, collection, and archiving of data to implement sustainable water resource development.

On the other hand, unfortunately there are very few organizations in Nigeria could keep observing and archiving their data in consistent manner. Therefore, it is hard to find reliable data which covers whole Nigeria.

In this section, the JICA Project Team shall explain implementation policy for observing data and collecting data which considers current Nigeria's condition.

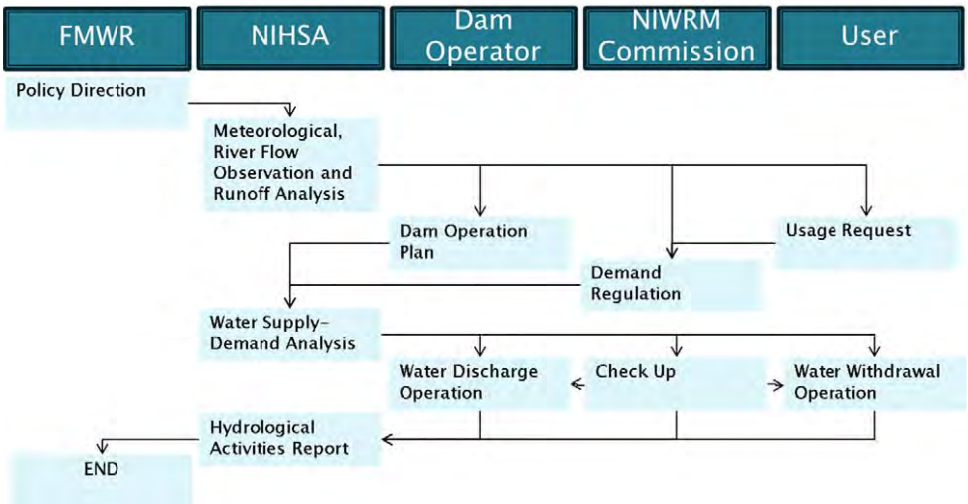
9.5.2 Suggestion

(1) Vision of Data and Information Management

Vision for the data and information management on hydrological data are as follows;

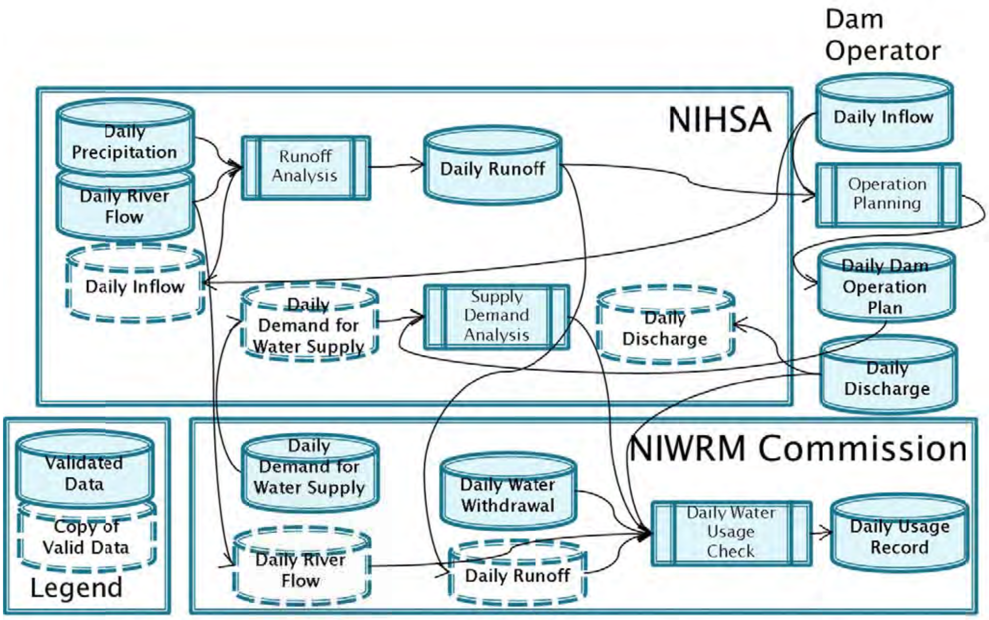
- Through sharing knowledge, allow people to make "INFORMED DECISION"
- NIHSA and NIWRMC should be focal Agencies of the database maintenance and operation

In addition, by developing data circulation scheme shown below, NIHSA and NIWRMC shall become body of archiving proven data which examined though utilization.



Source: JICA Project Team

Figure 9-11 Concept of Workflow Diagram during Dam Operation



Source: JICA Project Team

Figure 9-12 Concept of Data Flow Diagram for Utilized in Dam Operation

(2) Scope of Data

In this section, the JICA Project Team shall present management policy for following two (2) types of data.

- Observation data (Observed data in the observing station such as Precipitation, water level, water flow etc.)
- Inventory data (Location information and its attribute of Object such as observing station, dam, intake, irrigation project etc.)

(3) Policy for Data Acquisition

Currently, observing stations' operation is very weak in Nigeria. Therefore it often faces difficulty to maintain continuity and quality of observed data. Following table show major problem and its cause.

Table 9-17 Major Problems on Data Acquisition

Problem	Cause
Missing Observation	Due to unstable power supply, electricity outage or poor maintenance stops observing stations' equipment.
Entrain of Low Quality Data	There was no validation scheme or poor exchange of data between other divisions led no external check.
Disruption of Data	Due to lack of funding, renewal and maintenance of equipment has abandoned.

Source: JICA Project Team

In order to avoid above mentioned condition, especially for important observing point, adding redundancy with human-powered observation is recommended (e.g. Automatic hydrological observing station equipped with water level sensor, also requires water-level gauging with human-power). By utilizing redundant data, quality of observation data (continuance and validity) shall be improved. Reasons are as follows;

- During power outage, human-powered observation data shall alternate data
- For validation, human-powered observation data shall be comparison data
- During operation stage, utilize affordable and off-the-shelf equipment to avoid disruption of the data even in limited budget condition

(4) Management on Data Acquisition and Archiving

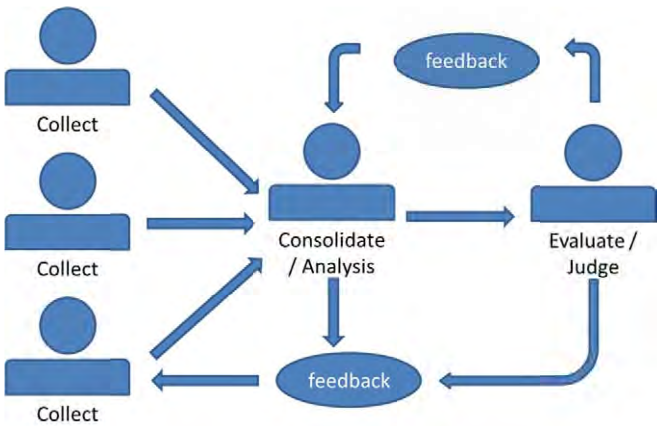
In the Vision of Data and Information Management, observation data and inventory data shall be archived at focal agencies after going through utilization and external checking. However, even before establishment of those data circulating environment, it is necessary to develop data validating mechanism inside of focal agencies such as NIHSA, NIWRWC and other related agencies.

Following table shows how to monitor progress of data acquisition and archiving, for management level (Evaluation / Judgment). It reports progress of observation and archiving on a regular and systematic manner. The JICA Project Team recommends to management level of focal agencies to understand and direct situation through this mechanism. Following figure shows data flow to make evaluation and judgment by management. Monitoring items shall be changed accordance with the progress of data collection and archiving. Therefore, monitoring item can be changed by situation.

Table 9-18 Data Acquisition and Archiving

Monitoring Item	Collection		Consolidation / Analysis		Evaluation / Judgment		Feedback	
	Frequency	Method	Frequency	Method	Frequency	Method	Frequency	Method
Observation Data								
Number of Missing Data	Monthly	Count Missing Data	Monthly	Inputting Form	Monthly	Checking Form	As Needed	Revise Input
Observation Error*	Daily	Comparing Data	Monthly	Inputting Form	Monthly	Checking Form	As Needed	Revise Input
Alternative Observation Data	Every Day	Human-powered observation	Every Day	Data Supplement	As Needed	Checking Form	As Needed	Input Repair parts
Inventory Data								
Location Data	Annually	GPS	Annually	Inputting Form	Annually	Checking Form	As Needed	Revise Budget
Attribute Data	As Needed	Manual Recording	As needed	Inputting Form	As Needed	Checking Form	As Needed	

*Only apply on observation station which added redundancy for observation.
Source: JICA Project Team



Source: JICA Project Team

Figure 9-13 Data Flow Diagram to make Evaluation / Judgment

(5) Conclusion

In this section, the JICA Project Team recommends to improve quality of observing data by adding redundancy to the observing method at especially important observing point. By adding redundancy, it will improve continuity and validity of the data.

In addition, the project team introduced monitor mechanism to help understanding and directing progress of data collection and archiving. The project team also recommends to management level of focal agencies to show commitment on building database by utilizing this mechanism.

9.6 Management of Floodplain

9.6.1 Current Situation

(1) History of River Usage in Nigeria

The significant usage of river in the present Nigerian territory started in nineteenth century as European countries began to trade between the West Africa and the European continent to use the Niger River as transportation route. The inland transportation in the Niger River had been active until the beginning of 20th century while some British state-owned companies exported agricultural products through the Niger and Benue rivers. After that, the inland transportation became less active because of the policy change by the British government to railway and ground transportation, as well as the losing interest in agriculture at the time of discovery of oil. Consequently the inland transportation in Nigeria has not been increasing rather decreasing whereas it has been a major sector in river management in Nigeria.

Historically the consumptive usage of river water was done in the small scale and traditional floodplain cultivation in the floodplains of the Niger and the Benue rivers as well as in the large scale irrigation and water supply by large dams. Those sectors as such the river water is used to intake by dams or weirs are the main sector in Nigeria. While some large dams were constructed during the oil boom for the purpose of flood control, those dams have not been used intentionally for flood control.

The floodplain in Nigeria has a wide variation from the riverine area along small stream whose width is several meters to run downstream in urban area to the vast flat plain of the Niger and Benue rivers confined by the pediment on the sedimentary rock complex. The urban settlement in Nigeria was developed on higher elevation areas because she has a lot of higher, flat topography, where they are not affected by river flood. It is understood that due to the above historical background they have not paid attention to flood control as well as management of floodplain. However, in HA-8 where the alluvial plain is dominant, the management of floodplain has been significant issue.

In Nigeria, while there is an inland navigation sector, there is a primary need to make use of river water by point facilities such as dam and reservoir. On the contrary, there was not much need to consider rivers longitudinally.

(2) Current Situations

Even in Nigeria, urban area by population increase encroached the floodplain around existing urban area, which caused inundation along streams and bank erosion. Consequently such physical damages draw attention of society. When flood damage took place in a dam downstream section, some of the society had interest in the operation of the dam. The historical flood of the Niger and the Benue rivers in 2012 brought significant damage to the urban areas along those rivers such as Lokoja, which highlighted the river feature that it is connected longitudinally. Moreover, as the concept of environmental flow is emphasized, to regard rivers as those longitudinally connected in order to assure the flow continuity in normal time have become important. The vast floodplain of the Niger and the Benue rivers has great potential for irrigation, however it has not been made use of. Table 9-19 shows the activities which each government level is taking to distinguish floodplain into riverine area in urban area, floodplain near urban center along rivers, and floodplain along the major rivers.

The improvement of urban environment which State governments and FMEnv area dealing with includes lining of natural stream, dredging, bank protection and flood early warning from the viewpoint of floodplain management. State governments have sections for land use planning, which are responsible for land use planning in floodplain. Federal Ministry of Niger Delta is a coordination body for relevant nine (9) states in Delta areas (Ondo, Edo, Delta, Bayelsa, Rivers, Imo, Abia, Akwa Ibom, Cross River). This ministry is also involved in the management of floodplain.

Table 9-19 Management of Floodplain

	Subjective Floodplain			
	Riverine area in urban area		Floodplain near urban center along rivers	Floodplain along major rivers
	Area of higher elevation	Lowland area (Delta area)		
State Government	Improvement of Urban Environment Land use planning	Improvement of Urban Environment Land use planning	Improvement of Urban Environment Land use planning	Land use planning
FME	Improvement of Urban Environment Flood Early Warning	Improvement of Urban Environment Flood Early Warning	Improvement of Urban Environment	—
FMWR	—	—	Regulation of Release from Dam Hydrological Monitoring	Regulation of Release from Dam Hydrological Monitoring Large scale Irrigation
FM Niger Delta	—	Improvement of Urban Environment (Delta area)	Improvement of Urban Environment (Delta area)	
FMT-NIWA	—	—	Management of Navigation Route	Management of Navigation Route

Source：JICA Project Team

(3) Issues

The management of floodplain in Nigeria can be defined as mitigation of flood damage, promoting of river usage in normal time and enhancement of land use, responding to the variety of river regime such as water level, discharge and velocity.

The management of floodplain should be prioritized among the national policies as well as the environmental management in urban areas.

In terms of small floodplain in urban area, State governments and FMEnv are in charge as a part of environmental administration. The sufficient fund for countermeasures and technical support such as hydrological data, planning and design methodology from Federal government are necessary.

In terms of mitigation of flood damage, FME is preparing flood early warning system based on rainfall prediction in urban area. The flood early warning against flooding of major rivers such as the 2012 flood is highly expected at present.

For the food production, large scale irrigation project in floodplain of major rivers is expected. However, the basic information on such floodplain such as historical change of river bank, river cross section, soil profile and river channel flow capacity is not enough.

NIWA is in charge of navigation route of major rivers. The management covers the entire width of floodplain, however, the actual activity is not clarified.

9.6.2 Suggestion

Considering the above issues, FMWR should start the basic investigation of floodplain of major rivers such as the Benue, the Niger, the Kaduna and the Sokoto-Rima rivers which have great potential of large scale irrigation.

Table 9-20 Proposed Items of Basic Investigation

Item	Contents
Historical change of river bank	Collecting of map in Colonial era、aerial photos、satellite image、to check the change of river bank and to study the channel stability
River cross section survey	Surveying of floodplain cross section、 to prepare cross section drawing indicating of detailed topography. Also surveying of river channel, to confirm the location of thalweg.
Soil profile	To prepare soil profile by boring survey.
Flow capacity	Based on the cross section survey drawing, calculating of waterlevel and flow capacity, to evaluate how frequent the flooding occurs on the floodplain.

Source：JICA Project Team

By doing the proposed basic investigation, it is possible to evaluate the channel stability, inundation frequency on floodplain and urban area. Further the evaluation results can be reflected in the dam operation, planning and design of large irrigation project within floodplain, reference to navigation route management and providing of disaster information with riverine area and land use planning.

9.7 Consideration of Risk Associated with Climate Change and Trans-boundary Water

Both climate change and trans-boundary water include uncertainty that cannot be controlled by Nigeria. In this section, the risk on water resources associated with climate change and trans-boundary water is discussed.

9.7.1 Current Situation

(1) Climate Change

(1-1) Policy related to Climate Change

<u>Nigeria's First National Communication (2003)</u>

In the Nigeria's First National Communication, the following adaptation measures were proposed.

- Modification of existing physical structures
- Increasing water supply capacity through construction of new structures
- Alterative management of new structures and integration of water supply systems
- Promoting water recycling and re-use
- Development of groundwater supplies
- Improving efficiency of sources of water already developed
- Protection of watersheds and reservoir sites through establishment of intensive vegetation cover to minimize evaporation
- Monitoring ground-water resources
- Improving on rain-harvesting techniques and construction of rain catchments back-up tanks.

<u>Draft National Climate Change Policy (2011)</u>

The following policy and strategy for water resources have been proposed in the Draft National Climate Change Policy in 2011.

<u>Policy Statement</u>

- Continue to pursue the development and implementation of water supply plans that will ensure sufficient water for various purposes under a changing climate regime with reduced rainfall.

<u>Strategies</u>

- Continue to use regulatory and fiscal measures to manage the supply of water including watershed re-charge.
- Review existing institutional, legal and regulatory frameworks for water supply and wastewater discharge within river basins.
- Invest in programs to upgrade canals and storage infrastructure to increase capacity and reduce losses in transport and storage.
- Develop more small-scale earth dams, optimally located for expanded storage of raw water.
- Continue rigorously, the on-going effort to promoting the adoption of water conservation and harvesting practices in every sector and at all levels.
- Exploit alternative water suppliers such as use of seawater and brackish water through desalination, inner and intra basin water transfer.
- Invest in and regulate wastewater treatment facilities to improve effluent quality.
- Scale-up international cooperation on River Basin Management by coordinating different interest groups among upstream and downstream users
- Delimit and protect watersheds to promote stream life and recharge aquifers.
- Continue the program of de-silting riverbeds and dams to improve their carrying capacities and water storage respectively.
- Continue the advancement of hydrometric network to monitor river flows and flood.

<u>Others</u>

According to Special Climate Change Unit under Federal Ministry of Environment, the Second Communication is now under review for its finalization. As soon as the review will be completed, the Second Communication will be opened to the public.

The World Bank conducted the Climate Risk Analysis in Nigeria, which discusses impacts of climate change on agriculture and water resources in Nigeria.

(1-2) Identification of Risk on Water Resources associated with Climate Change

In Chapters 4 to 6, the impact of climate change on water demand, water resources potential and water balance has been analyzed. On the basis of those analyses, the risk associated with climate change is summarized as follows.

- The scenarios for change in precipitation and air temperature at 2050 are set, based on the output from the GCMs.
- The following risk is expected under the scenario set.
  - The expected change in air temperature could bring about the reduction of annual runoff with about 20%
  - The response of runoff against the expected change in precipitation is more sensitive in the area with less precipitation. It could mitigate the impact of the expected change in air temperature in the northern area.
  - The irrigation water demand could increase with about 16% in average compared to base climate condition. The impact could be severer in rainy season than in dry season. The increase of irrigation water demand could be higher in private irrigation which utilizes groundwater than public irrigation.
  - Further lowering of groundwater level with 5 to 20m is expected due to reduction of recharge associated with the climate change.
  - The safety level of municipal water supply and the irrigable area with 1/5 safety level could decrease. The significant reduction of irrigable area in terms of safe water source supply may appear in HA-6 and 8, in which both municipal and irrigation water demands are large.
  - The average generated energy by hydropower plant could become 60-90% of the base case without climate change.

(2) Trans-boundary Water

(2-1) Policy related to Trans-boundary Water

Many parts of Nigeria are covered by international river basins. The most significant ones are 1) Niger River basin (total drainage area: 2,090,000km^2) and 2) Chad Lake River basin (total drainage area: 2,400,000km^2). On the basis of the results on water resources assessment shown in Chapter 5, almost 24% of water resources in Nigeria relies on the flow originated from the outside of Nigeria.

Nigeria currently joins the flowing four international organizations to property deal with the international rivers across the country.

- NBA (Niger Basin Authority)
- LCBC(Lake Chad Basin Commission)
- NNJC (Niger-Nigeria Joint Commission)
- NCJC (Nigeria Cameroon Joint Commission)

In the National Water Policy (2009), the objectives and strategies on trans-boundary water are set as follows

<u>Objectives</u>

- To have rational and optimal use of the shared water resources for the development of Nigeria in order to improve the living conditions among the people of shared basin
- To strengthen co-operation among riparian states in their efforts to find solution to development problems, thereby promoting cordial relationship among the people of the border regions to live as good neighbors

<u>Strategies</u>

- Nigeria will seek to cooperate with other riparian countries for the development, optimum use and protection of trans-boundary waters wherever possible and in her national interest without compromising her sovereignty.

- Establish an effective dispute resolution mechanism in consultation with co-riparian within the regional commission and authority.
- Review all international treaties and agreement on shared basis to reflect the key issues raised in the United Nations (UN) Convention.
- Establish comprehensive monitoring system for water resources in collaboration with co-riparian in all its boundary basins for essential data collection with a uniform format to be collected, analyzed and shared.
- Support the regional agencies' activities, meet its own commitment and exert influence to ensure protection of her interest as a vulnerable downstream riparian state.

(2-2) Examples of Trans-boundary Water Issues

Lagdo Dam in Benue River

The Lagdo dam was constructed in 1982 on Benue River in the territory of Cameroon, about 100km upstream from the Nigerian border. Its gross storage capacity is 8 billion m^3. The primary purposes of the dam are irrigation and hydropower generation. The average inflow to the dam was estimated at $260m^3/s$.

It is reported that the dam was constructed without due regard to an existing protocol and failed to adopt a mutual operating schedule which is acceptable to the downstream users[2]. The detected main influence of the dam was 1) siltation of river bed and water intake structure, 2) loss of Fadama cultivation and fishing lake due to regime change. The regime change could be beneficial for flood control, reclamation and improvement of river condition in dry season at some extent. It is therefore required to operate the dam for mutual benefit for the two countries. It is said that the sudden release from the Lagdo dam during flood in 2012 made the damage by flood around Yola severer.

Katsina-Ala River and Kashimbilla Dam

The Katsina-Ala River is originated in the territory of Cameroon. There is a deep maar lake called as Lake Nyos at the most upstream reach of the Katsina-Ala River. The lake was impounded by 50m wide natural dam that is structurally week and is being eroded. A breach of the natural dam in Lake Nyos is expected within the coming 10years[3]. According to the previous report[4], the eventual failure of the natural dam would cause a destructive dam break flood with maximum of $17,000m^3/s$ at just downstream of the lake. The estimated hydrograph shows the flood discharge at around 100km downstream of the lake, the border of Nigeria, would be no more than $3,400m^3/s$ and possibly $1,400m^3/s$. The possible collapse of Lake Nyos is a fear for the people resides along the Katsina-Ala River. The coordinated management of the lake between the two countries is necessary to prepare the possible dam break. The Kashimbilla dam was designed to be a buffer against such possible dam break flood by Lake Nyos. It is a multipurpose dam with storage volume of 500MCM, which is under construction.

Kandaji Dam in the Upper Niger River

The construction of the Kandaji dam, which is planned to be placed in the Upper Niger River, started in May 2012. The location of the Kandaji dam is about 197km upstream from Niamey, the capital of Niger. The total storage capacity is 1.6 BCM, and the installation of hydropower generation with 180MW as well as the development of 45,000ha of irrigation area (Target year: 2034) is planned. There is also another purpose to provide the minimum flow with $120m^3/s$ throughout a year for improvement of the river environment. The constant release of $120m^3/s$ will be beneficial for improving the flow condition in dry season in the Niger River. However, when the storage water will be utilized and consumed for irrigation in future, the total inflow to Nigeria will be somehow reduced.

Groundwater

Groundwater will flow following regional topography and aquifer structure. If aquifer extends beyond boundary, there is a possibility that groundwater can flow through the boundary. In case of Nigeria,

[2] Toro, S.M.: Post-Construction Effects of the Cameroonian Lagdo Dam on the River Benue, J.CIWEM,11, April, pp.109-113, 1997.
[3] Joint UNEP/OCHA Environment Unit: Lake Nyos Dam Assessment, 2005.
[4] Lockwood, J.P. et al.: The potential for catastrophic dam failure at Lake Nyos maar, Cameroon, Bulletin of Volcanology, 50, pp.340-349, 1988.

trans-boundary groundwater is limited in sedimentary rock area. There are four areas where trans-boundary groundwater flow can be found.

a) Sokoto Basin (Hydrological area-1)
b) Chad Basin (Hydrological area-8)
c) Upper Benue (Hydrological area-3)
d) Western Littoral (Hydrological area-6)

Groundwater is flowing from neighboring countries to Nigeria in above a) and c) areas. On the contrary, groundwater is flowing from Nigeria to neighboring country in above b) area. On the other hand, d) area has both characteristics. Currently there is no conflict of Trans-boundary groundwater in quantity and quality. However, it is necessary to accumulate monitoring data on Trans-boundary groundwater especially in a) and b) areas to prepare for future conflicts in the northern part of Nigeria, where large scale groundwater development is proposed in the near future.

(2-3) Identification of Risk on Water Resources associated with Trans-boundary Water

About 24% of the total water resources potential in Nigeria relies on trans-boundary water. Because most of the trans-boundary water is the inflow through the Niger and Benue rivers, the impact of trans-boundary water would mainly appear along the main course of the Niger and Benue rivers. Regarding the impact of trans-boundary water on the generated energy by the Kainji and Jebba hydropower plants which are located along the main course of the Niger River, the water balance study in Chapter 6 shows that the reduction rate of generated energy is almost same as that of inflow to Nigeria when the reduction rate is small, however, the higher reduction rate the lower impact on generated power.

In addition to the long-term regime change of inflow, sudden change in flow due to operation of dams in upstream countries should be taken care. In order to flexibly cope with the sudden change in flow condition, the real-time monitoring of flow condition as well as close communicant and information exchange with neighboring countries should be established.

9.7.2 Suggestion

The followings are recommended to cope with the risk associated with climate change and trans-boundary water.

- Refinement of identification of the risk by enhancement of water-related data/information
  - Enhancing accuracy of estimation of water resources by promoting refinement of meteorological and hydrological monitoring
  - Enhancing accuracy of estimation of water demand by promoting refinement of data/information on water use
  - Enhancing communication with neighboring countries and promoting information sharing on water resources
  - Preparing flood risk maps along the main course of the Niger and Benue rivers and other important rivers by conducting detail survey on rivers and flood plains
- Promotion of adaptive management
  - The impact by climate change and trans-boundary water always includes uncertainty. When the uncertainty will become more certain, the plan should be revised accordingly. The flexible implementation structure is required to do so. The importance of proper monitoring & evaluation will be more significant for the flexible implementation structure.
- Enhancement of emergency management against flood and drought
  - More frequent flood and drought could happen due to climate change and trans-boundary water. The mechanism for determining the water allocation during flood and drought by discussion among stakeholders should be established by CMCC in each hydrological area. Furthermore, preparedness and response on flood and drought should be enhanced in collaboration with LEMA, SEMA and NEMA.
- Promotion of Water Demand Management
  - In order to cope with possible future decrease in water resources, the water demand management such as decreasing delivery loss in municipal water supply and increasing irrigation efficiency. It can reduce the risk during drought condition.

9.8 Water Environment Management

Two Sectors namely Water Environment Conservation and Water Quality Management are considered as fundamental for proper Water Environment Management. As for Water Environment Conservation, the well management of forest plays an important role to protect the water resources of a basin. As for Water Quality Management, the control of pollution of sources and the monitoring of water quality are subcomponents on which relies the water quality of the water sources.

The JICA Project Team through field investigation, review of existing information and interview to relevant officers of various relevant agencies has identified the main problems and issues in the sector of water environment management in the country. In addition to this, the water related recreational areas were studied in order to know their current conditions and to propose recommendations for their improvement. Based on these findings recommendations are proposed as shown here down.

9.8.1 Current Situation

Water environment management is very poor in Nigeria permitting an increasing degradation of water resources. Many rivers in Nigeria especially their Sections passing through local urban centers, like the capital centers of the States, show the tendency of water pollution. Such pollution is caused by wastewater generated in urban and industrial activities, though the degree of pollution varies depending on the locations.

Identified important problems and issues on water environment management are as follows. The details are described in Section SR6.4, Volume-5 Supporting Report.

Table 9-21 Important Problems and Issues on Water Environment Management

Important Issues	Recommendations
Drinking Water Quality Monitoring	
There is a need of reliable database on water resources quality at national level.	The establishment of a reliable data base system on water resources quality at national level is indispensable. This data base should be operated by FMWR and shared with relevant agencies.
There is an urgent need to monitor and control of groundwater quality especially in those areas that may be influenced by: (a) polluted rivers such as flood plains along the banks of the rivers and; (b) by polluted soils such as wells around solid waste disposal sites or industrial areas.	Surveillance of groundwater quality needs to be improved especially in those areas that may be influenced by: (a) polluted rivers such as flood plains along the banks of the rivers and; (b) by polluted soils such as wells around solid waste disposal sites
A recent study entrusted by the FMWR to local consultants had found the presence of heavy metals in some rivers of Nigeria. However, the number of sampling was only two times (one in dry and one in wet season).	The FMWR should further study carefully the presence of heavy metals in some rivers of Nigeria, used as water source for drinking water, in order to confirm their presence and their concentration as well as to assess their origin and their trend in the environment.
Drinking Water Quality Monitoring is very poor in Nigeria and this present a risk for the public health of the population. Main constraints of the water quality monitoring system are financial, technical capability, lack of equipment and sufficient human power. Due to this fact, the Laboratories cannot cover the operational areas efficiently and the number of samples analyzed is very poor and not adequate for realistic water quality assessment.	A National Drinking Water Quality Monitoring Improvement Program is proposed to secure the public health of consumers. The main implementing agency should be the FMWR. Main content of the Program should include the design of monitoring network to cover all basins of the country, training of staff and the provision of equipment. For this program, the FMWR should recruit more personnel especially in the field of bacteriology, organic and heavy metals
There is a need of reliable data on water resources quality at national level	The water quality along important rivers should be comprehensively monitored and stored in an solid database for national water quality assessment
Water Pollution Control	
Low level of compliance by industrialists for wastewater discharging into water bodies	Awareness creation of industrialist and the establishment of financial mechanism for the installation of wastewater treatment facilities in the industries
Lack of Policies at national level to control water pollution. Lack of assessment of industrial facilities to know the generated wastewater volume, its characterization, the existence of treatment plant, its efficiency of load reduction and the impact of their discharges on water bodies	The establishment of Policies and Strategies for Water Pollution Control is a must for Nigeria. In this sense, the FME should analyze first the current condition of water pollution in the States including a comprehensive assessment of industrial facilities and sewage disposal status and then to set up the necessary Policies and Strategies. These Policies and Strategies must correspond to those that reduce industrial pollution most cost-effectively
Lack of awareness of the people on environmental issues, therefore not collaboration from them to avoid water pollution from solid waste and domestic wastewater	Environmental education and awareness campaign on water resources protection from pollution must be implemented for primary & secondary schools and for the general public. Special awareness campaign needs to be implemented to get connected people on the sewerage systems available in some places of the country such as Abuja City.
There is a poor enforcement of Laws, regulations and standards to control industrial wastewater pollution in the country	The preparation of a National Master Plan for Industrial Wastewater Pollution Control by NESREA and relevant agencies is recommended
Lack of coordination or cooperation among relevant institutions for water pollution control	A memorandum of understanding should be promoted among FMWR, FME and State Governments to prioritize programs for water pollution control of water sources used as domestic source.
In the rural communities of Nigeria are very common the activities of mining at artisanal and small-scale levels. However, most of these activities do not follow good mining practices resulting in environmental pollution	A joint-work between FMWR, FMM and NESREA is proposed to assess the impact of mining activities into the water sources, in order to determine possible countermeasures.

In many urban cities of Nigeria can be observed illegal disposal of solid waste generally in open spaces, along the roads or in watercourses polluting the environment.	Solid waste management needs to be improved in the country to avoid pollution of watercourses or water sources.
Standards	
The National Environmental Policy states the necessity of specification of water quality criteria for different water uses. So far, the surface water quality criteria was developed for recreational and fishery and for irrigation uses, lacking the criteria for other uses such as for domestic and industrial uses.	NESREA should make efforts to develop the surface Water Quality Standards for other uses such as for domestic and industrial uses.
Sanitation	
Important cities of Nigeria such as Abuja, receives a lot of people searching for job opportunities or for making informal business, however, not enough sanitation facilities are in place to attend this fluctuating population resulting in open defecation or urination everywhere which finally are transported to drains or watercourses by the rains.	The construction of more public toilets in urban areas and a strong promotion & education for its use are recommended for upgrading the sanitation level and public health of the population.
Lack of sewerage systems in urban areas of many important cities of Nigeria like State Capitals facilitates the discharge of untreated sewage into open drains which finally ends to watercourses putting in risk the public health of the population and the pollution of the environment.	Preparation of a National Master Plan on Sewerage Development for State Capitals in Nigeria is recommended.
Septic tank and latrine is highly used by Nigerian for sewage disposal. However, the lack of maintenance of these facilities and the disposal of the sludge in water bodies or in any land is very common in Nigeria and this fact contributes greatly to the pollution of water resources.	Preparation of a National Master Plan on Sanitation for Local Governments and Rural Areas of Nigeria incorporating the construction of septage treatment plants in strategic places for sludge treatment from on-site disposal facilities. The Master Plan should focus on the use of septic tanks for households having water connections and ventilated latrine for houses that not have water connections.
Water Environment Conservation	
Management Plans of forest are not implemented and as result there are uncontrolled clearing of forest in many parts of Nigeria and as results erosion increase affecting water courses	The management plans of forest should be put in place to achieve a sustainable production, protection and conservation of forest resources.
Currently many rivers and dams in Nigeria are affected negatively by aquatic weeds and plants	In the period 2007-2011, the FME implemented a project for aquatic weeds and plants control in 25 states. A second phase of this project is now under preparation. It is recommended that FMWR takes part actively of the above project to promote a sustainable control of this nuisance in important surface water of Nigeria.
Nigeria is blessed with many water recreational areas that can be exploited as tourism attractions in the world of tourist industry. Besides, the cultural celebrations by its population composed by diverse cultural groups could represent the best destinations for tourist lovers of the history and culture. However, these potentials of tourism need to be developed adequately to promote the sector in the country	The promotion of tourism in Nigeria is indispensable for creating jobs and income generation. The best point to start, is implementing the existing Master Plan for the Tourism Sector. The existence of water related recreation places should be considered when water resources development project is proposed. The management of these places should also be considered as a part of watershed conservation activities

Source：JICA Project Team

9.8.2 Suggestion

Based on the main problems and issues found by the JICA Project Team, the following two plans are proposed for water environment management improvement in Nigeria.

Project-1: National Drinking Water Quality Monitoring Improvement Plan

Justification

The establishment of an effective Water Quality Surveillance Programme to cover all basins of the country to analyze water sources and treated water by FMWR is recommended strongly. In this sense, the on-going project for the construction of the new 6 (six) Reference Water Quality Laboratories is the most important project of the Ministry towards the improvement of Water Quality Monitoring in the country.

However, the FMWR needs the assistance to replace their current equipment in the old laboratories and to equip the new laboratories which construction is near to be finalized. In addition, the training of human resources is fundamental at FMWR in order to be able to design a monitoring plan, analysis of samples and the interpretation of the results.

Objective

The objective of the National Drinking Water Quality Monitoring Improvement Program is to generate scientific data of the water source and drinking water quality in Nigeria to safeguard the health of the population.

Planning Policy

The target samples for this Program shall be the water sources (surface and groundwater) and the treated water consumed by the population and the parameters to be analyzed shall include those necessary to assess the water sources quality and drinking water quality.

Strategy

- The Program shall be formulated to strengthen the capability of FMWR and relevant agencies for water sources and drinking water quality monitoring
- The Program shall be formulated to strengthen the involvement of the State Water Boards, River Basin Authorities, environmental associations, etc. and the public in general for a better understanding and cooperation for the smooth implementation of the Plan.

Components

- Study for formulation of the National Drinking Water Quality Monitoring Improvement Plan
- Provision of equipment for:

  (i) Existing laboratories: replacement and provision of equipment for analyzing organic compounds and heavy metals in water.

  (ii) New laboratories: provision of equipment to analyze all physic-chemical, bacteriological, organic and heavy metal parameters
- Training of staff Laboratories and technicians on water quality monitoring design, analysis of water and assessment of the found results
- Implementation of the formulated improvement program as a pilot project from which can be learnt necessary adjustment to be applied in the National Drinking Water Quality Monitoring Improvement Plan

Project-2: Water Quality Monitoring Plan for Important Rivers of Nigeria

Justification

Information on water quality of important rivers is necessary to assess their current condition and to determine their possible trend in the future. Currently, the country, lack such as kind of information, consequently, this Plan is justified completely.

Objective

To assess the water quality condition of important rivers in Nigeria

Planning Policy

This Plan shall cover main monitoring stations for water quantity along important rives

Strategy

- The parameters to be analyzed will include all those necessary for water quality assessment for different water uses
- The solid database should be prepared for analysis and decision
- Laboratories of FMWR and trained personnel in (a) will take part of this Plan mainly

Components

- Study for formulation of the Water Quality Monitoring Plan for important rivers
- Implementation of the formulated Plan for important rivers

Necessary Equipment

Necessary equipment for these projects is shown in Table 9-22.

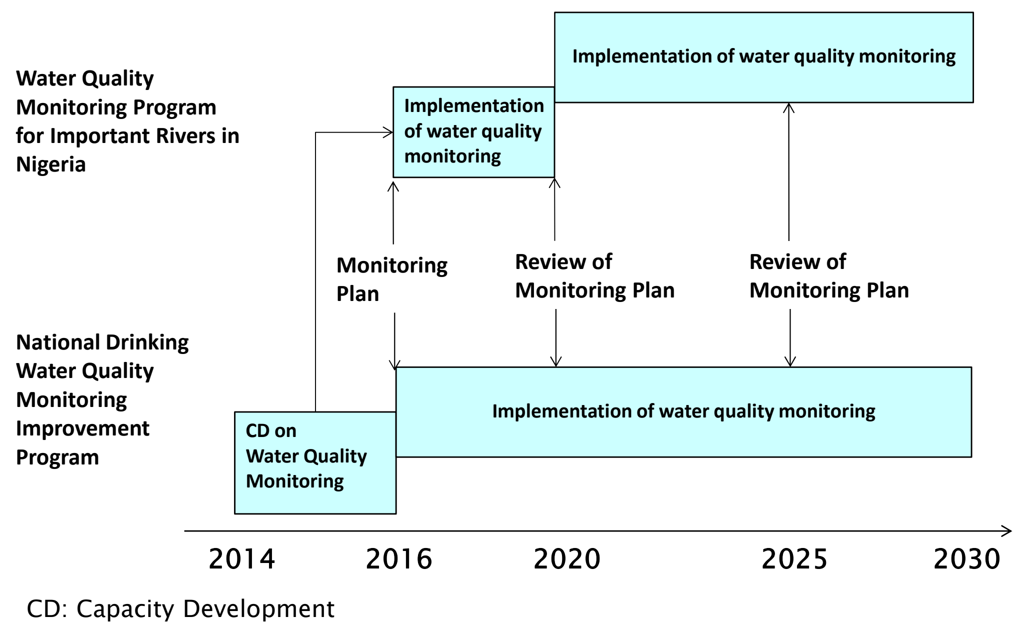
Table 9-22 Necessary equipment for Improvement of Water Environment Management

No	Activity	Parameters	Main Equipment by Each Laboratory
1	Sampling and testing of in-situ parameters	Temperature, Ph, Conductivity, DO	Field Monitoring Multi Tester, Conductivity/TDS/ºC Meter Portable (2), Ph/ion meter (2), DO meter (2)
2	Analysis of water in Laboratory	Physico-chemical and batecteriological parameters	Flame photometer with accessories (2), Spectrometer (1), COD Analyzer (1), BOD respirometer (2), Incubator (3), colony counter (1), Colorimeter (2),), Microscope (2), digital thermometer (2), miscelaneous material and equipment for supporting analysis*
		Heavy metals	Atomic Absorption Spectrometer with Accessories, Digestor (1)
		Organic and pesticides	HPLC System with accessories(1)

*: The equipment to support water quality analysis includes the followings.
Rotary pumps (2), balance (6), compressor (2), water batch (3), blender (1), Series Block Heaters (1), thermometer (1), centrifuge (4), Ice maker (1), Chamber furnace (1), hotplate (6), Fluidized bath (2), Drying oven (2), Overhead stirrer (8), Refrigerator (2), Water Solvent Delivery System (1), Industrial Fume Cupboard (1), Microfiltration system (1, Dessicator (5), Shaker (1), etc., Glasswares/miscellaneous/chemicals/reagents, Laboratory safety wares, etc.
Remarks:
The equipment are to be supplied with the necessary accessories for complete installation such as the required furniture, gas piping. The list of equipment is tentative and must be adjusted during the formulation of the National drinking Water Quality Monitoring.
Source: JICA Project Team

Proposed Implementation Schedule

It is proposed that the projects be implemented as shown in Figure 9-14. The relevant agencies by component of the projects are also shown in Table 9-23.



Source: JICA Project Team

Figure 9-14 Proposed Implementation Schedule on Improvement of Water Environment Management

Table 9-23 Relevant Agencies by Component of the Projects

		Organization																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	National Drinking Water Quality Monitoring Improvement Plan																		
(1)	Formulation of National Drinking Water Quality Monitoring Improvement Plan by International Assistance	M	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	S	P
(2)	Procurement of equipment for old Laboratories of FMWR	S																M	
(3)	Procurement of equipment for new Laboratories of FMWR	S																M	
(4)	Procurement of vehicles doble-cab type for water monitoring (for laboratories)	S																M	
(5)	Procurement of vehicles sedan type (for supervision of laboratories)																		
(6)	Procurement of computers, printers, software (for laboratories and supervision)																		
(7)	Training program for staff of Laboratories of FMWR	S																M	
(8)	Implementation of National Drinking Water Quality Monitoring Improvement Plan (pilot project)	M	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	S	P
(9)	Sustainable Implementation of National drinking Water Quality Monitoring Improvement Plan by FMWR	M	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
2	Water Quality Monitoring Program for Important Rivers of Nigeria																		
(1)	Formulation of the Program for water quality monitoring in primary rivers by FMWR	M	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
(2)	Sustainable Implementation of the Program for water quality monitoring in primary rivers by FMWR	M	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P

Organization:

1 FMWR(Water Quality & Sanitation Division)
2 Nigeria Integrated Water Resources Management Commission
3 FMWR(NIHSA)
4 FMWR(Water Research Institute)
5 FMWR (River Basin Authorities)
6 StateWater Board
7 Federal Ministry of Environment (NESREA)
8 Federal Ministry of Environment (Pollution Control and Environmental Health)
9 Federal/State Ministry of Health
10 States Ministry of Environment
11 Lagos Environment Protection Agency
12 Abuja Environment Protection Board
13 Federal Ministry of Mines
14 Federal Ministry of Trade and Investment
15 Industrial Associations
16 NGOs
17 Donor Organizations
18 Nigerian Citizens

Responsibility Assignment Matrix:

M=Main Responsibility
S=Sub Responsibilities
P=Participation in Discussions

Source: JICA Project Team

9.9 Water Allocation and Regulation

9.9.1 Current Situation

Although the necessity of obtaining the license for water abstraction and use for commercial scale water use is stated in Water Resources Act, 1993, the implementing framework for it has not yet been introduced. The current practices for licensing of water abstraction and use are as follows[5].

- Various State Water Boards/Corporations operate numerous boreholes without explicit license for groundwater abstraction.
- Existing contracts between any State Water Boards/Corporations and an RBDA is deemed to constitute a license for such an Agency to abstract surface water.

There are several overlapping laws related to the licensing system on water resources as shown in Table 9-24. There complicated situation have been made the water resources management difficult.

Table 9-24 Authorities for Licensing to Water Abstraction and Use

Law	Authorized Organization	Authorized Items
Water Resources Act, 1993	FMWR	• Define the place from which water may be taken • Fix the amount taken in times of shortage • Prohibit the taking if water is dangerous to public health • Prohibit the use of water or the operation and management of any borehole or hydraulic works • Prohibit any act which could interfere with the quality or quantity of water • Supply or sell raw water to any person, on terms and conditions determined by the minister
River Basin Development Authority Act, 1987	RBDA	• Develop of surface and underground water resources for multipurpose use • Construction, operation and maintenance of dams, dykes, wells, boreholes, irrigation and drainage systems, polders, etc. • Supply of water from storage scheme to all users for fee • Preparation of water resources master plans • Management of irrigation scheme and regulation of water, if approved by the National Council of Ministers
National Inland Waterways Authority Act, 1997	NIWA	• Grant permit and licenses for water intake • Provide hydraulic structures for rivers and dams, bed and bank stabilization barrages, groins • Advise government on all border matters that relate to the inland waters • Enter permanent structures within the right-of-way or divert water from a declared waterway
Minerals and Mining Act, 1999	FMM	• Obtain and convey such volume of water as may be required for the purpose of its mining operations • Construct any works necessary for the collection, storage or conveyance of the water • Occupy such land as may be required for a dam, reservoir of pumping station and for the conveyance of water to the area of the lease by means of pipes, ducts, flumes, furrows or otherwise

Source: NIWRMC, Final Report on Review of Water Related Policies, Legislation and Institutional Framework

In order to improve this situation, National Water Resources Bill was drafted based on i) National Water Policy (2004), ii) Water Resources Strategy (2006), iii) Draft National Irrigation Policy and Strategy (2006). It should be noted that the Draft National Water Resources Bill is still under review and modification at this moment.

Nigeria Integrated Water Resources Management Commission (NIWRMC) was established as a responsible organization for management of water use permit and regulation. NIWRMC consists of a central coordinating body as well as Catchment Management Offices (CMOs) at eight (8) hydrological areas. NIWRMC has started its activities from 2008 and waiting official approval for its establishment. According to draft establishment law of NIWRMC, the main functions of NIWRMC are as follows.

5 NIWRMC, Final Report on Review of Water Related Policies, Legislation and Institutional Framework, 2010.

Table 9-25 Function of NIWRMC

Category	Function
Planning	● Liaison with relevant agencies to conduct studies and surveys for the purpose of establishing water resources balance and catchments management plan and water efficiency strategies; ● Interact and consult with approved local and international organizations engaged In integrated Water Resources Management and liaise with other relevant agencies to determine Nigeria's input into the setting of international technical standards for water resources management within the provisions of this Act; ● In collaboration with other relevant agencies monitor and advice the Minister on International Treaties, Obligations, Conventions, on water resources development and management and take necessary measures to facilitate their domestication into national statues by the relevant authorities; ● In collaboration with other relevant agencies advice the Minister on bilateral and multilateral memoranda of understanding (MoU) and agreements with other countries and external agencies on water resources exploitation and management; ● Develop performance indices in relation to the quality of water resources services and facilities supplied to consumers having regard to international best practices performance indicators and Nigerian conditions; and ● Facilitate technical assistance in all aspects of Integrated Water Resources Management.
Management	● Effectively monitor and evaluate water sector programs and advice the Minister on the entire Nigerian Water Resources Sector including lending, foreign technical assistance and portfolio; ● Facilitate the entry into the market by persons wishing to supply water services and facilities; ● Arbitrate dispute between all stakeholders especially the licensees and other participants in the water resources sector; ● Receive and investigate complaints from licensees, developers, consumers and other persons in the water resources management; ● Liaise with relevant national and international agencies and advise the Minister on ways of promoting cooperation for effective and equitable management of trans-boundary waters (Niger Basin Development Authority, Lake Chad Basin Commission, Niger-Nigeria Joint Commission, Cameroon-n-Nigeria Joint Commission and such other agencies within the water resources sector); ● Monitor and report to the Minster charges paid by consumers, the performance of licensees and other person in meeting the standards developed under paragraph (xiv) of this section; ● Receive financial and technical aid from international organizations and non-governmental agencies for the purpose of proper regulation of water resources in Nigeria; and ● Perform such other functions which in the opinion of the Commission are required for the purpose of achieving its objectives under this Act including any of the functions of the Minister as contained in the Water Act, which the Minister may delegate to it from time to time.
Regulation	● Implement regulatory policies on activities relating to the management of water resources in Nigeria; ● Responsible for economic and technical regulation of all aspect of water resources exploitation and provision (construction, operation, maintenance and tariffs) of public and private water resources infrastructure; ● Ensure the safety and quality of water resources development and public water services by regulating standards for execution and performance; ● Promote competition in the public water service provision; ● Protect suppliers of public water resources services or facilities under this Act from unfair practices of other water resources developers or services providers which are damaging to competition; ● Protect licensees from misuse of market power by other developers and service providers; ● Responsible for protection of public interest by ensuring that the provisions of this Act are carried out with due regard to public interest; ● Protect consumers from unfair practices of licensees and other persons in supply of water resources services and facilities; ● Issue water resources licensees in accordance with the provision of this Act; and ● Monitor the conduct of holders of the licensees and to enforce the conditions included in the licenses.

Source：JICA Project Team

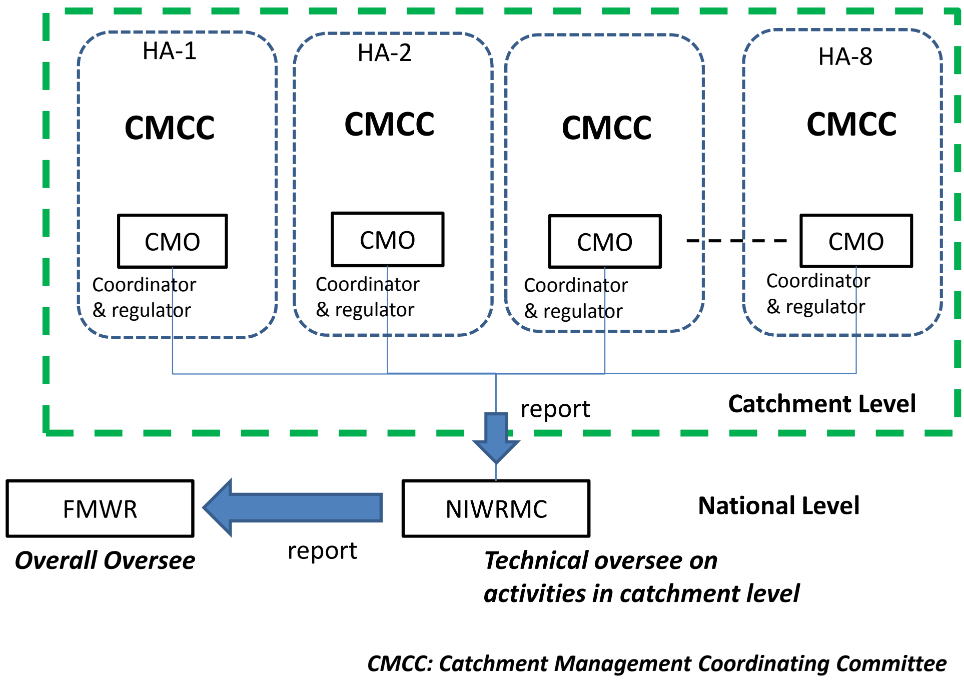
As observed in the objectives for establishing NIWRMC, sustainable water resources development and proper water allocation in consideration of equity and environment are sought by implementing proper water use permission and regulation in Nigeria. The main issues are as follows.

- Improvement of law and legislation related to water use permission and regulation
- Capacity building of regulator of water such as NIWRMC
- Improvement of estimation of water resources in order to allocate water properly
- Enhancement of data/information on water resources facilities and water use, in order to properly implement daily work on water regulation

9.9.2 Suggestion

(1) Framework

The Basic Policy-3 in Chapter 9.2: Institution and Organization for Public Water Services shows the principle of water resources planning, management and regulation by unit of hydrological area for establishing fair institution for water regulation. The framework on water resources planning, management and regulation by unit of hydrological area is proposed as shown in Figure 9-15.



Source: JICA Project Team

Figure 9-15 Framework on Water Resources Planning, Management and Regulation by Unit of Hydrological Area

The basic unit of water resources management is each of eight hydrological areas. The Catchment Management Office (CMO), which is local office of NIWRMC for each hydrological area, acts major role on water resources management in hydrological area. The headquarters of NIWRMC in Abuja oversees the activities of CMO. FMWR further oversees all activities by NIWRMC. NIWRMC reports its activities on water resources planning, management and regulation by unit of hydrological area to FMWR and receives advice from FMWR.

The framework of the activities of CMO at catchment level is proposed as shown in Figure 9-16.

The activities of CMO at catchment level can be divided into the following two categories;

- Coordination of stakeholders for macro management; and
- Daily work as regulator of water use for micro management.

The macro and micro management are defined as follows;

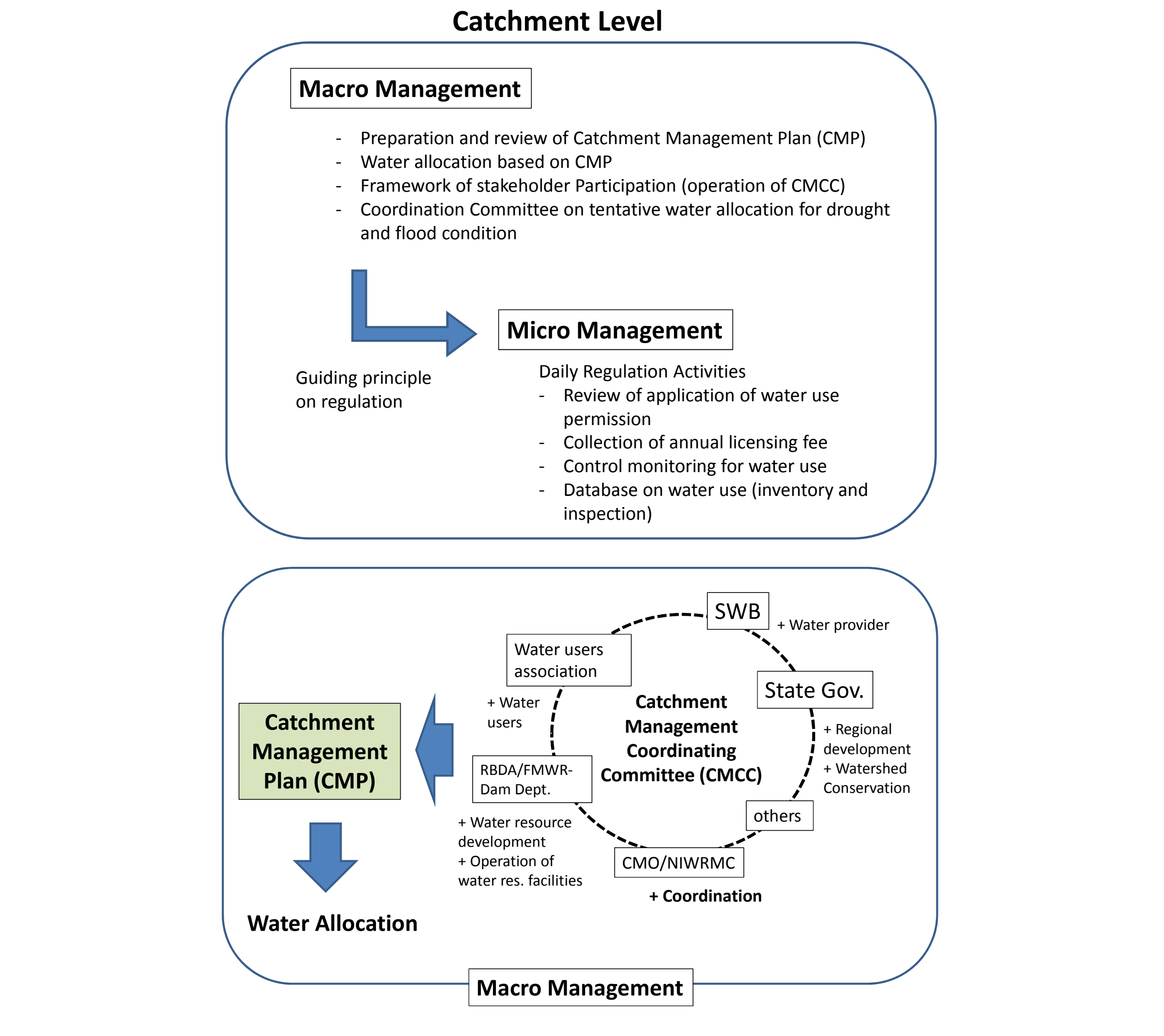
- Macro Management

- On the basis of the water use and water resources development plans included in the Catchment Management Plan, the water allocation in the scale of the entire hydrological area is managed. It is required that the proper water allocation which should reflect the progress of the implementation of the CMP be considered by monitoring the situation of water use facilities and water resources development facilities time to time.
- The Catchment Management Plan (CMP) would be formulated by consensus among Catchment Management Coordination Committee (CMCC) that consists of stakeholders in hydrological area. The CMO as well as NIWRMC plays important role to support formulation and revision of CMP from technical point of view and to coordinate stakeholders.
- Coordinating emergent water allocation during draught and/or flood conditions.

● Micro Management
- Based on the water allocation managed by the macro management, the daily activities for water regulation such as reviewing and approving the application of water use license, collection of license fee, data and information management related to water use permit and control monitoring should be implemented.

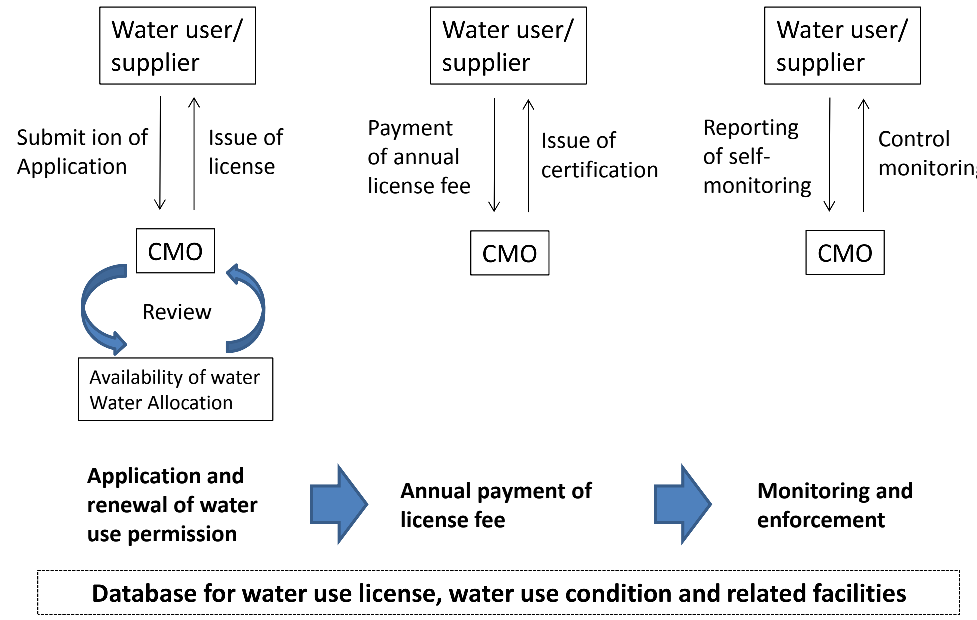
Without the macro management, it is impossible to implement the micro management. The knowledge obtained through the micro management should be reflected to the macro management.

The role of CMO for micro management is presented in Figure 9-16. The daily activities as regulator of water use include 1) Reviewing and approving the application of water use license, 2) Collection of license fee, 3) Data and information management related to water use permit and control monitoring.



Source: JICA Project Team

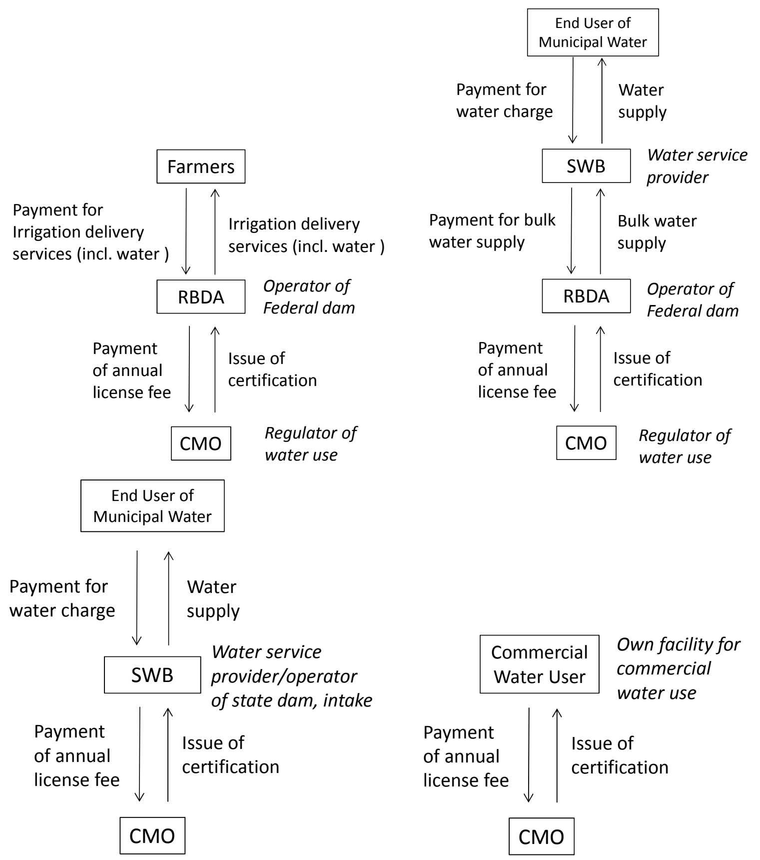
Figure 9-16 Framework on Activities of CMO at Catchment Level



Source: JICA Project Team

Figure 9-17 Role of CMO for Micro Management

It should be noted that the license fee for water use which is collected by CMO is different from water charge by SWB, service provider for municipal water supply, and irrigation service charge collected by RBDA from famers. These charges are collected to recover the cost for construction, operation and maintenance of water resources facilities by water users, whereas the license fee is collected against the opportunity cost of natural flow without any specific water uses. The license fees may be added to the water charges and be shouldered by the end user of water. The typical patterns of the cost recovery on water use are shown in Figure 9-18.



Source: JICA Project Team

Figure 9-18 Typical Patterns of Cost Recovery on Water Use

It is proposed that the guideline for water pricing including setting water charges and water license fee be prepared by FMWR through NIWRMC. The license fee collected by CMO should be utilized for supporting the activities related to water resources management such as organizing CMCC that consists of stakeholders in hydrological area.

(2) Proposed Projects

Referring to the main issues shown in Section 9.9.1, the following projects are proposed to be implemented by NIWRMC in order to realize the framework on water allocation and regulation shown in Section 9.9.2.

Project-1: Formulation of Catchment Management Plan for Eight (8) Hydrological Areas

This project is to formulate Catchment Management Plan for each of eight hydrological areas. The duration of the project is proposed to be three years from 2014 to 2016.

As discussed in the framework on water allocation and regulation shown in Section 9.8.2, the most fundamental things to do is to prepare the CMP as a starting point of the macro management. It would thereby be regarded as the important project to drive the proper water allocation and regulation in Nigeria.

NIWRMC and CMO do not have enough capacity to prepare the CMP by themselves, because they are just established. On the other hand, RBDAs have long history and have been implementing the practical water management in their management area. It is thereby proposed to prepare the draft CMP by the cooperative working group that consists of NIWRMC, CMO and RBDAs

NIWRMC and CMO as coordinator should play central role for implanting the macro management based on the formulated CMP. RBDAs as one of water users should have responsibility for implementing the water resources development, but the monitoring and evaluation for the progress of the CMP as well as the proper water allocation should be managed by CMCC. CMO should act as coordinator for CMCC. NIWRMC and CMO should develop their capacity on coordination of stakeholders through the process of formulating the CMP.

Project-2: Enhancement of Capacity on Water Use Permitting and Regulation

This is to enhance the capacity of NIWRMC and CMO on water use permitting and regulation.

It is proposed to be implemented in 2014-2016(3years), and the following components would be included.

- Preparation of manual on water use permission and regulation
- Implementation of water use permitting and regulation in pilot areas
- Inventory survey on water resources facilities
- Preparation of database for water resources facilities and water use permission
- Water allocation modeling

Project-3: Promotion of Catchment Management for Eight (8) Hydrological Areas

On the basis of the experiences by Project-1, 2, this project is proposed to be promoting catchment management for all hydrological areas including operation of the water use permitting and regulation system. The duration of project is 14years from 2017 to 2030, and the following components would be included.

- Enhancement of human resources in NIWRNC and CMO
- Revision of CMP
- Stakeholder meetings
- Implementation of water use permitting and regulation
- Revision of database on water resources facilities and water use permission

Project-4: Preparation of Guideline for Water Pricing

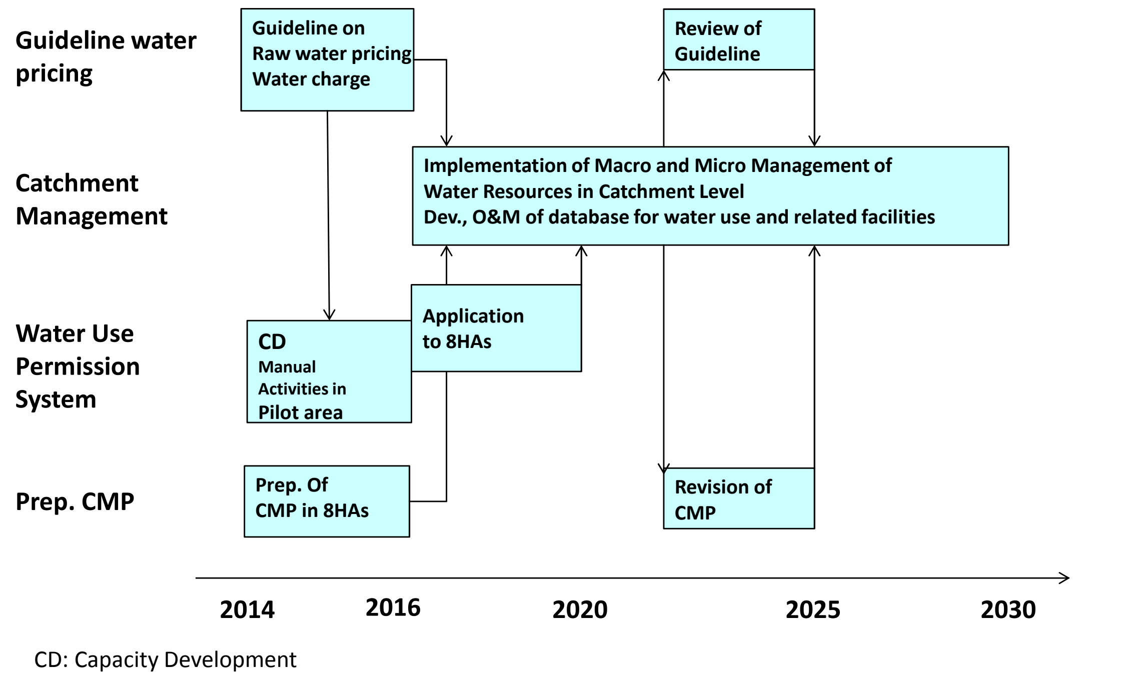
This project is to examine the cost of water use and consequently to prepare the guideline to set proper water license fee and water charge. It is proposed to be implemented in 2014-2016(3years), and the following components would be included.

- Evaluation of raw water price without water resources development in order to set appropriate water use license fee

- Preparation of guideline to set proper water charge for cost recovery for water resources development by RBDAs etc.

Proposed Implementation Schedule

It is proposed that the projects be implemented step by step as shown in Figure 9-19



Source: JICA Project Team

Figure 9-19 Proposed Implementation Schedule on Improvement of Water Allocation and Regulation

9.10 Public Relations for Water Sector

9.10.1 Current Situation

(1) Mission for Public Relations in Water Sector

The mission for Public Relations (PR) in water sector shall be clearly identified in the National Water Policy (Draft) and the National Water Resources Bill (Fourth Draft). It is summarized as follows.

- To establish and promote partnership between the government and civil society in water resources management through promoting public awareness and enlightenment on water conservation and management, and participatory approach for effective water resources management (the National Water Policy)
- To ensure the responsibilities of transparency and accountability in water resources development and management to be delivered by all levels of the governments (the National Water Resources Bill)

In line with the aforesaid mission, FMWR established the communication strategies including the followings.

- To engage the staff in educating the public to appreciate the Federal Governments (FGs) effort towards developing water resources in the country
- To partner with the media in dissemination of information on water related issues
- To provide a platform for feedback on the impact of FGs investment on water issues
- To promote transparency and accountability in the water sector
- To attract private investment in the water sector

(2) Roles of PR Unit of FMWR

The operation of PR of FMWR is mainly undertaken by the Press and Public Relations Unit (PR Unit). The PR-Unit is responsible for publication and introduction of the activities of FMWR through the media such as newspapers, TV, radio, magazines, in addition to website. One of the important operations for the PR Unit is periodical publication of a quarterly magazine known as “WATER”. The PR Unit also plays an important role in collection and management of information on international trend and movement in relation to water resources development and management.

The other core departments and units for the PR operation within FMWR are the Gender and Human Rights Unit, Department of Planning, Research and Statistics, NIWRMC, NWRI, SERVICOM, and the Anti-Corruption and Transparency Unit.

9.10.2 Suggestion

(1) Basic Policies for Public Relations in Water Sector

The basic policies for effective and sustaining public relations in water sector are discussed below.

- **Through PR, demonstrate greater dedications of FMWR, and establish and maintain mutual understanding between FMWR and civil society, ensuring transparency and accountability of all activities of FMWR in water resources development and management**

  It is one of the most important roles of PR to timely publicize and disclose the activities of FMWR as it can promote the image of FMWR in water sector. Disclosure of the policies and activities for water issues to the people is considered to contribute much to have understanding from all stakeholders for planning, development and management of the nation’s water resources.

- **Through PR, encourage participation of users, planners, decision-makers, etc. in water resources management**

  The operation of PR is also critical in terms of promoting cooperative relationship between the government and communities. As an example, in the case of development of irrigation projects, lack of awareness on importance for participation by farmers into planning and implementation of the project has resulted in inadequate infrastructure development, and operation and maintenance. Similarly, in water supply and sanitation sector, absence of people’s participation has brought about inadequate water supply and sanitation facilities.

- **Through PR, enlighten and spread education of water, sanitation and hygiene, gender issue, and environmental conservation at communities**

  Promoting gender equality and mainstreaming is one of the important roles for the PR operation in water sector. In addition, empowerment of women at communities is absolutely required to achieve adequate water resources management. With an eye to recognizing empowerment and gender issues, PR is greatly expected to play important roles in enlightening and spread of education on water issues for all stakeholders, especially for women and the youth.

(2) Action Plan

Taking into account the basic policies mentioned above, we suggest the following Action Plan, to be implemented in collaboration with other relevant institutions as previously stated.

- Strengthen PR, through updating FMWR's quarterly magazine (WATER)
- Strengthen and diversify the tools of PR to include all the media such as newspapers, TV, radio, magazines, etc.
- Strict and efficient management of document files within FMWR (digitalization, etc.)
- Support and assist in participatory process of water resources management considering gender equality, empowerment for women, local behavior practices at households and communities
- Development of workforce and capacity building in the PR-Unit and the Gender and Human Rights Unit

9.11 Public Private Partnership (PPP)

9.11.1 Current Situation

(1) Background of PPP

In Nigeria, government has been the major investor in the development of water infrastructure. With continuing increase in population, it is expected that an ever increasing demand for water infrastructure and water services will continue to grow. However, limited budget of the government creates difficulties in development and rehabilitation of water infrastructure. Under these circumstances, PPP is now being introduced into water services to procure additional investments from the private sector.

PPP is the contractual agreement between a public agency (federal, state or local) and a private sector entity. It must be noted that PPP ensures the Value for Money (VfM) of public services, and gives the government the right to retain ownership of the assets or infrastructure after the concession period. The government is always asked to consider provision of dependable and sustainable funding, increased accountability, accelerated infrastructure provision and faster implementation of PPP projects.

(2) Policies and Strategies for PPP in Water Resources Sector

Top policies and strategies for PPP in water resources sector in the national policy documents are:

- To encourage community participation, private sector participation and PPP in provision of water supply and sanitation schemes and services; and
- To achieve a better and more efficient service delivery to all users through enhanced private sector participation in water services.

The National Water Policy (Draft) stipulates the strategies on PPP as follows

- To create laws and regulations assuring conducive conditions of operation for local and foreign private companies.
- To establish a regulatory framework for the activities of water service providers to guarantee adequate protection of consumers
- To encourage various forms of participation (BOT, etc.)
- To assist all levels of government to cope with the requirements of managing contracts with the private sector;
- To promote the importance of the private sector participation in the provision of rural water supply and sanitation on community level; and
- To set up independent body for the mediation and regulation purpose of contracts entered into between government and the private sector

(3) Key Institutions for PPP Promotion

Key institutions for PPP are listed in the Table below.

Table 9-26 Key Institutions for PPP

Institution	Role
Infrastructure Concessionaire Regulatory Commission (ICRC)	Policy (National Policy on PPP), Guidelines, Regulations, Capacity Development and Contract Compliance
Federal Ministry of Water Resources (FMWR)	Policy, Guidelines and Overall Direction for the Sector Development
Water Sector Reform and PPP Unit of FMWR	PPP projects Identification, Preparation and Procurement
River Basin Development Authorities (RBDAs)	Basin Management and Development
Nigeria Integrated Water Resources Management Commission (NIWRMC)	Water Allocation, Watershed Protection and Regulation

Source: FMWR

FMWR intends to scale up PPP activities in the water resources sector to improve funding of projects and programs. For this purpose, PPP Unit was established in 2012 to serve as the focal point for PPP projects in water resources sector. The PPP Unit has embarked on the process of identification, preparation and procurement of potential PPP projects.

9.11.2 Suggestion

(1) PPP Lifecycle

Project lifecycle for PPP project is presented as follows.

Development Phase	⇨	Procurement Phase	⇨	Implementation Phase
● Need analysis ● PPP options appraisal ● Value for Money (VFM) ● Affordability ● Sustainability ● Prelim Risk Matrix ● Viability/Bankability ● VGF assessment ● OBC (Outline Business Case) Approval		● Transaction Adviser ● EOI and RFP (Concession) ● Bidding ● Bidding Conference ● Bid Evaluation ● Value for Money Test ● Preferred Bidder ● FBC (Full Business Case) Approval		● Technical Adviser ● Project Monitoring ● Commissioning Test ● Verify Output Requirements ● Contract Management ● FBC Approval

Source: PPP Unit, FMWR

Figure 9-20 PPP Project Lifecycle

(2) Areas of Investment Opportunities

Following areas are deemed to be potentially viable and attract the requisite private investment in the water resources sector.

- Irrigation projects (Medium and Large Irrigation)
- Water supply project (Brownfield and Greenfield)
- Hydro-electric power projects
- Water quality management projects
- Aquaculture and Horticulture projects
- Value added projects
- Tourism projects

(3) Responsibilities of FMWR for PPP Projects

To promote PPP projects, FGN and FMWR are expected to take the following responsibilities.

- Promotion of PPP through awareness creation, roadshows for private sectors to join public water services by incentives and preferential treatment for source of alternative funding
- Creation of sustainable enabling environment (policy, laws, regulation, etc.) to support PPP
- Identification and development of bankable PPP projects
- Facilitation of issuance of licenses, permits, etc.
- Provision of incentives to encourage the private sector (tax incentives, viability gap funding, etc.)
- Monitoring and evaluation of PPP projects to ensure delivery of intended value for money.

(4) Action Plan

Along with the above government responsibilities, the Project suggests following action plans.

- Strengthening of the PPP Unit of FMWR
- Capacity building for PPP projects preparation and implementation
- Budget allocation for PPP projects preparation
- Establishment of Projects Delivery Teams and Steering Committee
- Regular Partners/Stakeholders Consultation on the PPP process
- Regular updating of policies and strategies to promote private sector participation

9.12 Manpower Development and Capacity Building

9.12.1 Current Situation

Among other substantial ideas to strengthen manpower development and capacity building in the M/P1995 (JICA) and in other official reports, the “Nigerian Water Resources Management and Policy”, prepared with technical assistance from the Commission of the European Communities points out the problems of Human Resources Development (HRD) distinctly as follows,

- With regard to training opportunities for various engineers, such as hydrologist, hydrogeologist, etc. and from younger engineers to middle and top levels, they do not have much opportunity to have technical training.
- For realizing an adequate IWRM in each basin, lack of various specialists like economist, community specialist, regional planner, land use specialist, etc. is a critical problem.
- Shortage of skilled and experienced technical staff is a problem for an effective implementation of integrated water resources management. NWRI should continue to play an important role for expansion of training courses and places where all kinds of trainings can be done.

Under these circumstances, the National Water Policy (Revised, Draft) sets the following strategies for HRD;

- To build up a comprehensive personnel information system on institutional level in order to assess the available technical and managerial capacities and to plan and implement training programs on a periodic basis
- To develop succession plans for the sector staff in accordance with the manpower requirements as established in national plans
- To empower communities with skills and knowledge required for management of water resources schemes
- To develop infrastructure training facilities for On-the-Job Training (OJT)
- To strengthen the functions of NWRI to provide coordination for manpower development in the lower and middle level areas
- To establish training network centers in various states of the country under coordination of NWRI

9.12.2 Suggestion

(1) Basic Policy

The Project suggests the following basic policies for HRD for the M/P2013.

<u>Development and Increase Access to Training Opportunities</u>

For realization of IWRM with the central principles of management of water at river basin and catchment level, the needs and priority for HRD in various field is increasing. Of the various institutions responsible for HRD, placing the Human Resource Unit of FMWR and NWRI as core institutions in FMWR, access to training opportunities assuring the capacity building of all staff who engages in integrated water resources management shall be developed and increased.

<u>Strengthen Training to Respond to the Needs at River Basin Level</u>

It is noted that with regard to the needs to strengthen training to inspire the management at river basin level, HRD for NIWRMC including its subsidiary CMOs and their staff who shall be responsible for the water resources management at river basins is one of the most important and prioritized HRD.

<u>Strengthening and Enlargement of Training Functions of NWRI</u>

It is necessary to strengthen and enlarge the nationwide training functions of NWRI which is the foremost institution for HRD for sustainable water resources management inside and outside Nigeria.

(2) HRD Plan

Based on the basic policies mentioned above, the Project suggests the HRD Plan for the M/P2013 as proposed in Table 9-27. It shall cover all aspects of water resources carried out by various institutions within FMWR, and all relevant institutions such as NWRI, the Dept. of Human Resources, Dept. of Planning, Research and Statistics, etc. shall work under the collaborative system for completing the HRD Plan.

Table 9-27 Proposed HRD Plan

Selection	Contents
Target Group	Broadly, the target group for this HRD Plan shall include all government institutions including staff of the government at different levels (federal, states and LGAs) working in such water sub-sectors as water resources development, water supply and sanitation, irrigation and drainage. However, it is recommendable for this HRD Plan to consider first FMWR to be a prioritized group, taking into consideration the importance of having successful results of HRD first in FMWR and its parastatals and agencies prior to the States and LGAs. They are all Departments and Units of FMWR and the parastatals and agencies such as NIWRMC, 12 RBDAs, NIHSA, NWRI and GWMA. The target group will be expanded as the next step to the State and LGA Level. FMWR is highly required to provide them with assistance and support in doing HRD Plans.
Consideration	● The HRD Plan shall be carried out in consistent with institutional strengthening to be proposed in the M/P2013. ● NWRI shall undertake a strong initiative in planning, execution and monitoring and evaluation of the HRD Plan ● Introduction of external sources (technologies of advanced countries) for effective HRD shall be seriously considered. ● Earlier implementation of the National Water Policy, the National Water Resources Bill and NIWRMC Bill is presumed.
Targeted Specialization	● Groundwater Development Technology (Drilling plans) ● Management for operation and maintenance of irrigation schemes ● Dam safety ● Monitoring of hydrological and hydrogeological data ● Collection and management of basic water resources information ● Risk management for floods and droughts (flood risk assessment, etc.) ● Authorization and licensing systems for water use and regulation ● Watershed management (water quality monitoring technologies, etc.) ● PPP ● Others (Human Resources, etc.)
Activities	**<u>Development and Increase Access to Training Opportunities</u>** ● Formulation of the HRD plan in line with HRD needs and priority in the target water sub-sectors, vocational function and job-classes. It must be noted it is greatly requested to conduct a periodic survey for manpower to determine current status and capacity so as to adequately make a plan to fill the capacity gap. ● Budget plan (Assistance from development partners shall be considered) ● Development of multipronged and effective training courses in collaboration with NIHSA and other relevant agencies and bureaus ● Improvement of M & E systems ● Development of a comprehensive HRD programs for PPP to solve the problem of lack of funding of the sector (preparation of guidelines and manuals, etc.) ● Improvement of personnel appointment, promotion systems, including recruiting engineers and officers in mid-career **<u>Strengthen Training to Respond to the Needs at River Basin Level</u>** ● Development of HRD programs for water resources management in river basins (preparation of guidelines, etc.) ● Promotion of the HRD plans in quality in cooperation with river basin management institutions such as NIWRMC including CMOs, NIHSA, RBDAs, etc. ● A comprehensive HRD to be achieved through formulation and implementation of River Basin Strategies, etc. ● Strengthening of assistance for the purpose of increasing participation by all stakeholders in operation and maintenance of infrastructure **<u>Strengthening and Enlargement of Training Functions of NWRI within FMWR</u>** ● Establishment of NWRCBNet (National Water Resources Capacity Building Network)

Source: JICA Project Team

9.13 Monitoring and Evaluation

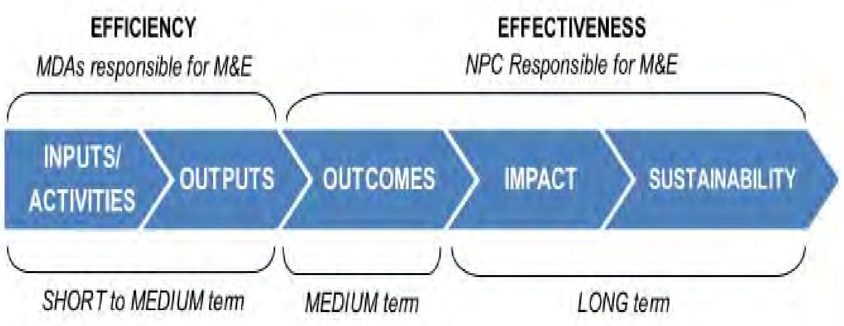
9.13.1 Current Situation

(1) Monitoring and Evaluation System of NPC

Monitoring and evaluation (M&E), this approach has been used as an effective method for managing the implementation of the projects, is employed to regulate the implementation plan of "Nigeria Vision 20:2020" - Top Plan of the M/P2013. National Planning Commission (NPC) has developed the MDA Scorecard to implementing the M&E to evaluate the performance and contribution of FGN and State Government bodies (Ministry, Department and Agency).

The scorecard is intended to define a consistent format that can be applied to all MDAs, to capture the Key Performance Indicators (KPIs) for Outcomes and Outputs in their strategic sector, and thereby ascertain their progress against annual targets and the efficiency of their strategy.

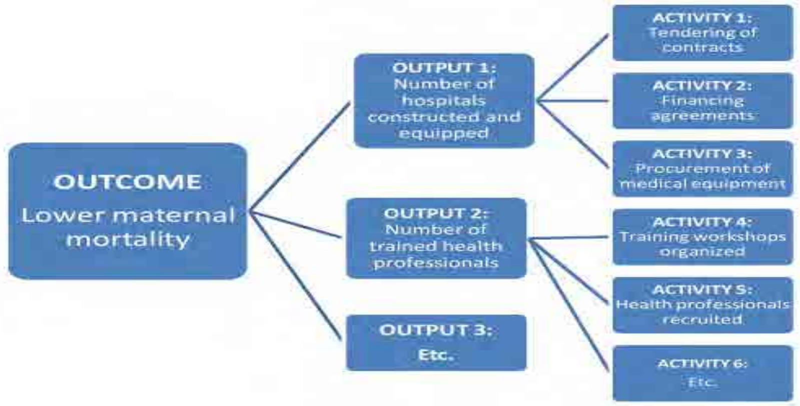
NPC will evaluate the impact and sustainability through Outcomes of MDAs and judge the effectiveness of their strategies. The information collected will support the performance-based approach to the budgeting process, as well as evidence-based planning and policy-making in other areas (see Figure 9-21).



Source：MDA Guideline - NPC

Figures 9-21 Results Chain of M&E (Role and Responsibility of MDAs and NPC)

A crucial aspect of the results chain is that many activities by many different stakeholders can be required to produce a single output. In turn, it is the case that many outputs from many stakeholders' input and activities may feed into a single outcome, etc. (see Figure 9-22).

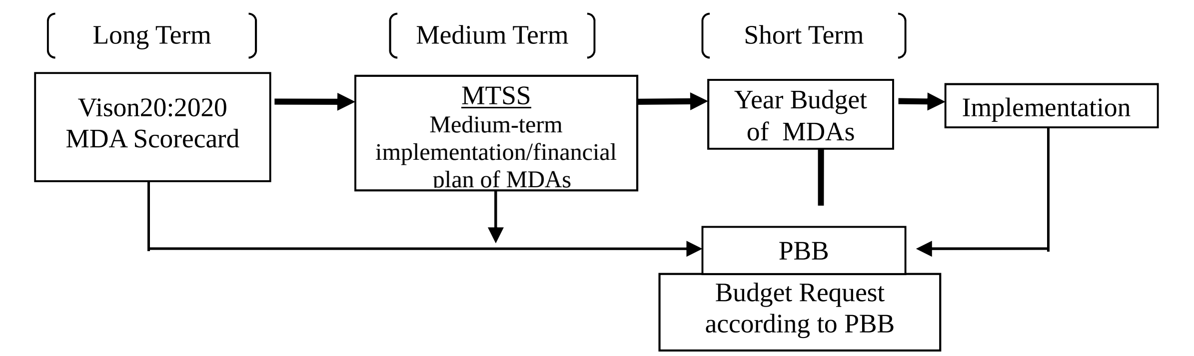


Source：MDA Guideline - NPC

Figure 9-22 An Example of "Multiple Outputs and Activities can feed into One Outcome" (Health Sector)

The above Scorecard has been enforced on all MDAs since the year 2011. NPC regards it as trial form and intends to reform it.

The Scorecard is defined as long-term evaluation tool for government strategy towards achieving the Nigerian Vision 20:2020. NPC envisages starting the modern budgeting system in future by combining the existing system of Medium-Term Sector Strategies (MTSS) and the currently studying Performance-based Budgeting (PBB) (see Figure 9-23).



Source: Elaborated by JICA Project Team based on the information from NPC

Figure 9-23 Expected Long- and Medium-term Framework of Government Budgeting

(2) M&E of FMWR

The role and responsibility of FMWR concerning the M&E is to determine the KPIs of the sub-sectors under the water-related sectors, monitor and evaluate them periodically and submit the results to NPC every year. The Monitoring & Evaluation Sub-department of the Planning, Research and Statistics Department is responsible for M&E of FMWR.

Table 9-28 shows the targets and achievements regarding 6 outcomes and 13 outputs of FMWR. These figures are to be achieved through the activities and inputs invested by FMWR and the related departments and agencies.

Table 9-28 Achievement and Targets of Outcome and Output KPI

Name of Outcome and Output		Key Performance Indicator (KPI)					
		Baseline	Achievement	Targets			
		2010	2011	2011	2012	2015	2020
＜Outcome＞							
1. Water	% of Population with access to potable water supply	58	60	63	66	100	100
2. Sanitation	1) % of Population with access to improved sanitation facilities	32	46	46	50	70	80
	2) No. of Awareness Campaigns carried out	40	57	n/a	65	85	95
3. Dam	% change in no. of Dam Construction	(88 dams)	0	29.5	31.8	40.1	40.9
4. Irrigation	Size of Irrigated Land (thousands of Ha)	60	96.5	96.5	147.5	275.3	519.4
5. Training & Research	1) No. of Trained Water Prof.	642	689	800	960	1,382	2,304
	2) No. of Research conducted	26	10	21	24	49	111
6. Monitoring	No. of Water Test conducted	1,850	3,050	5,520	8,570	15,640	34,040
<Output＞							
1. Water	1) No. of Urban Water Schemes	2	2	3	111 million Naira	224 million Naira	111 million Naira
	2) No. of Rural Water Schemes	-	93	204			
	3) No. of Small Towns Water Schemes	11	16	28			
	4) No. of Boreholes	710	117	228			
2. Sanitation	No. of Communities having access to improved facilities	695	1,017	1,007	85 million Naira	123 million Naira	163 million Naira
3. Dam	1) Water stored（BCM）	12.9	12.9	13.0	13.4	15.4	15.7
	2) Dams constructed	220	223	223	230	254	283
4. Irrigation	1) Irrigation Schemes	15	21	21	40	45	-
	2) Farmer having access to irrigation land (in thousand)	202.0	236.5	245.0	294.0	800.0	-
5. Training & Research	No. of Training & Research Activities	-	1,099	1,000	1,765	1,795	1,795
6. Monitoring	1) No. of Water Quality Test Lab. constructed	6	6	6	12	17	37
	2) Surface Water Monitoring Station constructed	213	252	253	313	402	482
	3) Groundwater Monitoring Stations constructed	12	20	20	30	52	100

Source: FMWR

9.13.2 Suggestion

The current M&E system of FMWR is to ascertain the progress of water resources and management strategies, and has undertaken from 2011. Although FMWR intends to reform and improve how to manage the M&E effectively in the future by reflecting the experiences, the JICA Project Team makes the following recommendations with regard to the M&E.

- To make the DAs of FMWR understand thoroughly the M&E System
- To enhance the M&E System implemented by NIWRM and CMO
- To develop the M&E system particularly for the preparatory stage of project

(1) To make the DAs of FMWR understand thoroughly the M&E System

Problems Identified

The KPI targets of the outcomes and outputs are changeable on the basis of the previous year's actual figures through the agreement between NPC and FMWR. FMWR discusses it every year.

However, the activities and input as illustrated in Figures 9-21 and 9-22, despite of responsibility of MDAs, were not prepared explicitly. Obviously the activities and input are essential to achieve the output of the FMWR subsectors. To set up the achievable target and accomplish it properly, the activities and inputs link to the outputs must be elaborated beforehand.

Actions to be taken

The activities are to secure the output of subsectors, and the inputs to secure the activities. These two items are closely related to the FMWR budgeting as shown in Figure 9-23; so, in planning of these two items, the detail preparation, proper management and periodical review are recommended as well as the explicit nomination of the responsible DAs.

The M/P2013 presents the cost of subsectors' development project in sum and year-wisely. Based on this, FMWR is recommended to revise the existing KPIs, adding the new outputs and targets. For instance, the new targets of KPIs could be set up from the number of dams in preparation in various stages (such as planning stage, F/S stage, detail design stage and contract stage) for the subsector of dam and the agriculture production of main products for the subsector of irrigation.

Table 9-29 Activities and Input to Achieve Outcomes of FMWR Subsectors (An Example)

Outputs of Sub-sectors		Activity Plan (example)	Responsible MDA	Implementation time	Input
1	Urban water supply facilities are constructed.	1.To carry out feasibility study			
		2.To study PPP formation			
		3. To accomplish financial break-even management			
		.			
2	Rural water supply facilities are constructed.	1.To strengthen the drilling kills			
		2. To collaborate with NGO			
		3.To develop the organizational capacity			

Source: JICA Project Team

(2) To enhance the M&E System managed by NIWRM and CMO

Problems Identified

NIWRMC has started to utilize the Scorecard from 2012 as presented in Table 9-30.

Table 9-30 Targets and Actual of KPIs managed by NIWRMC

Outcome	KPI		
	Performance Indicator	2012	
		Planned Target	Actual
1-1 Equitable and sustainable water resources development 1-2 Revenue generation through issuance of water permits and licenses	Number of water development/use licenses issued	20	0
2. Ensuring the improvement of river flow and sustenance of ecosystem	Number of water management activities by catchment management plan（river channels weed cleaning and de-silting, flood protection dykes, awareness creation on water demand management, etc.）	1	0
3. Stakeholders' participation in implementation of integrated water resources management principle	Number of meetings	2	2

Source: NIWRMC

NIWRMC was established in August 2010 as a coordinator and regulator among the stakeholders of water sectors including the roles of strategy and policy formulation and M&E. NIWRMC has been granted a variety of roles and rights; however, has not yet operated in full function because the presidential assent has not been given the mandate yet. For this, the Scorecard can be an efficient tool for promote the functions of the NIWRMC. Nevertheless, the current utilization of the Scorecard is regarded still in a primitive stage as presented in Table 9-30.

Actions to be taken

The followings are recommended for the issues above.

- To review the KPIs whether every outcome is determined in line with the function of NIWRMC as well as of CMO and "Nigeria Vision 20:2020" or not.
- As illustrated in Figure 9-22, NIRMAC has to prepare the outputs promptly that secure to achieve the outcomes of the above table; since, the organization has not yet prepared them.
- Also, NIWRMC has to prepare the activity plan that secure the outputs and the input plan that secure the activities; since these plans are inevitable for the medium-term strategy and the budgeting.

(3) To develop the M&E system particularly for the preparatory stage of project

The implementation of the projects proposed in the M/P1995 is far behind the proposed schedules as described in Chapter 2.7. One of the causes is that the proper preparation for initial stage of the implementation has been neither planned nor managed appropriately.

For this stage, the processes below must be pursued properly and definitely:

1) To draft a Project Proposal based on the M/P2013

2) To carry out the F/S

3) To prepare the Project Explanatory Note

4) To propose the Budget Request

5) To secure Budge Approval, and

6)To implement the projects.

Taking the PDCA（Plan-Do-Check-Action）system as examples, the above numbers of 1), 2) and 3) can be compared to the definition of "Plan" in the PDCA, and 4), 5),and 6) to "Do". Finally, by monitoring and evaluating carefully the above processes, the project can be promoted and progressed. The processes of 1), 2) and 3) are described more in details below.

Project Proposal

The DAs responsible for each project proposed in the M/P2013 prepares the project proposal as shown in Table 9-31.

Table 9-31 Drafting Project Proposal (An Example)

<table>
<tr><td colspan="4">Name of responsible DA:</td><td colspan="2">Drafting date:</td></tr>
<tr><td>Projects</td><td colspan="2">Component</td><td>Implementation</td><td>Cost</td><td>Direct effect</td></tr>
<tr><td rowspan="3">1.Irrigation A</td><td>1. Dam</td><td>MCM</td><td>2 years from 20xx</td><td>Naira</td><td rowspan="3">1)Irrigation Area: ZZ ha
2)Increase of production: ZZ ton/ha
3)Increase of farmers’ income: ZZ Naira</td></tr>
<tr><td>2. Irrigation channel</td><td>km</td><td>ditto</td><td>Naira</td></tr>
<tr><td>3. Paddy fields</td><td>ha</td><td>ditto</td><td>Naira</td></tr>
<tr><td>2.Irriagtion B</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Source: JICA Project Team

F/S

FMWR makes a detail examination of the above proposal, selects the priority projects among all and finally implement the F/S on the selected projects for the detail design, implementation schedule, project cost estimate, and social, environmental and economic/financial evaluation.

Project Explanatory Note

The responsible DAs prepare the detail plan of the projects on the items such as the construction work, equipment composition, procurement schedule, cost and financing.

M&E for “Plan Stage”

Thus, the definite processing of the “Plan stage of PDCA” can lead the selected projects to the implementation stage followed by the budget request and the budget approval. Accordingly, the M&E work during this “Plan stage” is essential; so the actions as shown in Table 9-32 are strongly recommended to be taken.

Table 9-32 Progress and Achievement of Irrigation Projects “A” (An Example)

<table>
<tr><td></td><td>Time</td><td>Activities</td><td>Plan</td><td>Actual</td><td>Action to be followed</td></tr>
<tr><td rowspan="2">Proposal</td><td>1st half</td><td rowspan="2">Drafting and submission</td><td>50%</td><td>40%</td><td>To discuss in the internal meeting of ministry</td></tr>
<tr><td>2nd half</td><td>100%</td><td>100%</td><td>To prepare budget request for F/S implementation</td></tr>
<tr><td rowspan="2">F/S</td><td>1st half</td><td rowspan="2">Preparation</td><td>30%</td><td>30%</td><td>Preparation of TOR</td></tr>
<tr><td>2nd half</td><td>60%</td><td>60%</td><td>Preparation of bidding documents sheet</td></tr>
<tr><td rowspan="2">---</td><td>1st half</td><td rowspan="2"></td><td></td><td></td><td></td></tr>
<tr><td>2nd half</td><td></td><td></td><td></td></tr>
</table>

Source: JICA Project Team

CHAPTER 10 IMPLEMENTATION PROGRAM

10.1 Implementation Schedule

(1) Outline of Projects

Outline of the proposed Project in the M/P2013 is shown in Table 10-1.

Table 10-1 Outline of Proposed Schemes

Project	Outline	Responsible Agency
A. Water Source Development		
A.1 Surface Water Development		
A.1.1 On-going Projects		
● On-going Surface water source development	On-going surface water source development. Number of dams: 30. Total storage capacity: 1,500MCM.	FMWR
A.1.2 Effective Utilization of Existing Dams		
● Capacity development of dam management	This project is to enhance the capacity of dam department of FWMR, as well as dam owners such as RBDAs, SWAs on dam management.	FMWR
● Rehabilitation of equipment for proper operation of major dams	This project is to rehabilitate the equipment for proper operation of dams such as meteorological, hydrological mentoring, monitoring for reservoir operation.	FMWR
● Rehabilitation of deteriorated dams	This project is to rehabilitate deteriorated dam which may threaten the downstream area. The rehabilitation would be implemented case by case up to 2030.	FMWR
A.1.3 New Water Source Development		
● Surface water development for municipal water supply	This project is to prepare stable water source for municipal water supply against the water source where the safety level is expected to be lower than 90% yearly dependability in 2030. Number of dams/weir: 22, Total storage capacity: 207MCM	FMWR
● Surface water development for irrigation development	This project is to secure necessary water volume for irrigation development, according to irrigation development plan proposed in the M/P2013. Number of dams: 21, Total storage capacity: 969MCM	FMWR
● Integrated surface water development	This is an integrated project to combine hydropower generation and irrigation development. Three project sites along the Benue River are proposed. Total storage capacity: 970MCM	FMWR
A.2 Groundwater Development		
A.2.1 Borehole rehabilitation		
● Urban/small-urban/small town	Rehabilitation of 4,880 boreholes with motorized pumps with yield of 2,193,335 m^3/day	SWA
● Rural	Rehabilitation of 949 boreholes with motorized pumps with yield of 422,640 m^3/day, and 13,364 of hand pumps with yield of 133,640m^3/day.	RUWASAA
A.2.2 New boreholes drillings		
● Urban/small-urban/small town	New drilling of boreholes with motorized pumps: 3,858 boreholes with 200m depth, 10,790 boreholes with depth of 50m, total yield of 6,937,613 m^3/day.	SWAs
● Rural	● New drilling of boreholes with motorized pumps: 3,736 boreholes with 200m depth, 5,369 boreholes with depth of 50m, total yield of 1,241,448 m^3/day. ● New drilling of boreholes with hand-pumps: 82,538 boreholes with depth of 50m, total yield of 825,380 m^3/day.	RUWASSAs
B. Sub-sector Development		
B.1 Water Supply and Sanitation		
B.1.1 Water Supply Rehabilitation Scheme		
● Urban and Semi-Urban / Small Town	Target: Urban and semi-urban/small town in 36 states and FCT Abuja Scope: Rehabilitation of piped water supply facilities using surface water or groundwater (2015-2030) Beneficiaries: 19,773,000 Development: 3,148 MLD (Surface water : 1,388, Groundwater: 1,761)	FMWR, State Ministries, SWAs, STWSSAs
● Rural	Target: Rural areas in 36 states and FCT Abuja Scope: Rehabilitation of point-source type water supply facilities equipped with motorized pump or handpump using groundwater (2015-2030) Beneficiaries: 12,058,000	FMWR, State Ministries, RUWASSAs

Project	Outline	Responsible Agency
	Development: 430 MLD (Groundwater only)	
B.1.2 Water Supply Newly Construction Scheme		
● Urban and Semi-Urban / Small Town	Target: Urban and semi-urban/small town in 36 states and FCT Abuja Scope: Newly construction of piped water supply facilities using surface water or groundwater (2015-2030) Beneficiaries: 60,971,000 Development: 9,707 MLD (Surface water: 4,146, Groundwater: 5,561)	FMWR, State Ministries, SWAs, STWSSAs
● Rural	Target: Rural areas in 36 states and FCT Abuja Scope: Newly construction of point-source type water supply facilities equipped with motorized pump or handpump using groundwater (2015-2030) Beneficiaries: 44,725,000 Development: 1,595 MLD (Groundwater only)	FMWR, State Ministries, RUWASSAs
B.1.3 Sanitation Scheme		
● Public Toilet	Target: Urban and semi-urban/small town in 36 states and FCT Abuja Place of installation: Markets, bus terminal and so on (2015-2030) Development: 20,326 places	FMWR, state ministries
● Final Septage Disposal Facility / Site	Target: Urban in 36 states and FCT Abuja Scope: Septage disposal system with considering collection and transportation from domestic septic tanks (2015-2030) Beneficiaries: 6,419,000 households	FMWR, FME, FEPA, SEPA
● Sewerage System	Target: Major urban area of Benin in Edo state, Central in Lagos state, Osogbo in Osun state, Ibadan in Oyo, and FCT Abuja Scope: Sewerage system including sewerage treatment plant and sewer (2015-2030) Beneficiaries: 320,000 households Treatment; 473,266 m3/day	MWR, FME, FEPA, SEPA
● Hygiene Promotion	Target: Urban, semi-urban/small town and rural in 36 states and FCT Abuja Scope: Education and promotion through community-led total sanitation (2015-2030) Beneficiaries: 29,154,000 households	FMWR, state ministries, LGAs
● Domestic Sanitation Facilities	Responsibility: Residents in urban, semi-urban/small town and rural in 36 states and FCT Abuja (2015-2030) Description: Installation of domestic toilet or latrine Households: Urban:16,651,000, Semi-Urban/Small Town: 13,407,0000 Rural: 36,796,000	
B.2 Irrigation/Drainage		
B.2.1 Rehabilitation of Existing scheme	Subject: 37 schemes, Future Irrigation Area 36,163ha,	FMWR, State
B.2.2 New Irrigation scheme		
● Ongoing Scheme	Scheme which has been on-going by FMWR and has a sure plan to implement in future. Subject: 32 schemes, Future Irrigation Area 98,897ha	FMWR
● Extension Scheme	Scheme which is recommended to expand planned irrigation area more in future, even if scheme has already completed or suspended. Subject: 92 schemes, Future Irrigation Area 103,937ha	FMWR, State
● Supplementary Irrigation Scheme	Scheme which comprises of land reclamation and supplementary irrigation. Scheme is specified in HA-5 and HA-7 owning much precipitation. Subject: HA-5 A=19,000ha, HA-7 A=29,000ha	FMWR
● Dam Irrigation Scheme	Scheme which has irrigation dam considered in the M/P1995 and the M/P2013 in order to assure full-year irrigated farmland. Subject: 17schemes, Future Irrigation Area 80,900ha,	FMWR
● Integrated Development Scheme	Scheme which is extensively developed by multipurpose dam, utilizing water and hydropower deriving from that dam, where are Donga-Suntai river, Taraba river and Akini river which are tributary of Benue river. Subject: 3schemes, Future Irrigation Area 90,000ha,	FMWR
B.3 Hydropower Generation		
● Installation in to existing dams	Promotion of installation of hydropower generation facilities into potential existing dams for self-supporting agriculture with irrigation. Survey for availability is necessary from now on.	
● Installation to newly constructed dams	Subordination hydropower generation will be conducted at Nasarawa, Taraba, Donga-Suntai dam.	
C. Water Resources Management		
C.1 Hydrological Monitoring		
● Improvement of Surface Water Monitoring	The monitoring network on surface water is setup step by step. Depending on the main purpose of monitoring, the monitoring stations	NIHSA

Project	Outline	Responsible Agency
Network	are categorized into four types: primary (18), priority secondary (22), secondary (35) and tertiary (93).	
● Improvement of Groundwater Monitoring Network	Project to install groundwater level monitoring: 1) Assessment for groundwater potential (120 sites), 2) Groundwater environmental monitoring such as over-pumping, regional lowering of groundwater level and sea water intrusion (22 sites)	NIHSA
● Enhancement of Data Management Capacity in NIHSA	This project is to enhance the data management of hydrological monitoring. Phase-1 is to enhance the capacity of the following items in a pilot area. In phase-2, the activities conducted in Phase-1 will be expanded continuously by NIHSA with more proactive manner.	NIHSA
● Establishment of Hydrological Modeling Center within NIHSA	In order to make use of hydrological monitoring data and assure high quality of those data, it is proposed that Nigerian Government establish Hydrological Modeling Center within NIHSA. The capacity development project related to hydrological modeling is proposed, in order to consolidate the related activities.	NIHSA
● Enhancement of Awareness on Importance of Hydrological Monitoring	This project is to promote awareness on importance of hydrological monitoring by NIHSA staffs.	NIHSA
C.2 Water Allocation and Regulation		
● Formulation of Catchment Management Plan for Eight (8) Hydrological Areas	This project is to formulate Catchment Management Plan for each of eight hydrological areas.	NIWRMC
● Enhancement of Capacity on Water Use Permitting and Regulation	This is to enhance the capacity of NIWRMC and CMO on water use permitting and regulation.	NIWRMC
● Promotion of Catchment Management for Eight (8) Hydrological Areas	This project is proposed to be promoting catchment management for all hydrological areas including operation of the water use permitting and regulation system, on the basis of the experiences by the above two projects.	NIWRMC
● Preparation of Guideline for Water Pricing	This project is to examine the cost of water use and consequently to prepare the guideline to set proper water license fee and water charge.	NIWRMC
C.3 Water Environment Management		
● National Drinking Water Quality Monitoring Improvement Plan	In order to generate scientific data of the water source and drinking water quality in Nigeria, the capacity development for water quality monitoring is proposed to be conducted. The continuous water quality monitoring is implemented after the capacity development.	FMWR
● Water Quality Monitoring Plan for Important Rivers of Nigeria	This project is to implement the water quality monitoring for important rivers in Nigeria, in order to assess the water quality situation in the important rivers.	FMWR

Source: JICA Project Team

(2) Implementation Schedule

Implementation schedule of the proposed projects is shown in Table 10-2 to 10-5. The schedule is decided based on strategies of each sector explained below:

(2-1) Water Sources Development

<u>**Surface Water Development**</u>

On-Going Projects

At least, the on-going projects would be completed by 2020.

Effective Utilization of Existing Dams

It is proposed to implement urgently the capacity development project on dam management for FMWR and relevant agencies. During the capacity development activities, necessary survey such as safety management survey and dam body survey should be implemented as many as possible, so as to materialize the rehabilitation project. Higher priority is given to the rehabilitation of equipment for proper operation of major dams.

New Water Sources Development

It is proposed that the stable water source for urban water supply should be achieved by 2025 at which the 100% coverage of the municipal water supply is targeted. The water source development for irrigation development would be implemented according to the irrigation development plan. As for the integrated project, relatively small scale project would be implemented as a pilot case, and then the remaining large projects would be implemented by 2030.

Groundwater Development

Groundwater will be developed by new borehole drilling and rehabilitation of nonoperational boreholes. It is most efficient to develop groundwater following growth of groundwater demand. Therefore, amount of groundwater development, i.e. total yield from new boreholes and rehabilitated boreholes, will be increased in proportional to increase of groundwater demand, which can be assumed as linear growth during 2014 to 2030. It means that number of new boreholes and rehabilitated borehole is the same every year.

(2-2) Water Resources Sub-sector Development

Water Supply and Sanitation

Water supply facilities using surface water; the M/P2013 proposes rehabilitation of existing facilities and newly construction of the facilities in the process of concrete designing as priorities in the 1st state, and then continuing newly construction of facilities according to progress of water sources development in the 2nd and 3rd stages.

Water supply facilities using groundwater; the M/P2013 proposes rehabilitation of existing facilities and newly construction of facilities in the entire period from 1st to 3rd stage.

As for sanitation, the M/P2013 proposes construction of public toilets in the entire period, construction of final septage disposal facilities and/or sites in the short term, and construction of sewerage systems in the 2nd and 3rd stages.

Irrigation and Drainage

It is proposed that the Ongoing Scheme should be achieved by 2025 considering their high priority. Supplementary Irrigation Scheme, which is expected earlier effective benefit due to comparatively small and economical scale development, would be achieved by 2025. Extension Scheme and Integrated Development Scheme would be prepared on 1st Stage and implemented by 2025 considering their own large scale development. Dam Irrigation Scheme would be implemented by 2030 in accordance with those irrigation dams construction period. Integrated Development Scheme also would be implemented by 2030.

(2-3) Water Resources Management

Hydrological Monitoring

The monitoring network would be improved step by step. As for the hydrological services such as data management and hydrological modeling, the capacity development project would be urgently implemented. Then, the related hydrological services would be continuously implemented. The awareness on importance of hydrology would be promoted continuously for the entire period.

Water Allocation and Regulation

The Catchment Management Plans should be urgently prepared. Simultaneously, capacity on water use permitting and regulation by NIWRMC should be enhanced. Furthermore, guideline for water pricing should be prepared. These should be implemented urgently in short term. On the basis of these experiences, catchment management for Eight (8) hydrological areas would be implemented continuously.

Water Environment Management

The capacity development for water quality monitoring would be implemented firstly. Then, the continuous water quality monitoring for drinking water as well as for important rivers would be implemented.

Table 10-2 Implementation Schedule of Water Sources Schemes

Project	1st Stage							2nd Stage					3rd Stage				
	2014-2020							2021-2025					2026-2030				
	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1.Surface Water Development																	
1.1 Ono-going Project	XXX	XXX	XXX	XXX	XXX	XXX	XXX										
1.2 Effective Utilization of Existing Dams																	
● Capacity development of dam management	XXX	XXX	XXX														
● Rehabilitation of equipment for proper operation of major dams				XXX	XXX	XXX	XXX										
● Rehabilitation of deteriorated dams				XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
1.3 New Water Source Development																	
● Surface water development for municipal water supply					***	***	***	XXX	XXX	XXX	XXX						
● Surface water development for irrigation development					***	***	***	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
● Integrated surface water development	***	***	***	***	***	***	***	***	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
2 Groundwater development																	
2.1Rehabilitation of existing boreholes																	
● Urban/small-urban/small town	***	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
● Rural	***	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
2.2New drilling boreholes																	
● Urban/small-urban/small town	***	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
● Rural	***	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX

[Note] ***: Preparation, XXX: Implementation
Source: JICA Project Team

Table 10-3 Implementation Schedule of Water Supply and Sanitation Schemes

Project	1st Stage							2nd Stage					3rd Stage				
	2014-2020							2021-2025					2026-2030				
	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1 Water Supply Rehabilitation Scheme																	
● Urban and Semi-Urban/Small Town	***	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
● Rural	***	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
2 Water Supply Newly Construction Scheme																	
● Urban and Semi-Urban/Small Town	***	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
● Rural	***	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
3 Sanitation Scheme																	
● Public Toilet	***	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
● Final Septage Disposal Facility/Site	***	XXX	XXX	XXX	XXX	XXX	XXX										
● Sewerage System							***	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
● Hygiene Promotion	***	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
● Domestic Sanitation Facility	***	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX

[Note] ***: Preparation, XXX: Implementation
Source: JICA Project Team

Table 10-4 Implementation Schedule of Irrigation and Drainage Schemes

Project	1st Stage							2nd Stage					3rd Stage				
	2014-2020							2021-2025					2026-2030				
	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1. Existing Irrigation scheme																	
1.1 Ongoing Scheme	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XX					
1.2 Extension Scheme		***	***	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
2. New Irrigation scheme																	
2.1 Supplementary Irrigation scheme	***	***	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX					
2.2 Dam Irrigation Scheme					***	***	***	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
2.3 Integrated Development Scheme	***	***	***	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX

[Note] ***: Preparation, XXX: Implementation
Source: JICA Project Team

Table 10-5 Implementation Schedule of Water Resources Management Schemes

Project	1st Stage							2nd Stage					3rd Stage				
	2014-2020							2021-2025					2026-2030				
	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1. Hydrological Monitoring																	
● Improvement of Surface Water Monitoring Network	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
● Improvement of Groundwater Monitoring Network	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
● Enhancement of Data Management Capacity in NIHSA	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
● Establishment of Hydrological Modeling Center within NIHSA	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
● Enhancement of Awareness on Importance of Hydrological Monitoring	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
2. Water Allocation and Regulation																	
● Formulation of CMP for Eight (8) Hydrological Areas	XXX	XXX	XXX														
● Enhancement of Capacity on Water Use Permitting and Regulation	XXX	XXX	XXX														
● Promotion of Catchment Management for Eight (8) Hydrological Areas				XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
● Preparation of Guideline for Water Pricing	XXX	XXX	XXX														
3. Water Environment Management																	
● National Drinking Water Quality Monitoring Improvement Plan	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
● Water Quality Monitoring Plan for Important Rivers of Nigeria	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
4. Floodplain Management																	
● Flood Risk Evaluation in Floodplain		XXX	XXX	XXX													
● Flood control for proposed irrigation project in the Benue river floodplain		XXX	XXX	XXX													
5. Financial Strengthening																	
● Capacity Develop't of RDBA's Accounting		XXX	XXX	XXX													
6. Operation & Maintenance																	
● Optimization Project of Irrigation Water Pricing of RBDA		XXX	XXX	XXX													
● Human Resources Devlop't in Dam Operation		XXX	XXX	XXX													
7. Project Management																	
● Capacity Develop't of Project Management on Water Resources		XXX	XXX	XXX													
● Capacity Develop't of Water Resources Development and Management		XXX	XXX	XXX													

[Note] ***: Preparation, XXX: Implementation
Source: JICA Project Team

10.2 Cost Estimate

Among the projects proposed in the M/P2013, the costs of these projects that FMWR supervise and manage are estimated below: that is, Water Resources Development Projects, Water Supply & Sanitation Projects, and Irrigation & Drainage Projects. The costs of these projects that contain the explicit scope are also presented below; that is, the hydrological monitoring project and the water environment management project.

The project costs are estimated based on the price and exchange rate (US$1=155Naira) as of December 2012. The unit price is set up on the basis of the actual construction orders done by FMWR.

(1) Conditions for Cost Estimate

Table 10-6 presents the conditions for cost estimate applied here.

Table 10-6 Conditions for Estimate

Cost Items	Contents and Conditions
(1) Construction	Labor, materials, machinery, etc.
(2) Equipment	Procurement of equipment not included in above construction costs: that is, hydropower generators and irrigation pumps
(3) Engineering	10% of the sum of above (1) and (2)
(4) Administration	5% of the sum of above (1) and (2)
(5) Physical Contingency	10% of the sum of above (1) to (4)

Source: JICA Project Team

(2) Project Cost

Cost of high priority projects is shown in Table 10-7 to 10-9 with its detail. Total amount of the Project cost is 376 billion Naira for surface water development, 100 billion Naira for groundwater development, and 476 billion Naira in total. On the other hand, it is 4,117 billion Naira for water supply and sanitation and 1,531 billion Naira for irrigation and drainage. Also it is 29 billion Naira for water resources management.

Of the total project cost, 8% for water supply development and water resources management, 67% for water supply and sanitation and 25% for irrigation and drainage. Water supply and sanitation cost occupies large part of the total cost.

Table 10-7 Project Cost for Water sources Development Schemes

Project	Content (Million Naira)					Total (Millionaire)
	Construction	Equipment	Engineering	Admini-stration	Physical contingency	
1. Surface Water Development	**295,722**	**1,228**	**29,695**	**14,848**	**34,149**	**375,642**
1.1 On-going Project	77,830		7,783	3,892	8,950	98,455
1.2 New Water Source Development	217,832	1,228	21,912	10,956	25,199	277,187
● Surface water development for municipal water supply	*63,000*		*6,300*	*3,150*	*7,245*	*79,695*
● Surface water development for irrigation development	*98,800*		*9,880*	*4,940*	*11,362*	*124,982*
● Integrated surface water development	*56,092*	*1,228*	*5,732*	*2,866*	*6,592*	*72,510*
2 Groundwater development	**79,124**	**0**	**7,912**	**3,957**	**9,099**	**100,092**
2.1Rehabilitation of existing boreholes	2,851		285	143	328	3,607
● Urban/small-urban/small town	*1,109*		*111*	*56*	*128*	*1,403*
● Rural	*1,742*		*174*	*87*	*200*	*2,204*
2.2New drilling boreholes	76,273		7,627	3,814	8,771	96,484
● Urban/small-urban/small town	*20,228*		*2,023*	*1,012*	*2,326*	*25,589*
● Rural	*56,045*		*5,604*	*2,802*	*6,445*	*70,895*
Total	**374,846**	**1,228**	**37,607**	**18,805**	**43,248**	**475,734**

Source: JICA Project Team

Table 10-8 Cost of Sub-sector Development Schemes

Project	Content (Million Naira)					Total (Million Naira)
	Construction	Equipment	Engineering	Administration	Physical contingency	
1. Water Supply and Sanitation	**3,254,770**		**325,477**	**162,738**	**374,298**	**4,117,284**
1.1 Water Supply Rehabilitation Scheme	186,282		18,628	9,314	21,422	235,646
● Urban and Semi-Urban/Small Town	*171,917*		*17,192*	*8,596*	*19,770*	*217,475*
● Rural	*14,365*		*1,436*	*718*	*1,652*	*18,171*
1.2 Water Supply Newly Construction Scheme	2,409,720		240,972	120,486	277,118	3,048,296
● Urban and Semi-Urban/Small Town	*2,320,863*		*232,086*	*116,043*	*266,899*	*2,935,891*
● Rural	*88,858*		*8,886*	*4,443*	*10,219*	*112,405*
1.3 Sanitation Scheme	658,768		65,877	32,938	75,758	833,342
● Public Toilet	*26,424*		*2,642*	*1,321*	*3,039*	*33,426*
● Final Septage Disposal Facility / Site	*151,480*		*15,148*	*7,574*	*17,420*	*191,622*
● Sewerage System	*480,865*		*48,086*	*24,043*	*55,299*	*608,294*
2. Irrigation and Drainage	**1,180,086**	**30,725**	**121,080**	**60,317**	**139,221**	**1,531,429**
2.1 Rehabilitation of Existing scheme	39,670	568	4,023	2,012	4,627	50,900
2.2 New Irrigation scheme	1,140,416	30,157	117,057	58,305	134,594	1,480,529
● Ongoing Scheme	*206,449*	*4,431*	*21,088*	*10,322*	*24,229*	*266,520*
● Extension Scheme	*191,372*	*7,726*	*19,909*	*9,954*	*22,896*	*251,856*
● Supplementary Irrigation Scheme	*148,800*	*0*	*14,880*	*7,440*	*17,112*	*188,232*
● Dam Irrigation Scheme	*259,249*	*0*	*25,925*	*12,962*	*29,814*	*327,950*
● Integrated Development Scheme	*334,546*	*18,000*	*35,255*	*17,627*	*40,543*	*445,971*
Total	**4,465,581**		**446,557**	**223,055**	**513,519**	**5,648,713**

Source: JICA Project Team

Table 10-9 Cost of Water Resources Management Schemes

Project	Content (Million Naira)		Total (Million Naira)
	Equipment	Administration	
1. Hydrological Monitoring	**10,512**	**13,115**	**23,627**
● Improvement of Surface Water Monitoring Network	*2,022*	*9,845*	*11,867*
● Improvement of Groundwater Monitoring Network	*8,400*	*1,900*	*10,300*
● Establishment of Hydrological Modeling Center within NIHSA	*90*	*1,370*	*1,460*
2. Water Environment Management	**3,700**	**2,009**	**5,709**
● National Drinking Water Quality Monitoring Improvement Plan	*3,700*	*1,912*	*5,612*
● Water Quality Monitoring Plan for Important Rivers of Nigeria	*0*	*97*	*97*

Remarks
1) The project cost is shown for the project which may require considerable cost for equipment as well as operation and maintenance.
2) The cost in the table does not include the cost for foreign experts for capacity development.

Source: JICA Project Team

10.3 Financial Program for Project Implementation

Financial program is shown in Table 10-10, which was estimated in the previous sections for water sources development, water supply and sanitation and irrigation and drainage.

In water sources development sector (surface water and groundwater), 30% of the total investment is for the 1st Stage, 31% for the 2nd Stage and 39% for the 3rd Stage. Investment is almost the same at every stage though it is a little higher in the 3rd stage.

In water supply and sanitation sector, 45% of the total investment is for the 1st Stage, 34% for the 2nd Stage and 22% for the 3rd Stage. Investment for the 1st Stage is the largest of all the stage. Then investment will gradually reduce afterward.

In irrigation and drainage sector, 23% of the total investment is for the 1st Stage, 50% for the 2nd Stage and 27% for the 3rd Stage. Investment for the 2nd stage is the largest of all the stage.

Table 10-10 Financial Program of Investment for Water Resources Development Schemes

Project	Investment for each Stage (Billion Naira)			Total (Billion Naira)
	1st Stage 2014-2020	2nd Stage 2021-2025	3rd Stage 2026-2030	
A. Water Source Development	**144.0**	**146.8**	**184.8**	**475.7**
A.1 Surface Water Development	98.4	108.8	168.4	375.6
A.1.1 On-going Project	98.4	0	0	98.4
A.1.2 New Water Source Development	0	108.8	168.4	277.2
● Surface water development for municipal water supply	*0*	*79.7*	*0*	*79.7*
● Surface water development for irrigation development	*0*	*7.7*	*117.3*	*125.0*
● Integrated surface water development	*0*	*21.4*	*51.1*	*72.5*
A.2 Groundwater development	45.6	38.0	16.4	100.1
A.2.1 Rehabilitation of existing boreholes	1.4	1.2	1.0	3.6
● Urban/small-urban/small town	*0.5*	*0.5*	*0.4*	*1.4*
● Rural	*0.9*	*0.7*	*0.6*	*2.2*
A.2.2 New drilling boreholes	44.2	36.8	15.4	96.5
● Urban/small-urban/small town	*10.5*	*8.7*	*6.3*	*25.6*
● Rural	*33.7*	*28.1*	*9.1*	*70.9*
B. Water Supply and Sanitation	**1,836.9**	**1,393.5**	**886.9**	**4,117.3**
B.1 Water Supply Rehabilitation Scheme	142.5	49.8	43.3	235.6
● Urban and Semi-Urban/Small Town	*134.5*	*43.2*	*39.8*	*217.5*
● Rural	*8.0*	*6.7*	*3.5*	*18.2*
B.2 Water Supply Newly Construction Scheme	1,489.4	994.6	564.3	3,048.3
● Urban and Semi-Urban/Small Town	*1,439.3*	*952.8*	*543.7*	*2,935.9*
● Rural	*50.1*	*41.8*	*20.5*	*112.4*
B.3 Sanitation Scheme	205.0	349.1	279.3	833.3
● Public Toilet	*13.4*	*11.1*	*8.9*	*33.4*
● Final Septage Disposal Facility / Site	*191.6*	*0.0*	*0.0*	*191.6*
● Sewerage System	*0.0*	*337.9*	*270.4*	*608.3*
C. Irrigation and Drainage	**353.8**	**757.6**	**420.0**	**1,531.4**
C.1 Rehabilitation of Existing scheme	14.7	33.8	2.4	50.9
C.2 New Irrigation scheme	339.1	723.8	417.6	1,480.5
● Ongoing Scheme	*177.1*	*85.4*	*4.0*	*266.5*
● Extension Scheme	*27.9*	*151.1*	*72.8*	*251.9*
● Supplementary Irrigation Scheme	*94.1*	*94.1*	*0.0*	*188.2*
● Dam Irrigation Scheme	*0.0*	*145.4*	*182.6*	*328.0*
● Integrated Development Scheme	*40.0*	*247.8*	*158.2*	*446.0*
Total	**2,334.7**	**2,297.9**	**1,491.7**	**6,124.4**

Source: JICA Project Team

CHAPTER 11 EVALUATION OF NATIONAL WATER RESOURCES MASTER PLAN 2013

11.1 Evaluation from Economic and Financial Aspects

11.1.1 Economic Evaluation

An economic evaluation on projects such as “B.1 Water Supply” and “B.2 Irrigation and Drainage” proposed as the sub-sector development project in Chapter 10 is carried out in this chapter based on the manner shown in Table 11-1.

Table 11-1 Evaluation Manner

Projects		Project Cost			Benefit
		Water Res. Develop. Cost	Own Cost	O&M	
1.Water Supply					
1) Rehabilitation Schemes					
・Urban Supply	State-wise	-	Repair & Replacement	O&M	Increase of Water Supply
・Rural Supply		-			
2) New Development Schemes					
・Urban Supply	State-wise	Dam・GW	WTP & Distribution	O&M	Increase of Water Supply
・Rural Supply		GW			
2.Irrigationand Drainage					
1) Existing Schemes					
・Rehabilitation	HA-wise	-	Repair & Replacement	O&M	Increase of Producers' Net Income
・Irrigation Extension of ongoing scheme		Dam (1 project)	Irrigation & Farm Field		
・Irrigation Extension of coming scheme		Dam (3 projects)			
2) New Irrigation Schemes					
・Supplementary Irrigation	HA-wise	-	Irrigation & Farm Field	O&M	Increase of Producers' Net Income
・Dam Irrigation		Dam			
・Integrated Development (3)	Individually	Dam	Irrigation, Field & Power Plant		The above benefit + Net Income from Power Sale

Concepts and Assumptions	
1. Evaluation Measures	Economic Internal Rate of Return (EIRR), Benefit-to-Cost Ratio (B/C) and Net Present Value (NPV)
2. Opportunity Cost of Capital	10% (adopted by referring the other projects in Nigeria)
3. Evaluation Period	30 years from the next year of construction termination
4. Economic Life (year)	WTP: 40, Irrigation & Farm Field: 50, Dam: 80, Well: 40, Equipment: 15
5. Project Cost	Cost presented in Chapter 10
6. O&M Cost	Structures: 0.1% on its projects cost, Equipment: 2.5% on its project cost, Desalination: 10% on its project cost
7. Economic Conversion Factors	Mechanical: 0.8, Civil 0.72 (Referred the projects in other developing country)

Source: JICA Project Team

(1) Water Supply Projects

The economic evaluation of the projects is carried out based on the projects costs and the implementation schedule presented in Chapter 10 and the benefits below.

Benefit = Increase of Water Supply with Projects (m^3) x Ability-to-Pay of Customers (Naira/m^3)

The ability-to-pay of customers is estimated in the manner as shown in Table11-2.

Table 11-2 Manners to estimate Ability-to Pay of Customers

Customers	Items	Estimates and Assumptions
1. Domestic	Water consumption per person	(liter/person) Urban & Semi-urban: 67～91, Rural: 30
	Persons living in household (NBS data)	5.2 persons
	Household income （based on NBS data）	State-wise (Rural: 50% on Urban)
	Ability-to-Pay on household income	Urban & Semi-urban: 3%, Rural 1%
	Figures obtained from the above manner	(Naira/m^3) Urban & Semi-urban: 65～170, Rural: 20～40
2. Commercial & Industry・	Adopted by referring the data of water agencies in Indonesia and Brazil	1.6 X domestic water

Source: JICA Project Team

Table 11-3 shows the results of economic analysis conducted in line with the above manners.

Actually, the above results vary from state to state. However, from the national viewpoint, the EIRR exceeds the 10 % of opportunity cost of capital (OCC) or slightly below it. Accordingly, the water supply projects of the M/P2013 as a whole are judged to be economically feasible. The analysis of each project is summarized below.

(1-1) Rehabilitation Schemes

Urban and Semi-urban

The EIRR of the nation as a whole shows quite high rate of 50%. This is mostly due to the low project cost of rehabilitation compared to new construction. Particularly the states, where the rehabilitation work concentrates in groundwater supply improvement show the higher EIRR. Meanwhile, Ebonyi State is resulted in the very low EIRR; this is because Ebonyi is only state that incurs the cost of dam construction.

Rural

The EIRR of the nation as a whole shows also quite high; 28%; because all rehabilitation work in rural area converges on groundwater supply improvement.

(1-2) New Development Schemes

Urban and Semi-urban

Projects cost is estimated higher than rehabilitation projects due to new wells and water treatment facilities and new dams of some states. Accordingly, the EIRR vary from state to state. However, the EIRR of the nation as a whole is 12% that exceeds 10% of OCC.

Rural

The EIRR of the nation as a whole presents 9.2%, slightly below 10% of OCC because of burdening new wells and equipment costs. However, it could be judged rather economically feasible if taking into account the low level of ability-to pay of rural areas.

Table 11-3 Results of Economic Analysis of Water Supply Projects (NPV: Naira in billion)

Region		Rehabilitation Schemes						New Development Schemes					
		Urban & Semi-urban			Rural			Urban & Semi-urban			Rural		
		EIRR	B/C	NPV	EIRR	B/C	NPV	EIRR	B/C	NPV	EIRR	B/C	NPV
Nigeria		50.0%	3.6	314.7	27.6%	2.2	11.1	10.1%	1.01	13.5	9.2%	0.94	-4.9
States													
1	Abia	34%	2.2	3.8	24%	2.0	0.1	5.8%	0.71	-5.9	7.6%	0.82	-0.2
2	Adamawa	13%	1.2	0.5	12%	1.2	0.0	5.0%	0.64	-12.1	6.5%	0.74	-0.7
3	Akwa Ibom	59%	3.5	9.3	27%	8.2	0.4	7.6%	0.83	-3.3	7.3%	0.80	-0.4
4	Anambra	61%	3.6	2.7	29%	2.3	0.1	5.3%	0.64	-30.4	9.1%	0.93	-1.4
5	Bauchi	32%	2.5	5.1	15%	1.4	0.1	3.8%	0.58	-11.8	4.5%	0.60	-1.8
6	Bayelsa	121%	5.2	0.5	42%	3.0	0.3	13.7%	1.26	8.0	11.8%	1.14	0.1
7	Benue	77%	4.5	7.9	36%	2.6	0.6	12.9%	1.19	1.6	12.2%	1.17	0.5
8	Borno	23%	2.0	2.0	10%	1.0	0.0	3.8%	0.58	-15.4	4.3%	0.58	-1.5
9	Cross River	52%	3.7	9.8	40%	2.9	0.9	9.0%	0.93	-1.2	11.8%	1.14	0.2
10	Delta	122%	5.1	25.3	40%	2.9	0.8	12.9%	1.20	5.4	11.5%	1.12	0.2
11	Ebonyi	4%	0.5	-0.7	16%	1.4	0.0	-	-	-	6.6%	0.75	-0.4
12	Edo	36%	3.5	0.9	22%	1.9	0.0	12.7%	1.19	5.3	12.4%	1.18	0.4
13	Ekiti	51%	4.8	11.9	40%	2.9	0.4	9.7%	0.97	-0.5	12.9%	1.22	0.2
14	Enugu	49%	2.9	4.2	40%	2.9	0.2	12.7%	1.19	9.0	12.7%	1.21	0.4
15	Gombe	33%	2.7	3.1	12%	1.1	0.0	4.1%	0.58	-10.3	6.4%	0.73	-0.5
16	Imo	19%	1.6	2.3	24%	2.0	0.1	6.1%	0.73	-10.8	7.6%	0.82	-0.5
17	Jigawa	47%	3.2	1.0	14%	1.3	0.1	5.7%	0.70	-10.9	7.4%	0.81	-0.4
18	Kaduna	24%	2.1	9.1	23%	1.9	0.7	4.7%	0.60	-14.7	8.1%	0.86	-0.3
19	Kano	45%	3.9	21.9	22%	1.8	0.3	8.1%	0.85	-11.6	9.8%	1.00	-0.1
20	Katsina	36%	3.1	5.6	19%	1.7	0.2	7.4%	0.82	-9.6	8.0%	0.85	-0.6
21	Kebbi	48%	3.6	7.3	24%	2.0	0.4	9.1%	1.00	-1.1	9.1%	0.93	-0.2
22	Kogi	71%	4.2	8.2	33%	2.5	0.3	11.2%	1.08	1.8	11.1%	1.08	0.2
23	Kwara	32%	2.4	6.9	24%	2.0	0.2	8.7%	1.00	-0.8	9.6%	1.00	0.0
24	Lagos	74%	8.2	49.6	27%	2.2	0.1	14.7%	1.41	140.1	11.7%	1.13	0.0
25	Nasarawa	57%	3.2	5.4	57%	2.5	0.4	8.7%	1.00	-1.5	11.7%	1.13	0.1
26	Niger	27%	2.2	6.7	16%	1.5	0.2	5.3%	0.67	-4.4	6.0%	0.70	-0.6
27	Ogun	40%	4.0	7.8	41%	2.9	0.3	8.6%	1.00	-5.2	17.4%	1.40	0.6
28	Ondo	125%	5.4	10.3	38%	0.0	0.7	14.2%	1.31	3.3	12.6%	1.20	0.3
29	Osun	51%	5.0	16.7	41%	3.0	0.7	10.5%	1.04	1.0	12.9%	1.22	0.2
30	Oyo	47%	4.8	13.4	37%	2.7	0.8	9.3%	0.94	-3.6	13.0%	1.23	0.5
31	Plateau	25%	1.7	3.2	32%	2.4	0.2	9.3%	1.00	-1.1	11.5%	1.12	0.3
32	Rivers	112%	5.0	20.5	37%	2.8	0.5	14.4%	1.27	14.1	12.7%	1.21	0.6
33	Sokoto	42%	1.0	11.1	26%	2.1	0.5	7.8%	0.85	-1.8	7.9%	0.84	-0.3
34	Taraba	26%	2.3	0.7	15%	1.4	0.0	4.6%	0.62	-9.4	6.6%	0.75	-0.6
35	Yobe	60%	3.6	4.1	20%	1.7	0.2	7.6%	0.83	-2.9	7.3%	0.80	-0.4
36	Zamfara	36%	2.3	3.8	26%	2.1	0.2	9.9%	0.99	-0.1	10.0%	1.00	0.0
37	FCT Abuja	48%	4.4	12.8	21%	1.8	0.1	12.6%	1.18	10.8	12.9%	1.21	0.1

Source: JICA Project Team

(2) Irrigation and Drainage Projects

The economic evaluation of the projects is carried out based on the projects costs and the implementation schedule presented in Chapter 10 and the benefits bellow.

Benefit
1. Integration Schemes
= Producers' Net Income (With-project Net Income - Without-project Net Income) + Net Income from Electric Power Sale
2. Other Schemes
= Producers' Net Income (With-project Net Income - Without-project Net Income)

The net incomes of producer and electric power sale are estimated in the manner as shown in Table 11-4.

Table 11-4 Items and Assumptions to estimate Net Income of Producer and Power Sale

Net Income of Producers					
With-project		Without-project		In common	
Products	Yield ton/ha	Products	Yield ton/ha	Producer's Price Naira/kg	Producer's Cost
Irrigated Rice	4.9	Rain-fed Rice	2.6	170	50% of Price
Maize	3.0	Maize	1.7	80	
-	-	Millet: HA1 and HA8	1.1	40	
Net Income from Electric Power Sale					
Power Generation	/day	Nassarawa: 6MWx24h, Taraba: 9MWx24h, Donga-Suntai: 15MWx24h			
Selling Price	Naira/MWh	9,563 :Whole Sale Contract Price of 2012 (Source：MYTO)			

Note: 1) Producers' price was unavailable. So JICA Project Team estimated it in the manner by deducting processing, distribution and retail cost from market price. 2) Producer's cost includes the variable cost only. Since fixed cost such as labor cost was considered as family internal cost and excluded from it.
Source: Producers' price of maize and millet – NBS data.

Table 11-5 and -6 shows the results of economic analysis worked out in line with the above manners.

Table 11-5 Results of Economic Analysis of Existing Schemes (NPV: Naira in billion)

Region	Rehabilitation Schemes			Irrigation Extension of ongoing Schemes			Irrigation Extension of coming Schemes		
	EIRR	B/C	NPV	EIRR	B/C	NPV	EIRR	B/C	NPV
Nigeria	41.8%	4.1	47.9	13.2%	1.3	33.4	10.8%	1.1	5.2
HA									
HA-1	30.5%	2.9	1.7	9.7%	1.1	-0.2	9.0%	0.8	-0.5
HA-2	39.6%	3.8	7.3	14.9%	1.4	2.6	8.2%	0.9	-2.7
HA-3	39.6%	3.8	1.7	12.7%	1.2	5.2	12.0%	1.0	1.4
HA-4	39.6%	3.8	1.3	11.0%	1.1	0.1	11.5%	1.0	1.3
HA-5	57.4%	5.5	1.3	15.3%	1.5	7.1	16.7%	1.4	1.6
HA-6	45.5%	4.3	2.9	14.6%	1.4	16.9	14.3%	1.3	0.7
HA-7	57.3%	5.5	5.0	-	-	-	18.6%	1.7	3.5
HA-8	39.7%	3.9	26.6	10.9%	1.1	1.9	9.9%	0.9	-0.3

Source: JICA Project Team

Table 11-6 Results of Economic Analysis of New Schemes (NPV: Naira in billion)

Region	Supplementary Irrigation Schemes			Dam Irrigation Schemes			Integration Schemes		
	EIRR	B/C	NPV	EIRR	B/C	NPV	EIRR	B/C	NPV
Nigeria	20.3%	2.0	66.5	9.6%	0.96	-3.9	10.4%	1.0	4.3
HA									
HA-1	-	-	-	4.6%	0.5	-0.9	-	-	-
HA-2	-	-	-	8.9%	0.9	-0.9	-	-	-
HA-3	-	-	-	9.3%	0.9	-3.0	-	-	-
HA-4	-	-	-	9.7%	1.0	-0.8	-	-	-
HA-5	20.3%	2.0	26.3	13.2%	1.3	1.6	-	-	-
HA-6	-	-	-	8.0%	0.8	-0.4	-	-	-
HA-7	20.3%	2.0	40.2	10.7%	1.1	0.4	-	-	-
HA-8	-	-	-	-	-	-	-	-	-
Integration									
1.Nassarawa	-	-	-	-	-	-	10.1%	1.0	0.7
2.Taraba	-	-	-	-	-	-	10.4%	1.0	2.1
3.Donga-Suntai	-	-	-	-	-	-	10.4%	1.0	1.5

Source: JICA Project Team

Actually, the above results vary from HA to HA. However, from the national viewpoint, the EIRR exceeds the 10 % of OCC. Accordingly, the irrigation and drainage projects of the M/P2013 as a whole are judged to be economically feasible. The analysis of each project is summarized below.

Rehabilitation Schemes

The EIRR of the nation as a whole presents quite high rate of 41.5%, due to lower cost of rehabilitation projects compared to of new projects.

Supplementary Irrigation Schemes

The target area is HA-5 and HA-7. Supplementary irrigation enables 2 HAs to product rice even in dry season. Accordingly, the EIRR of both HAs presents economically high viability of 20%.

Irrigation Extension Projects of ongoing Scheme

The EIRR of the nation as a whole is 13.2%, exceeding 10% of OCC. However, HA-1 projects is only one project where the EIRR presents lower than 10% due to limited rice farming area even in rainy season.

Irrigation Extension Projects of coming Scheme, and Dam Irrigation Schemes

The EIRR of the irrigation extension projects as a whole presents economically feasible, 10.8%. On the other hand, the EIRR of the dam irrigation schemes shows slightly lower than 10% of OCC; however, the EIRR of HA-5 and HA-7 exceeds 10% of OCC.

Integration Schemes

The combined EIRR of 3 projects such as Nassarawa, Taraba and Donga-Suntai presents economically feasible, 10.4%; however, slightly higher than 10% of OCC, which is induced by long construction period of 9 years due to large development project. Provided that the construction period would be reduced to 5 years, the larger economical effectiveness could be expected, that is, 12% of EIRR and 160billion Naira of NPV.

Benefits of Flood Control by Dam

Construction of dam would produce the possibility of preventing a serious impact on human lives, property and socio-economic activities damaged by flood and erosion; as a result, the long-time prevention enables to develop furthermore the new farm land and residence area. Such economical effectiveness obviously increases the EIRR and other economic figures if considered as benefit. In the M/P2013, the monetary calculation of this kind of effectiveness is not carried out; however, such implicit benefit should be kept in mind when evaluate the dam project, as well as “Dam Irrigation Projects” mentioned above.

(3) Sensitivity Analysis

The sensitivity analysis is carried out on the projects of water supply and irrigation and drainage by applying the increase and decrease of the project costs and benefits as a variation factor.

(3-1) Water Supply Projects

Table 11-7 presents the results of sensitivity analysis on water supply projects. It is revealed that the changes of the project costs have an impact slightly larger than that of the benefits in terms of variation of EIRR. Meanwhile, "what is the percentage of the change that could secure to maintain 10% of EIRR?" is analyzed on the project costs. The analysis unveiled that the rehabilitation could keep the 10% of EIRR even though the project cost increase substantially because of its high level of EIRR. The EIRR of the urban water supply schemes of new development takes downturn to 10% if the project costs increase by 1%. And the EIRR of the rural water supply schemes takes upturn to 10% if the project costs decrease by 6.5%.

(3-2) Irrigation and Drainage Projects

Table 11-8 shows the results of sensitivity analysis on irrigation and drainage projects. It is also revealed that the changes of the project costs have a slightly larger impact that that of the benefits in terms of variation of EIRR. "What is the percentage of the change that could secure to maintain 10% of EIRR?" is also analyzed on the project costs. The EIRR could be just at 10% if the project costs of the ongoing schemes increase by 30%, the extension schemes increase by 5%, the supplementary irrigation schemes increase by 90%, the dam irrigation schemes decrease by 5% and the integration schemes increase by 3%. On the other hand, the rehabilitation scheme could keep the 10% of EIRR even though the project cost increase substantially because of its high level of EIRR.

Table 11-7 Sensitivity Analysis on Water Supply Projects

I. Rehabilitation Schemes							
Project Areas		Urban Water Supply			Rural Water Supply		
Economic Analysis Items		EIRR	B/C	NPV	EIRR	B/C	NPV
1. Base Case		50.0%	3.6	314.7	27.6%	2.2	11.1
2. Sensibility Analysis							
1) Changes of Project Costs	+20%	39.2%	3.0	290	21.5%	1.8	9
	+10%	43.9%	3.3	302	24.4%	2.0	10
	-10%	58.2%	4.0	327	31.8%	2.5	12
2) Changes of Benefits	-20%	37.2%	2.9	227	20.7%	1.8	7
	-10%	43.3%	3.3	271	24.1%	2.0	9
	+10%	57.3%	4.0	358	31.3%	2.4	13
II. New Development Schemes							
Project Areas		Urban Water Supply			Rural Water Supply		
Economic Analysis Items		EIRR	B/C	NPV	EIRR	B/C	NPV
1. Base Case		10.1%	1.01	13.5	9.2%	0.94	-4.9
2. Sensibility Analysis							
1) Changes of Project Costs	+10%	8.9%	0.92	-128	-	-	-
	-10%	11.6%	1.1	155	10.5%	1.0	3
2) Changes of Benefits	-10%	8.8%	0.9	-129	-	-	-
	+10%	11.4%	1.1	156	10.4%	1.0	2
3) Change of Project Costs to the level of 10% EIRR		+1.1%	-	-	-6.5%	-	-

Note) 1.Project cost is the sum of investment cost and O&M cost. 2. NPV = million Naira.
Source: JICA Project Team

Table 11-8 Sensitivity Analysis on Irrigation and Drainage Projects

I. Existing Irrigation and Drainage Schemes										
Project Areas		Rehabilitation Schemes			On-going Schemes			Extension Schemes		
Economic Analysis Items		EIRR	B/C	NPV	EIRR	B/C	NPV	EIRR	B/C	NPV
1. Base Case		41.8%	4.0	47.8	13.2%	1.3	33.4	10.8%	1.1	4.6
2. Sensibility Analysis										
1) Changes of Project Costs	+25%	33.3%	3.2	43.8	10.3%	1.0	4.2	-	-	-
	+20%	34.7%	3.3	44.6	10.8%	1.1	10.1	-	-	-
	+10%	38.0%	3.6	46.2	-	-	-	9.7%	0.97	-2.3
	-10%	-	-	-	-	-	-	12.2%	1.2	12.7
2) Changes of Benefits	-25%	31.2%	3.0	31.9	9.6%	0.96	-4.1	-	-	-
	-20%	33.3%	3.2	35.1	10.3%	1.0	3.4	-	-	-
	-10%	37.6%	3.6	41.5	-	-	-	9.5%	0.96	-2.8
	+10%	-	-	-	-	-	-	12.1%	1.2	13.1
3) Change of Project Costs to the level of 10% EIRR		-			+30%			+5%		
II. New Development Schemes										
Project Areas		Supplement Schemes			Dam Irrigation Schemes			Integration Schemes		
Economic Analysis Items		EIRR	B/C	NPV	EIRR	B/C	NPV	EIRR	B/C	NPV
1. Base Case		20.3%	2.0	66.5	9.6%	0.96	-3.9	10.4%	1.0	4.3
2. Sensibility Analysis										
1) Changes of Project Costs	+25%	16.2%	1.57	49.4	-	-	-	-	-	-
	+20%	16.8%	1.64	52.8	-	-	-	-	-	-
	+10%	18.4%	1.8	59.7	8.7%	0.9	-13.1	9.4%	0.94	-8.2
	-10%	-	-	-	10.6%	1.1	5.2	11.5%	1.1	16.8
2) Changes of Benefits	-25%	15.1%	1.5	32.7	-	-	-	-	-	-
	-20%	16.2%	1.6	39.5	-	-	-	-	-	-
	-10%	18.2%	1.8	53.0	8.6%	0.9	-12.7	9.3%	0.93	-8.6
	+10%	-	-	-	10.5%	1.1	4.8	11.4%	1.1	17.2
3) Change of Project Costs to the level of 10% EIRR		+90%			-5.0%			3.0%		

Note) 1.Project cost is the sum of investment cost and O&M cost. 2. NPV = million Naira.
Source: JICA Project Team

11.1.2 Financial Consideration

In Nigeria, the irrigation development is assumed centrally by FGN and the water supply development generally by FGN and state governments. This chapter observes the necessary financing of the development cost of the projects proposed by the M/P2013.

(1) Government Budget Allocation

Table 11-9 presents a yearly average budget amount of FGN and state governments over the period of three (3) years from 2009 to 2011 allocated to these two (2) sectors of water supply development and irrigation development; that is 148billion Naira and 35billion Naira respectively. The allocations correspond to 2% of the capital budget of FGN and 4% of that of state governments. Actually the almost same level of allocation continued in these three (3) years. So it is assumed in this chapter that the like level of budget would continue to be allocated to these two (2) sectors hereafter in the future.

Table 11-9 Government Budget Allocation to Water Supply and Irrigation Development
(Naira in billion: average from 2009 to 2011)

Items			Water Supply Develop.	Irrigation Develop.	Total
Government	FGN	FMWR	11	19	30
		RBDA	17	16	33
		Total	28	35	63
	State	37 states	120	-	120
	Total		148	35	183

Note: Budget books of 11 states could not be obtained.
Source: JICA Project Team elaborated from the budget books; meanwhile, allocations of 11states were estimated on the basis of each state population.

(2) Project Cost of Water Supply and Irrigation & Drainage Projects

Table 11-10 shows the sum of cost for water supply projects and irrigation & drainage projects after combining of surface & groundwater resources development project cost. It amounts to 5.2trillion Naira in 17 years of implementation: respectively 3.5trillion Naira for water supply projects and 1.7trillion Naira for irrigation & drainage projects.

Table 11-10 Sum of Project Cost (Naira in billion)

Projects		1st Stage	2nd Stage	3rd Stage	Total
		2014-2020	2021-2025	2026-2030	2014-2030
Water Supply	Rehabilitation	145	112	45	302
	New Development	1,534	1,051	580	3,165
	Total	1,679	1,163	625	3,467
Irrigation & Drainage	Rehabilitation	15	33	2	50
	Irrigation Extension of ongoing schemes	179	84	11	274
	Irrigation Extension of coming schemes	27	155	85	267
	Supplementary Irrigation	94	94		188
	Dam Irrigation	0	153	278	431
	Integration	38	257	202	497
	Total	353	776	578	1,707

Source: JICA Project Team

(3) Financing of Project Cost

As figured in Table 11-9, the budget of the both governments to water supply development and irrigation & drainage development amounted to 148billion Naira and 35billion Naira respectively. Assuming that the like budget continues hereafter in the future, the allocations to the project costs of the M/P2013 from the governments are presumed bellow.

1st Stage: year 2014 - 2020

In consideration of priority and antecedent allocation to the existing and implementing projects for its acceleration and completion, 50% out of the year budget allocation (see Table 11-9) to the projects of the M/P2013, namely 91.5billion Naira

2nd Stage: year 2021 - 2025

On completion of the existing and implementing projects, 100% to the projects of the M/P2013 out of the year budget allocation, namely 183billion Naira

3rd Stage: year 2026 - 2030

100% to the projects of the M/P2013 out of the year budget allocation, namely 183billion Naira

(3-1) Water Supply Projects

Table 11-11 shows the combined financing, of both FGN and state governments, to the project costs on the basis of the presumption above. An amount of 3,467billion Naira is required to complete the water supply projects proposed by the M/P2013. This amount is around two times (194%) of the 3 years' averaged (from 2009 to 2011) water supply sector investment costs of 1,779billion Naira which were allocated from the FGN and state governments' budget.

Firstly, the allocated budget to the M/P2013 would be disbursed to the projects that could achieve the highest economical effectiveness, namely the rehabilitation projects. Secondary, the remaining budget would be spent to the new development projects. However, it is mathematically obvious that the project cost of these new development projects could not be financed entirely with this remaining government budget. Meanwhile, FGN strongly envisages the 100% nationwide coverage with water supply. To attain this national goal, it is earnestly suggested that the government would aggressively finance with an additional budgeting to enable the said uncovered part of the new development project costs to be fulfilled

Particularly, the state governments play the crucial role for the development of water supply sector in Nigeria, currently bearing more than 80% of the water supply development costs of Nigeria (see Table 11-9). The M/P2013 requires a year average amount of 224billion Naira in 1st Stage, 186billion Naira in 2nd Stage and 100billion Naira in 3rd Stage from the state governments (Project Cost X 80%). Accordingly, a substantial amount of additional budget especially for the respective stage is estimated at 165billion Naira, 68billion Naira and 5billion Naira. As a result, the state governments have to collaborate closely with FGN and also discuss the financial support from FGN on the implementation of the M/P2013.

Table 11-11 Financing to Water Supply Projects (Naira in billion)

Items	1st Stage 2014-2020		2nd Stage 2021-2025		3rd Stage 2026-2030		Total 2014-2030	
	Entire Stage	Year Average	Entire Stage	Year Average	Entire Stage	Year Average	Entire Stage	Year Average
1. Current FGN & State Gov. Budget Allocation (Year average of 2009/11)	445	74 100%	741	148 100%	593	119 100%	1,779	105 100%
2. Way of Financing for Project Costs	1,679	280 379%	1,163	233 191%	625	125 105%	3.467	204 194%
1) Rehabilitation (FGN & State Gov. Budget)	*145*	*24*	*112*	*22*	*45*	*9*	*302*	*18*
2) New Development (FGN & State Gov. Budget)	*300*	*50*	*629*	*126*	*548*	*110*	*1,477*	*87*
3) New Development (Additional Budget)	*1,234*	*206*	*422*	*85*	*32*	*6*	*1,688*	*99*

Note：Additional budget means the additional budget allocation of both FGN and the states governments to the M/P2013 projects including financing from the soft loan.
Source: JICA Project Team

(3-2) Irrigation and Drainage Projects

Table 11-12 shows the financing to the project costs on the basis of the presumption above. An amount of 1,707billion Naira is required to complete the irrigation and drainage projects proposed by the M/P2013. This amount is around 4 times (396%) of the 3 years' averaged (from 2009 to 2011) irrigation sector investment costs of 432billion Naira which were allocated from the FGN. budget.

Firstly, the allocated budget to the M/P2013 would be disbursed to the projects that could achieve the highest economical effectiveness, namely the rehabilitation projects and the supplementary irrigation projects. Secondary, the remaining budget would be spent to the new projects. However, obviously, the project cost of these new development projects could not be financed entirely with this remaining budget. Meanwhile, FGN has been challenging the 100% self-supply of rice. To accomplish this national plan, it is strongly proposed that the government would aggressively finance with an additional budget to enable the said uncovered part of the new project costs to be disbursed.

Table 11-12 Financing to Irrigation Projects (Naira in billion)

Items	1st Stage 12014-2020		2nd Stage 2021-2025		3rd Stage 2026-2030		Total 2014-2030	
	Entire Stage	Year Average	Entire Stage	Year Average	Entire Stage	Year Average[3]	Entire Stage	Year Average[4]
1. Current FGN Budget Allocation (Year average of 2009/11)	121	17 100%	173	35 100%	138	35 100%	432	27 100%
2. Way of Financing for Project Costs	353	50 294%	776	155 442%	578	144 411%	1,707	107 396%
1) Rehabilitation (FGN Budget)	*15*	*2*	*33*	*7*	*2*	*0.5*	*50*	*3*
2) Supplementary (FGN Budget)	*94*	*13*	*94*	*19*	-	-	*188*	*12*
3) Other New Development [1] (FGN Budget)	*12*	*2*	*46*	*9*	*136*	*34*	*194*	*12*
4) Other New Development (Additional Budget [2])	*232*	*33*	*603*	*120*	*440*	*109*	*1,275*	*80*

Note : 1) New Development means these 4 schemes: Irrigation Extension of Ongoing Schemes, Extension Schemes, Dam Irrigation Schemes and Integration Schemes, 2) Additional budget means the additional budget allocation of both FGN and the states governments to the projects of the M/P2013 including financing from the soft loan. 3) Year average of 3rd stage: 4 years' average because of completion of construction estimated until end 2029, 4) 16 years' average

Source: JICA Project Team

11.2 Evaluation from Social and Environmental Aspects

11.2.1 Objectives of Evaluation from Social and Environmental Aspects

The principal objective of this evaluation is to examine how the proposed projects in the M/P2013 may potentially influence on the current condition of the natural and social environment. If negative impacts are forecasted by the project's implementation, then, necessary mitigation measures will be examined.

11.2.2 Methodology on Evaluation of Environmental and Social Aspects

The projects proposed in the M/P2013 shall be evaluated through the execution of the Initial Environmental Examination (IEE). The Terms of Reference is presented in Annex SR7-1, Section SR7.2.2, Volume-5 Supporting Report.

11.2.3 Evaluation through IEE

(1) Natural and Social-Environmental Condition of the Study Area

The current condition of the natural and social environment is described in Chapter 1 and 5. The summary of them is presented in Item (2) of Section SR7.2.3, Volume-5 Supporting Report.

(2) List of Projects and Brief Description

The list of projects is composed of five (5) sectors which include 64 ongoing and 934 proposed projects as listed in Table 11-13. The complete list of the projects with a brief description of the main activities is given in Annex SR7-2 to SR7-6, Section SR7.2.3, Volume-5 Supporting Report.

Table 11-13 Number of Projects under M/P2013

Sector	Ongoing Projects	Proposed Projects*	Total
1. Dam	32	49	81
2. Municipal Water Supply**	0	489	489
3. Irrigation and Drainage	32	114	146
4. Sanitation	-	264	264
5. Water Resources Management and others	-	18	18
Total	64	934	998

Note (*): Proposed by JICA Project Team based on existing proposed projects by Nigerian government as well as necessary measures for achieving the target of the M/P2013, (**): The projects for groundwater development are included in the projects for Municipal Water Supply for the purpose of conducting IEE.
Source: JICA Project Team

It is opportune to mention here that for IEE purposes the Sector Municipal Water Supply includes projects for construction and rehabilitation of boreholes since the categorization depend on the volume to be abstracted from the water source.

(3) Categorization of Projects (Screening)

The screening of projects was made based on the Categories List stipulated in the Procedural Guidelines on Environmental Impact Assessment, Decree 86, 1992. The result of the screening is summarized in Table 11-14.

Projects in Category 3 such as capacity development, awareness creation, etc. do not require EIA therefore these projects are not scoped for IEE.

From the above table, 321 projects in Category 1 and 471 projects in Category 2 are subject to scoping at IEE study level (total 792) in four (4) Sectors (Dams, Municipal Water Supply, Irrigation and Drainage, and Sanitation). This is in compliance with the Guidelines for EIA and JICA guidelines for environmental and social considerations (ver.2004).

Table 11-14 Categorization of Projects in M/P2013 subjected to IEE/EIA Study

EIA Category	Description	Documents Required For Application to EIA Division	Projects affected	
			Sector	Number
1	Full EIA is required	Submission of Project Proposal or FS and the TOR for EIA Study	Dam	55
			Municipal Water Supply	179
			Irrigation and Drainage	45
			Sanitation	42
			WRM and other	0
			Total Category 1	321
2	Partial EIA may be required	Submission of Project Proposal or FS and the TOR for EIA Study	Dam	25
			Municipal Water Supply	276
			Irrigation and Drainage	96
			Sanitation	74
			WRM and other	0
			Total Category 2	471
3	Not require EIA	Application letter for EIS	Dam	1
			Municipal Water Supply	34
			Irrigation and Drainage	0
			Sanitation	148
			WRM and other	18
			Total Category 3	201
	Disregarded projects*		Irrigation	5
Total Projects in the M/P2013				998

*: Five (5) projects were disregarded in the Sector of Irrigation/Drainage and not proposed in this MP due to unavailability of water for their implementation. Project's Codes are IG21, IG24, IP39, IP42 and IP109.
Source: JICA Project Team

(4) Identification of Potential Impacts and Its Significance

For projects that have been scoped for IEE study, the identification of potential impacts and its significance were made based on scoping matrix. The summary is shown in Tables 11-15 and 11-16. The detail of the scoping matrix is shown in Item (5) of Section SR7.2.3, Volume-5 Supporting Report.

Table 11-15 Summary of Matrix for Scoping (Dams and Municipal Water Supply Sectors)

Environmental Component	Nº	Likely Impact Items	Overall Rating										
			Sector Dams				Sector Municipal Water Supply						
			Dams with surface area > 200 has- Group 1	Dams with surface area < 200 has - Group 2	Dam with surface area > 200 has located in Protected Areas- Group 3	Dam with surface area < 200 has located in Protected Areas - Group 4	WS with Treatment Plant Capacity more than 4,500 m3/d- Group 1	WS with Treatment Plant Capacity less than 4,500 m3/d- Group 2	WS with Field Motorized Boreholes Capacity > 4,500 m3/d- Group 3	WS with Single Motorized Borehole- Group 4	WS with Single Borehole with Hand Pump- Group 5	Rehabilitation of Facilities with big scale of activities- Group R1	Rehabilitation of Facilities with smale scale of activities- Group R2
Social Environment	1	Involuntary resettlement	A-	B-	-	-	-	-	-	-	-	-	-
	2	Local Economy such as Employment & Livelihood, etc.	A+	B+	A+	B+	A+	B+	B+	-	-	A+	B+
	3	Land use and utilization of local resources	A-	B-	A-	B-	B-	B-	-	-	-	-	-
	4	Social institutions such as social infrastructure and local decision-making institutions	C-	C-	C-	C-	-	C-	C-	-	-	-	-
	5	Existing social infrastructure & Services such as Traffic/Public Facilities	A-	B-	A-	B-	A-	B-	-	-	-	A-	B-
	6	The poor, indigenous and ethnic people	C-	C-	C-	C-	-	-	-	-	-	-	-
	7	Inequality between beneficiaries and project-affected peoples	-	-	-	-	-	-	-	-	-	-	-
	8	Cultural heritage	-	-	C-	C-	-	-	-	-	-	-	-
	9	Local conflict of interests	C-	C-	A-	A-	-	C-	-	-	-	-	-
	10	Water use right and common land use right	C-	C-	C-	C-	-	-	-	-	-	-	-
	11	Water supply and/or Irrigation with Potential Power generation	A+	A+	A+	A+	A+	A+	A+	A+	A+	-	-
	12	Vector of diseases	A-	A-	A-	A-	-	-		-	-	-	-
	13	Disaster (natural risk) and infectious diseases such as HIV/AIDS	A-	B-	A-	B-	B-	B-	B-	B-	B-	B-	B-
Natural Environment	14	Topography and geographical features	C-	B-	B-	B-	-	-	-	-	-	-	-
	15	Accumulation of sediment into Dams	B-	B-	B-	B-	-	-	-	-	-	-	-
	16	Protected Area	-	-	A-	A-	C-/C+	C-/C+	C-/C+	-	-	-	-
	17	Ground water	C-/C+	C-/C+	C-/C+	C-/C+	-	-	-	-	-	-	-
	18	Soil erosion	B-	B-	B-	B-	B-	B-	-	-	-	-	-
	19	Hydrological situation (flow regime)	B-	B-	B-	B-	B-	B-	C-	-	-	-	-
	20	Coastal zone	-	-	-	-	C-	C-	-	-	-	-	-
	21	Flora, Fauna and Biodiversity	A-	B-	A-	A-	B-	B-	-	-	-	-	-
	22	Meteorology	-	-	-	-	-	-	-	-	-	-	-
	23	Landscape	-	-	-	-	-	-	-	-	-	-	-
	24	Global warming	-	-	-	-	-	-	-	-	-	-	-
Pollution	25	Air pollution	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-
	26	Water pollution	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-
	27	Soil pollution	-				-	-	-		-	-	
	28	Waste	B-	B-	B-	B-	B-	B-	B-	B-	-	B-	B-
	29	Noise and vibration	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-
	30	Ground subsidence	-	-	-	-	-	-	-	-	-	-	-
	31	Offensive odor	-	-	-	-	-	-	-	-	-	-	-
	32	Bottom sediment	C-	C-	C-	C-	B-	B-	-	-	-	-	-
	33	Accident	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-

Rating Criteria
A+/-: Significant positive/negative impact is expected.
B+/-: Some positive/negative impact is expected.
C+/-: Extent of positive/negative impact is unknown. (A further examination is required in the further project formulation)
• -: No impact is expected.
Source: JICA Project Team

Table 11-16 Summary of Matrix for Scoping (Irrigation/Drainage and Sanitation Sectors)

Environmental Component	Nº	Likely Impact Items	Overall Rating						
			Sector Irrigation and Drainage				Sector Sanitation		
			Irrigation Schemes with Area > 5,000 ha - Group 1	Irrigation Schemes with Area < 5,000 ha - Group 2	Irrigation Schemes with Area > 5,000 ha located in protected area - Group 3	Irrigation Schemes with Area < 5,000 ha located in protected area - Group 4	Construction of Sewerage- Group 1	Construction of Septage Treatment System- Group 2	Construction of Public Toilets- Group 3
Social Environment	1	Involuntary resettlement	A-	B-	C-	C-	-	-	-
	2	Local Economy such as Employment & Livelihood, etc.	A+	A+	A+	B+	B+	B+	-
	3	Land use and utilization of local resources	A-	B-	A-	B-	B-	B-	-
	4	Social institutions such as social infrastructure and local decision-making institutions	C-	C-	C-	C-	-	-	-
	5	Existing social infrastructure & Services such as Traffic/Public Facilities	A-	B-	A-	B-	B-	B-	-
	6	The poor, indigenous and ethnic people	C-	C-	C-	C-	-	-	-
	7	Inequality between beneficiaries and project-affected peoples		-	-	-	-	-	-
	8	Cultural heritage		-	-	-	-	-	-
	9	Local conflict of interests	C-	C-	C-	C-	A-	A-	-
	10	Water use right and common land use right	B-	B-	C-	C-	-	-	-
	11	Sanitation	-	-	-	-	A+	A+	A+
	12	Vector of diseases	A-	B-	A-	B-	B-	B-	B-
	13	Disaster (natural risk) and infectious diseases such as HIV/AIDS	B-	B-	A-	B-	B-	B-	-
Natural Environment	14	Topography and geographical features	-	-	-	-	-	-	-
	15	Accumulation of sediment into Dams	-	-	-	-	-	-	-
	16	Protected Area	-	-	A-	A-	C-/C+	C-/C+	-
	17	Ground water	-	-		-	-	-	-
	18	Soil erosion	B-	B-	B-	B-	B-	B-	-
	19	Hydrological situation (flow regime)	B-	B-	B-	B-	-	-	-
	20	Coastal zone	-	-	-	-	-	-	-
	21	Flora, Fauna and Biodiversity	A-	B-	A-	A-	B-	B-	-
	22	Meteorology	-	-	-	-	-	-	-
	23	Landscape	-	-	-	-	-	-	-
	24	Global warming	-	-	-	-	-	-	-
Pollution	25	Air pollution	B-	B-	B-	B-	B-	B-	-
	26	Water pollution	A-	B-	A-	A-	B-	B-	B-
	27	Soil pollution	B-	B-	B-	B-	-	-	-
	28	Waste	B-	B-	B-	B-	B-	B-	B-
	29	Noise and vibration	B-	B-	B-	B-	B-	B-	-
	30	Ground subsidence	-	-	-	-	-	-	-
	31	Offensive odor	-	-	-	-	A-	A-	A-
	32	Bottom sediment	B-	B-	B-	B-	B-	B-	-
	33	Accident	C-	C-	C-	C-	C-	C-	C-

Rating Criteria
A+/-: Significant positive/negative impact is expected.
B+/-: Some positive/negative impact is expected.
C+/-: Extent of positive/negative impact is unknown. (A further examination is required in the further project formulation)
・-: No impact is expected.
Source: JICA Project Team

(5) Description of Mitigation Measures against Adverse Impacts

Based on the scoping activities as shown above, the following main mitigation measures are recommended for major adverse impacts in each Sector.

Table 11-17 Recommended Main Mitigation Measures

Sector	Major Impact	Main Mitigation Measures
Dam	Resettlement	Conduct public consultation with Project affected person (PAPs) and local residents to explain the benefits of the project. For PAPs prepare detail analysis for compensation
	Utilization of Local Resources	Prepare utilization and post utilization plan for those areas from where materials will be extracted for construction of the dam
	Traffic	Control on the number of vehicles/equipment to avoid traffic congestion during construction
	Vector of diseases and HIV/AIDS	Implement medical check-up program
	Flora & Fauna	Plantation of forest to be home of the biodiversity and to compensate deforestation due to the construction of the dams.
Municipal Water Supply	Traffic	Control on the number of vehicles/equipment to avoid traffic congestion during construction.
Irrigation and Drainage	Resettlement	Conduct public consultation with Project affected person (PAPs) and local residents to explain the benefits of the project. For PAPs prepare detail analysis for compensation
	Utilization of Local Resources	Prepare utilization and post utilization plan for those areas from where materials will be extracted for construction of the dam
	Traffic	Control on the number of vehicles/equipment to avoid traffic congestion during construction.
	Vector of diseases and HIV/AIDS	Implement medical check-up program
	Flora & Fauna	Plantation of forest to be home of the biodiversity and to compensate deforestation due to the construction of the dams.
	Water Pollution	- Proper management of chemicals and waste oil from equipment maintenance - Implement training and education of farmers on the kind of chemicals they can use rationally - Check that only authorized chemicals are used at the site - Implement water quality monitoring for existing drinking wells. If affected, construct boreholes for affected people
Sanitation	Social Conflict	Conflicts to get approval from citizens for the location of the facility may arise. It is recommended to conduct public consultation with project affected person to arrive to a beneficial agreement. The Agency should make a compromise to manage properly the facility to obtain the consensus of the population on the Project implementation.
	Offensive Odor	Proper management of the facility

Source: JICA Project Team

(6) Conclusions and Recommendations

In general, the projects proposed in the M/P2013 will benefit three main sectors namely municipal water supply, irrigation, drainage and sanitation. As for municipal water supply high positive impacts are expected through the project implementation on the current health level of the beneficiary population by consuming potable water which in turn will allow the exercise of better hygiene practices in the households. As for irrigation/drainage, the socio-economic status of the population will be highly upgraded through the increase of agricultural production and employment opportunities. In addition food security for the population will be improved. As for sanitation, a high positive impact is expected on the public health of the population through the safe disposal of sewage and excreta.

Some adverse impacts on the environment are also expected from the project implementation which shall be diminished through the proposed mitigation measures. In this sense, especial attention must be given to the dam sectors since it involve huge physical intervention and may need the resettlement of people living around the candidate site.

CHAPTER 12 RECOMMENDATIONS

12.1 Practical Use and Periodic Review of National Water Resources Master Plan 2013 (M/P2013)

(1) Practical Use of M/P2013

The M/P2013 shows the road map of water resources development and management up to 2030 and handles a comprehensive development and management of water resources in Nigeria as a whole country. Therefore, for the Federal Ministry of Water Resources (FMWR) responsible for the main trunk water resources development and management, it has become a convenient plan. However, the matters of water resources development and management should be conducted at the state level and hydrological basin level in many cases. In addition, in the water sector, there are many water sub-sectors under the jurisdiction of the other federal ministries other than the FMWR. Therefore, the M/P2013 has been compiled to practically use such matters as follows:

- Catchment Management Plan (CMP) as a master plan by Hydrological Area
- Water Sub-sector Development Plan other than "water supply and sanitation" and "irrigation and drainage"

The M/P2013 has been prepared in the collaboration for about two and a half years with the consultant team dispatched by JICA with the technical cooperation of Japan (JICA Project Team) and “Steering Committee”, “Technical Advisory Committee” and “Counterpart Team” formulated by the members from the FMWR. In other words, this plan is a work produced by enthusiasm for the water vision of Nigeria and technology of Japan on water resources development and management.

In the future, the FMWR is recommended to elaborate and maintain this work (M/P2013) for better utilization of it.

(2) Periodic Review of M/P2013

The M/P2013 has been formulated on the basis of evidence of water resource potential based on a scientific approach and water demand forecast based on economic growth and population projections up to 2030. Future, it is necessary to check the water demand forecast and look at the track record of economic growth and population growth.

In addition, it is necessary also to check water resource potential on a regular basis. The reason is a matter of trans-boundary water. About 1/4 (88BCM/Year) amount of water resources of Nigeria (374BCM/Year) are flowing in from outside the country through the Benue and Niger rivers. Reduction of inflow will take place by water resources development in the basins on both rivers. The other reason is the problem of global climate change. Increase in drought frequency and occurrence of large floods have been foreseen. Some situations, water resource potential also may change.

In view of the above, the FMWR is recommended to carry out periodic reviews (for example, every five years) of the M/P2013.

12.2 Implementation of Water Resources Development Plan

As water resources development plan, the M/P2013 shows two (2) development plans for water sub-sectors, namely "Water Supply Development Plan" and "Irrigation and Drainage Development Plan", including the water source development (groundwater development and surface water development).

(1) Water Supply Development Plan

Water Supply Development Plan is a development plan that corresponds to the improvement of water supply rate and new water demand of future population growth (100 million people) to increase to up to 2030. The current water supply rates are: 71% (Urban), 51% (Semi-urban), 40% (Rural) and 56% in the national average. In accordance with the road map of the FMWR (2011), the water supply rate in 2025 is planned to achieve 100% of each.

Water supply system is a critical infrastructure underlying the country. As the investment to water source development facilities (dams and wells), water purification facilities and water distribution networks will be large-scale, investment in government level become essential. Both governments of Federal and State are recommended to implement steadily the projects proposed in the plan.

(2) Irrigation and Drainage Development Plan

Irrigation and Drainage Plan is a development plan with the aim of 100% self-sufficiency rate of rice in conjunction with the promotion of rain-fed rice cultivation by 2030. The projects with high investment efficiency have been selected in the development plan. Areas with a gravity irrigation system and areas with good development efficiency for water source development have been selected. The investment efficiency "Supplementary Irrigation Scheme" proposed in the basins of HA5 HA7 with high rainfall amount is particularly high.

In the case of pump irrigation system, the promotion of sound and self-reliant irrigation with hydroelectric power generation using the dam for water resources development is recommendable. The “Integrated Irrigation Scheme” newly planned at three locations propose multipurpose dam (for irrigation and hydropower generation) and irrigation land reclamation at each location. For the potential of hydroelectric power plant installation at existing dams, future research is needed.

For food security of the country, the promotion of irrigated agriculture with high yield and toughness to drought is of particular importance. Urbanization progresses, there is a tendency for demand for rice will increase. In Nigeria urbanizing, future demand for rice will increase. In addition, large-scale projects such as irrigated agriculture, will contribute significantly to the creation of employment opportunities in rural areas. From these points of view, planned investment of the federal government to irrigation scheme will be necessary. The FMWR is recommended to steadily implement the irrigation scheme proposed in the M/P2013.

(3) Involvement in Other Sub-sectors

Also in water resource-related schemes under the jurisdiction different, involvement of the FMWR becomes more and more important in future. For example, flood management and hydroelectric power generation are important areas.

As noted above, the promotion of sound and self-reliant irrigation with hydroelectric power generation using the dam for water resources development is recommendable. Although the proposed plan covers small scale of hydropower generation only for pump irrigation, multi-purpose dam project with large-scale hydropower generation and irrigation is the subject of future investigation. Future cooperation with the Federal Ministry of Power having jurisdiction over the power becomes necessary.

In the wake of the flood damage in 2012, occurred in the Benue and Niger rivers, involvement in flood management of the FMWR has become important. If the FMWR increases the ability of flood management, the FMWR will be able to contribute to the flood forecasting and warning evacuation or flood management of the floodplain along large rivers. Future cooperation with the Federal Ministry of Environment having jurisdiction over the flood becomes necessary.

Against this background, for water related project which other ministries are under the jurisdiction, the FMWR is recommended to strengthen cooperation with other ministry in order to participate actively.

12.3 Implementation of Water Resource Management Plan

Water Resources Management Plan shows the methodology how to provide the water services based on the Sufficiency, Efficiency, Fairness, Safety and Sustainability, to the water users who expect [Effective Use of Water], [Mitigation of Flood Damage] and [Conservation of Water Quality], by using the facilities and operational systems installed on the basis of Water Resources Development Plan.

The FMWR is recommended to implement steadily the projects and action plans which are indicated by Water Resources Management Plan proposed in the M/P2013. Water Resources Management Plan is aiming at the state shown below.

- There is a good plan. There is an appropriate action.
- There are organizations and systems for desirable Water Services.
- Water Services to suffice safety and security are provided for water users.

- Water Services are never delayed. If there is trouble in delivery system for Water Service, someone restores it immediately.
- Water users pay the price gladly for the right price of Water Services.
- Information relating to Water Services is collected and analyzed. This information is managed and utilized to improve Water Services
- People engaging Water Service study every day with the spirit of self-advancement.
- Water Services are always monitored by water users, and the results of services are evaluated.

12.4 Steady and Sound Investment

(1) Direct Capital Investment of Federal Government of Nigeria (FGN)

The year 2012 planned expenditure budget of FGN totaled 4.9 trillion Naira, out of which the allocation to capital expenditures amounted to 1.5trillion Naira equal to 28.5% of total budget.

On the other hand, the anticipated revenues of FGN excluding the debts such as the government bonds were estimated at 3.6trillion Naira that largely depended on the oil; meanwhile the revenues from the income taxes and the value added taxes contributed 14% only. The nation revenues cannot be expected to grow largely in the future; under these circumstances FGN is facing a difficult fiscal policy in the midst of increasing population.

The M/P2013 presents investment plans to attain the goal of 100% water supply coverage and100% self-supply of rice. Water supply projects recommended in the M/P2013 require yearly amount of 200billion Naira which is double (194%) of average investment amount spent to this sector by Government in the last three (3) years. Particularly, the 1st phase (2014-2020) requires yearly 280billion Naira, almost four (4) times (380%) more than Government investment in the last three (3) years. Meanwhile, irrigation and drainage projects require yearly amount of 107 billion Naira which is four (4) times (390%) more than investment of Government in the last three (3) years. The 1st phase (2014-2020) requires yearly amount of 50billion Naira, almost triple (290%) of Government investment in the last three (3) years.

Obviously, to achieve national goal of these, the government financial support is indispensable; so that FGN is strongly recommended, despite a severe financial status, to allocate the necessary budget amount preferentially to these two (2) sectors.

On the other hand, the FMWR, as a ministry to supervise and manage directly “Water Supply Projects” and “Irrigation and Drainage Projects”, is recommended to take following actions.

- To design the medium-term implementation and financial plan over the period of the 1st stage of the M/P2013 until the year 2020 in line with the Medium-term Sector Strategy (MTSS) and propose it definitely in order to secure the medium-term budgetary framework.
- To put it in action to take the steps of “M&E System for preparatory stage of Project Implementation” as discussed in Chapter 9.11.2, in order to secure the budget for implementation of the projects.

(2) Other Sources of Financing

The M/P2013 envisages that the governments will make an intensive capital investment up until 2030: 2 to 4 times of the current capital expenditures of annual average to the water supply projects and to the irrigation & drainage projects. For the smooth financing and implementation of the projects, the efforts to find other source of funds like below are indispensable, apart from relying heavily on the increase of the government direct capital investment.

- **Utilization of Private-sector Funds**

  The FMWR shall promote the introduction of the Public-Private Partnership (PPP) and the privatization of the water supply projects and the irrigation projects currently undertaken by the governments in order to decrease the government direct capital investment.

- **Utilization of International Development Partners’ (IDPs) Funds**

The intensive efforts to get the awards such as the “Grant Technical Aid and Grant Financial Aid” or “Soft Loan” from IDPs are to be made for decreasing the government direct capital investment. Besides, for realizing actually the investment programs efficiently and concretely, it is also requested to share the related information among all IDPs through the actions such as the stakeholders’ meetings and the use of the donor’s coordination platforms.

- **Promotion of Users’ Pay Principle**

  Every user of treated water and irrigation water must pay the charge according to the volume they use. However, most of the users actually don’t pay the charge. This causes the quite low level of revenues of these projects. So, it is a crucial matter to improve the revenues through the efforts in making users aware of the importance of payment through such as public awareness campaign. As a result, the incomes from the projects are expected to grow, which could generate the incremental cash flow for the coming new projects and simultaneously decrease the government direct capital investment.

The FGN, aiming to realize steadily the M/P2013, is recommend to actualize the above three (3) actions which contribute toward decreasing the government direct capital investment.

12.5 Establishment of Project Promotion Function/Body

“A beginning of big job is critical. (The first step is always the hardest)”

The FMWR is recommended to establish immediately project promotion function/body, e.g. “Project Promotion Mission Unit (PMU)” in the FMWR, so that the FMWR utilizes the M/P2013 effectively under her ownership, strength implementation system and responds flexibly to future problems and issues. Missions of the PMU are as follow:

- **Follow-up of Dissemination Document**

  To coordinate and take procedures in and out of the FMWR, in order to put the seal on the M/P2013 as a dissemination document.

- **Implementation of Water Resources Development Plan**

  To promote and accelerate immediately the various action plans and projects proposed in Water Resources Development Plan of the M/P2013, such as water source (surface water and groundwater) development plan, sub-sector (water supply and irrigation) development plans and involvement in other sub-sectors.

- **Implementation of Water Resources Management Plan**

  To promote and accelerate immediately the various action plans and projects proposed in Water Resources Management Plan of the M/P2013, in order to adequate provision of water services.

- **Coordination with Related Ministries and Agencies**

  To be liaison for active coordination with the related ministries and agencies in charge of other sectors such as hydropower generation and flood control.

The PMU works under the direct control of the Permanent Secretary of FMWR and composed of about ten (10) members, and can be supported by various departments if necessary. The unit leader is appointed by the Minister of FMWR. In terms of introduction of advanced technology and human resources development, the PMU should be assisted technically by IDPs.

The PMU is a time-limited organization for five (5) years, which is the proposed time frame of periodical review of the M/P2013, and should establish the methodology for project promotion and acceleration in this period.

Besides, PMU’s activities should be monitored and evaluated, and then fed back to the M/P2013 for further utilization and improvement.