# FEDERAL REPUBLIC of NIGERIA

## FEDERAL MINISTRY OF WATER RESOURCES

**PROPOSED TRIMING II PROGRAM**

Consultancy Services for the Benue River Basin Water Resources Development and Management Program for Formulation of TRIMING Project II: Update existing knowledge on available water resources in Benue basin; improve water resources planning and management through capacity gap analysis and upscaling; formulate and implement priority investment for Irrigation development (as main thrust); multipurpose water productivity enhancement, reduce water induced risks and enhance the effectiveness of investments**.**

## Terms of Reference (ToR)

**Dated:……..2020**

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## I. ASSIGNMENT BACKGROUND

1. Preliminary discussions in 2019 between the Federal Government of Nigeria (FGN) and the World Bank Task Team have focused on scaling-up and deepening collaboration in the Water Resources sector through a dedicated operation focusing on irrigation and water resources management. Initial discussions were held with officials of the Federal Ministry of Water Resources (FMWR), the Client, in November 2019. Following these discussions an official request for mobilization of World Bank support to Dam safety operations, Water Resources Management Project in the irrigation sub-sector was put forward from the FMWR to the Federal Ministry of Finance (FMF) in January 2019.

2. There is general consensus and wide-spread agreement that stepping-up investments in irrigated agriculture in Nigeria makes imminent sense. To the extent that increased agricultural productivity depends on increased dry season production, higher-value farming systems and the adoption of Green Revolution-type yield enhancing technologies, these require reliable access to water.

## II. INTRODUCTION

3. Nigeria, with the land area of 924 thousand km2, a population of about 202.8 million (2019) and a steady increase in population growth rate, coupled with transmigration from the neighboring countries, would face food security crisis if it cannot effectively manage its land and water resources. With low levels of cultivation and food production (without adequate irrigation management), Nigeria has rightly adopted the Sustainable Development Goals (SDGs) to **end poverty and ensure food security, protect the environment** and **ensure prosperity for its population.** The agenda consists of two most important goals of *(i) No Poverty;* and *(ii) Zero Hunger*. The Federal Government of Nigeria (FGN) has realized that the ***Strategic Development and Management of Resources*** are the only sustainable way to ensure national food security and poverty alleviation.

4. Under the fixed asset of land resources, the only remaining resources to manage effectively is **its water resources**. Nigeria's water resources availability is ***highly variable in space and time.*** The country has a mixed semi-arid and tropic climate and receives annual average precipitations of 1150 mm. The Northern part features a semi-arid climate, with low precipitations of 250mm/year in the extreme North-East. By contrast, the climate in the Southern is very humid, with seasonal precipitations reaching 4,000 mm/year in the South-East corner. In recent decades, the Nigerian Sahelian belt has faced dire rainfall variability with prolonging drought durations contributing to near drying of Lake Chad and many of its rivers to becoming ephemeral.

5. Given the importance of water as a basic resource, the FGN has taken essential steps for proper management of water resources and has formulated water resources development plans since the 1970s under the leadership of the Federal Ministry of Water Resources (FMWR). The

FMWR had formulated the **National Water Resources Policy and Strategy,** the **National Irrigation and Drainage Policy and Strategy, Nigeria Vision 20:2020, "Water Sector Roadmap, National Water Resources Master Plan,** and **Draft Water Bill** (still with the National Assembly awaiting passage) and associated regulations to be ratified into law soon. The underlying objectives of these documents are to facilitate and enhance sustainable access to safe and adequate water to meet current and future demand. With the localized water shortage becoming more pronounced and competing demand increased, the first systematic "National Water Resources Master Plan" was first drawn in 1995 (MP1995), which had been revised and developed into a more comprehensive and integrated National Water Resources Master Plan with the assistance of Japan International Cooperation Agency (JICA) from 2011 to 2013 now referred as (MP2013). Meanwhile, increasingly separate basin-wise water management plans are being drawn for implementation.

6. As per MP2013, the existing total annual water demand estimated at 5.93 Billion Cubic Meter (BCM) is expected to increase nearly threefold by 2030 to about 17 BCM. The most recent estimates (MP2013) suggest total estimated annual renewable water resources of **531** BCM, of which **287** BCM internally generated surface water, **88** BCM cross-boundary inflows from neighboring countries, and **156** BCM available as groundwater. It is projected that by 2030 the demand for domestic and industrial water supply will increase by 53% and irrigation by 45%, thus reaching 16.6 BCM/yr. Today's water demands thus account for 1.6% of total surface water resources available in the country, and this will increase to 4.4% by 2030. However, the high variability of seasonal flows of the rivers dictate a need for better regulation and management of water resources.

7. The Nigeria objective regarding provision of water services is based on **3S & 3E** principles (**S**ufficiency, **S**afety, **S**ustainability, **E**fficiency, **E**fficacy, **E**quitability) 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 based on well-formulated Water Resources Development Plan. Under these circumstances, future water resources development planning and management need to be re-examined in a broader development perspective for all subsectors and all parts of the country. There is an urgent need to develop a better understanding of available water resource, balance appropriation of such resources for effective and efficient utilization to fulfill the demands in the future through appropriate institutional arrangements, and coordination for efficient management of infrastructure and resources using modern state-of-the-art analytical tools.

8. The Federal Government of Nigeria (FGN) intends to use part of the funds of the on-going World Bank-funded TRIMING project to carry out **detailed land and water resources study**, on the basis of which to formulate an appropriate **water resources development and investment project** for the Benue River Basin lying in the North Eastern and North Central corridors (Hydrological Areas 3 and 4 or Upper and Lower Benue Basins ) of the country. The study will *update existing knowledge on the available water resources in the water rich basin; Improve water resources planning and management through capacity gap analysis and upscaling; and formulate and implement priority investment* ***for irrigation development and management (as the main***

***thrust),*** *multipurpose water productivity enhancement, reduce water induced risks, safety of dams and enhance the effectiveness of investments.*

9. This will be achieved through; refining/updating data of the available surface and groundwater resources of the basin covered in the past studies; using the state-of-the-art-tools to access and analyze the needed hydro-meteorological information, forecasting future demands of the various sub-sectors of the basin in a reasonable time frame of the next 20-35 years, analyzing the capacity of water sector institutions of the country, particularly in the context of **the Benue basin related States and Basin Water Authorities** and supporting Federal institutions, and suggesting gap analysis for capacity building of the concerned national agencies for carrying out such development plan in the next 20 (2040) years. **Based on that outcome of the study**, screen and select the most promising group of schemes or a scheme to formulate into **a development project** by following the "Participatory Irrigation Management" principle like the ongoing TRIMING project. The development project can thus be named as **TRIMING II project**. The consultancy services will be in three stages comprising of (i) Stage I: Pre-feasibility/Feasibility Studies (ii) Stage II: Project Prioritization and Detailed Designs with possibility of a time lag to enable the realization of the project - the TRIMING II, and (iii) Stage III: Project Implementation, with government priority to irrigation development. The Stage I and Stage II will be for 18 consecutive months while Stage III implementation is expected to run for 7 years.

## III. OBJECTIVES AND STAGES OF THE CONSULTANCY

10. **As indicated above, the objectives of the consultancy are to: (**i) update existing knowledge on the available water resources in the Benue Basin; (ii) improve water resources planning and management through capacity gap analysis and upscaling (iii); and formulate and implement priority investment for irrigation development (as the main thrust), multipurpose water productivity enhancement, reduce water induced risks and enhance the effectiveness of investments. The Objectives would be realized by three stages as follows:

**<u>Stage I</u> (Pre- feasibility/Feasibility Studies);**

This stage would (i) **update** the essential parts of the water resources management data by evaluating available resources spatially and temporally for the Benue River Basin "Hydrological Area (HA) 3 and 4" considering the available Water in the Water Resources Master Plans of 1995 and 2013 and their related studies in the past; (ii) the study would **draw out** the Benue Basin **Water Management Plan** using most up-to-date state of the art tools. Next, the study would forecast demand projection of various sub-sectors of water uses, evaluate demand projection for the Benue Basin sub-sectors according to their order of priority: as Municipal and Rural domestic water supply, Irrigation, Hydropower generation schemes, environmental flows, Flood and Drought Control, Inland Navigation and River training, Aquaculture and Livestock schemes taking into consideration the socio-environmental risks and needs for downstream; and (iii) **prepare** a Development Plan including a set of possible irrigation and water resources development schemes, including some of which may already be in various stages of implementation. The Client will use

available human resources within its employment including the Ministry of Water Resources and other relevant MDAs to oversee and guide the implementation of this stage, which will be handled by qualified Consultants.

**Stage II: (Project Prioritization and Detailed Designs);**
This stage would be the formulation of a bankable project following the feasibility studies and support for its implementation by the client after evaluating the portfolio of projects from the most promising schemes or a scheme, sizable enough to prepare an internationally fundable project of $600 million to be implemented in 7 years. The chosen scheme(s) would first be put under feasibility level study and to a final design completed with an estimated costs and implementation schedule. The feasibility and the final design of the project would follow the successful "Participatory Irrigation Management Principle (PIM)" like the ongoing TRIMING Project, and thus the Stage II definitive project can then be named as TRIMING II Project. The Stage II would culminate to the final design with a set of tender drawings and bidding documents for the first 18 months program of works. It will be obligatory for the consultants to make clarifications on completed detailed designs and Bidding Documents, especially during procurement processes.

**Stage III. (Project Implementation);**
Subject to the satisfactory outcome of the consultancy and the project realization of stage II, this stage is envisaged to usher in the works **contract procurement** (for detailed studies and design completed in Stage II) and full **project implementation** including supervision of works contracts. The Client at this stage will setup a Project Management Unit consisting of Specialists in various disciplines required for smooth implementation of the Project during the 7 years implementation.

11. The assignments in stages I & II are expected to be completed by a team of competent professionals within a time frame of 18 consecutive months, followed by Stage III. Within the study period, the consultants are required to perform, but not limited to, the following specific tasks.

## IV. STAGE I - SPECIFIC BASIN DEVELOPMENT PLAN

12. **The Stage 1** - Specific Basin Development Plan step is essential to select a development plan which would ***enhance productivity, reduce water induced risks to the public safety, and enhance the effectiveness of integrated water-use investments among very many possible options. The review in Stage 1 includes a background that touches why Benue Basin is the chosen basin among others. The following tasks would be carried out in Stage 1:***

**Task 1: Reviewing and studying of the two past Water Resources Master Plans 2013 and their associated studies, promulgated policies and strategies:**

13. The following data on the Nigeria Water Resources (SW, GW, and Lakes) by hydrological areas as abstracted from the MP-1995 and MP-2013 which are almost decade old and need to be updated or refined as necessary making supplemental use of the recently collected data. Based on the Rainfall-Runoff Model 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 is runoff while the remaining is lost through evapotranspiration and others. In terms of total water resources, MP2013 estimated over 38 MCM above MP 1995. For that, the consultancy services would pay attention to study the river basin area, **Benue, and its sub-basins**. In earlier studies, Nigeria is divided into eight Hydrological Areas (HA) for the purpose of water resources management, considering hydrological and topographical perspectives. These 8 HAs are shown in the map below: (i) Niger North -HA1; (ii) Niger Central- HA2; (iii) Upper Benue –HA3; (iv) Lower Benue – HA4; (v) Niger South–HA 5; (vi) Western Littoral–HA 6; (vii) Eastern Littoral-HA7; and (viii) Chad Basin – HA 8.

14. In Nigeria, the freshwater consists of several rivers and their flood plains, streams, lakes, and wetlands, with the rivers and streams relatively evenly distributed all over the country. Annual rainfall is however highly variable across the different regions, varying from about 250 mm in the extreme north of the country, to about 4,000 mm in the south. Rainfall constitutes a significant source of water, with the annual renewable total estimated water resources potentials of **531** BCM, of which **287** BCM is internally generated surface water, cross-boundary of **88** BCM inflow from neighboring countries, and **156** BCM available as groundwater.

15. The distribution of average annual renewable water across the different hydrological areas (HAs) as indicated in MP 2013 is as shown in Table 1.1. As can be seen from Table 1.1, both the Benue (Upper and Lower) and Lower Niger has constituted the largest source of annual renewable water in Nigeria. The River Benue is of great significance in the management of water resources in Nigeria as it's a major tributary of Niger that flows into Nigeria passing through some West African countries like the Republic of Benin, Burkina Faso, Chad, Cote d' Ivoire, Guinea, Mali, Niger, and Sierra Leone. Within the context of the co-operative management of water resources, it is important to note that shared rivers have implications for the perception of water rights, as well as on the issue of national security and sovereignty.

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Fig.1. Eight Hydrological (boundary) Areas of Nigeria.


**Figure 1: Eight Hydrological (boundary) Areas of Nigeria**

**Table 1: Estimated Water Resources Potential Distribution of Annual Average Yield of Surface and Ground Water by HA in Nigeria (MP2013)**

| | | 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 | (BCM /year) | 35.1 | 32.3 | 56.4 | 46.0 | 40.1 | 35.7 | 79.9 | 7.2 | 332.7 |

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| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| outside Nigeria | | | | | | | | | | |
| 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 |

16. **Water resources by river basins:** The River Niger flows into Kebbi State, which is in northwestern Nigeria, from Benin and continues to flow toward the southeast. It merges with the **River Benue** and changes its flow direction to the south. The flow finally reaches the Gulf of Guinea through the Niger Delta. The flow course of the **rivers Niger and Benue** 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. The country is well-drained with a close network of rivers and streams as shown in Fig. 1.1. Some of these, particularly the smaller ones in the north, are seasonal. There are four principal surface water basins in Nigeria: (i)**The Niger Basin (HAs 1, 2, 3, 4, 5)** has an area of 584,193 km$^2$ within the country, which is 63 percent of the total area of the country and covers a large area in central and north-western Nigeria. The most important rivers in the basin are the Niger and its tributaries, **Benue (HA 3 & 4** Eastern main tributary**)**, Sokoto, and Kaduna; (ii) **The Lake Chad Basin (HA 8)** in the northeast with an area of 179,282 km$^2$, or 20 percent of the total area of the country is the only internal drainage basin in Nigeria. Important rivers are the Komadougou-Yobe and its tributaries, Hadejia, Jama 'are, Komadougou Gena, and Yedzeram; (iii) **The south-western littoral basins (HA 6)** have an area of 101,802 km$^2$, which is 11 percent of the total area of the country. The rivers originate in the hilly areas to the south and west of the River Niger; (iv) **The**

**south-eastern littoral basins (HA 7)**, with the major watercourses being the Cross and Imo Rivers, has an area of 58,493 $km^2$, which is 6 percent of the total area of the country, and receive much of their runoff from the plateau and mountain areas along the Cameroon border.

17. Nigeria's extensive groundwater resources are in eight recognized hydrogeological areas together with local groundwater in shallow alluvial (Fadama) aquifers adjacent to major rivers, namely: (i) The Sokoto Basin Zone comprises sedimentary rocks in northwest Nigeria. Yields range from below 1.0 to 5.0 liter per second (l/s); (ii) The Chad Basin Zone comprises sedimentary rocks. There are three distinct aquifer zones: Upper, Middle, and Lower. Borehole yields are about 1.2 to 1.6 l/s from the Upper unconfined aquifer and 1.5 to 2.1 l/s from the Middle aquifer; (iii) The Middle Niger Basin Zone comprises sandstone aquifers yielding between 0.7and 5.0 l/s and the Alluvium in the Niger Valley yielding between 7.5 and 37.0 l/s; (iv) The Benue Basin Zone is the least exploited basin in Nigeria extending from the Cameroon Border to the Niger-Benue confluence. The Sandstone aquifers in the area yield between 1.0 to 8.0 l/s; (v) The South-western Zone comprises sedimentary rocks bounded in the south by the coastal alluvium and in the north by the Basement Complex; (vi) The South-Central Zone is made up of Cretaceous and Tertiary sediments centered on the Niger Delta. Yields are from 3.0 to 7.0 l/s; (vii) The South-Eastern Zone comprises Cretaceous sediments in the Anambra and Cross River basins. Borehole numbers are low due to abundant surface water resources; (viii) The Basement Complex comprises over 60 percent of the country's area. It consists of low permeability rocks and groundwater occurs in the weathered mantle and fracture zones with yields between 1.0 to 2.0 l/s.

18. Lake Chad is an important wetland lying in the semi-arid Sahel corridor. With a mean depth of 3.9 meters (m), its surface area is highly variable, ranging from a minimum of 2,000 $km^2$ in 1907 to a maximum of 22,000 $km^2$ in 1961, the lake presently covers an area of less than 1,500 $km^2$. Development potential in Nigeria rests largely on the abundant natural resources and well-educated workforce, with major economic challenges coming from rapid population growth, high levels of poverty and inequality, low productivity, and intensified global competition.

**Task 2: To Carry out an updated evaluation of the water resources of surface and groundwater available in the Benue Basin Area understudy using state-of-the-art tools.**

19. The Review and Updating in the Benue Hydrological Area water resources potential will also specifically address socio-economic and water resources development related issues concerning the following: (i) General Socio-Economics and administrative data (federal and regional); (ii) Hydrological Data (Basin and sub basin); (iii) Meteorological Data (Basin and Sub basin); (iv) Watershed Characteristics Data (Basin and Sub basin); (v) Demography, Population and Land Area (Basin); (vi) Demarcation of sub-hydrological areas; (vii) Hydrology (Basin and Sub-Basin); (viii) Hydrogeology, aquifer types, characteristics, and yield; (ix) Agriculture and irrigation production, potentials and specification; (x) Hydropower potentials and existing development; (xi) Water supply and sanitation statistics (quality and pollution); (xi) Watershed Management; (xii) River Managements and navigation, etc. In updating the Water Resources potential, the use of state-of-the-art modeling for long term average, potential wet and dry period analysis of different recurrences accounting for the probable climate change analysis is to be

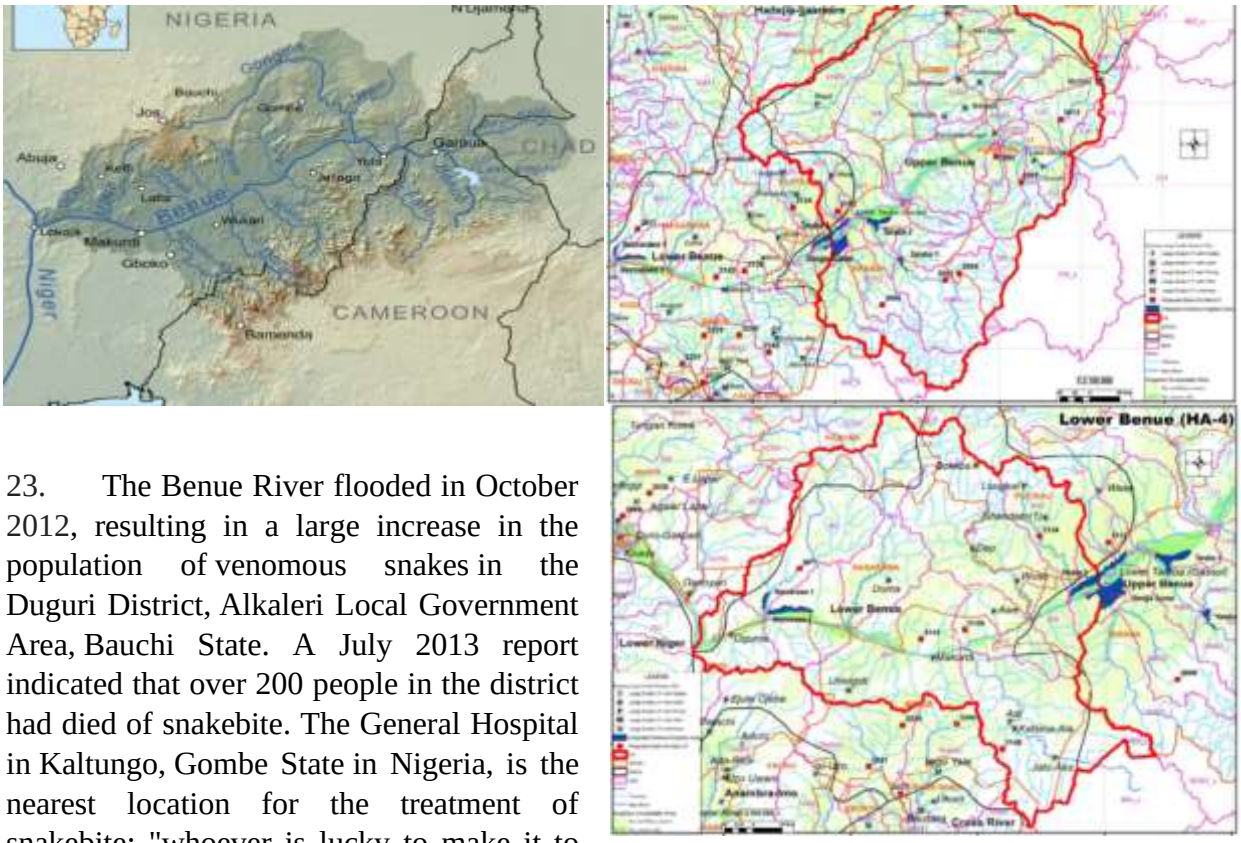
included. In MP2013 a set of hydrological observations stations are recommended as such by this time the Consultants may get additional data from the extended network for use in the analysis.

20. Along with the above-mentioned metadata updating, the institutional and administration at the Federal, State, and Local Levels issues are also to be updated and reviewed as these may influence the water resources development. In that, things that may include updating in the current study are: (i) Organizational Structure and Function of FMWR (if change any); (ii) Executive Branches of the Federal Government of Nigeria in water management and development; (iii) State-wise Land Area and Population of Nigeria (after National WR Master Plan 2013); (iv) Nominal GDP (Naira in Billion) (optional or update for Benue Basin) and GDP growth at 2000 Price;(v) Contribution to GDP (%) by Economic Sector of Water Resources (Irrigated Agriculture, Hydropower; Fisheries; Inland Transport, etc.); (vi) Summary of Foreign Trade and Labor Market**;** (vii) Working Population by Occupation in the study area; (viii) Operational RBDAs and other water organization in the study area.

21. **The Benue Basin:** The study area is to be confined within Nigeria only. The **River Benue**, previously known as the **Chadda River** or **Tchadda.** The Benue river is approximately 1,400 km (870 miles) long and is almost entirely navigable during the raining season months. As a result, it is an important transportation route in the regions through which it flows. It rises in the Adamawa Plateau of northern Cameroon, from where it flows west, and through the town of Garoua and Lagdo Lake Reservoir, into Nigeria south of the Mandara mountains, and through Jimeta, Numan, Jen, Lau, Ibi and Makurdi before meeting the River Niger at Lokoja. By visualization, over 70 percent of the catchment area lies in Nigeria. Large tributaries are the Faro River, the River Gongola , and the Mayo Kébbi, which connects it with the Logone River (part of the Lake Chad system) during floods. Other tributaries are River Taraba, River Donga and River Katsina Ala. At the point of confluence near Lokoja, the Benue exceeds the Niger by flow volume. It should be also noted that the contribution from river Benue basin to the total runoff volume in the River Niger is relatively large compared to its drainage area. The mean discharge before 1960 was 3,400 cubic meters per second (120,000 cu ft/s) for the Benue and 2,500 cubic meters per second (88,000 cu ft/s) for the Niger. These however need to be reviewed again and updated.

22. The Nigeria Hydrological Services Agency (NIHSA), Upper Benue River Basin Development and Lower Benue River Basin development Authorities provides some gauging stations on the Benue river and its tributaries most of which have suffered vandalization or non-functional. NIHSA provide 6Nos Hydrological Stations on the Benue River at Wurobokki (DCP not Functioning) near the border with Cameroon, at Lau, Ibi , Katsina Ala, Umaisha and Makurdi. Nigeria government signed a Memorandum of Understanding MoU with the Republic of Cameroon on Technical Consultations for the Management of the Water Resources of the Benue Basin on 3rd May, 2016 for a five-year automatic renewal period. Further detailed information of the Benue and its tributary rivers including hydrology, hydrogeology is provided below:

**Figure 2: Benue River Basin including areas in Chad and Cameroon (enlarged HA-3 & HA-4)**




23. The Benue River flooded in October 2012, resulting in a large increase in the population of venomous snakes in the Duguri District, Alkaleri Local Government Area, Bauchi State. A July 2013 report indicated that over 200 people in the district had died of snakebite. The General Hospital in Kaltungo, Gombe State in Nigeria, is the nearest location for the treatment of snakebite; "whoever is lucky to make it to Kaltungo is treated in only two days and then they returned home. This social health issue related to flooding is also worth consideration in flood protection works. The consultants are required to define the administrative boundary of the states involving the Benue River basin partly or fully so that the concerned study areas can be identified clearly. It is suggested to name the Sub-Hydrological Areas (SHA) for HA-3 and HA-4 basins.

24. **The Hydrology and Hydrogeology of the Benue River Basin:** Benue River is a major and longest tributary of the Niger River, originating in the high-altitude of Adamawa Plateau in Cameroon from where River Mayo Rey, Mayo Godi, Mayo Farda from Poli mountains all converge and flow through a vast plain of alluvial deposits, passing through the Lagdo Gorge, now the site of Lagdo dam. The Benue river subsequently flows past a wide alluvial plain before the confluence with Mayo Kebbi upstream of Garoua and 300 kilometers from its source. During flood periods its waters are linked via the Mayo-Kebbi tributary with the Logone, which flows into Lake Chad.

25. The river is approximately 1,400kilometers and is almost entirely navigable during the summer months. It is an important transportation route in the regions through which it flows. It rises in the Adamawa Plateau of northern Cameroon, from where it flows west, and through the town of Garoua and Lagdo Reservoir, into Nigeria south of the Mandara mountains, and through Jimeta, Ibi and Makurdi before meeting the Niger River at Lokoja. The Benue flows in a southwest direction through Garoua and westwards into the Nigerian-Cameroon border where it makes

encounters and receives the Faro river system. In Nigeria, the Benue passes Yola and collects the flow from River Ini and at Numan the Gongola River discharges heavy sediment laden flows into the Benue. The Benue then takes a southwest direction, which it follows for approximately 450 kilometers, to Makurdi. Between Numan and Makurdi., The right bank tributaries coming from the Jos Plateau remain small.

26. The river collects significant flows from its left Bank; Rivers Taraba, the Mentchum, Donga and the Katsina Ala rivers, discharge into the Benue River within this reach. Between Makurdi and the confluence of the Benue River with the Niger at Lokoja, the Benue collects flows from small tributaries from the left bank but Rivers Mada and the Okwa, coming from the southern Jos Plateau, on the right bank flows into the Benue. At Lokoja, the Benue meets the Niger. The Benue River basin extends between latitudes 5.70oN in Cameroun and 11.75oN; and longitudes 6.74º E and 15.66º E and flows over a 1,440km channel before discharging into the River Niger at Lokoja having drained Adamawa, Benue, Taraba, Nasarawa, Plateau, Gombe, States and parts of Kogi, Yobe Bauchi, Borno States and FCT.

27. **River Katsina-Ala** rises in the western region of Cameroon before entering Nigeria, it passes through Katsina-Ala before joining the **River Benue** about 40km east of Makurdi. The River **Donga**, which provides up to 20% of the Benue flow, starts in the Adamawa Highlands of Nigeria, adjacent to the Cameroon. The **River Donga** joins the River Benue at Jibu. The **River Taraba** also has its origins in the Adamawa Highlands and it joins the **River Benue** about 20km northeast of Jibu. The Rivers Katsina Ala, Donga and Taraba drain a part of the western region of Cameroon and an area in Nigeria south of the River Benue.

28. The combined river systems in the basin are referred to as the Benue River Basin and comprises the rivers Gongola, Mada, Ankwe, Wase, Pai, Okwa, Mayo Kebbi, Taraba, Dong, Katsina Ala, Faro and their tributaries. The Benue Basin to the left of the main channel consisted of its major tributaries viz Faro, Taraba, Donga and Katsina Ala while the right bank tributaries consisted of collection of minor tributaries (Mada, Ankwe, Wase, Pai, and Okwa) except for the Mayo Kebbi and Gongola Rivers.

29. **The Gongola River System** as Benue tributary: The Gongola River is the major right bank tributary of the River Benue rises on the eastern slopes of the Jos Plateau as River Lere and Maijuju in the Wadi hills and Shere hills respectively and cascades (with several scenic waterfalls) onto the plains of the Gongola Basin, where it follows a northeasterly course through Bauchi and Gombe States. It then flows past Dadin Kowa where a dam was constructed across it. After receiving the Hawal (its major tributary, which rises on the Biu Plateau), it continues in a southerly direction before joining the Benue, opposite the town of Numan, after a journey of 330 miles (531 km). During the dry season, however, the upper Gongola and many of the river's tributaries practically disappear, and even the lower course becomes unnavigable. Almost all of the Gongola Basin lies in a dry savanna area. The basin has been enlarged by the Gongola's capture of several rivers that formerly flowed to Lake Chad—the sharp southerly bend east of Nafada is the result of the capture of the upper Gongola, and the Gungeru, another tributary from the Biu Plateau, is also

a captured stream. A second dam across the Gongola River was constructed at Kiri to supply irrigation water to the Savannah Sugar Company Sugar Cane plantation.

30. **Katsina Ala River**: River Katsina Ala is a river took its source from the Bamenda highlands northeast of Cameroon. It flows 200 miles (320 km) northwest in Cameroon, crossing the Nigerian Cameroon border into Nigeria it passes through Katsina-Ala before joining the River Benue about 40km east of Makurdi.

31. **Donga River**: The Donga River rises from the Mambilla Plateau in southeastern Nigeria, forms part of the international border between Nigeria and Cameroon, and flows northwest to eventually merge with the Benue River near Jibu Town. The Donga watershed is 20,000 square kilometres (7,700 sq mi) in area. At its peak, near the Benue the river delivers 1,800 cubic metres (64,000 cu ft) of water per second providing about 20% of the Benue flows

32. **General Geomorphology of the Benue River Basin**: The Benue trough is an elongate sedimentary basin, over 800km long and 100 – 120km wide. It has a general NE-SW trend and extends from the Niger Delta Basin to the southern margin of Lake Chad Basin. In its upper part, the basin bifurcates into a N – S trending arm (Gongola arm) and an E – W trending arm (Yola arm). The sedimentary infilling contains marine and continental deposits (Albian- Maestrichtian age) (Carter et-al, 1963).

33. The Benue river valley is believed to have formed as a result of the failure of the Benue arm to continue opening at the beginning of the Cretaceous when gondwana land started breaking-up (Benkhelil, et al, 1989). The valley was therefore filled up with both continental and marine sediments which have all experienced extensive brittle and ductile deformational events giving rise to extensive folding, faulting and jointing along the entire length of the valley.

34. The river is a typical plain river with low slope, a wide flow variation and a sandy bed over pre-existing sandstone through its entire length. Its width is variable and its narrowest bed is in Yola, near the border of Cameroun Republic (with a width of approximately 780m to 1,000m in Lokoja. From the morphological point of view, the study area, Wuroboki to Makurdi, may be classified as a meandering river, with many islands, some of which are the results of previous changes in the course of the river.

35. Within the larger river bed, there is a smaller one between sand banks which almost always form a series of bends, with typical distribution of greater depths near the concave banks. During the season when the water fills the whole of the larger bed, the course of the river is reasonably straightened. The Faro River, a tributary on the left bank of the Benue meets the Benue River at the border of the Republic of Cameroun.

36. The river which carries great quantities of sediment has a strong morphological influence on the upper section of the Benue River. However, the river bed is alluvial, there is some appearance of rocks which act as control sections and influence the morphology of the river bed besides presenting obstacles for Navigation. Apart from the tributaries carrying sediments to the

main river bed, these tributaries have an influence on the hydrological discharge, contributing to the increase in flow and consequently to the depth and width of the main bed as the flow get closer to the confluence with River Niger.

37. Although the above problems cause difficulty to navigation as in any large rivers on plains, the problem is aggravated in Benue because of the low water flow during the dry season which makes the river practically inaccessible for larger commercial vessels during the greater part of the year under normal conditions.

38. **The Geology:** In view of the large and varied models on the tectonic origin of the Benue trough, only a summary is given here. There are three geodynamic models on the trough:

a) The sea floor model of Burke and Dewey (1973), which interpreted the trough as being related to the opening of the South Atlantic and separation of Africa from South America in Lower Cretaceous times. Olade (1976) modified this model and described the Benue trough as an aulacogen, the failed arm of an 'rrr' rift system.
b) A true rift system of Wright (1976, 1989) who compared the Benue trough with the Afar in E. Africa.
c) The pull-apart basin model of Benkhelil (1986) and Benkhelil et-al (1989). According to these authors, the formation of the trough is closely related to the transform zone which characterized the northern margin of the Gulf of Guinea during the Lower Cretaceous continental separation of Africa from S. America. Transcurrent faulting along N600 E and N250 E trends resulted in the formation of sub-basins.

39. The infilling seems to have been diachronous from south to north. A compressive phase of Late Maestritchian age was thought of as being responsible for the fracturing and folding of the Cretaceous cover. The style and direction of folds are greatly influenced by the basement structures. The Benue and Niger Valleys, otherwise known as the Niger/Benue trough, were transgressed by the waters of the Atlantic Ocean. As a result, marine sediments form the dominant surface geology of much of Benue trough. These sediments have undergone varying degrees of metamorphism. These sedimentary materials are underlain at variable depth by basement complex rocks. On the flood plains of the Benue are Katsina Ala Rivers and other smaller rivers, alluvial deposits, comprising an assortment clays, sand, gravels and pebbles, overlie the met sediments and form the superficial geology.

40. The basement rocks are dominated by porphyritic granites, migmatites, diorites, pegmatites and gneisses. In much of Benue State, both the tertiary sedimentary rocks and the basement complex have been deeply weathered to produce regolith and saprolite several metres deep. These rocks are rich in solid minerals, such as limestone, baryte, coal, gypsum, salt, shales, silica, sand and kaolin which are currently being mined. The basement of the area is underlain by three major lithological units which elsewhere have been ascribed to the Nigerian Basement Complex (Precambrian to Lower Paleozoic age). The lithological units are migmatites, olivine monzonite and biotite-hornblende granites. While the migmatites belong to the "Gneiss – migmatite – quartzite complex", the monzonite and granites belong to the "Older Granite" suite.

41. The Benue trough is an elongated sedim ventary basin, over 800km long and 100 – 120km wide. It has a general NE-SW trend and extends from the northern edge of the Niger Delta Basin to the southern margin of Lake Chad Basin. In its upper part, the basin bifurcates into a N – S trending arm (Gongola arm) and an E – W trending arm (Yola arm). The sedimentary infilling contains marine and continental deposits of Albian- Maestrichtian age (Carter et-al, 1963, Reyment, 1965). In its path following the ENE-WSW direction, the Benue River flows along the axis of a sedimentary rock belt of cretaceous age consisting of arkosic sandstones and similar clastic deposits which outcropped in many places in the river bed. There are also shales interbedded with limestones. The sedimentary belt is bordered on both the northern and southern sides by PreCambrian crystalline basement rock. Within the cretaceous sedimentary belt there are basalts and rhyolites, basic and intermediate intrusions of several ages, all of them younger than the cretaceous age.

42. The basement complex presents granitic intrusions. The oldest of the sedimentary pile in the Benue river valley is Bima sandstone to the north-east. Its lateral equivalent to the south-west is Lafia sandstone which is largely arkosic(Adeleye,1989). Overlying the sandstones are various thicknesses of siltstones and shales some of which are calcareous. A careful examination of the geologic map of Nigeria (2004 edition) would reveal that to the north-eastern reach of the Benue valley, particularly between longitudes $10^{o}$ 30' and $11^{o}$ 30' E and Latitudes $9^{o}$ 15' and $10^{o}$ 00', a large number of volcanic plugs are evident.

43. Although these are quite some distance from the river channel, some volcanic plugs occur within the flood plain, examples being Gyawana, Salti and numerous other volcanic hills around the north-eastern region. Sedimentation is thought to have been caused by a series of Cretaceous transgressions and regressions. It started in the Middle Albian (Lower Cretaceous) and ended in the Maestritchian (Upper Cretaceous). A regressive phase led to the deposition of the Keana Sandstones in the Middle Benue as well as the Muri and Bima Sandstones in the Upper Benue trough.

44. The thickness of the Sedimentary pile increases from NE to SW and the interpretation of gravity anomalies reveals important variations across the trough (Cratchley and Jones, 1965). In the Middle Benue two long and narrow negative anomalies running parallel to the trough, flank a central positive anomaly. The negative anomalies are ascribed to maximum Cretaceous sediments of up to 5km. The central positive anomaly would correspond to either a shallow basement or a zone of intrusive rocks or lava flows (Cratchley and Jones, 1965).

45. **Basin Water Resources Development:** The Benue River Basin between the International border with Cameroon and Lokoja is classified as hydrological area III and IV in the Nigerian drainage system classification, covering 98.0 x $10^3$ sq km at the International border of Cameroun and drainage area of 338.2x103 sq km at Lokoja and gross surface water potential of **$108.10x10^9$**$m^3$/year. The groundwater potential is estimated at **$37.9x10^9$**$m^3$ /year (JICA MP, 2013).

46. The human population of the Benue River Basin within Nigeria is over 26.5 million people and the basin supported millions of herds of cattle that provided source of protein for the

population. In pursuant of the present policy on self-sufficiency on food supply, emphasis is placed on promotion of agriculture. Several initiatives are in place such as Special Programmes on Food Security, National Fadama Projects, Sure-P, U-Win etc all aimed producing food for the teeming Nigerian Population. With increasing population, the demand for water in the Benue basin for socio economic development is expected to exert pressure on the available surface and ground water resources. Sustainable development of the basin water resources against competing demand for water requires an integrated approach to the development in order to surmount the emerging challenges of water stresses and water disaster in the basin.

47. The existing and future water demand on the Benue River basin is 0.60x109$m^3$ /year and expected to increase to 3.42x109$m^3$ /year by 2030, out of which the municipal water demand is expected to increase from 0.23x109$m^3$ /year in 2010 to 0.956 x109$m^3$ /year in 2030 (JICA MP 2013). The demand profiles presented indicated an overall water resources potential of the basin outweighing the demand even into the future but the distribution in space and time is a challenge to be overcome by an Integrated Water Resources Management.

**Table 2: Water Demand by Sector (MCM)/year**

| | HA III - 2030 | HA IV -2030 |
|---|---|---|
| Irrigation | 1,650 | 661 |
| Aquaculture | 28 | 36 |
| Livestock | 65 | 11 |
| Municipal | 527 | 439 |
| Total | 2,270 | 1,147 |

Source: JICA, MP 2013.

48. There are currently two River Basin Development Authorities (RBDAs) within the Benue Basin: the Upper Benue River Basin Development Authority and the Lower Benue River Basin Development Authority. They are responsible for implementing water resources development policies of the Federal government. Their main functions as outlined in the Federal Government Decree No. 35 of 1987 are as follows:

a) To undertake comprehensive development of both surface and groundwater resources for multipurpose use, with particular emphasis on the provision of irrigation infrastructure, flood and erosion control, and water management;
b) To construct, operate and maintain dams, lakes, polders, wells, irrigation and drainage systems for achievement of the RBDAs functions and to hand over all lands to be cultivated on irrigation schemes to farmers;
c) To supply water from completed storage schemes to all users for a fee to be determined by the RBDA with approval of the Ministry;
d) To construct, operate and maintain infrastructural services such as roads and bridges linking project sites; and
e) To develop and keep up-to-date, a comprehensive water resources masterplan, identifying all water resources requirements, through adequate collection and collation

of water resources, water use, socio-economic and environmental data of the River Basins.

49. The RBDAs and the State Water Boards within the basin facilitated the use of the abundant water resources in the basin for the provision of hydro-electric power, raw water for domestic and industrial uses, control erosion and prevent floods, for irrigation purposes and the development of aquatic resources such as fisheries. The related states in the upper Benue are; Adamawa, Taraba, Gombe and Bauchi. That of the Lower Benue are Plateau, Nassarawa, Beneu and Kogi States.

50. **Water Storage Schemes Development:** Surface water resources are developed for storage dams particularly due to the variable regime of the rivers in order to guarantee uninterrupted, all year-round supply of raw water for hydropower generation, public water supply and irrigation. A number of storage dams were constructed and several others were various stages of planning and construction in the Benue basin.

51. According to the Compendium of Nigerian Dams produced by the Department of Dams Federal Ministry of Water Resources (2007), there are over twenty-five (25) surface water storage schemes in the Benue River Basin represented by hydrological areas III and IV, storing a total of 1,718MCM of water for water supply, irrigation, and hydropower generation purposes across the Basin. The major ones are discussed below;

a) The Dadin-Kowa dam completed in 1987 and constructed across the Gongola River at Dadin-Kowa Gombe State is a multipurpose dam with a storage capacity of $2.88x10^9m^3$. It was designed to provide water for hydroelectric power generation of 14MW, Irrigation development, and domestic water supply to the Gombe Township. The status of Gombe as a Sate Capital will further increase the water allocation to domestic water supply to the Town due to increase population concentration and growth of small-scale industries in the Capital. Both the hydropower components and irrigation infrastructures of the dam are just been completed and about to commence rehabilitation and construction of 80ha and 2000ha as at date.
b) The Kiri dam was completed in 1982 and constructed downstream the DadinKowa dam on the Gongola River at Kiri in Shelleng LGA of Adamawa Sate to supply Irrigation water for the Savannah Sugar plantation at Numan. The dam has a reservoir capacity of $6.15x10^2m^3$
c) The Kashimbilla Multipurpose Buffer Dam Project, presently under construction, is located between the towns of Kashimbilla and Gamovo on River Katsina-Ala in Takum Local Government Area of Taraba State. The project is intended to mitigate the threat of flood from the possible / imminent break of the structurally weak volcanic Lake Nyos, located in the high Bamenda Plateau (300m above sea level) upstream along the Cameroun line of volcanic activity. This disaster, if allowed to occur, will affect the States of Taraba, Benue, Cross River, Kogi, Delta and Imo. The eruption of the Lake which took place on August 21, 1986, in Cameroun, released thousands of tonnes of poisonous gas (carbon dioxide) and, caused extensive flooding resulting in the death of 1700 people, 3000 herds of cattle and other livestock. The dam is multipurpose an is under construction and shall supply water for Hydropower

generation of 40MW; Water Supply with treatment plant capacity of 60,000$m^3$ /day (for 400,000 people) for Kashimbilla in Taraba State and for Jato-Aka in Benue State; Irrigation of 2000ha of farmlands; Fishery Development; and Tourism.

d) The **Lagdo dam**, a rockfill dam constructed on the Benue River between 1977 and 1982 is located 50 km south of the city of Garoua within the Arrondissement de Lagdo in the Département de la Benoué in the North Province of Cameroun. The dam which is 308 m long, 40 m in height and 9 m thick covers an area of 586 km² and storage capacity of 8,000MCM.

e) The **Mambilla Plateau** Hydropower Project has been called Nigeria's Three Gorges Project, initially planned for 2,600MW, now 3,050MW installed capacity dam when built, could have been one of Africa's and Nigeria's biggest hydro dams. The proposed project was to be connected to three dams across the brownish River Donga snaking through the fabulous Mambilla mountains in Taraba State of Nigeria. Conceived in 1982, the project has suffered neglect by successive past military administrations and under the democratic dispensation, Mambilla Dam is supposed to be a large rolled compact concrete dam and reservoir at 1300 meters above sea level meant for storing and regulating water. From this dam, water is diverted off the reservoir towards the western side of the plateau through three hydraulic tunnels totaling 33 km, intercepted by two smaller dams, Sum Sum Dam and Nghu Dam, both at an elevation of 1250metres. Beyond these dams, the tunnels lead into 1000 meters drop shaft tunneled down through the rock to a massive underground powerhouse with a generating capacity of 3050 MW. Through a short tunnel, the water then exits the base of the plateau and flows into a tributary river that rejoins the Donga River downstream of the plateau.

52. **Borehole Schemes Development** in the Basin: The State governments, through the State Water Boards (SWBs) and the Rural Water Supply and Sanitation Agencies (RUWATSAN), have primary responsibility for urban and rural water supplies. These they provided through conjunctive surface and groundwater developments particularly small towns and rural water supplies are borehole-based schemes. According to JICA Master Plan 2013, the groundwater potentials of the Benue Basin within Nigeria is estimated at 37,968MCM/year or 24.38% of the National Potentials. The demand for groundwater for multipurpose uses in the basin varies from 333MCM in 2010 to 1,049MCM in 2030 or 9.48% and 12.48% respectively of the national groundwater demand. According to the JICA 2013, there are 1559 motorized boreholes and 3375 handpump boreholes in the Benue basin and additional investment in groundwater development is expected to add 2719 motorized boreholes and 16438 handpump boreholes by 2030.

53. **Irrigation Schemes Development** in the Basin: The Dadin Kowa dam Infrastructure was originally designed to irrigate a gross area of 6,200 ha (72% sprinkler and 28% gravity) at Dadin Kowa and 18,800 ha (55% sprinkler and 45% gravity) by a diversion weir not yet constructed at Guyok. The dam has a nominal storage capacity of 2.8 billion m3 with live storage of 1.77 billion m3. The spillway gates are in a permanent open position to keep the dam safe by lowering the reservoir level but for the recent Hydropower development the gates are now closed. The irrigation intake gate is also permanently open to discharge 10 m3 /s of flow through the concrete canal on

the right side of the river to only return back to the river over the side escape as the downstream irrigation system is incomplete. The is an ongoing contract for the development of 2000ha quick win irrigation infrastructure.

54. In addition, the following infrastructures were constructed on the right side of the river:

a) 4,28 km concrete canal (2.3 km up to the side escape);
b) 150 m long inverted siphon to cross Gongola river and convey irrigation water from the right side to the left side of the river;
c) 0.72 km pipe of 1 m diameter receiving water from the concrete canal to cross a residential area; and
d) 7,500 m3 capacity flow regulating reservoir to serve interested farmers to irrigate by pump.
e) The 37.5 billion cubic metre capacity Doma dam, which formed part of the Mada river basin in the Nasarawa State and was planned to irrigate a total of 39,000 hectares for agriculture.
f) 2000 hectares of land had been developed for sprinkler irrigation at Doma, but funds for the purchase of pumps, generator and pipes has stalled the completion work on the irrigation project.
g) The Kiri dam was completed in 1982 and constructed downstream the DadinKowa dam on the Gongola River at Kiri in Shelleng LGA of Adamawa Sate to supply Irrigation water for the Savannah Sugar plantation at Numan.

55. **The Lagdo dam** The Bénué River is partly regulated in Cameroon by the multi-purpose Lagdo dam built in 1982 (for generating hydropower and irrigation water supply) south of the Cameroonian city of Garoua. The dam has a hydropower generation capacity of 700 MW, installed capacity of 84 MW but only one turbine generating 21 MW is in use. Apart from supplying electricity to the northern part of the country and allowing irrigation of 15,000 hectares of crops downstream, the dam is the only significant flood control structure in the River Benue basin. In 2012, water released from the dam flooded several communities downstream in Nigeria.

56. **The Tede dam**, in Nasarawa State was conceived in 1976, with a potential of generating 1,500 megawatts of electricity. Awarded by the Nigerian FEC (Federal Executive Council) in March 2011, to Coyne et Bellier – the Hydro division of Tractebel Engineering (France), the contract for the design and works supervision of the Mambilla HPP (2600 MW) is a first step towards realizing a scheme that will more than double Nigeria's current installed hydro capacity in one go. Taking advantage of the unique topographical and hydrological characteristics of the site in a very remote part of the country on the Mambilla plateau where the Donga River flows from its source. The dam is to use the full potential drop of +/-1000 m of the Donga River from the Mambilla plateau to generate the 2600MW hydroelectricity target.

57. The key element of the design includes: A main, large rolled compact concrete (RCC) dam and reservoir (storing water and thus regulating river flow) at 1300 m above sea level – Gembu Dam. Water is also diverted off the reservoir towards the western side of the plateau through 3 hydraulic tunnels totalling 33 km intercepted by 2 smaller RCC dams, both at an elevation of 1250

m – Sum Sum Dam and Nghu Dam. Beyond these dams, the tunnels lead into a 1000 m drop shaft tunnel led down through the rock to a massive underground powerhouse. Via a short tunnel, the water then exits the base of the plateau and flows into a tributary river that rejoins the Donga River downstream of the plateau.

**Task 3: Evaluating demand projection for the Benue Basin by sub-sectors**

This shall be carried out according to the order of priority as Municipal and Rural domestic water supply, Irrigation, Hydropower generation, Flood and Drought Control, Inland Navigation and River training, Aquaculture and livestock taking into consideration for socio-environmental needs of downstream river water.

58. **Water Supply and Sanitation**: Water supply and sanitation sector is one of the nation's highest priority for 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 the three-pronged strategies. It is however worthy to note that the government has secured a good number of interventions in this area.

59. In checking the efficiency of the existing systems, their operability and correctness in design, and any room for expansion or projection for a new system for development, the Study should base the population projection (including farm animals) and industrial supply increase to the period of 25 to 30 years (say 2050) using the design rate of growth. The study shall cover water supply and sanitation systems for Rural area (population < 5000), Semi-Urban (population 5000 to 20,000) and Urban area (population>20,000), and the daily per capita water requirement recommended by MP2013 are Urban areas 120 l/cap/day, semi-urban 60 l/cap/day, and rural 30 l/cap/day. These norms are to be rectified along with the assurance level for the supply schemes and adjusted if necessary. Discussion and recommendations for responsible agency implementing the scheme(s) should also be mentioned. The suitable operating systems for the development are also expected to be included in the study. Like when and where applicable, the water supply and sanitation system can be integrated/combined with other sub-sector development schemes in an integrated manner for developing multipurpose projects.

60. **Irrigation and Drainage Development**: The operation and management of public irrigation schemes are mainly in the charge of RBDAs and states. A part of farmer groups in some schemes have been supporting the maintenance of irrigation facilities. However, many of the Irrigation and Drainage facilities owned and operated by the public agencies need rehabilitation and repairs, that have not been carried out for decades mainly because of insufficient funding amongst several other challenges. Knowing that shortcoming, the FGN has commenced the process of gradual management transfer for O&M of tertiary canal networks of the large public irrigation systems to the beneficiary farmer groups (through TRIMING Project intervention). The irrigation infrastructure is dilapidated in most public schemes with many pumps in need of repair/replacement, conveyance structures damaged or deteriorated, weed-infested and silted up, etc.

61. The causes of deterioration as per findings of MP2013 are due to:

a) **Management capacity of RBDAs**, with 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.
b) **Irrigation Infrastructure,** gravity systems are comparatively better because of low operation and maintenance cost and little trouble compared to equipment heavy public irrigation schemes that regularly suffers from deterioration, breakdown, repair/replacement of pumps, and high cost of fuel. Also, the farmers are not been able to adapt to the sprinkler system easily. The conveyance structures are damaged or deteriorated, weed-infested, and silted up.
c) **Inadequate water delivery:** Water delivery to the secondary canal from the 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. Measuring gauges to determine water depth for measurements are missing or unreadable where they exist. Thus, there are no records of actual flow into the canal systems. Also, the farmers are not easily able to adapt to the sprinkler system.
d) **Water Users Associations (WUAs)**: The Water Users Associations (WUAs) rarely exist in most of the schemes, and where they do exist, are neither effective nor active. The farmers believe that the insufficient water charge paid should cover the maintenance, thus farmer's motivation to participate or collaborate is low in the maintenance work on the scheme.
e) **Cost-Recovery**: The water charge paid in most of the public irrigation schemes is generally too low to cover full maintenance expenses while inadequate service delivery leads to lack of users' willingness to pay.
f) **Equipment**: The equipment in use at the schemes are in two main categories namely: water delivery equipment as well as agricultural support equipment and machinery. The water delivery equipment mainly (in lift irrigation) comprises pumps of various capacities used for water abstraction. Most of the pumps were purchased during the 1980s, and their spare parts are now no longer available. Most of the agricultural equipment and machinery such as tractors, combined harvesters, and rice mills are either non- existent or poorly maintained. Maintenance personnel working on schemes are either non-existent or inadequate. Workshop at all RBDAs are run down, poorly equipped and under staffed. Spare parts are rarely stocked, and records not kept.

62. The future Irrigation and Drainage development should be planned in conformity with the Government's Irrigation and Drainage Policy supporting the SDGs', to the regional feature such as climate, hydrology, terrain, and habitant, economic efficiency, and the situation in the existing public irrigation scheme. The Development Policy as defined step by step in MP2013, which are to be rectified by this study are as follows:

a) to complete the ongoing public irrigation scheme early;
b) to implement rehabilitation and expansion on public irrigation schemes which FMWR identifies as a high priority;
c) to develop new water resource for high priority public irrigation schemes;

d) to utilize existing dams for public irrigation schemes and expand its system developed area;
e) to develop new proposed irrigated farmland; and
f) to formulate an effective structure for operation and maintenance following PIM principle to run schemes.
g) to evaluate based on surface water

63. The Consultants are required to update the data mentioned under MP2013 (according to the categorical status of the Irrigation Schemes for the region), as at the time the MP2013 was prepared, and in recent past. Based on these updates, the consultants are required to assess the potentiality of water requirement and use for irrigation schemes in the Benue River Basin. ***According to the MP2013, out of 301 potential- schemes for the whole country, 177 public schemes are either completed or canceled. The remaining 124 schemes are at various stages of the project cycle, namely; On-going Schemes, Extension Schemes, New Schemes, Supplementary Schemes, Dam Storage Schemes, and Integrated Development schemes.*** In updating such schemes in Benue River Basin (HA 3-4) attention is required for water budgeting (or) water allocation to cater for water demand for the completed and ongoing schemes, schemes under implementation - planned and potential, the ongoing feasibility and detailed design of Guyuk Irrigation scheme (GIS) of about 32,000ha (e.g. ongoing Dadin Kowa under TRIMING) and future potential schemes coming into development. In doing that, it is necessary to account for all methods of diversion use of water (direct, retention, storage – seasonal & long term, pumping, groundwater, conjunctive of GW and SW, etc.).

64. The two water uses so far discussed "Water Supply" and "Irrigation" is the conjunctive nature of water use that, once water is diverted to the targeted area, there will be no return to the river basin. In that case, attention must be called for leaving "managed water amount or so-called socio-environmental amount of required water" for downstream use. This is an important aspect of non-conflicting upstream and downstream water use. The Guyuk feasibility and design for irrigation development and management consultancy reports was recently reviewed by stakeholders and its hoped the final design report would be available soon and given to the Consultancy for review and noting.

65. In calculating the Crop Water Requirement, for the current water balance study in the Benue River Basin, the recommended pattern of MP2013 can be used in general, unless, there are modified crop patterns introduced for the Benue Basin in the post-MP-2013 period. Assurance for irrigation as 80% reliability can be used as in MP 2013. Wherever there is a possibility for conceptualizing integrated use of water resources, the consultants are required to adopt the National Water Policy as mentioned earlier. Many of the irrigation schemes in the world are completed without paying attention to the "drainage" part and therefore, the study consultants are requested to pay attention to that part in their recommendations using the basin rainfall pattern and suitable drainage hydro modulus in them. The pre-feasibility level costing under Task 5 shall include drainage part together in the analysis. Just for information, the planned potential irrigation area including already existing areas under the Benue River Basin by MP 2013 came to about 192,000 ha.

66. **Other Sub-Sectors (Hydropower Generation):** Most of the other sub-sector of Water Resources Development falls under "non-consumptive use". Therefore, in terms of water use they are not taking out physically the amount of water from the river basin under consideration, but there can be some temporal changes due to the manipulation of resources for their use. Among them, Hydropower development is an important subsector for national income generation and domestic uses. The MP2013 envisaged that constructing a large-scale hydroelectric station results to major environmental and social impacts, in addition to lack of suitable dam sites with large enough capacities. Hence, 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 this regard, the large-scale hydroelectric dam development projects are being planned and managed by Nigeria's Federal Ministry of Power (FMP), FMWR as the administrator of the river environment needs to provide FMP appropriate guidance continuingly guiding them to check the existence of low-flow sections and, if necessary, discharge water to secure the predetermined minimum flow level in downstream reaches.

67. According to the MP2013 report, the estimated hydroelectric potential of each dam site based on the flow regime and dam height for each site that was identified and examined for hydroelectric stations gave the approximate results of total annual energy output for the country as 1,188,217 MWhr. The Benue River Basin total output estimated was 607,331 MWhr, while Upper Benue Basin has the highest output energy among all 8 HAs with an annual value of 537,402 MWhr. As mentioned earlier the storage type hydropower station may need to have a well-regulated flow regime as well as an attractive return for the high investment that MP2013 views were to make use of more run-off-the-river diversion hydropower stations. In some cases where there is a sizable main irrigation canal and or Barrages/weirs, canal hydropower stations are also worth considering.

68. Making use of the water balance study under the Irrigation Development, the study consultant is requested to evaluate the potential integrated use of the hydropower generation under the irrigation and water supply projects. However, there are few cases in the Benue river basin (like Dadin-Kowa, Kiri, etc.) irrigation development project which already have provisions for the development of hydropower (though hydropower equipment is not yet installed) are to be included as the potential for the Hydropower generation in an integrated fashion. Whether stand-alone storage hydropower stations are to be considered or not especially if there are suitable sites has to be discussed with FMWR at the realization of this consultancy contract.

69. **Other Sub-sector (Flood and Erosion Control).** The flow regime of most of the Nigerian rivers is quite seasonal because of the semi-arid or sub-tropical climate and their watershed sizes. Major rivers in Nigeria flow through wide floodplain in a flat valley usually confined by hard terraces, like in the lower Niger and Benue, where traditional floodplain irrigation was popular for agriculture. Also, in Nigeria, there remained such traditional floodplain irrigation called Fadama along the Niger and Benue Rivers and their tributaries. This made irrigation on floodplain comparatively easy, making use of direct abstraction from the rivers thereby minimizing the use of irrigation structures, so that large scale mechanical irrigation system was not so developed until recently. In that way, the flood protection and erosion control work along the river terrace becomes

important in the water resources development works in Nigeria. Where there are good sites, the direct diversion or low lift pumping irrigated agriculture are also common. These bank development sites need to be protected from the river floods up to frequent events like once in 20 years.

70. 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 an urban area. Figure 3 below 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. Though there is no prominent flood disaster in the Benue basin some of the reported flood disaster events by media are in the Sokoto State flood of September 2010, Ibadan flood in August 2011, and Lagos flood in July 2011. Benue capital for 3 days maximum rainfall of ten-year return period may be at a medium value of the country around 125 mm, nevertheless, there can be some localized depressions and at the entrance of the flood plain (when the torrential streams exit from the mountainous sites can have overland flooding).

71. In 2012 from July to October, Nigeria experienced historical flood along the Benue and the Niger rivers, causing lots of destruction killing 363 people, and displacing 2.2 million people and many lands and properties. According to NIMET that was 80 years RT flood. Regarding these events, MP2013 has recommended sets of flood data observations along Niger and Benue Rivers, Modeling of Flooding along these major rivers using that data, modeling of inundation along these rivers, and setting up of early warning systems (EWS) for potential flooding since MP2013. Those models if they are in use by FMWR can be referred to. The consultants are required to update the flooding situations with such data in Benue River Basin sites where large habituated cities and towns and permanent infrastructure and cultivations are located. A reasonable amount of protection works is to be suggested with their cost. The requirement for reservoir control operation may also be considered for events caused by excessive overflow from a dam or reservoir to result in flooding in the downstream reach.

72. According to the MP2013 report, the estimated hydroelectric potential of each dam site based on the flow regime and dam height for each site that was identified and examined for hydroelectric stations gave the approximate results of total annual energy output for the country as 1,188,217 MWhr. The Benue River Basin total output estimated was 607,331 MWhr, while Upper Benue Basin has the highest output energy among all 8 HAs with an annual value of 537,402 MWhr. As mentioned earlier the storage type hydropower station may need to have a well-regulated flow regime as well as an attractive return for the high investment that MP2013 views were to make use of more run-off-the-river diversion hydropower stations. In some cases where there is a sizable main irrigation canal and or Barrages/weirs, canal hydropower stations are also worth considering.

73. Making use of the water balance study under the Irrigation Development, the study consultant is requested to evaluate the potential integrated use of the hydropower generation under

the irrigation and water supply projects. However, there are few cases in the Benue river basin (like Dadin-Kowa, Kiri, etc.) irrigation development project which already have provisions for the development of hydropower (though hydropower equipment is not yet installed) are to be included as the potential for the Hydropower generation in an integrated fashion. Whether stand-alone storage hydropower stations are to be considered or not especially if there are suitable sites has to be discussed with FMWR at the realization of this consultancy contract

74. **Other Sub-sector (Navigation and River Training).** The Federal Government of Nigeria prepared the Draft National Transport Policy in August 2010. This policy states that the Nigerian Transport System from the perspective of the pre- and post-colonial period marked the origin of the modern transport system. The networks of rail, water, and road developed then were geared essentially to meet the export of cash crops, such as groundnuts, cocoa, cotton, and palm products, and to the import of cheap, mass-produced public consumption goods. Goods and passenger movements in Nigeria are performed mainly by road, with the railways and inland waterways playing insignificant and less important roles as Nigeria produces oil. The international freight movement is principally by the sea while air transportation is the main passenger carrier. MP 2013 has highlighted that 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 comparatively 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 in the future.

75. The Nigerian inland waterways are a major natural resource, traversing 20 out of its 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 (Benue State), and Lafia areas (Nasarawa State) can be transported to Onitsha (Anambra State) and Port Harcourt (Rivers State) through the waterways. The National Inland Waterways Authority (NIWA) was established by Decree in 1997. The Decree vests in NIWA the power of exclusive management, direction, and control on the Nigerian inland waterways. The inland waterways of Nigeria comprise the main river system (Rivers Niger and Benue which form a confluence at Lokoja, see HA 4 map), creeks, lagoons, lakes, and intra-coastal waters. They are declared by the 1997 decree as Federal navigable waterways. The right of land usage for improvement of navigability and provision of infrastructure shall cover areas on both banks of the waterways which would submerge in a flood of 100 years return period. According to WB's 2005 document, the overall navigable network of Nigeria 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 river network. The Benue River is navigable to Makurdi from June to December, and Garoua in Cameroon from August to November.

76. The consultants under the study are to explore the possibility of a positive or negative impact on the riverine transport of the Benue River in the future after the development of all Benue River Basin development works are implemented. Large scale dredging projects are also being implemented in the lower part of Niger River delta after its confluence with Benue River. FMWR owns and manages dams upstream which may affect flow regimes along navigable river sections in the country. Furthermore, FMWR must provide necessary information for disaster management

in cities along rivers as well as for the management of large-scale irrigation areas in the floodplain which is under the jurisdiction of NIWA. A high capacity computer simulation model can be schematized with possible impact prediction under the joint operation of all capacious reservoirs along the Niger and Benue Rivers in the future.

77. **Improve river training in the Benue basin.** River training, in its broad aspects, covers all engineering works constructed on a river to guide and confine the flow to the river channel, and to control and regulate the river bed configuration for effective and safe movement of floods and river sediments. In essence, river training envisages training and stabilising a river within a suitable waterway and along a certain alignment for a variety of purposes. To prepare for the basin involved:

a) River training assessment Report along with detailed designs and bid documents for main infrastructure works and equipment repairs and/or rehabilitation to be implemented under the Project beside that which is being handle under River navigation by NIWA.
b) Equipment specifications and implementation procedures for river training to be carried out in the sub-basin; and
c) Detailed plan for institutional arrangements needed to improve O&M and staff required. To include the setting up the organization for operation and maintenance of the infrastructures, as well as training of the staff.

78. **Integrated Water Resources Management Project (IWRM) Identified earlier in the Benue Basin.** In identifying the possible IWRM nature of projects that include information and potential for development in all the above-mentioned sub-sectors of water resources development, the FGN has identified the dam storage in Table 3 (below) under the Benue Basin area. These have been identified as the priority projects as per MP (2013) and need to reassess and recalibrated their potential and magnitude in the context of their impact on basin development.

79. The options proposed by the JICA MP 2013 study for Integrated Surface Water Development in the Benue Valley is shown in the Table 2 below. These projects have the potential to substantially increase rural production, incomes, and employment opportunities, by changing the approach by which public irrigation schemes operate. The actual extent and locations for these interventions should be reviewed and verified during this task along with the others. In addition to these the consultants attentions are called for the existence of one of the TRIMING sub-projects, Dadin-Kowa Irrigation Project, which is now being implemented as a quick-yielding project size of 2000 ha only, but the corresponding study of the project showed that it could have a potential of much more than that if the existing large storage reservoir of Dadin Kowa dam is fully operationalized. The review should include Dadin Kowa and Guyuk irrigation potential studies in comparison with others.

**Table 3: MP 2013 identified priority projects in Benue River Basin**

| S/N | Hydrology Area | Proposed Project | State | Potential Irrigation/HP Scheme | Dam Name | Storage MCM | Height (m) |
|---|---|---|---|---|---|---|---|
| 1 | HA-4 | Nasarawa Integrated | Nasarawa | 19,000ha/ 4MW | Ragwa | 30 | 24 |
| 2 | HA-3 | Taraba Integrated | Taraba | 45,000ha/ 7MW | Bandue | 240 | 37 |
| 3 | HA-3 | Taraba Integrated | Taraba | | Kogin | 290 | 39 |
| 4 | HA-3 | Donga-Suntai Integrated | Taraba | 35,000ha/ 9MW | Kwossa | 400 | 78 |
| 5 | HA -3 | Dadin Kowa | Gombe | 34,000ha/40 MW | Dadin Kowa | 2800 | 42 |

80. Close attention should be given to Improved instrumentation and upgrading of hydrological stations, with respect to high flows for flooding analysis and to low flows in relation to water balance analysis. A diagnostic of the hydrometric network (hydrology needs assessment report) along with detailed designs and bid documents for remedial works and equipment: water level observation equipment and practices should be adjusted and discharge measurement frequencies be increased, sediment and water quality monitoring resumed; Data collection, validation, processing, storage and dissemination practices should be strongly improved and be brought up to the required level, using a fully updated hydrological data management and storage system; Staffing is to be reviewed to match with the required measurement frequencies and processing activities and technical skills to be improved through an extensive training operation including an extensive data validation and processing component for meteorological, surface water hydrology and groundwater hydrological quantity and quality data.

81. Groundwater availability through groundwater monitoring wells and tube wells should also be included for a sustainable water resources management. Equipment specifications and implementation procedures for hydrometry in the basin; to be in conformity with those in use under TRIMING I Project. Detailed plan for institutional arrangements needed, improve O&M and staff required, development and validation of a hydro-meteorological database. To include the setting up the organization for extensive data validation and processing component for meteorological, surface water hydrology and groundwater hydrological quantity and quality data, as well as operation and maintenance and training of the staff.

82. **Operationalization of an Integrated Water Resources Management (IWRM) plan of the basin.** The JICA MP2013 recommend the development of Catchment Management Plans (CMP) for all the 8 hydrological areas in Nigeria. The need for this arises from the fact that various institutions and organizations within the basin do not have concrete IWRM action plans hence,

many environmental issues. Unfortunately, not only are the institutions and organizations involved are often uncoordinated, the development plans by them have not been integrated into a single and more comprehensive action plan. Draft CMP should be prepared for the Basin .In addition, new developments within the basin clearly demonstrate the need to update some of these action plans to take account of progress made and to ensure integrated water resource management (IWRM) and the conservation and sustainable use of natural resources within the economic and social development frameworks of the basin.

83. The IWRM plan of the basin shall be updated with the overall purpose of addressing major problems at a river basin level related to: water resource availability, water quality and environmental/ecosystem sustainability. Due account shall be taken to water use, and the social and economic implications of implementing an IWRM plan. Actions to be taken as a consequence of planning shall be prepared based on scenarios describing different approaches for solving major management problems (that might be described with natural resources, socio-cultural, economic and regulatory, administrative and institutional indicators) within a medium-term of 20 years, and a long-term period of 50 years incorporating possible effects of climate change.

84. As such the prime outcome to be provided is an action plan with a prioritized and ranked sets of programmes/actions, which from a political, legal, technical, sociological and economic point of view are considered as the most sustainable and efficient solutions. Political (democratic) aspects of IWRM planning in this regard require, that plans shall be elaborated with a participatory approach. More specifically, the objective of the IWRM plan report is to:

a) contribute to the provision of sufficient supply of good quality surface water and groundwater and evaluate demand as needed for sustainable, balanced and equitable water use;
b) prevent further deterioration and protect the status of aquatic ecosystems with regard to their water needs;
c) protect terrestrial ecosystems directly depending on the aquatic ecosystems;
d) contribute to mitigating the effects of floods and droughts; and
e) provide appropriate water management with efficient and transparent governance in irrigation sector as well as at basin-wide level.

85. **Other Sub-sector (Fisheries and Livestock).** Inland fishery competes with water supply and irrigation sector in terms of consumptive water use. However, it is recommendable to apply fish farming in irrigation dams and reservoirs created for water supply and agricultural purposes. Mandatory fish ladder insertion in the storage and water diversion projects would also help the transmigration of fish from downstream to upstream and vice versa of the water control structures. Consultants are to determine these impacts if any structural intervention in the plan involves some impacts on the existing fishery works in the rivers. Obligatory downstream minimum release after impounding must be worked out and recommended in the operation rules. Farmland fish breeding in the case of long-term bondage paddy cultivation can also be encouraged to farmers as for their subsidiary incomes and consumption.

86. The national policies do not include specifically water resources development and management for promoting the livestock industry. In practice, however, animal water at lakes,

ponds, rivers, reservoirs, canals, etc. is indispensable for livestock maintenance including water spots for seasonal transhuman activities. Also, commercial livestock sub-sector (diary and meat processing) may need means of water supply exclusively provided for livestock. The consultants are requested to consider for such consumption in case regional plans associated with such plans exist. Finally, an important aspect is the fodder crop area provision irrigation cropping pattern and provision of fodder land for the livestock in every water resource development project. In Nigeria, like other Africa countries, there are always land disputes and water rights between the herdsmen and farmers and some fishers and farmers.

**Task 4: Balancing the Demand and Supply Scenarios and Prioritization Schemes**

87. In this task, the consultants of the study are to balance the available surface and Groundwater in Benue River Basin (HA 3 and HA 4) according to the current and future water use of the completed, on-going and yet to be completed; and planned schemes to be accommodated in the next 20 years (if necessary) depending upon the latest requirements. Balancing the available resources in terms of demand should be done in the context of physical, financial, and socio-economic analysis. The context of physical analysis may include the size of the project, completion of the project (on-going or underutilized storage schemes), number of beneficiaries, single or multipurpose, area coverage by the project, etc. The financial analysis includes, sunk costs (idle infrastructure investment) and costs in new investment, affordability by the local, state, and federal governments, the financial returns by the project, nature of the project in terms of local sufficiency, or tradable goods, etc. The Socio-economic analysis of the project include social benefits (health, environment, area development), economic rate of return by the project, etc. The Consulting team will formulate or propose the prioritization criteria for the selection of schemes in the Benue River Basin for implementation in the next 10 years (2020-2030) and in the next 20 years (2030-2040) time horizon. The prioritization criteria, in general, preferably be multi-criteria nature covering the broad spectrum of physical, financial, and socio-economic aspects.

88. In prioritization of the selected schemes, the development and management aspects of the projects need to be considered. At the time of MP2013, the main findings were that the country is short of skilled professionals in water resources management, particularly for integrated water resources development and management. As development cannot wait for full completion of human resources development, the proposed plan of development should include capacity analysis of local institutions developing the schemes, and the associated requirement of further training areas for the development. The small and medium single purpose schemes may be carried out by the local professionals for the whole project cycle, while the large-scale development may need inputs from outside assistance from design to implementation. This should be considered in the selection of schemes and projects in terms of the implementation period and capacity availability.

89. The consultants are required to make use of the institutional gap analysis and recommendations under MP2013. Of the various institutions responsible for Human Resources Development (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 engaged in integrated water resources management shall be developed and increased. While NWRI is

important for HRD at the national level, it was noted that the needs to strengthen training to inspire the management at river basin level, HRD for NIWRMC including its subsidiary Catchment Management Organizations (CMO) and their staff who shall be responsible for the water resources management at river basins as one of the most important and prioritized HRD.

90. The schemes selected and implemented are also to be monitored and evaluated throughout their project cycles by the National Planning Commission NPC using their scorecards, performance indicators to check to achieve the development objectives and goals or not. The M&E body under the NPC needs to be strengthened. That will cover the efficiency, effectiveness and suitability of the schemes under implementation. Attention must be paid to achieve the FMWR set targets for SDGs in selecting the schemes at least for the Benue Basin Area.

91. The costs of the schemes identified in the study in the Benue Basin Hydrological Area have been estimated at a different period. Attention should be called for when these are compared in selection for further improvement or expansion in the next 10 to 20 years as priority schemes. The updating of the scheme costs (completed, under rehabilitation, under expansion, or new) should be based on the same datum at the 2019-2020 cost level. In the case of old completed schemes where it is hard to trace back the quantity for structures, the sunk costs can be ignored or compared with similar structure costs taken up recently.

92. To be a comparable format of the MP2013 project scheme costs with the new intake schemes, the same norms of MP2013 are to be used as in the Table 4 below. No price contingency is considered.

**Table 4: Norm for Cost Estimate**

| Cost Items | Contents and Conditions |
|---|---|
| (1) Construction | Labor, materials, machinery, etc. |
| (2) Equipment | Procurement of equipment not included in above construction costs: i.e., hydropower electro-mechanical equipment 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) |

**Task 5: Formulating the Benue River Basin Water Resources Management Plan**

93. The outcome of the priority lists drawn under Task 4 will lead to the finalized list of priority project schemes in the Benue River Basin for the next 20 years. The consultant will prepare a pre-feasibility level project implementation schedule and their associated costs (at 2019-2020 level). A pre-feasibility level project Benefit Costs analysis for the proposed schemes' investment can be carried out for (a) Financial analysis (b) Economic Analysis (c) suggested implementation

schedule including investment phasing including the sensitivity analysis, and (d) Evaluation of Social and Environmental impact on the selected project.

**Task 6. Feasibility Study of the Chosen TRIMING II Project**

94. The identified group of selected schemes would be further processed into a detailed level feasibility study. Under this task, the corresponding prefeasibility level schemes of the chosen project group will be upgraded to the feasibility level in terms of technical details as well as corresponding costs. For that the consultants may be required to collect additional data in topography, geology, soil and agriculture of the specific schemes. The requirement of the details is such that the resulting feasibility dimensions of the project elements must be within the allowable limit of 12-15% physical and price contingencies. In doing that it is required to bear in mind that after the feasibility study, the feasibility level design would need to be transformed into a final design and tender document for the first 18 months implementation period of works.

95. **Reservoir Simulation:** It is very possible that the chosen scheme will be reservoir fed scheme as the Benue Basin, as per MP 1995 and 2013, statements, has about 29 storage dams. If the chosen project is of a multipurpose nature project fed from an existing reservoir, the final water balance study for finalization of the project size must be based on long-term reservoir simulation including extension of the hydrologic series of inflow- outflow data into long-term using an acceptable known method for data extension or generation, including the sensitivity for climate change aspects on the inflow regime of normal, flood and drought flows. The simulation must be carried out on a monthly basis or if not fort-nightly basis to synchronize with the irrigation water intervals. If it is for multipurpose use, the water supply would be given a top priority, followed by irrigation requirements and the hydropower generation (HP) which should be incidental. Inclusion of Hydropower (HP) generation in the project is desirable from the stand point of multipurpose usage of Water Resources, but optional and the consultants are requested to get the guidance from the PMU and FMWR. The general guidance from the FGN and Technical Committee should be sought for inclusion of multipurpose uses whether the HP developed would be for standalone station or supply to the nearest grid. The water supply component, if any, should be projected for at least 25-30 years' timeline.

96. Notwithstanding of limited time available, the consultants are expected to evaluate available data and verify those data by carrying out their own surveys, as relates to geomechanics and foundation for structures to ensure data reliability. The cropping pattern used for the Feasibility Study (FS) must be reasonably suitable for the country's need in general and the Benue Basin in particular. Irrigation area survey map scale must be detailed enough to cover 1:25,000 H and 1.0-meter V for the general area rectified for the estimate by using 10% of the area with a more precise sample area map scale of 1:5000 H and 0.33-meter V. It can be generated by means of interpolation from available aerial survey map or from satellite imagery or Lidar Survey.

97. The feasibility level design should cover up to tertiary canals layout if it is a new irrigation project or modified according to the requirement for rehabilitation portion. For the bill of quantity (BoQ) of work volume, the 10% sample area must be used down to field channel layout and the

volume of work thus determined from the sample area design can be extrapolated for the whole project. The BoQ must be complete up to Tertiary Canal network. The sample area map can also be used for recommendations regarding number of Water User Group/Association formation. The same principle of details may also be required for town/community water supply component (if any) supply network layout. If Hydropower (HP) is considered and is included, the Feasibility Study (FS) design must be complete with required size and number of recommended turbine/generators with a complete study information on firm and secondary power installation and respective energy production.

98. ***Dam Safety and Operation Rules:*** If the project water is derived from existing storage dam(s), the conventional dam safety study must be carried out for its, physical, hydrological, and hydraulic safety of the dam(s) and its appurtenances, as well as test for hazardous level for the downstream habitants by making use of PFMA (Potential Failure Mode Analysis) and Dam Break analysis. The downstream flood protection measure requirement must be gauged with nominal safety against 20-25 return period floods with any additional structural intervention as flood protection work by manipulation and modification of reservoir operation rules. If not, the flood component must be included in the project. Appropriate measures for the dam safety component must be built in the project feasibility study and the corresponding cost estimate. For information, there is a parallel study of the "**Dam Safety and Operation Efficiency Project**" carried out by another consulting team, and the cross reference is required for the consultants to make use of the outcome of other study usable for the Benue Basin dams. Review and modification of existing reservoir operation rules are also suggested as a requirement of the FS from the safety aspects of downstream inhabitants and the dam.

99. **Dam safety as well as revision of operational procedures.** A Dam Safety Assessment Report fulfilling the requirements of the WB's OP 4.37 along with a detailed assessment the safety conditions of the Basins dams not covered under recent similar consultancies, operational reservoir including their hydrological, geotechnical and structural aspects. Hydrological assessment should include inflow flood frequency and PMF analyses as well as possible embankment overtopping risks. The Report should also undertake a Potential Failure Mode Analysis (PFMA), assessing safety risks (with grades) and hazards (consequences by potential failure) as well as mitigation measures. The Consultant shall organize a workshop to discuss PFMA for the identified high-risk dams in the basin. The objective of the workshop is to identify and assess potential failure modes and to ascertain opportunities for risk reduction, further investigations or analyses, and means for monitoring and inspecting of potential failure modes development. Other consideration include;

a) Preparation of designs and bid documents for remedial works and repairs, rehabilitation, or replacement of equipment, including safety monitoring instruments, gates and valves, etc, to be implemented under the Project;
b) Instrumentation Plan, which would specify required instruments to monitor and record dam embankment behaviour and the related hydro-meteorological, structural and seismic factors, based on the review of current conditions of existing instruments and monitoring requirements.
c) Upgraded Operation and Maintenance (O&M) P*lan*, which will cover organizational structure, staffing, technical expertise, training required; equipment and facilities

needed to operate and maintain the dam; O&M procedures; and arrangements for funding O&M, including long-term maintenance and safety inspections. A full-fledged O&M Plan for each dam is to be prepared under NIWRMP. The O&M procedure should stipulate outlet gate opening, timing/degree in connection with incoming flood volume (m3/s) and reservoir level & rising speed, as well as backup operation procedure and power sources.

d) Tentative Emergency Preparedness Plan that will specify the responsibility for dam operations decision making and for the related emergency communications, maps outlining flooding levels for various emergency conditions, flood warning system characteristics, and procedures for evacuating threatened areas and mobilizing emergency forces and equipment. A separate dam break analysis should be conducted to prepare maps for indicating downstream flooding areas for the high-risk dams.

100. **Irrigation and Drainage Development.** Refer to Table 3 above. The consultant should thoroughly carry out the FS and DS including BoQ and BDs for the Irrigation Potential for the existing Dams in the Basin.

101. **Environmental and Social Aspects*:*** A feasibility level Environmental and Social studies are to be prepared. The project estimate should include Resettlement Action Plan and associated costs for the first-year implementation program.

102. ***Feasibility Study (FS) Cost Estimates:*** The cost estimate used for the project will be of **unit rate-based estimate** for all quantifiable items. The unit rates are to be derived from existing labor and material costs of the locally available as well as for imported items. Thus, FS level cost estimate should be broken down into Local Currency Component, Foreign Exchange component, and Total cost component by project components as well as project category (works, services, Goods, and Training, O&M and Admin) breakdown. The prevailing cost level should be valid for the mid-point level of the study period. A reasonable percentage for physical contingency can be suggested (see table 3 above) depending on the confident level of estimation. A base cost should be shown separately, and then physical and price contingency added to arrive at total project costs. The yearly breakdown of T.C, LC, and FEC are to be shown in the cost scheduling. The implementation period of the TRIMING II should be around 6 years.

103. ***A detailed Benefit Cost Analysis*** (BCA) considering all tangible and intangible (social benefits and disbenefits) and their associated cost of mitigation along with the construction costs are required. The benefits and costs estimation must be separable for each component of the water use (Domestic water supply, irrigation, hydropower, flood control etc.) and the component wise BCA as well as a whole project should be carried out. The common costs for the rehabilitation of dam and its appurtenant structures must be prorated to the water use amount by each sub-sector. The BCA is to be carried out for at least three discounting factors (6%, 10% and 12%). The conventional Internal Rate of Returns (IRR) for both Economic and Financial are also to be determined. A sensitivity analysis for possible cost escalation and benefit reduction are to be carried out including the determination of break-even point and project investment recovery period.

104. **Agriculture & Agriculture development**. The major crop production constraints in the Guyuk area lack of affordable and timely agricultural input supply, lack of credit schemes, unavailability or scarcity of irrigation water, lack of technical supportive services, weak institutional arrangement and coordination for agricultural services delivery, insecure land property rights, low level of farm mechanization, climate variability and rainfall availability, high level of crop pest infestation associated with low level of agronomic practices, and others. These interlinked constraints result in low level of productivity and production in the area. The current level of production and productivity is by far less than half of the potential productivity for major crops due to the above interdependent production constraints. To say the least, this zone is relatively unexploited to a large extent for agricultural purposes. The main crops grown by mixed cropping by the local farmers are sorghum, millet, maize, cowpea, yam, cassava, soybean and rice. In the Benue valley, soybean cultivation has been an outstanding crop introduced in the colonial days. On the floodplains, swamp rice is the major crop. Small irrigation schemes managed by Lower Benue River Basin Development Authority are in the zone, they are the Ejule Irrigation Project, Katsina-Ala Irrigation Project and Makurdi Irrigation Project. The crops are rice and vegetables. Pastoral herders (nomadic grazers) use several parts of the zone as watering points for their cattle, sheep and goats in the dry season. The numbers of livestock that move into the valleys every year are quite substantial. Locally, however, farmers keep goats, sheep, pigs and poultry usually on a small scale per farm family.

105. **Agro-climate.** The zone falls within a dry sub-humid area having 508-1016mm mean annual rainfall, a long dry season of not less than 6 months and mean annual temperature of about 27 .8C (data for Yola). The rainy season starts effectively in April and extends to October; however, the humid months when rainfall is adequate to recharge soil moisture are June to September (4 months). The average annual evapotranspiration is about 1500mm. The mean relative humidity varies from about 17 in February (dry season) to 77 in August, when the peak of the rains occurs. Soil leaching occurs significantly from June to September. The growing season is the months of June to September (4 months) in most years as the current aggregate data of rainfall for Gombe State (NAERLS/PCU, 2004) suggest that rainfall in May is unreliable in present times.

106. **Soils.** The soils of the zone are varied and are greatly influenced by parent material and topography. Based on soils, the major ARAs in the zone are as follows:

a) Soils on Dukku Plain and Hills Soils on undulating plain with deeply incised valleys bounded by an escarpment and with very low subdivided reworked dunes with north to north-west orientation on Kerri Kerri Sandstone (northern sector)
b) Soils on Deji Plain and Hills Soils on undulating to rolling plain with deeply incised valleys bounded by steep escarpment on Kerri Kerri Sandstone
c) Soils on Bima Plains Soils occupying undulating to rolling plains with weakly incised valleys
d) Soils on Gombe Plains Soils on gently sloping plains leading from the Kerri Kerri Plain to the Gongola Valley.

e) Soils on Clay Plains - Soils on flat to undulating plains developed on a complex pattern of sandstone, shales and mudstones with some limestones
f) Soils on Depositional Landforms - Mainly floodplain soils of rivers such as Gongola and Benue.

# V. STAGE II – PROJECT PRIORITIZATION AND DETAILED DESIGNS FOR TRIMING II PROJECT

## Task I: Selection of TRIMING II Projects

107. Upon satisfactory completion of the study under Stage I, a set of development (single/multi-purpose) projects would become available in the form of Specific Master/Development Plan for Benue Basin and their indicative sets of priority projects/schemes proposed by the consultants. The Stage I culmination study on the Development plan of the Benue basin will be reviewed by the FGN and the assigned technical committees. A stakeholders meeting (FGN and State representatives, TRIMING project staff and RBDA, Consultants) will be held for the final chosen scheme (s) or a sizable scheme to accommodate an implementable size of $600 million project in 7 years. **The Benue Basin Water Resources Management Project** would give high priority to Irrigation schemes only or most probably multi-purpose (Water Supply+ Irrigation and with or without Hydropower) development under PIM and TRIMING guidelines and **may be renamed as TRIMING II**. The chosen project will then be processed in the following tasks for the next stage of Feasibility Study, Final Design, and Tender Documents.

## Task 2: Construction Plan, PIP and Organization

108. The project implementation would be done by ICB/NCB (under the new procurement framework) contract nature for implementation in 7 years period. The Consultants are required to draw a reasonably detailed **construction schedule** and the **project implementation plan** (PIP) describing all pertinent components of the project with their time bound plan broken down to a yearly interval. The required manpower organization for the project management of the client are to be estimated and mentioned in the feasibility study. Based on the gap analysis of the two RBDAs (Upper and Lower Benue River Basins), the consultants are required to propose institutional training program and financial requirement to implement the identified project for construction as well as for operation and maintenance phases.

## Task 3: Final Design, Tender Drawings and Bidding Documents of the Chosen TRIMING II Project**s**

109. Upon formal comments and acceptance of the project Final Study Report (FSR) by the client, the consultants are required to prepare the final design of the project, the corresponding Tender drawings and Bidding Document for the first 18 months period of the project. The final design should include all required details of essential structures of the components of projects, their specifications for construction and elaboration of the tender drawings detailed enough for the

international and local bidding contractors to be able to use for their bids. The bidding document format must be in conformity to the World Bank ICB and NCB tender for Work, Goods and Services. The consultants are requested to prepare a general work plan for the entire project and a related procurement plan envisaged for the first 18 months, to include details by categories, to the extent possible.

110. Without knowing the extent and nature and quantum of works involved in the TRIMING II, it is early to mandate the consultants to prepare a separate TD for the Dam Safety and Flood protection work, Irrigation Work, Water Supply Work, and Hydropower work into separate bidding packages. If the size and complexity of these items of works are manageable under a qualified civil work contractor, the consultants are suggested to put them under the same civil work contract for simplicity in contract management. If not, they are to be separated accordingly and the BDs for the first 18 months are also to be prepared accordingly.

111. As there will be a requirement for few internal administrative matters for making loan proposal to the International Financing Institution (like the World Bank) the FGN may need some time to follow up for getting into Stage III (Project Implementation). But if the flow of works and preparation are reasonably in continuum, the client FMWR may need some technical support intermittently during the project loan formulation phase under stage II.

## VI. STAGE III – IMPLEMENTATION OF TRIMING II PROJECT

112. Subject to the satisfactory outcome of the consultants and the project realization of stage II, this stage is envisaged to usher in the Works Contract Procurement for completed Detailed Studies and full Project Implementation. As mentioned earlier, after the satisfactory completion of the Stage I and Stage II tasks, the Stage III will be implementation arrangement by the client, FMWR.

### Task 1: TA Backstopping Services

113. The consultants will be involved for TA backstopping for clarifications on Project formulation, appraisal and the detailed studies carried out on major Works Procurement. A core team will be on standby to provide technical assistance intermittently to the client. Since the service is of an ad-hoc nature, the consultants are required to provide a lumpsum provision for this Stage III, Task I inputs from their home office. Some of the TA nature of works may involve a desk study analysis, suggestions, guidance and clarifications during the procurement of major works captured under the Bank approved 18 months workplan.

### Task 2: Construction Supervision Services

114. Subject to the satisfactory outcome of the project realization, and satisfactory performance of the Consultants, they may be required to provide services for Construction Supervision during the project Implementation.

115. **Schedule for Completion.** The total duration of the consultancy services will be about 18 months for combined Stage I and II duration from the inception of the consultancy contract. The

breakdown between the Stage I and Stage II is up for the Consultants to decide based on their proposed plan, approach and methodology for the study. Tentatively it can be assumed as 6 months for Stage I- and 12-months for Stage II respectively. Stage III, Task I will be for another 6 months making a total engagement period of 24 months.

116. **Data, Services, and Facilities to be provided by the Client.** The Federal Ministry of Water Resources (FMWR) has set up a Project Management Unit (PMU) led by a Project Coordinator for the TRIMING project who will undertake full-time coordination and support to the study. The concerned client organizations will provide: (a) concerned Master Plans 2013 and 1995 related reports, and the past Benue River Basin reports necessary to understand the existing condition of WR development schemes proposed to be covered for prioritization under the study; (b) all relevant information, including reports of previous studies regarding the Meteorological and Hydrometric networks in the basin; and (c) previous national and regional level water resources development master plans and sector master plans necessary to understand the existing condition in water sector planning capability and achievements so far. The organizations will assign counterpart staff to participate in working groups (sub-sector) for discussion and liaise with the consultants. Office accommodation for the study will also be the responsibility of the consultants. The consultants must bring on their laptops and associated IT equipment and software and the workstation facilities (like computers, printers, fax, telephone, accommodations, etc.). The PMU will;

a) support the consultants in communicating with the concerned Federal and Local authorities and agencies to organize field trips;
b) support the consultants in organizing necessary meetings and workshops;
c) provide the consultants with technical materials prepared during the FS report preparation and other available studies, reports, materials and documents relating to the project;
d) support the consultants in their field trips for gathering necessary data /information for the FS;
e) coordinate with the "Dam Safety and Operation Efficiency Study" consultants

117. All the materials, documents, reports and the TORs of the study to be prepared by the consultants (including draft versions) shall be the Client's assets and the consultants shall ensure that they are not transferred to a third party without the Client's prior approval.

118. **Reporting Schedule and Deliverables.** The general reporting schedule is provided below:

a) ***Inception Report*** will be required within four to six weeks from the date of commencement of the study.
b) ***Monthly Progress Reports*** are to be submitted at the end of every month.
c) ***Outcome Reports*** will be prepared at the end of each Stage.
d) ***Draft Final Report*** should be submitted two weeks before the end of the consultancy.
e) ***Final Report*** is to be submitted incorporating the comments of the consultative group members and assigned reviewers by the Client.

119. Schedule for the Preparation of the Report:

**Table 5: Schedule for preparation of reports**

| *No* | *Reporting* | *Number of copies* | *Time from Date of Commencement* |
|---|---|---|---|
| 1 | Discussions and Inception report (refer task 1) | In English 20 copies, 1 CD, E-copy | End of week 4 |
| 2 | Monthly Progress Report | In English 20 copies, 1 CD, E-copy | Monthly |
| 3 | Draft reviewed and updated report of 2013 MP and associated surface and Gw in the Basin; and CPM study report | In English 20 copies, 1 CD, E-copy | End of 4 months |
| | Draft Feasibility Reports; of water demand projections for various water uses including IWRM Plans (balancing demand and scenarios and Prioritization of identified schemes etc. | In English 20 copies, 1 CD, E-copy | End of 8 months |
| 4 | Final Feasibility Reports of prioritized projects and detailed designs, and related documents such as PIP, various TORs, Implementation Schedule, Training Program/Plan for Institutional Development & Capacity Building, etc.) | In English 30 copies, 1 CD, E-copy | End of 10-14 months |
| 5. | TD drawings and BD for the selected projects proposed under first 18 months of work | In English 30 copies, 1 CD, E-copy | End of 16-18 months |
| 6. | Brief back stopping support for project implementation. | In English 20 copies, 1 CD, E-copy | As and when necessary during 19-24 months |

120. **Output Review.** The leaders of the working/discussion groups and the Project Coordinator will monitor the progress of the consultants. They will also be responsible for coordinating the integration of all individual groups' final inputs into the main final reports of the project at every Stage.

121. The final review committee will comprise the members of the FMWR, PMU members, and appointed professional Specialists and/or from Universities nominated/proposed by the concerned heads of organizations. The Review Committee will evaluate the quality of reports considering the proposals included in the reports to achieve the requirements specified in TOR and fulfillment of the vision and development objective of the Project. The Review Committee shall provide comments within four weeks of submission of the Reports of the consultant. The consultant is required to incorporate such comments before proceeding to finalization. Comments for monthly progress reports shall be provided within one week.

122. **Experience and Qualifications:** It is expected that the Consulting team would comprise a team of competent international and national professionals mainly in key disciplines including; (i)

Water Resources Specialists (Team Leader of the study) with a broad experience in multi-sector water resources planning, development and management and extensive knowledge on water institutional development; (ii) Dam Safety Design and Management Specialists of all types of dams; (iii) Dam Operation and Monitoring for HP related Electromechanical Instrument/Equipment Specialists for short-term intervention; (iv) Irrigation Specialist (v) Water Supply specialists, (v) Hydrologists with extensive experience in hydrometric modeling and networking; (vi) Hydro-geologists and Geomechanics with dam building and groundwater networking experience and modeling; (vii) Meteorologists with extensive experience in network establishment and analysis; and (viii) part-time support of other subject matter specialists in water resources management, environment and water economics. But it is optional for the consulting firm to suggest a suitable manning schedule and for the whole term duration and for each of the short-term specialist of international and national positions. While these specialists must be professionally competent in their field of expertise, preferably they also should have experience in implementing World Bank-funded projects, particularly in Africa.

123. Individual Qualifications required for the study team specialists are mentioned below.

**Table 6: Indicative Staff requirements**

| **Objectives** | **Profile personnel needed** | **Total staff-months input** | | |
|---|---|---|---|---|
| | | **International** | **Local** | **Total** |
| 1,2,3,4,5 | Team Leader / Water Resources Management Specialist | 12 | 6 | 18 |
| | Hydrologist | 6 | 6 | 12 |
| | Dam design and safety operation specialist | 6 | 6 | 12 |
| | Irrigation and Drainage Specialist | 6 | 6 | 12 |
| | Geologist/hydrogeologist Specialist | 6 | 6 | 12 |
| | Water supply and sanitation specialist | 6 | 6 | 12 |
| | Human Resources/Institutional development specialist | 4 | 6 | 10 |
| | Agricultural/Agronomist planner | 4 | 4 | 8 |
| | Socio-economist expert | 4 | 4 | 8 |
| | Livestock Expert | 4 | 4 | 8 |
| | Communication/Gender Specialist / Facilitator | 6 | | 6 |
| | GIS/Environmental Specialist | 3 | 1 | 4 |
| | Rural development Specialist | 3 | 5 | 8 |
| | PPP specialist and financial engineering | 4 | | 4 |
| | **Total** | **Approx. 74** | | **134** |

124. In their proposals, consultants are free to comment to modify any or all of these indicative key staff positions and inputs, in conjunction with the provision of corresponding sound reasoning and justifications, and provided that such changes are commensurate with the required scope of

services. Each position can be filled by more than one staff if timing and the level of effort so requires, in which case the CV of all proposed staffs shall be included in the technical proposal. Proposals should include an account of proposed staff assignments, their durations and schedules, and their levels of input by task.

125. All key staff should have the equivalent of at least a master's degree in their field of specialization or related fields, and at least 10 years of professional experience in related assignments. Other staffs shall have at least 5 years of professional experience in related assignments. Satisfactory execution of the I&D scheme feasibility studies as well as the institutional development objective will require a multi-disciplinary study team with high levels of both technical and social skills. Consultants are required to propose teams that will bring an appropriate mix of disciplines, educations, skills and levels of experience, a sound understanding of development issues, and strong international and/or regional experience on similar projects.

126. The team leader in particular is to have extensive management experience working in a developing country environment on I&D development projects that have included substantial engineering, agricultural, social, institutional, environmental and economic components. Demonstrated skills in project planning and management, execution of multi-disciplinary studies and assessments, and facilitation of stakeholder consultations and interactions, coupled with sound technical experience and understanding gained through a career in I&D development, are considered essential. The nominated team leader should have a professional background in planning and/or engineering in the water/rural/agricultural sector, and substantial experience with directing and managing similar multi-disciplinary assignments, preferably in Africa.

127. A high-level upstream water resources engineer and an downstream senior irrigation and drainage specialists that will be the study facilitator or moderator, through a number of studies, coaching and follow-up facilitation missions (one for the upstream and the other for the downstream aspects of the study). They should have broad international knowledge in irrigation development and management (institutional, technical, and economic related matters), and a strong record of acting as moderator-facilitator of restitutions consultation sessions, objective based planning workshops and negotiations. They must also have a good record of leading multi-disciplinary teams and studies in various countries so that he can provide a peer coaching to the local team. They should have at least 15 years of relevant professional experience.

128. A number of subject specialists through specific short-term inputs, mainly during the first project year. Altogether the team of subject specialists shall demonstrate a strong background in irrigation development and management of O&M, a wealth of international and national experience, as well as the following indicative managerial skills.

i. Water Resources Planning Specialist/Team Leader: Postgraduate degree in Water Resources Engineering or related field covering multi-sector water resources planning and development. In addition to the team leader's role, the consultant will also be responsible for multi-sector water resources planning and development tasks mentioned under Task 3. The consultant shall have at least 25 years of experience after graduation in the water

resources engineering fields and a minimum of 15 years' experience in planning, development, and management of multi-sector water resources development particularly for national and regional master plans with extensive experience in dealing with large public water resources organizations in Africa and similar regions.

ii. Irrigation and Drainage Specialist (s): Postgraduate degree in Irrigation or Soil and Water Engineering with 15 years' experience in Africa or other compatible experience in the Water Resources Engineering or related fields (irrigation and agriculture) covering multi-sector water resources planning and development. Besides, to assist the team leader as deputy, the consultant will also be responsible for multi-sector water resources planning and development tasks mentioned under Task 3. The consultant shall have at least 20 years of experience after graduation in the water resources engineering or related fields and a minimum of 15 years' experience in planning, development, and management of multi-sector water resources development particularly for Irrigation development in national and regional master plans with extensive experience in managing large public water resources organizations in a country.

iii. Agronomist/ Agriculture Specialist: Postgraduate degree in Agriculture and related fields specialized in Irrigated Agronomist. The consultant shall have at least 20 years of experience after graduation in the related fields and a minimum of 15 years hands-on experience in analytical assessment and participatory techniques. The specialist should be familiar with Good Agricultural Practices (GAP). Must also be familiar with up-to-date data collection, collation, and processing to support project implementation procedure.

iv. Dam Design and Safety Operation Specialist(s): Postgraduate degree in Civil or Geo-technical Engineering with a minimum experience of 20 years (after basic degree graduation) in planning, design, construction, and operation and management of large dams of various types and categories. Must have the ability to give technical leadership to develop a safety plan for the dam operation and safety assurance program and its related institution. Must also familiar with all electro-mechanical equipment and monitoring instrument used/installed in dams for operation. Should also experience in the application of FMECA (Failure Modes, Effects, and Criticality Analysis) or equivalent in risk assessment of reservoirs, and familiar with Safety Evaluations and Risk Assessment Guidelines of UK, USA, and Australia or Africa equivalent. Experience in SCADA Systems associated with dam operations and emergency management.

v. Hydrologist (hydrometric networking/instrumentation): Postgraduate degree in Civil/Water Resources Engineering or related fields specialized in hydrology, hydrometric application, flood, and drought forecasting, sediment management, and river basin modeling. The consultant shall have at least 20 years of experience after graduation in the related fields and a minimum of 15 years hands-on experience in the specialized field in designing, operation, and management of hydrological and hydrometric networks for water resources development. Must also familiar with up-to-date data collection, collation, and processing software/hardware and instrumentation in hydrology and hydrometry and basin

simulation study. Preferable to have additional knowledge on data transmission and RS/GIS technology.

vi. Hydrogeologist/Engineering Geologist for groundwater network: Postgraduate degree in Geology/Engineering Geology or related fields specialized in hydrogeology and groundwater observation network. The consultant shall have at least 20 years of experience after graduation in the related fields and a minimum of 15 years hands-on experience in the specialized field in designing, operation, and management of hydrogeological and groundwater observation networks for water resources development. Must also familiar with up-to-date groundwater data collection, collation, and processing software/hardware and instrumentation. Must also know water quality analysis for drinking and agriculture. Preferable to have additional knowledge on data transmission and RS/GIS technology.

vii. Water Supply and Sanitation Specialist: Postgraduate degree in Water Supply and Sanitation or related fields specialized in Urban and Rural Water Supply network planning and Design. The consultant shall have at least 20 years of experience after graduation in the related fields and a minimum of 15 years hands-on experience in the specialized field in designing, operation, and management of Water Supply networks for water resources development. Must also familiar with up-to-date Water supply data collection, collation, and processing software/hardware and modeling. Must also know water quality analysis for drinking. Preferable to have additional knowledge on data transmission and RS/GIS technology.

viii. Institutional Development Specialist. Postgraduate degree in Sociology or Public Administration and or related fields specialized in human resources administration, development planning and organization. The consultant shall have at least 20 years of experience after graduation in the related fields and a minimum of 15 years hands-on experience in an institutional development need analysis, succession planning, training and capacity building requirement. Have experience with multi-stakeholder's project and especially donor funded projects. Must also familiar with and use of computer. Experience and Knowledge of formation and establishment of water user's association and farmers cooperatives is required.

ix. Other subject matter specialists: Specialists or short-term interventions in related water resources development subject such as Quantity Survey and Cost Estimation, Environmental Impact and Mitigation for WR projects, Sociology and Water User Organization, and some other allied fields to the study like Information Technology, Institutional Strengthening and Training, and Financial Management, etc. are required. All must be with graduate-level education with at least 15 years of experience in the related field. Their short-term deployment must be proposed in lump sum provision and can be mobilized in consultation with the TWG leader and the approval of Project Coordinator.

## VII. DELIVERABLES FROM THE STUDY OBJECTIVES, STAGES AND TASKS REPORTS

Objective 1: Update existing knowledge on the available water resources in the Benue Basin;
Objective 2: Improve water resources planning and management through capacity gap analysis and upscaling
Objective 3: Formulate and implement priority investment for irrigation development (as the main thrust),
Objective 4: Multipurpose water productivity enhancement (IWRM),
Objective 5: Reduce water induced risks and enhance the effectiveness of investments.

129. The Consultant with respect to the objectives1,2, 3,4 and 5 above will provide the following reports:

a) Deliverable 1. Inception Report: to be submitted four weeks after mobilization and substantial completion of Task 1 of stage 1
b) Deliverable 2. Draft Report to be submitted upon completion of task 2,3 and 4 of Stage 1.
c) Deliverable 3. Draft Design Report upon completion of Tasks 1and 2 of stage II Project prioritization
d) Deliverable 4. Draft Report Integrated Water Resources Management Plan and Catchment Management Plans upon completion of Tasks 1 ,2 and 3 of Stage 1.
e) Deliverable 5. Draft Report "River training" upon completion of tasks 3 of Stage 1.
f) Deliverable 6. Draft Final Report: Integrated development of the basin with main infrastructure interventions. To include:
    - Complete technical descriptions of all aspects of the recommended and finally agreed scheme developments, including recommended operational arrangements and performance targets based on the participatory diagnostic design process;
    - Details of all data collection, survey and investigation findings and results to develop new water resources for high priority public irrigation schemes;
    - Details of all land and water resource, engineering, agricultural, social, environmental, and economic and financial studies, analyses, findings and results to develop new proposed irrigated farmland;
    - Details of stakeholder consultation, information dissemination and consensus-building activities and achievements including an explanation of responses to stakeholder concerns;
    - Preliminary design details and calculations;
    - Estimated O&M costs
g) Deliverable 7. Detailed Design, Draft Bid Documents & Detailed Construction Drawings for improved hydrometric network–to be submitted upon completion of Tasks 2 and 3 of stage 1;
h) Deliverable 8. Detailed Design, Draft Bid Documents & Detailed Construction Drawings for dam safety -to be submitted upon completion of Tasks 3 of stage 2

i) Deliverable 9. Detailed Design, Draft Bid Documents & Detailed Construction Drawings for river training, aquaculture and livestock -to be submitted upon completion of Tasks 3 stage 2;
j) Deliverable 10. Final Design Report of all agreed priority interventions incorporating Client comments.

130. **Client's Obligations:** The Client will provide the consultants with available reports and studies and relevant policy documents related to the Benue Basin.

131. **Area of operational HQs**: Abuja, FCT and Jalingo, Taraba State- Nigeria.

132. **Selection Procedure**: The selection procedure will be QCBS using the World Bank Procurement Guidelines for Selection and Employment of Consultants by World Bank Borrowers.