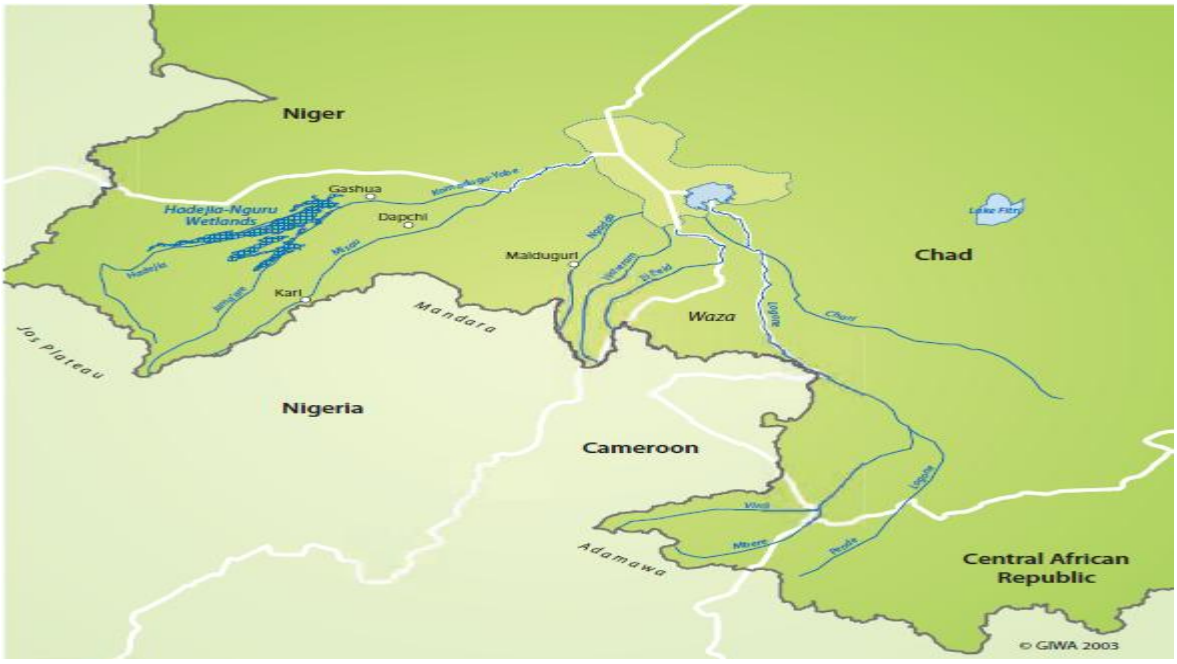
FEDERAL GOVERNMENT OF NIGERIA

WATER AUDIT

for

Lake Chad Basin in Nigeria



Draft Final Report

IUCN- Komadugu Yobe Basin Project
Phase 2

Nigeria Integrated Water Resources Management Commission

About Nigeria Integrated Water Resources Management Commission

The Nigeria Integrated Water Resources Management Commission (NIWRMC) is a Federal Government of Nigeria organisation whose mission is "to provide sustainable, effective, efficient and equitable management of Nigeria's water resources through local, regional and national actions and cooperation". In recent years the concept of integrated water resources management (IWRM) has come to the fore as a strategy to ensure conservation and wise use of water as an integral part of ecosystems to ensure optimum social and economic welfare of all. A key element of IWRM is that catchments are usually the most appropriate physical units on which to plan the management of water. Accordingly, the Commission has its headquarters in Abuja and operates through 8 semi-autonomous Catchment (also referred to as River Basin or watersheds) Management Offices; one of which is the Lake Chad Catchment.

This document has been produced to promote discusiion and understanding of water resources situation among key stakeholders in the Lake Chad Basin in Nigeria.

Consultants/Resource persons:

Engr. I. K. Musa, FNSE, mni (Project Director/IWRM Specialist)
Prof. F. A. Adeniji (Quality Assurance Director/ Soils and Ecology)
Prof. O. D. Jimoh (Team Leader/Hydologist)
Engr. U. M. Shehu (Deputy Team Leader/ Infrastructre Specialist)
Prof. I. B. Goni (Hydrogeologist)
Dr. P. I. Kwanghe (Socio-Economists)
Mr. Abdulrazak Sanusi (ICT)

Afremedev Consultancy Services Limited
House 3 45 close off 45 Street, Gwarimpa,
PO Box 9115 Wuse, Abuja.

Tele: 09 523 8332
Fax: 09 523 8343
Email: afremedev@afremedev.com
http://www.afremedev.com

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Foreward

Lake Chad Basin has remained a hot spot of water resources management in Nigeria. The list of challenges facing water resource sector in the basin are numerous. Water resources management in the basin has been complicated by inadequate knowledge base, fragmentation of institutions responsible for various water function and the erronous belief by many citizens of the basin that the country and indeed the basin has abundant water resources. Water is life, but like every resource, it is finite and needs to be managed sustainably to benefit the present and future generations.

The Federal Ministry of Water Resources recognizes the important role water plays in improving health, economic productivity and livelihoods as well as many other very vital environmental uses. The basin is water stressed, as the demands for water resources have outsrip the available finite water. A spiralling increase in population against the backdrop of a viberant and growing economy is resulting in even greater demand for the finite water. The situation has further been compounded by the emerging uncertainties associated with effects of climate change on water resources. In recognition of these, the Ministry in collaboration with the International Union for Conservation of Nature has developed this knowledge based document to provide the background information in the process of preparing an Integrated Water Resources Management and Water Efficiency Implementation Plan, or more briefly the Catchment Management Plan for LCB in Nigeria. It is to complement the National Integrated Water Resources Management Strategy.

The preparation of the Water Audit Report for Lake Chad Basin in Nigeria has built on the knowledge and experienced gained in FMWR-IUCN-NCF Komadugu Yobe Basin Project, a sub-basin in the larger Lake Chad Basin, which included the Water Audit and the Catchment Management Plan prepared for the sub-basin based the framework for water resources management through an integrated water resources management approach. Subsequent developments and several knowledge base studies were conducted in the Lake Chad basin by LCBC-GEF Project provided vital inputs to the understanding of prevailing water situation in the basin. The preparation process of this Water Audit also benefited from extensive consultations at the basin and national levels, consultations through high level water related government institutions. In further consultations, stakeholders at the catchment level were engaged to bring out priority issues to be tackled in the Catchment Management Plan. At the State and Local government level, ministries, departments and agencies, traditional leaders, civil society and water users were consulted. These have enriched our understanding of the situation.

I am therefore please to recommend this to all the water resources stakeholders in this Basin to own, study and appreciate the complexity of water situation in the Lake Chad Basin. Understanding the problems is more than halfway to solving the problems. May God grace us all with the understanding of the situation and to be part of the solution of water resources problems of the Lake Chad Basin in particular and Nigeria in general.

Hon. MINISTER
Federal Ministry of Water Resources

ACKNOWLEDGEMENTS

The Coordinating Director, Nigeria Integrated Water Resources Management Commission and Project Coordinator of FMWR-IUCN Komadugu-Yobe Project wishes to acknowledge the contribution and support of various stakeholders in the Water Auditing and Integrated Water Resources Management planning processes for Lake Chad Basin in Nigeria. Special thanks are due the Management and Staff of Federal Ministry of Water Resources and IUCN-BRAO for facilitating the process; the Project Core Team for leading and directing the project. IUCN have been and continue to be supportive of effort to improve water resources and environmental management in the basin, we thank them for hosting and supporting the project; the Water Auditing Team of the consultant Messrs Afremedev Consultancy Services Limited for their excellent work, sacrifices in very trying times in the basin and for their other contributions, the various stakeholders and communities who participated in the consultations, the Lake Chad Basin Commission, and Nigeria Water Partnership for technical support and guidance, and to NIWRMC and IUCN for funding the project.

Engr. R. A. K. Jimoh
Coordinating Director
NIWRMC, Abuja

Dr. D. Yawson
Project Coordinator
FMWR-IUCN KYB Project Phase II

Executive Summary

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Abbreviations and Acronyms

ABU	Ahmadu Bello University
ADP	Agricultural Development Project (part of State Ministries of Agriculture)
ArcView	Geographical Information System software package (by ESRI Inc.)
ASADP	Adamawa State Agricultural Development Project
ASMWR	Adamawa State Ministry of Water Resources
ASWB	Adamawa State Water Board
BaSADP	Bauchi State Agricultural Development Project
BaSMRD	Bauchi State Ministry of Rural Development
BaSWB	Bauchi State Water Board
BoSADP	Borno State Agricultural Development Project
BoSMWR	Borno State Ministry of Water Resources
BoSWC	Borno State Water Corporation
BRAO	West Africa Regional Office of IUCN
BUK	Bayero University Kano
CAZS	Centre for Arid-Zone Studies (University of Maiduguri)
CBDA	Chad Basin Development Authority
CBO	Community-Based Organisation
CMA	Catchment Management Authority
CMP	Catchment Management Plan
CTS	Centre for Trans-sahara Studies (University of Maiduguri)
DDT	Diphenyl-Trichloroethane
DFID	Department for International Development (U.K.)
DH&H	Department of Hydrology and Hydrogeology (FMWR)
DSS	Decision Support System
EIA	Environment Impact Assessment
FAO	United Nations Food and Agriculture Organisation
FMARD	Federal Ministry of Agriculture and Rural Development
FME	Federal Ministry of Environment
FMWR	Federal Ministry of Water Resources
GDP	Gross Domestic Product
GEF	Global Environment Facility
GIS	Geographical Information System
HJKYBCC	Hadejia-Jama'are-Komadugu-Yobe Basin Coordinating Committee
HJRBDA	Hadejia-Jama'are River Basin Development Authority
HJKYB	Hadejia-Jama'are Komadugu Yobe Basin
HVIP	Hadejia Valley Irrigation project
ITCZ	Inter-Tropical Convergence Zone
IUCN	International Union for the Conservation of Nature
IWRM	Integrated Water Resources Management
IWRMES	Integrated Water Resources Management Environment System
IWRMIS	Integrated Water Resources Management Information System
JAC	Joint Advisory Committee

Abbreviations and Acronyms cont.

JSADP	Jigawa State Agricultural Development Project
JSMWR	Jigawa State Ministry of Water Resources
JWL	Joint Wetlands Livelihood
KCWS	Kano City Water Supply
KNARDA	Kano State Agricultural and Rural Development Authority
KRIP	Kano River Irrigation Project
KSMWR	Kano State Ministry of Water Resources
KSWB	Kano State Water Basin
KYB	Komadugu Yobe Basin
KYBP	Komadugu Yobe Basin Project
KYCCC	Komadugu Yobe Catchment Coordinating Council
KYCMA	Komadugu Yobe Catchment Management Authority
LCBC	Lake Chad Basin Commission
LEAP	Local Environmental Plan
LGA	Local Government Area or Local Government Authority
MDGs	Millennium Development Goals
NCF	Nigerian Conservation Foundation
NEAZDP	North East Arid Zone Development Programme
NEEDS	National Economic Empowerment and Development Strategy
NGO	Non-Governmental Organisation
NNJC	Nigeria-Niger Joint Commission
NWRI	National Water Resources Institute
NWRMP	National Water Resources Master Plan
O&M	Operation and Maintenance
PCBs	Polychlorinated Biphenyls
POPs	Persistent Organic Pollutants
PPP	Public-Private Partnership
RBDA	River Basin Development Authority
RUP	Resource Use Planning
SCF	Stakeholders Consultative Forum
SEEDS	State Economic Empowerment and Development Strategy
SLGP	State and Local Government Programme
SMWR	State Ministry of Water Resources
TAC	Technical Advisory Committee (of the HJKYB)
ToR	Terms of Reference
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNICEF	United Nations Children's Fund
UNIMAID	University of Maiduguri
WANI	Water and Nature Initiative
WCA	Wetlands Conservation Agency
WES	Water Supply and Sanitation

Abbreviations and Acronyms cont.

WHO	World Health Organisation
WRECA	Water Resources and Engineering Construction Agency
WSSD	World Summit on Sustainable Development
WUA	Water Users Association
YSADP	Yobe State Agricultural Development Project
YSMWR	Yobe State Ministry of Water Resources
YUTECH	Yola University of Technology
YSWB	Yobe State Water Board

EXECUTIVE SUMMARY

INTRODUCTION 1

1.1 The Contract

In the letter reference No IUCN-Project No. 89114-001 dated 21/03/2011, the IUCN-KYB project of 15A race Course Road, Kano commissioned Messrs Afremedev Consultancy Services Ltd of Abuja **(ACS)** to execute the project titled ***Update of Knowledge Base and Catchment Management Plan for Lake Chad Basin within Nigeria***, all to be completed on or before Sunday 31/07/2011 unless the contract is otherwise extended or terminated.

Nigeria it would appear prefers a rapid initial approach to preparing Catchment IWRM Plans (CMP), to be updated in the process of implementing the plan, to take into account new information and changing conditions. This is in recognition of the fact that CMP, which is the final output of the study, is a dynamic instrument that should progressively be modified to reflect the emerging priority issues and innovative strategies and actions in water resources management, development and use.

The Komadugu-Yobe Basin (KYB) CMP that was prepared in 2006 is still relevant, but has remained largely unimplemented, and ordinarily it is due for review. KYB is a sub-system of Lake Chad Basin (LCB). The reasons for the poor implementation are many, but principal among these is lack of capacity. Therefore, to ensure that the updated and up-scaled CMP for LCB would be implemented, the required capacity will have to be built. This should however be a continuous process, with each step bringing in demands for new knowledge and competencies to help understand new directions and build commitment as well as develop appropriate responses to water resource management challenges.

1.2 Project Description

1.2.1 The Johannesburg Implementation Plan

The World Summit on Sustainable Development (WSSD), in Johannesburg in 2002 brought together world leaders to critically assess the state of the world in the context of economic and social development over the foreseeable future to ensure that development plans are sustainable. A key item on the agenda was water, because it has been universally recognised that good access to good quality water underpins all socio-economic development of all nations.

The major step forward at the World Summit on Sustainable Development (WSSD) was that the Plan of Implementation included a specific directive calling for all countries to develop IWRM and water efficiency plans by 2005. Specifically, Paragraph 26 of the WSSD Plan of Implementation, issued in Johannesburg in September 2002, read as follows:

Develop integrated water resources management and water efficiency plans by 2005, with support to developing countries, through actions at all levels to:

a) Develop and implement national/regional strategies, plans and programmes with regard to integrated river basin, watershed and groundwater management, and introduce measures to improve the efficiency of water infrastructure to reduce losses and increase recycling of water
b) Employ the full range of policy instruments, including regulation, monitoring, voluntary measures, market and information-based tools, land-use management and cost recovery of water services, without cost recovery objectives becoming a barrier to access to safe water by poor people, and adopt an integrated water basin approach
c) Improve the efficient use of water resources and promote their allocation among competing uses in a way that gives priority to the satisfaction of basic human needs and balances requirement of preserving or restoring ecosystems and their functions, in particular in fragile environments, with human domestic, industrial and agriculture needs, including safeguarding the drinking water quality
d) Develop programmes for mitigating the effects of extreme water-related events
e) Support the diffusion of technology and capacity-building for non-conventional water resources and conservation technologies, to developing countries and regions facing water scarcity conditions or subject to drought and desertification, through technical and financial support and capacity-building
f) Support wherever appropriate, efforts and programmes for energy-efficient, sustainable and cost-effective desalination of seawater, water recycling and water harvesting from coastal fogs in developing countries, through such measures as technological, technical and financial assistance and other modalities
g) Facilitate the establishment of public-private partnerships and other forms of partnership that give priority to the needs of the poor, within stable and transparent national regulatory frameworks provided by the Governments, while respecting local conditions, involving all concerned stakeholders, and monitoring the performance and improving accountability of public institutions and private companies.

Explicitly or implicitly, the above directive conveys five clear messages:

1. *Countries must translate principles of IWRM into a specific plan.*
2. *Countries should complete IWRM Plans by a target date – 2005.* Nigeria prepared a new draft Water Policy (2004) embracing many principles of IWRM and also a 'CMP for KYB' in 2006.
3. *All countries should have a Plan-whether they are rich or poor, whether they have plentiful water resources or scarce water resources.*
4. *Developing countries must be supported by the developing partners in the process of preparing their Plans.* Nigeria is not being supported under this Project, but support could be obtained to prepare detailed programme and funding strategy for the reform process as well as for implementation.

5. *The content of these Plans must be wide-ranging, covering enabling environment (policies, strategies and legislation) institutional framework to implement the enabling environment, and the management instruments to achieve the desired financial and technological reforms.*

It is significant to note that the target on IWRM 2005 planning is an intermediate target on the road towards IWRM. IWRM is a means towards achieving the objective of equitable, efficient and sustainable management of water. Meeting this objective is widely recognized as essential for achieving several of the Millennium Development Goals (MDGs).

The IWRM plans would focus on the key steps necessary to support the transition process towards a "water governance system" in which the principles of IWRM are made operational in Nigeria. The "water governance system" should be understood as a very broad system *extending well beyond the water sector* and involving all governance frameworks and activities relating to water, directly or indirectly. It indeed relates to all relevant societal levels (community, local, state, national, international) and all spheres of activities having to do with water resources (energy, agriculture, trade, water supply, sanitation, transport etc.).

The IWRM plan will take stock of the water governance situation today, provide a description of the vision for the future situation (water governance following IWRM principles and concepts) and develop strategies, programmes and plans for attainment of the envisioned water governance situation. The monitoring and evaluation mechanisms necessary to assess the progress and performance of the process towards the set goals will be integral parts of the system.

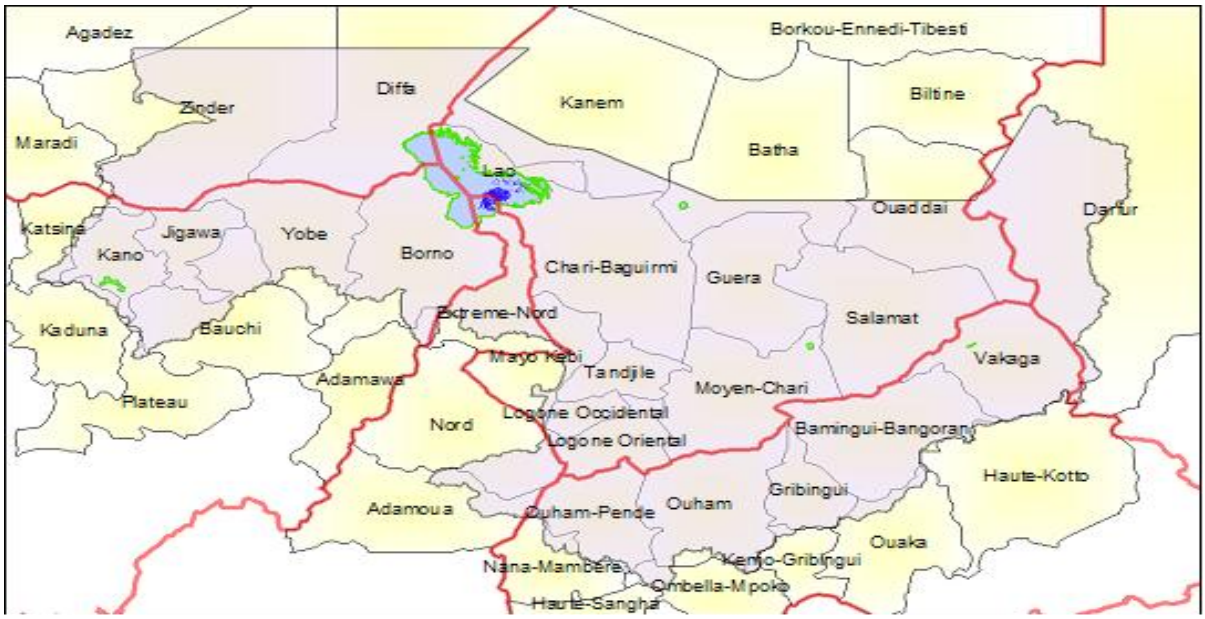
Finally, it is important to stress that while the Johannesburg WSSD Implementation Plan specifies a National IWRM Plan, real water resources management happens at the basin level – the catchments. Therefore, the Catchment Management Plan for Lake Chad Basin is in tandem with Johannesburg Directive.

1.2.2 Description of Lake Chad Basin in Nigeria

1.2.2.1 The Lake Chad Conventional Basin

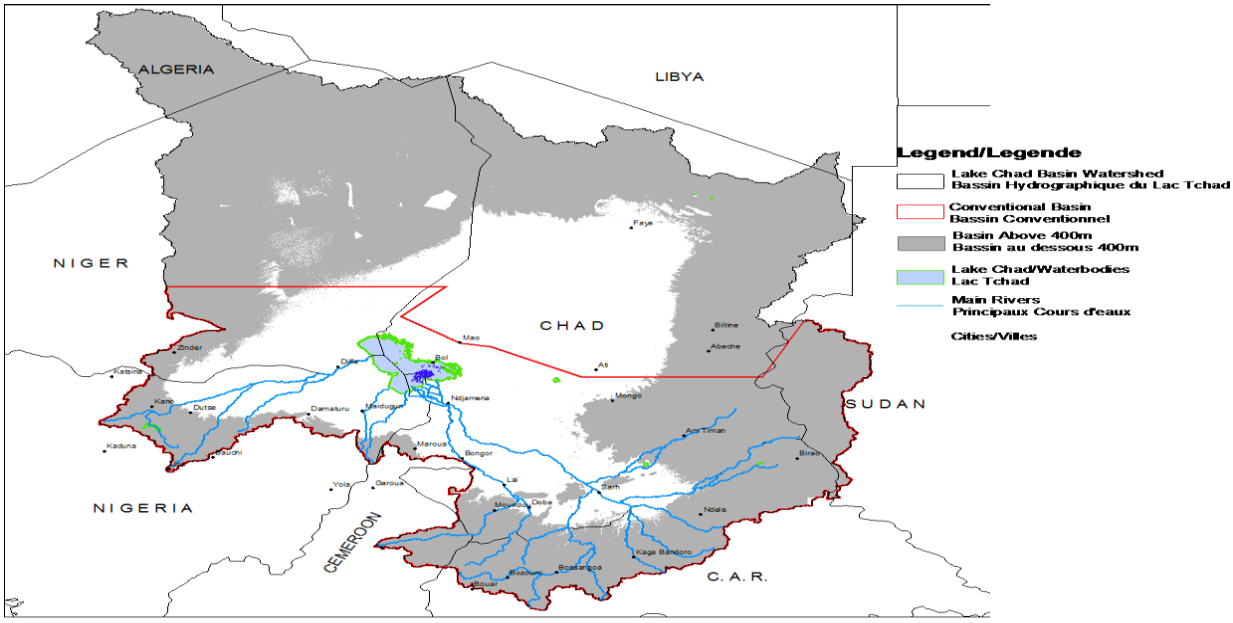
The Lake Chad Basin, which is the largest area of inland drainage basin in Africa, is situated in West/Central Africa region between 6° to 24° N and 8° to 24° E. It comprises a vast expanse of land made up of several catchments that feed Lake Chad. Figure 1.1 shows a general map of the Lake Chad Basin. UNEP (2004) reported that, based on EROS Data Center 2002, the entire geographical basin covers an area of 2,434,000 km^2. This is about 8% of the surface area of the African continent, shared between the countries of Algeria, Cameroon, Central African Republic (CAR), Chad, Libya, Niger, Nigeria and Sudan.

Figure 1.1: Administrative and Conventional Lake Chad Basin



The region is bounded to the north by the Ahaggar Mountains in Algeria. From this summit, the border descends southwards towards the Tibesti Highlands that forms the border between Libya and Chad, and continues to about 19° N near the Djebel Mara volcanic mountains in Sudan. The southern border is defined by the Mongos Hills in CAR and the Adamawa Mountains at about 6° N and further west by the Mandaras in northern Cameroon at approximately 10° N. Aïr Plateau in Niger forms the border to the northwest while the Jos Plateau marks the western boundary in the Nigerian sector of the Basin (UNEP, 2004).

Fig 1.2. Lake Chad Hydrological and Conventional Basin.



A framework for economic cooperation and integration built around the shared resources of Lake Chad was first muted by the political leaders of Cameroon, Chad,

Niger and Nigeria when, through a Convention and Statutes signed at Fort Lamy (N'djamena) on May 22, 1964, brought about the establishment of an intergovernmental organisation - Lake Chad Basin Commission (LCBC) - for the development of the Lake Chad Basin. In 1994, the Central African Republic was admitted as the fifth signatory. It is however, instructive to note that until 1994, the "Conventional Basin" excluded the upstream Basins of the Komadugu-Yobe and the Chari-Logone Rivers. Sudan was admitted during the Tenth Head of State Summit held on July 28, 2000, increasing the LCBC conventional basin from 966,955 square kilometres to 1,053,000 square kilometres (Fig. 1. 2).

About 52% of the annual statutory financial contributions to the LCBC come from Nigeria, who recently gave a grant of US$5.0 million for the Feasibility Study of the Commission's proposed Inter-basin Water Transfer Project.

1.2.2.2 Nigeria and Lake Chad Basin in Nigeria

Nigeria has a population of over 140 million people[1], of which about 25 million inhabit the Basin, which makes it the most populous nation in Africa and indeed the Basin. It has common borders with the Republic of Cameroon to the east, Republic of Niger to the north and Benin Republic to the West. One of country's most prominent geographic features is the River Niger, which together with its main tributary - the Benue - drains most of the country. The prominent feature of the Lake Chad, which unlike all other river systems in Nigeria that drain finally into the Sea, the river systems in the Lake Chad basin drain into the land-locked lake which Nigeria shares with five other countries. Water resources development in Nigeria, therefore raises many international issues and is thus a stakeholder/partner in the co-operative harnessing and management of Niger River and the Lake Chad Basin. The Nigerian Sector (205,500 km^2) constitutes about 8½% of the total hydrological basin and 19½% of the current conventional basin. It represents the semi-arid region of the country with average rainfall of between 450 and 1000 mm and an evapo-transpiration in excess of 2000 mm.

The Lake Chad Basin serves as a source of fresh water, fisheries, and pastoral and agricultural lands for the inhabitants of the basin. The main surface water resources of the Lake Chad Basin in Nigeria, beside the Lake Chad itself, are: the Komadugu-Yobe River sub-system to the north, which is the more commonly known and extensively studied, the Borno drainages consisting Yedseram, Ngadda/Alau and the Gubio Rivers sub-systems; Ebeji/El-Beid River sub-system that forms part of the border between Nigeria and Cameroon. The sources of all these rivers are the highlands to the south and south-west of the sub-Basin, where the rainfall is relatively high. None of the rivers in the Nigerian sector of the sub-systems is perennial and most of their waters, if not all, flow into marshy areas on the plains and disappear before reaching Lake Chad, except partially for Komadugu Yobe and Ebeji rivers that often discharge into the Lake during the short wet season. This situation is in part due to high evapotranspiration in

[1] 140 million was the actual population figure of 2005 census growing at long-term national rate of 2.5%/yr..

excess of 2000 mm and the equally high infiltration losses. Details of these subsystems are further discussed in section 2.3.

1.3 Water management problems in the Lake Chad basin

A recap of the major hydrological and institutional issues of concern in the Lake Chad Basin in Nigeria are summarised below:

i) Scarcity of water with substantial portion of available water sources that can possibility be economically exploited having already been developed. The potential surface water requirements in the Hadejia sub-basin by estimation of the late nineties are 2.6 and 1.8 times larger than the mean available surface water resources, for the Hadejia and Jama'are Rivers, respectively.

ii) Fragmented, inequitable and uncoordinated surface water uses, with ill-defined and often conflicting responsibilities between agencies (e.g. three River Basin Development Authorities RBDAs (HJRBDA, LCBDA, UBRBDA) responsible for water management in the catchment with little coordination) as well as ***the limited knowledge about available water, and the nature and magnitude for the water demands*** remains a major constraint to improved water management in the basin.

iii) The invasion of aquatic weeds, notably Typha domingenis, in the Hadejia sub-basin, whose consequences include:
- Macrophyte and silt blockages in the HNW which prevent the Hadejia River from contributing to the Yobe River
- Hindrances in the use of surface water bodies from fishing and navigation
- The creation of a favourable environment for the multiplication of vectors of waterborne diseases
- A reduction in biodiversity

iv) Extremely large and small floods were recorded in 1992, 1993, 1998, 2001 and 2010 in particular. The extremely large floods combined with irregular reservoir operations resulted in the displacement of thousands of people in 1998. The floods in 2001 took the lives of over 200 people and displaced over 35,000. Furthermore, contrary to what was expected after the completion of the dams, the timing of the floods in the HNW became less predictable and even resulted in dry-season floods. Along the Marma Channel in the HNW, the flooding has become more or less permanent since 2001. Some villages like Dabar Magini had to be moved to the west of Nguru Lake while the Hadejia-Nguru road is almost completely inaccessible during the wet-season.

v) The irregular and low flows in the Yobe River have affected the small and large irrigation schemes along this river, and many of them have now been abandoned. With the exception of year 2001, the flooding of the floodplains along the Yobe River has been very limited in the past five years. Fadama exploitation has been stimulated in the basin through World Bank assisted subsidies, which has raised concern over possible over-abstraction of groundwater in the basin.

vi) The shrinking and splitting of the Lake Chad at the downstream part of the Yobe River. Although the historical contribution from the Yobe River to Lake Chad had been small, under the present circumstances any little increase in inflow into the lake would be significant.

vii) A suspected degradation in water quality.

2 STUDY APPRAISAL AND METHODOLOGY

A description of the study approach and the critical characteristics of Lake Chad Basin in Nigeria, followed with highlights of activities including the desk review of documents as well as reconnaissance survey, data collection, hydrological, hydro-geological and ecological analyses are described herein.

2.1 Study Approach

2.1.1 A Coordinated and Consultative Process

The study being essentially an integrated water resources management strategy and water efficiency planning for a catchment; it was executed in a cross sectoral manner, focusing on water governance problems without ignoring related vital concerns and priorities in the basin. In order to make the analysis more effective and sustainable it included a detailed 'governance analysis' and took into consideration the local institutional, legal and policy environment.

The study built upon all the past studies especially those that were products of active stakeholder participation. Overall, four key points that underpin the study are:

- Building on past works while updating and authenticating the facts;
- Coordination and Participation;
- Prioritisation; and
- Consensus.

To build on relevant past works the following actions were undertaken. We consulted both the client and core stakeholders to identify recent studies that involved active participation of key stakeholders. Several relevant documents and literature were identified; most of which are available at Centre for Arid Zone Studies, University of Maiduguri and KYB-Project library. In particular the study team identified the following as most relevant works:

1. Report of the LCBC-GEF Project sponsored Transboundary Diagnostic Analysis (TDA) of Lake Chad Basin in Nigeria that was completed in August 2006;
2. The LCBC-GEF Project sponsored National Action Plan (NAP) of Lake Chad Basin in Nigeria that was completed early in 2007;
3. Strategic Action Programme (SAP) for the Lake Chad Basin: Agreed by the LCBC Member States of Cameroon, Central African Republic, Chad, Niger, and Nigeria on 11 June 2008;
4. Draft National Water Resources Policy and Draft National Water Resources Bill, substantially completed since 2004 and 2009 respectively, but both are yet to be approved and adopted. Both contain many elements of IWRM. CMP and its

implementation can be seen simply **as part of the processes of implementing them.**

The following actions were also structured and undertaken to facilitate coordination and consultation between various players at all levels:

- Stakeholder analysis was carried out early to update the stakeholders to reflect prevailing institutional restructuring that must have transpired in KYB since 2006 and to include those in Adamawa state. This was primarily to ensure participation of all stakeholders in the processes. This is included in this report.
- The use of e-mail to contact some persons in the core stakeholders to maintain informal participation to keep them abreast and to discuss and address some of the emerging issues. This would create good opportunity to strengthen the engagement of stakeholders.
- The Project Team will play a key role in sharing the process with all local players: during the field visits through dialogue and exchange of ideas about critical issues regarding land use and water management in the Basin.
- We recommend the establishment of a Project Steering Committee (PSC) to provide link with core Ministries, Department and Agencies (MDAs) of partner governments and to promote public involvement through the use of mass media.

In addition, the Core study team members will provide thematic analysis and a national draft report to the Team Leader, who together with the Project Director and Advisory Team will review the reports and provide inputs for the first draft Final report that would be due by mid May 2011. The Core Study Team members would also be involved in: Legislative and Institutional Assessment, Capacity deficiency assessment and Assessment of Economic, Financial and Social Aspects of IWRM. The draft final report will be validated at a Stakeholder Workshop and the comments, observation and recommendations of the workshop will be incorporated into the final CMP.

The scientific foundation of the CMP, the update of knowledge based documents will be corroborated by the work of consultant resource persons/ selected experts, and members of Core Study Team. The Project Director would facilitate and follow- up the regular work of the Core Study Team and serve as Quality Assurance Manager.

2.1.2 Integration of Results from Previous Studies in the Basin

The preparation of Water Audit is a scientific and technical process of fact-finding (or diagnosing) the state of water resources management in the basin. The major outputs of the Water Audit include:

- Information and data 'stock taking' exercise;
- Identification and initial prioritisation of water management issues and problems;
- Analysis of impacts/consequences of each issue/problem;

- Integration of results from relevant previous studies in the Basin, especially the IWRM related studies;
- Governance analysis; and
- Final prioritisation of water resources problems.

The updated Water Audit would provide the factual basis for the formulation of the up-scaled CMP based on a reasoned and multi-sectoral consideration of the water resources problems. It will therefore highlight several knowledge-based studies, structural and non-structural activities; and integrate results from past and on-going studies and activities in the basin. This would be valuable to the eventual formulation of the upscaled CMP for Lake Chad.

2.2 Generating the Knowledge Needed to Develop CMP

As soon as the contract was signed, the team mobilised and commenced the collection of documents and preliminary activities on the assignment. In order to carry out the assignment within the limited time, the assignment was divided into two parts of 1) field visit and data collection and 2) assessment and sectoral analyses and catchment management planning with each part having 3 activities. The team of consultants was split into two to carry out the three activities of part one consecutively. The first team was assigned the review and updating of information from the KYB sub-system, while the second team handled the collation of data from the Borno and Ebeji/El-Beid sub-systems. The activities were as follows:-

Activity 1: Start-up and preparatory activities

Activity 2: Collation and review of existing reports on KYB

Activity 3: Meeting with relevant agencies and collation of reports on Borno and Ebeji/El-Beid sub-systems

Activity 4: Assessment of data in terms of quantity and quality, and gaps filling. Quality control process involved the use of double-mass analysis for rainfall data, comparison of previous rating curves, inter-comparison of data and statistics from different sources, analysis and discussions aimed at understanding the reasons for disparities and concluding on which data to discard. The gap filling involved the use of records from adjacent station or river sub-system and normalized ratio.

Activity 5: Sectoral analyses (hydrology, hydro-geology, environmental and ecology and socio-economic).

a) The hydrologist determined the weekly surface water availability (for very-dry year, dry year, normal year, wet year and very-wet year) for all the sections in the basin on the basis of statistical analysis of the river flow data. The Hydrologist, also in collaboration with the Hydro-geologist, and Environmentalist (i) quantified, on a monthly basis, the present water uses for all water audit sections in the Borno and Ebeji/El-Beid sub-systems (surface water and groundwater in the first aquifer), (ii) estimated the future water uses for three years (namely 2020 and 2050) for five different development scenarios, (iii) ranked the future water uses on the

basis of their likelihood in a high inter-annual rainfall variability due to climate change, cultural practices of the farmers in the floodplains (flood and flood recession agriculture), environmental flow requirements (notably in HNW and Lake Chad)], and (iv) developed scenarios with the above identified possible future trends in water uses as well as those with the proposed engineering improvement.
Climate scenarios were based on normalized ratio of rainfall or runoff series. Normalised ratio being the difference of the seasonal (annual) from mean value, normalized by the standard deviation. Water balance was calculated (using mass balance) to assess the status of water resource availability, with particular attention given to evaluating impact of climate change and water users.

b) Hydro-ecologist determined the environmental river flow requirements of the HNW, Lake Chad and other ecologically valuable areas and examined the impact of flow removal from the hydrographs on the ecosystem.

c) The Hydro-geologist (i) analysed the shallow groundwater data (first aquifer) in the basin and prepared a GIS map that contains: the monitoring wells with their identified long-term trends, abstraction points (with abstraction rates) and areas where the number of wells tapping the first aquifer will increase significantly, (ii) compared (per sub-section) the estimated annual recharge of the shallow aquifer (river bed, floodplain and rain-fed) with the present and projected shallow groundwater abstractions, (iii) identified critical areas where over-abstraction from the first aquifer may occur, and (iv) suggested locations and depths of additional monitoring wells, and estimated the annual shallow groundwater availability, or recharge rates, for the water audit sections (very-dry year, dry year, normal year, wet year, very-wet year).

d) The Socio-Economist (i) reviewed the existing report on KYB sub-system, (ii) compiled existing demographic and socio-economic information and developed a detailed profile of the Borno and Ebeji/El-Beid sub-systems; (ii) carried out surveys and participatory appraisals on the sub-systems populations' needs and priorities, institutional landscape, constraints and opportunities to participation in water and natural resources management decisions; (iii) assessed the environmental and health impacts of changes in traditional water related activities, hydraulic and hydro-agricultural infrastructure, and human settlement dynamics as they relate to water management; (iv) assessed the current state of the environment in the sub-systems and the environmental flow requirements for selected critical basin ecosystems; and (v) analyzed possible socio-economic and environmental impacts of identified water demand scenarios and any planned interventions.

Collection and analysis of socio-economic and institutional information: Primary data were collected using some checklist for rapid rural appraisal. Secondary data and literature from past socio-economic studies that was commissioned by KYBP, LCBC and partner projects was reviewed and used as the main source of qualitative water-related socio-economic information.

e) The Catchment Management Planner reviewed the Catchment Management Plan (CMP) for the KYB system, and harnessed the water audit and socio-economic reports to prepare the CMP of the Lake Chad Basin.

f) The DSS developed for the KYB sector (KYBP, 2006) was reviewed and made more user friendly, especially in terms of installation of the package. The water balance analysis was updated based on output from later studies.

Activity 6: The catchment management plan was submitted to stakeholders for discussion, review, adoption and approval.

2.2.1 Desk Study

For a start various formal and informal documents on previous studies in the LCB in Nigeria were collated, relevant hydrological, hydro-geological, meteorological and water use data update from HJTF and the FMWR-IUCN-NCF KYB Project database. Others were items of information concerning available data on water uses, river flow, groundwater and meteorology collected from Nigeria Meteorological Agency (NIMET) and Nigeria Hydrological Services Agency (NIHSA). Also collated were available pieces of information on socio-economic parameters, as well as any relevant information. These were prerequisites for proper analysis of subsequent information gaps that were filled during field trips and the eventual update of KYB Water Audit and preparation of Catchment Management Plan for Lake Chad Basin.

2.3 Hydrological analysis

Detailed hydrological analysis in the LCB in Nigeria is constrained by length and spatial coverage of hydro-meteorological data. The KYB sector of LCB in Nigeria has consistent hydrological records between 1970 and 1990 for some stations. There are long rainfall records (1931 to date) for synoptic stations (operated by NIMET) within and around the KYB. These data could be used for hydrological analysis. But the analysis would not be spatially distributed. In carrying out the analysis, the KYB headwater was divided into four sub-units (three in Hadejia and one in Jamaare). Hadejia sub-basin was divided into three units in line with the current water resources development situation, while Jama'are sub-basin was considered as a unit up to the Bunga gauging station, where the proposed Kafin Zaki Dam is located. The units within the Hadejia sub-basin are:

a) Tiga - area contributing to Tiga Reservoir
b) Challawa – area contributing to Challawa Gorge Reservoir

c) Unregulated area – that is area within the Hadejia sub-basin that does not drain to the two reservoirs.

Weighted average technique was used to determine the area rainfall for each sub-unit. A 9-parameter rainfall-runoff was used for the analysis. The model was used to estimate the streamflow or inflow to the reservoirs 1930 - 2010 on weekly time scale. Although, land use pattern has significant effect on runoff, the effect of inter-annual variation in land use pattern on runoff could not be considered due to lack of data.

The basis of the model is a water balance between the following:

a. Input to the catchment as rainfall
b. Output from the catchment as evapotranspiration loss, surface runoff and sub-surface flow.

These are summarized in the equation

$$P = E_t + Q_i + Q_s + DS \quad \text{..... (2)}$$

Where: P is rainfall, E_t is evapotranspiration loss, Q_i is Surface runoff, Q_s is subsurface flow, and DS is the change in storage (positive or negative).

The model is conceived as a linear combination of four storage elements identified as:

(i) Surface storage
(ii) Channel storage
(iii) Soil moisture storage
(iv) Groundwater storage

At the beginning of the first interval, the potential evapotranspiration (a function of the meteorological parameters) is estimated. The loss is satisfied from the rainfall (if the rain is sufficient) or from the soil moisture storage, if the rainfall is insufficient. The amount of water that is lost as infiltration from the effective rainfall (rain less potential evapotranspiration) is evaluated depending on the state of soil moisture. A simple budget gives the amount of water left in the surface storage. The surface runoff is evaluated as a proportion of the excess surface storage over the maximum storage value the unit can hold. The subsurface flow is evaluated from the groundwater storage depending on the capillary rise and deep percolation between the soil moisture storage and groundwater storage. The sum of the surface and subsurface flow gives the discharge at the catchment. The next data for the next time interval is used to repeat the cycle of operations. The water budget model has nine parameters (Table 2.1).

The parameter optimization involves inputting the values of the nine parameters, running the model and checking the goodness of fit. The parameters are modified as required, and the whole procedure is repeated. An automatic optimization technique is adopted. This involves setting a range of values for each parameter. The range of values is received by the computer interactively or obtained from the working file. A value within the range of values for each parameter is selected, the model performance R^2_{log} is found.

Table 2.1: Rainfall-runoff model parameters

s/no.	Parameter	Code name	Unit
1.	Threshold value of surface storage	TVSS	**Metre**
2.	Maximum infiltration rate	FMAX	**Metre**
3.	Infiltration Coefficient	HINFEL	**Per unit time**
4.	Channel storage constant	CHSTK	**Fraction**
5.	Threshold value of soil moisture storage	TVSM	**Metre**
6.	Maximum capillary rate	CMAX	**Fraction**
7.	Rate of evaporation from subsurface zone	PCUS	**Fraction**
8.	Groundwater storage constant	GWSC	**Fraction**
9.	Threshold value of Groundwater storage	TVGW	**Metre**

The search involved setting an arbitrary length for the parameters in 9–orthogonal direction. The movement in a direction is termed successful when the resulting R^2_{log} is an improvement over the previous value. The step is increased and the routing process is automatically repeated. If the movement is a failure, the arbitrary length is reduced and the routing process is repeated for the 9–orthogonal directions. The range of values of the parameters is subject to physical constraint. The behaviour of the parameters during the search for the 'best –fit' serves as the sensitivity analysis for the catchment model. Values of parameters and the model performance are printed out for assessment.

2.4 Scenario based Climate analysis

The simulated flow for KYB and historical record for the Borno and Ebeji sub-systems were stratified into normal, dry, extra-dry, wet and extra-wet years using normalised flow index. The characteristics of each flow pattern were expressed in terms of mean flow, standard deviation and coefficient of variation. Water balance analysis based on the current water demand and projected demand in the 2030 and 2050 was carried out on weekly basis. The reliability of the system during the five climatic scenario was evaluated. Reliability is a measure of the frequency of failures to meet the monthly water requirements.

PHYSICAL CHARACTERISTICS OF THE BASIN 3

3.1 General Information

The Lake Chad Basin, which is the largest area of inland drainage basin in Africa, is situated in West/Central Africa region between 6° to 24° N and 8° to 24° E (Fig. 3.1). It comprises a vast expanse of land made up of several catchments that feed Lake Chad. The entire geographical basin covers an area of 2,434,000 km^2 (UNEP, 2004). This is about 8% of the surface area of the African continent, shared between the countries of Algeria, Cameroon, Central African Republic (CAR), Chad, Libya, Niger, Nigeria and Sudan. The drainage area of LCB in Nigeria comprises the Komadugu Yobe Basin (KYB), Borno drainage area and Ebeji/El-Beid drainage area. The Komadugu-Yobe basin is the third largest river system in the Conventional Lake Chad Basin and has a catchment in northeast of Nigeria and south of Niger Republic. The KYB covers an area of 148,000 km^2, 57% of which lies in north eastern Nigeria and the rest in south eastern Niger. It represents approximately 35 percent of the conventional basin of Lake Chad. The Nigerian sector of KYB accounts for 95% of the basin's total contribution to the lake. The portion of the KYB in Nigeria consists of area lying in Kano, Jigawa, Yobe, Borno, and parts of Bauchi, Plateau and Katsina States. The Kano/Hadejia and Jama'are Rivers rise from Jos Plateau. The former flows north-east, while the latter flows in the north-easterly direction, until the two systems meet in an extensive floodplain (Hadejia-Nguru Wetlands) west of Gashua. Here the system is known as the Yobe River. Further, 100 kilometres east at Damasak (between Geidam and Gashagar), it joins the Komadugu-Gana River whose headwaters is in Bauchi plains and then finally flows into Lake Chad. The Komadugu-Yobe river system is estimated to contribute only about 1% of the total annual flow into the Lake (LCBC, 1992 and IUCN, 2006).

The climate is tropical and determined by the movement of the ITCZ north and south of the equator. The rainy season falls between May (or June) and October. Annual rainfall varies from 1,000 mm around Jos Plateau, to 500 mm in Nguru wetlands, decreasing to less than 300 mm near Lake Chad. The average rainfall may occur in only 3-4 short bursts, with common max intensity of 33-67mm in 24 hours. The basin lies largely within the Sudan Savannah agro-ecological region of West Africa. Its uplands are in the Northern Guinea zone while its floodplains in the north, mark the beginning of the Sahel. The Climate of the region is governed primarily by the interaction of two major air masses, the Tropical Maritime (TM) and the Tropical Continental (TC), which meet along the Inter-Tropical Convergence Zone (ITCZ). Warm and moist TM air moves inland in a general southwest to northeast direction from the Gulf of Guinea. Warm and dry TC air moves southwest from the desert and rises over

the TM air, which assumes a wedge shape increasing in thickness towards the southwest.

The rainfall at any location in West Africa depends on the relative movement of the ITCZ. In general, the thicker the mass of the TM air, the greater the rainfall. The seasonal migration of the ITCZ results in a decrease in mean annual rainfall from the southwest to the northeast and gives rise to two distinct seasons. The length of time that the TM air remains at any location determines the length of the rainy season of that location. The TC air mass is associated with the dry season, during which rainfall is extremely scarce.

The ITCZ contact with the ground arrives from the southwest in April or May and passes back over the basin in September or October. During these transitional months the wedge of humid air is too thin for convective rain but line squalls are common providing intense, localized rainfall of short duration. For agricultural requirements, this type of rainfall is unreliable, because the ITCZ may either become stationary or oscillate before moving on.

From June through September, the humid air mass is usually thick enough for convective rain, with the highest concentration generally occurring in August. The months of November to March are almost totally dry throughout the basin and river flows are essentially zero by the end of March. During this period, the TC air mass overlies the basin and winds, locally known as "Harmattan", laden with fine dust, are frequent. Variations in rainfall and evaporation also exist from the upland to the lowland areas of the basin which generally trends southwest – northeast.

The highly seasonal nature of the rainfall is a result of the annual migration of the Inter-Tropical Convergence Zone. Notable trends within the annual rainfall series have been a feature over the last 50 years, with periods of significantly below average rainfall occurring in both the early 1970s and particularly the 1980s.

3.1.1 Hadejia Sub-basin

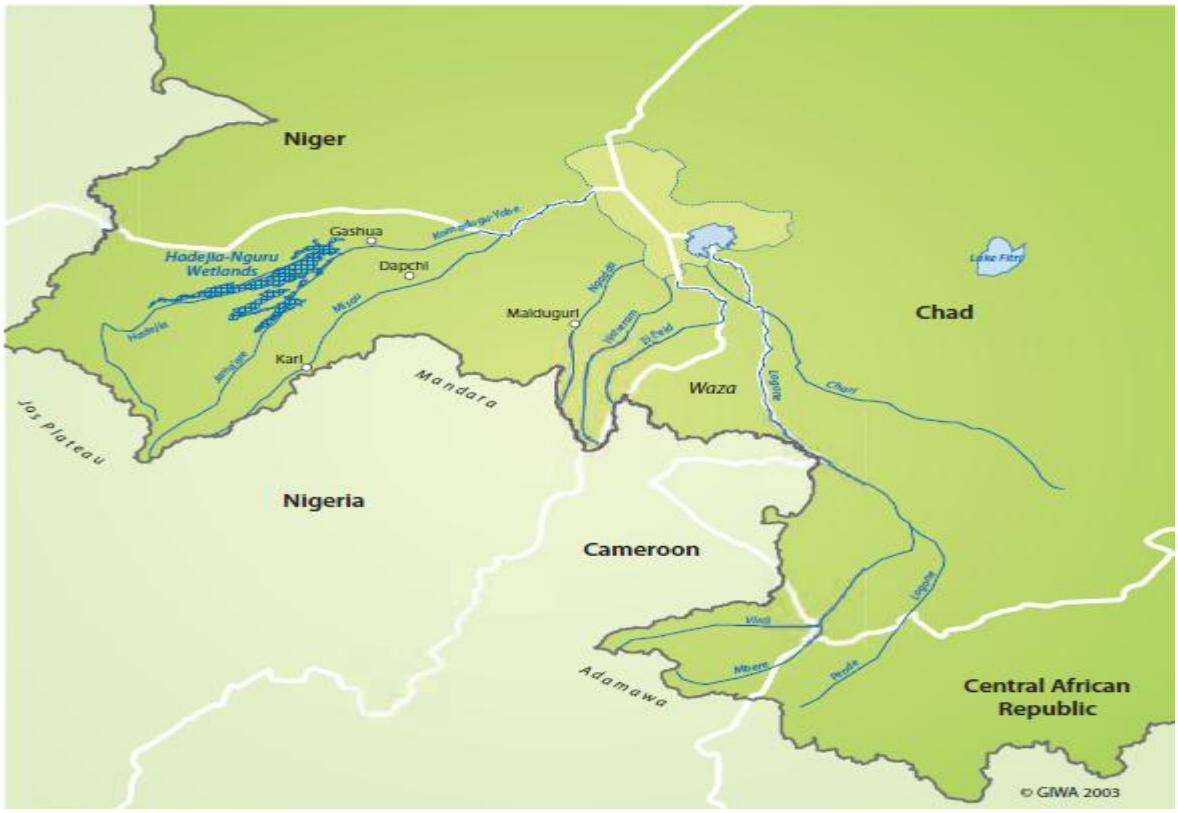
River Hadejia is formed by the confluence of the Challawa and Kano Rivers at Tamburawa (Figure 3.2). For the first 50 km of its course the Hadejia River never maintains a gradient of 2.5 m per km. As it enters the Lake Chad Formation below Wudil (coinciding roughly with the Kano-Kari highway), this gradient reduces abruptly resulting in the channel becomes poorly defined and characterized by numerous oxbow lakes. The hydraulic capacity of the river channel is insufficient to contain flood flows. Portions of the flood flows leave the main river channel and spread out through distributaries to inundate vast areas to varying depths and to raise the water levels in perennial oxbow lakes.

The third main river in the upstream part of the Hadejia sub-basin is the Watari River. This river joins River Hadejia upstream of Wudil. The Hadejia River is a gaining river until the geological boundary between the Basement Complex and the Chad Formation. The upstream Basement Complex region is hilly (with peaks of up to 1,200 m). In the

upstream area, from 1980 onwards, there has been a tendency for the tree-dominated savannah to be replaced by land-use for rainfed agriculture and grazing (Afremedev, 1999). The middle and downstream parts are, except for some ancient sand dunes, relatively flat.

The Challawa River forms the most northerly sub-catchment of the headwaters. Compared to the southern headwater catchments, the area is relatively flat. Deep sandy soils dominate with a tendency for the soils to form crusts (Geomatics International, 1998). The catchment area at Challawa Gorge is 3,860 km^2 and the average annual rainfall (1928 to 2001) is 931 mm. Most of the natural grass dominated scrub has been altered by man with various forms of rainfed agriculture and grazing dominating. Since the 1970s, there appears to have been a significant increase in denuded and gullied areas.

Figure 3.1: Major rivers of the LCB



The Kano River catchment lies in the south of Kano City. The watershed lies in the foothills of the Jos Plateau. The land use is dominated by a mixture of intensive and extensive agriculture practice, with remnants of natural vegetation occurring in the south. However over the last 20 years there has been a tendency for the tree dominated savannah to be replaced by forms of rainfed agriculture and grazing. The catchment area at Tiga Rapid is 6,975 km^2 and the average annual catchment rainfall from is 1,063 mm.

The Hadejia River system is more than 80% controlled by both the Tiga Dam (closed in 1974) on the Kano River and the Challawa Gorge Dam (closed 1992) on the Challawa River (IUCN, 1998). These dams feed two large, partly finished, formal irrigation schemes (Kano River Irrigation Project – KRIP, and the Hadejia Valley Irrigation Project – HVIP) near Kano and Hadejia respectively. Both also contribute to the Kano City Water Supply. The Jama'are River system is presently uncontrolled but plans do exist to build a dam at Kafin Zaki. Plans are already being considered for building a structure at the upstream end of the Nguru Wetlands to control the destination of the wetland's flow. This is known as the Likori split flow proportioning structure.

3.1.2 Jama'are Sub-basin

River Jama'are rises from Jos Plateau and flows through Fogo, Bunga and Katagum to join River Hadejia system at Gashua within the HNWs. The cathment area of the Jama'are River system is 7,980 km^2 at Bunga and 15,000 km^2 at Katagum. The soils tend to be sandy though shallower than those in the rest of the sub-catchments (Geomatics International, 1998). Hilly areas with significant areas of bare rock are common. The catchment area within Bunga retained more of its natural vegetation cover than the headwater sub-catchments of Hadejia. However over the last 20 years there has been a tendency for the tree dominated savannah to be replaced by forms of rainfed agriculture and grazing. The mean annual rainfall is 1,239 mm.

The flow in the Jama'are River is ephemeral (June to October) because there are no major dams in this sub-basin. The river is a gaining river until the geological boundary between the Basement Complex and the Chad Formation. In the Basement Complex area the soils tend to be sandy though shallower than those in the Hadejia sub-basin. The upstream Basement Complex region is hilly (up to 1,700 m) with significant areas of bare rock. This implies that the river flow in the upstream part of the basin responds relatively fast to rainfall. Furthermore, the Basement Complex area has retained more of its natural vegetation than in the Hadejia sub-basin (Afremedev, 1999). Downstream of Katagum in the flat HNWs, the Jama'are River splits into a number of smaller channels. *Typha domingenis* and other weeds did not invade the channels of the uncontrolled ephemeral Jama'are River. The weeds cannot survive in this river because of a lack of water during the dry season and the high wet season peak flows that flush the main channels clean.

3.1.3 Komadugu Gana Sub-basin

The period of predominant flow in the Komadugu Gana is June to October at Kari and August to December further downstream at Dapchi. The river is a gaining river until the geological boundary between the Basement Complex and the Chad Formation. The river flow reductions are, compared to the Jama'are and Hadejia rivers, relatively large. On average (1970-1977) the river flow reduction between Kari and Dapchi is 73%. The river forms a wide floodplain downstream of Dapchi. The confluence of the Komadugu Gana and Komadugu Yobe is largely silted up. This river, thus, provides only a small and unreliable contribution to the Yobe River. In almost all the studies on the KYB, this river is neglected.

3.1.4 Yobe Sub-basin

The Yobe River is situated in a very flat ancient alluvial plain overlying the lake sediments of the Lake Chad formation. Approximately 43% of the water that flows into the HNWs flows into the Yobe River at Gashua. Due to the weed and silt blockages the contribution from the Hadejia to the Yobe River has been practically nil since at least the early 1990s. NEAZDP and YSADP reported a slight increase in the contribution from the Hadejia to the Yobe River due to the clearing of weeds and silts in a part of the Burum Gana River. The clearing was initiated by JWL Project in the 2004/2005 dry season. If the Gashua annual discharge is taken as 100% then roughly 70% arrives at Geidam, 45% at Damasak and 28% at Yau (IUCN, 1999). The period of predominant flow is June to October at Gashua and August to January at the downstream end (Yau). The Yobe River ends in the northern pool of Lake Chad and is the only river flowing into the northern pool. The present contribution into the Lake Chad area is estimated at less than 2% of the total input.

3.1.5 The Borno Drainages sub-system

The sub-system (comprising the Yedseram, the Ngadda/Alau and the Gubio Rivers) is a featureless plain for the most part, that slopes gently east and northeast towards the Lake Chad. Except for a relatively short period during the rainy season, most of the seasonal flow from the rivers in the sub-system end up in the marshy areas on the plain, from where it disappears by infiltration and evapotranspiration before reaching Lake Chad. This phenomenon is even more prominent between the Ngadda and Komadugu Yobe sub-system, representing the Gubio catchment of 26,560km^2. It has no distinct drainage pattern and resembles a relic of shallow lake depression, where water collects, infiltrates and evaporates. This, in part, explains the over-reliance on groundwater for the urban and rural water supply and even small-scale irrigation in this area than in other parts of the system/basin.

The Yedseram river, also called the Mbuli river in its lower reach, rises east of Mubi from Mandara Hills of northern Cameroon along with its upper tributaries such as the Vintim and the Delirium, flowing northwards through a 7 km wide flood plain, where it loses much of its water. Further downstream, an 80 km^2 swamp is formed at Bama ridge. Northward there from at about 30km west of Bama, south of the Gombole Forest Reserve, Yedseram is joined by the Ngadda River (FAO, 1997). The rivers converge into a large Sambissa swamp covering about 130 km^2 through which the main water courses are ill-defined. Leaving the swamp, the Yedseram turns eastward and cuts through the Bama ridge. On the other hand, the Ngadda River flows to the north from Sambissa swamp and meets the Bama ridge south of Konduga, where it fills the seasonal Lake Yare. From there it flows parallel to the ridge into Lake Alau from where it flows to Maiduguri along the Maiduguri-Bama Road. It continues until it eventually breaks through the extensive sand dunes at Maiduguri, and is dispersed in the low flow zone of the Lake Chad bed. After the ridge, no distinct watercourse exists downstream of the swamp. Rather, the rivers keep changing courses very often around discontinuous higher elevations, where evapotranspiration losses are extremely

high. Neither Yedseram nor Ngadda River System is perennial, during the periodic high water-flow; the rivers often flood the adjacent plains and depressions that are underlain by clayey soil.

Upstream of Maiduguri, the Ngadda River passes through two shallow but perennial Lakes Yare and Alau. At high water, Lakes Yare and Alau cover up to 26 km^2 and 6.5 km^2 respectively. Ngadda River enters Lake Yare and is drained through twin channels one of which flows into Lake Alau. The outlet of Lake Alau subsequently joins the other channel from Lake Yare about 19 km from Maiduguri. The Ngadda system contains the Alau Dam 162 MCM reservoir, which is located 23 km southeast of Maiduguri. The construction of the dam has significantly affected the flow of Ngadda River downstream of the dam. Prior to the construction of the dam, Unimaid (2005) reported that the river used to flow for almost six months from July to December with annual mean total runoff of about 300 MCM, whereas the current flow lasts for just about a month. It was estimated that the flow in 2001 was 30 MCM, representing about 10% of the flows before the dam was constructed.

3.1.6 Ebeji/El-Beid sub-system

Ebeji River is by far the largest of the rivers draining into the Lake Chad from Nigeria, with the total yearly runoff at Gamboru Bridge Station, Borno State (a few kilometres from Lake Chad) as 647.8 MCM. Although it discharges into Lake Chad through Borno, the bulk of its water shade lies in Cameroon. Compared to other water courses in the sub-basin, this sub-system has the highest monthly peak discharge, the greatest runoff volume and the longest duration of discharge. This may be attributed to the fact that most of its catchment area extends into the wetter Republic of Cameroon, where the river is called El-Beid. The lower reaches has moved progressively to the west, which has led to wide stretch of channels along the western courses, which fan out in the north before entering Lake Chad as a delta (Unimaid, 2005). On the way to Lake Chad, there are two irrigation projects at Gamboru and Ngala with total area of 1,200 hectares that are fed by water pumped from the Ebeji River. The assessment of water resources potential of this sub-system is limited by the TOR, which does not cover collation of hydro-meteorological data from the Republic of Cameroun.

About 57% of the Komadugu Yobe catchment lies in Nigeria, and the sector contributes 95% of the water resources of the sub-basin. Four sub-basins are identified in the Nigerian sector of the KYB. These are: Hadejia, Jama'are, Gana and Yobe sub-basins. The catchment area of Hadejia is 16,380 km^2, while Jamaare sub-basin has an area of 7,980 km^2 and 15,000 km^2 at Bunga and Katagum, respectively. The area of Gana sub-basin is 5,865 km^2 at Kari and Yobe sub-basin has an area of 62,150 km^2 at Gashua.

El-Beid River, locally known as the Ebeji, forms part of the border between Nigeria and the Cameroon. It drains the area of approximately 22,640 km^2. This stream flows most of the year, with peak discharge in November or December. The El-Beid is by far the largest Nigerian river flowing into Lake Chad, but its water comes mostly from the Cameroon. Three main sources of water are: (1) direct runoff from the Mandara

Mountains, (2) flood overspill from the Logone River into Yaeres, and (3) relatively small overspills from the Serbewel River. The lower reach of the river has moved progressively to the west, resulting in a wide stretch of abandoned channels all following westerly courses. These channels break up in the north and enter the lake on the delta. Flow to the El-Beid from the Logone is estimated to begin when flows reach 1500m^3. The annual runoff data for the Gamboru station obtained from the Borno State Water Board in Maiduguri are as presented in Table 3.1.

Table 3.1: Annual flow at Gamboru station

Year	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77	1977/78	1978/79
Flow Mm^3	570.2	1,617.2	2,556.5	393.0	4.4	17.3	300.8	735.8	641.7	231.0	773.5

Except for a relatively short period during the rainy season, most of the seasonal rivers in Borno drainages flow into marshy areas on the plain and disappear by infiltration and evapotranspiration before reaching Lake Chad. The reliance on groundwater for the urban and rural supply and small-scale irrigation is heavier in this area than in other parts of the basin. Any adverse affect on groundwater systems arising from their exploitation is bound to have far-reaching consequences. The available record is inadequate for assessing seasonal and intra-annual variation in flow in the river.

Table 3.2: Annual Runoff Volumes on River Yedseram at Uba Bridge

Source	Annual Runoff Volume x 10^{6}m^3										Sample size	Mean	Standard Deviation
	1975 / 76	1976 / 77	1977 / 78	1978 / 79	1979 / 80	1980 / 81	1981 / 82	1982 / 83	1983 / 84	1984 / 85			
Diyam (1990)	-	214	225	476	204	481	212	230	85	56	9	242.6	147.8
TCIA (1987)	407.4	209.3	225.7	475.5	209.3	161.4	211.6	231.9	172	200.3	10	250.4	104.2

Source: Diyam Consultants (1990)

The Yedseram River, which is called the Mbuli River in its lower reaches, has a catchment area of 16,320 km² (FAO, 1972). The source of the river is in the Mandara Mountains, about 250 km south of Lake Chad. Numerous tributaries fall rapidly from this mountain range into the piedmont flats before flowing westerly to meet the main Yedseram River. The piedmont flats which range in altitude from 400 to 800 m cover up to 2,300 km^2 of the upper catchment. The main river cuts here through about a 6 km wide flood plain of recent alluvial deposits, and much of flood flow seems to be lost through infiltration and evaporation in this region. Below Yaza, recent quaternary lagoon deposits underlie the catchment (MacDonald, 1973). About 30 km west of Bama, south of the Gombole Forest Reserve, the Yedseram is joined by the Ngadda

River. The rivers converge in a large Sambissa swamp covering about 130 km^2, through which the main water courses are ill-defined. Leaving the swamp, the Yedseram turns eastward and cuts through the Bama Ridge. Below Bama, the river follows an indistinct course through many lowland swamps where evapotranspiration losses are extremely high. North of Dikwa the river breaks up into a series of braided channels which flow across the plain. Near Ngala the river channel again becomes more visible, it crosses the Maidiguri-Gambaru road at Mbuli Bridge and finally empties into Lake Chad about 20 km downstream. Table 3.2 summarises the annual flow of River Yedseram at Uba.

About 4,800 of about 15,540 km^2 area of Lake Chad lies in Nigeria (LCBC, 2006). The Lake is shallow, with depth of between 1.5-5.0 m, and possesses no outlet. It is therefore very sensitive to changes in level due to fluctuations in inflow and losses. Surprisingly, the water in the lake is fresh with the electric conductivity of 180, salinity of 0.165 milligram and a pH of 8.0 to 8.5 in spite of inflow of 10 - 20 x 10^3 tons of TDS. The Chari, Logone and El-Beid/Ebeji provide more than 95% of the Lake's entire intake. Although, Komadugu-Yobe River is the third largest river in the basin, it contributes only about 1% to the lake inflow, with its most significant contribution being probably to groundwater stock. The other two2 rivers, Yedseram and the Ngadda, also discharge small volume of water into the Lake Chad (LCBC, 2006).

The NWRMP (1995) projected water consumption and demand by 2020 took into consideration the various water resources strategies, projects and programs proposed in the plan. It concluded that the water consumption and demand would increase from 2,730 MCM in 1995 to 24,140 MCM (approximately nine fold increase) by 2020. This would probably be much higher than this because the projected population were conservative as the figures have almost been reached by 2006. It further projected that only a national average of about 8 per cent of both the potential surface and ground water will be consumed by 2020, with the notable exception of Lake Chad Basin where 35.6 percent of the surface water and 11 percent of the groundwater would be utilised. It is therefore significant to stress the need for greater attention to water resources monitoring and more innovative water operations of projects in this Basin.

Table 3.3: Annual runoff volume at Mandara Mountains in Yedseram catchment

Year	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77	1977/78	1978/79
Flow Mm^3	86.8	73.5	-	8.4	45.0	70.6	3.6	50.7	125.5

MacDonald (1972) reported that the annual volume of runoff from the Mandara Mountains in the upper catchment of Yedseram is in the range of 28 to 40 percent of the annual rainfall. In the Kuzzum profile (about 20 km downstream from the Uba Bridge), it was estimated in the wet years of 1965, 1966 and 1967 to be 306, 300 and 406 x 10^6 m^3, respectively. In the same years, the annual runoff recorded at the Mbuli

Bridge was reported to be 94.3, 79.5, and 157 x 10^6 m^3 respectively. This indicates that considerable losses occur directly from the river channel and over the flood plain, between the Kuzzum profile and the Mbuli Bridge. More recent annual runoff data for Mbuli Bridge, obtained from the Borno State Water Board (Table 3.3).

The Ngadda River has a catchment area of 14,400 km² (FAO, 1972). From the Sambissa swamp it flows to the north and meets the Bama Ridge south of Konduga. There it fills the seasonal Lake Yare. From there on it flows parallel to the ridge into Lake Alau, which can reach a size of 700 ha in years of high rainfall. From Lake Alau it flows to Maidiguri along the Maidiguri-Bama Road, until it eventually breaks through the extensive sand dunes at Maidiguri, and is dispersed in the low flow zone of the old Lake Chad bed. The Ngadda River does not, therefore, succeed in maintaining the definite course to the lake. Between Ngadda and Komadugu Yobe there is an area of about 27,000 km² around Gubio, which has no distinct drainage pattern. The ground slope towards the lake is very small and surface water moves slowly toward shallow depressions from where it disappears by infiltration and evaporation (Kindler et al, 1990). Thus, the contribution of the seasonal rivers of Borno to Lake Chad (excluding El-Beid and Komadugu Yobe), are negligible in comparison with the total lake inflow.

3.2 Monitoring Hydro-meteorological data

The meteorological stations within and around the basin are operated by agencies such as Nigerian Meteorological Services Agency (NIMET), state ministries (Kano, Jigawa, Yobe, Borno, Bauchi, Plateau and Kaduna) of Agriculture, River Basin Development Authorities, Lake Chad Research Institute (LCRI) and various other institutions. Recently, the HJKYBTF have installed some hydromet monitoring stations in the Basin. Overall, water assessment and in particular, monitoring the network has become more and more inconsistent. The data remains the property of the agencies using them for their various projects. The quality of rainfall data were ascertained using double mass curve method, while gaps were filled using normal ratio method.

There are synoptic and agricultural stations within and around the project area. Table 3.4 is a summary of organisation responsible for meteorological data while Table 3.5 shows rainfall data collated for this study. The available data from some of the stations are short length record, making them inadequate for hydrological modelling. The stations with adequate rainfall data for the study are:- Kano Airport, Kano IAR station, Samaru, Zaria, Jos and Bauchi. Only Kano Airport and Kano IAR station lie within the basin. There were no published data on Yedseram, Ngadda and Ebeji sub-systems, since in its headwater is Cameroun. Other meteorological data (relative humidity, temperature and evaporation) have been collected from synoptic stations relevant to the study. These include:

- Monthly relative humidity: IAR Kano (1974 – 2004), Bauchi (2000 – 2003)
- Monthly minimum and maximum temperature: IAR Kano (1974 – 2004), Bauchi (2000 – 2003)
- Pan evaporation: IAR Kano (1974 – 2004), Bauchi (2000 – 2003)

Table 3.4: Overview of organisation responsible for meteorological data

No.	Organisation	Activities
1	Nigerian Meteorological Agency	Synoptic meteorological stations (for rainfall and evaporation) in or near the basin: Nguru, Maiduguri, Potiskum, Kano, Jos, Zaria and Bauchi (the last two stations are just outside the basin). The data can be bought for a relatively high price.
2	Borno State Water Corporation	Monitor stage levels at Damasak from 1987 to 2004. The data are available with the FMWR-IUCN-NCF-KYBP.
3	KSMWR	Monitor the stage levels at Tiga Dam, Chiromawa (Kano River), Tomas Dam, Kafin Chiri Dam and at Wudil.
4	BaSADP	nine meteorological stations (rainfall, evaporation, etc.) within the whole of Bauchi State
5	Jigawa State ADP	collects meteorological data for 21 stations within their state
6	HJRBDA and KSMWR	meteorological stations at three large reservoirs in the basin (Tiga Dam, Challawa Dam and Hadejia Barrage).
7	NEAZDP	meteorological station (rainfall, evaporation, wind, temperature, humidity, etc.) within their compound at Garin Alkali. In addition, they run 17 meteorological stations in their project area (the northern part of Yobe State).
8	KSMWR	15 meteorological stations within Kano State. Many of the stations are at the sites of their small dams.

Data quality analysis was carried out using double mass analysis technique. The quality of rainfall data at Kano from 1996 is not consistent with the pre-1995 record (Fig. 3.2). The quality of rainfall data from Samaru, Jos, Bauchi, Nguru, Maiduguri and Potiskum were found to be consistent and adequate for climate analysis. The short length record at Tiga, Challawa Gorge were also used for comparative analysis.

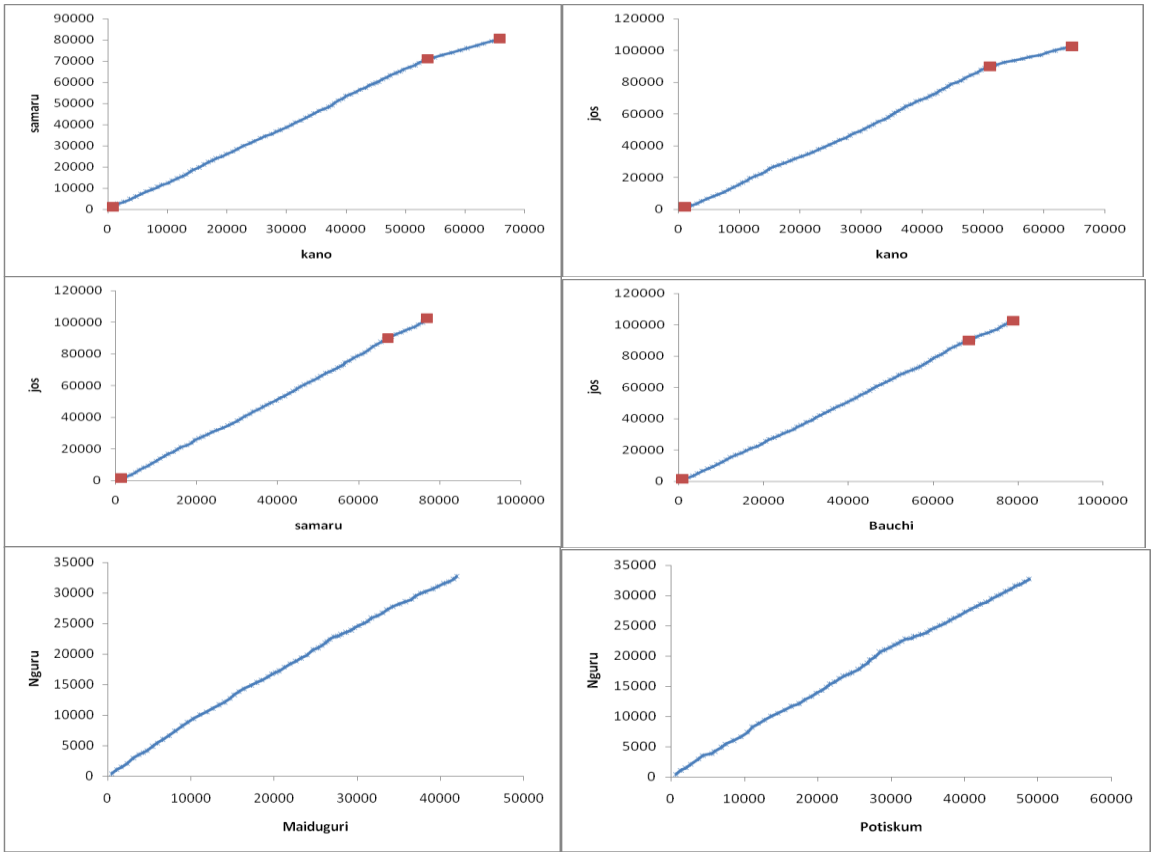
Table 3.5: Summary of Rainfall Data collated

Station	Monthly record	Daily record
Dapchi	1992 – 2004	
Geidam	1992 – 2004	
Potiskum	1936 – 2010	
Nguru	1942 – 2010	
Bauchi	1906 – 2009	**1972 – 2009**
Kano airport	1905 – 2010	**1916 – 2010**
Kano – IAR	1974 – 2005	**1974 – 2005**
Zaria	1943 – 1994	
Jos	1922 – 2009	**1972 – 2009**
Maiduguri	1909 – 2010	
Samaru	1928 – 2010	**1928 - 2010**
Yola	1931 – 1997	

River gauging stations were installed between 1960s and 1970s to monitor the river flow by USAID during the pre-feasibility studies of the KYB and by WRECA who constructed Tiga dam. Other agencies involved in hydro-climatic data monitoring are: WRECA, HJRBDA, HNWCP, NEAZDP, CBDA, BaSADP, BSMOA, YSADP, JSMWR, YSADP, YSMWR, JSADP and KSMWR, HJKY-TF among others. Inadequate resources appropriated for the purpose have weakened all these, with the possible exception of HJKYTF. Another source would have been the National Inland Waterways Authority but curiously they do not operate any river gauging station in the basin. Organisations that have some gauging station monitoring river flow are summarised in Table 3.6 while records available for this study are summarised in Table 3.7. Figure 3.3 shows the status of stations with river flow data in the KYB sector of the basin. The rating curves

for Hadejia and Likori are presented in Figures 3.4 and 3.5 respectively, while the rating curve for Wudil is summarised in Table 3.8. The rating curve during the 2005/2006 (KYBP, 2006) differ significantly from the curves in 1970s and 1980s. This might be attributed to changes in river morphology.

Figure 3.2: Double mass curve for rainfall records



The following limitations were observed in the river data collated from the various agencies:-

- Not many gaugings have been taken at high water levels; this makes the rating curve at higher discharges less precise.
- The water levels are daily averages or once a day reading so the actual peak flow within a day may be slightly higher.
- The number of river gaugings and their quality are not sufficient to take into account possible effects such as hysteresis or, for Likori, backwater from the Nguru Lake in estimating the discharge.
- The peak flow at Hadejia Bridge in September 2001, the year with the highest peak flows since at least 1964, may have been higher than estimated because some surface water bypassed the bridge on the eastern side as overland flow and via the overflowing drainage canal from the HVIP. Furthermore, the Hadejia peak flows would have been higher if the Kafin Hausa River had not been excavated in March 2001.

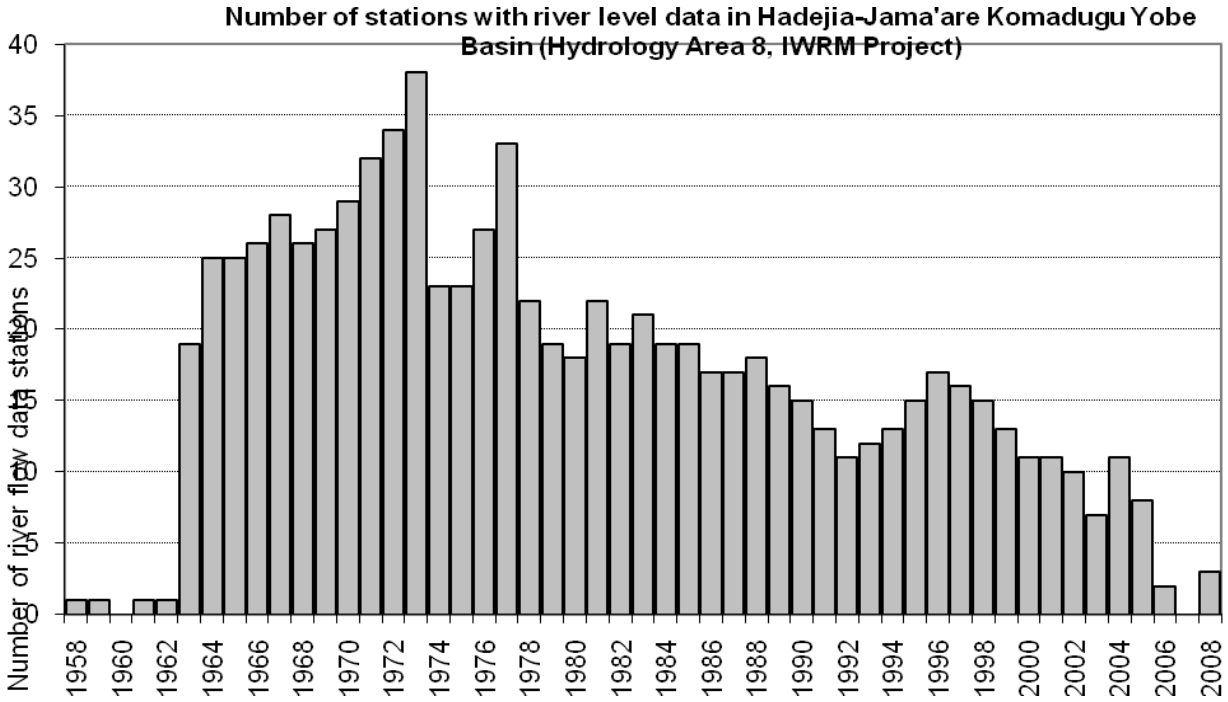
Table 3.6: Organisations monitoring river flow in LCB

No.	Organisation	Activities
1	FMWR	Automatic stage level recorders (installed in 2001) near Chiromawa Bridge (on Kano River downstream of Tiga and Bagauda dams) and Auyo Bridge (on Hadejia River upstream of Hadejia), and in 2005 installed automatic stage level recorders at Dabi (Hadejia River downstream of Wudil) and Jorda
2	HJRBDA	Automatic stage level recorders installed downstream of Tiga Dam (Kura-Karaye Bridge), at Wudil downstream of Challawa Dam, and at Kafin Hausa and Hadejia. The HJRBDA have daily data on reservoir levels and rough outflow rates (based on the characteristics of the release structures) for the Tiga Dam, Challawa Gorge Dam and Hadejia Barrage. The HJRBDA also monitors the inflow into KRIP. The amount of water coming from the spillways is however not currently monitored.
3	JSMWR	Stageboard readers at sites on: the Hadejia River (Dabi, Suntulmawa-Ringim, Nahuche, Marke, Haidin, and Hadejia), the Kafin Hausa River (Kafin Hausa), the Marma Channel (Likori), a small river near Kazaure (Jekarada) and a tributary to the Jama'are River (Iggi). The water level data for these are available with the FMWR-IUCN-NCF-KYBP.
4	NEAZDP	Daily stageboard readers (since late 1990s) on the Yobe River (Gashua and Geidam) and on the Komadugu Gana (Gada near Dapchi).
5	JWL Project	Monitor (once a month in the dry season and twice a month in the wet season) on the Hadejia River (at Hadejia), Marma Channel (at Likori) and Burum Gana River (at Guri and Wachakal) since June 2004.
6	Borno State Water Corporation	Monitor stage levels at Damasak from 1987 to date.
7	KSMWR	Monitor the stage levels at Tiga Dam, Chiromawa (Kano River), Tomas Dam, Kafin Chiri Dam and at Wudil.

Table 3.7: Summary of Discharge Record in the Basin

Type of data	Discharge Record	Daily Gauge Height Record
Challawa George	**1971 – 1992**	
Challawa Bridge	**1964 – 1992**	
Chiromawa	**1963 – 1992**	
Wudil	**1963 – 1992**	**Apr. 1981 – Feb. 1982, Apr. 1983 – Oct. 1991 (Mar. – May 1989 missing), Apr. 1999 – Dec. 1999, Apr. 2001 – Oct. 2001, Jun. 2004 – Jan. 2005**
Gaya River at Chai	**1964 – 1991**	
Hadejia Bridge	**1963 – 1996**	**2002 – 2003 , Sept. 2005**
Kafin Hausa	**1973 – 1996**	**Apr. 1998 – Oct. 2001 with some missing months, Sept. – Oct. 2005**
Marma Channel at Likori	**1973 – 1997**	**Oct. 1991 – June 2002 with some missing months, Apr. – July 2004**
Bunga	**1964 – 1996**	
Katagum	**1975 - 1996**	
Gashua	**1963 – 1996**	
Bagara Diffa	**1968 – 1991**	
Likori	**1992 – 1996**	
Kasaga	**1994 – 1997**	
Gabarau	**1994 – 1996**	**1992 – 1997, Oct 1999 – Apr. 2002 (with some missing months)**
Nahuche (Jigawa State)		**1993 – Mar 1998**
Jekarade		**July 1992 – Sep. 1998, Dec. 1998 – Feb. 2003**
Suntulmawa		**Dec. 2004 – Jan. 2005**
Alau dam	**1995**	**Jan – June, Sept – Dec missing**
	1996	**Sept. and Oct missing**
	1997, 1998,	**Sept 1998 missing**
Ebeji at Gamboru	**1980, 1983**	**Rating curve only**
Ebeji at pumping house	**1980**	**Aug –Oct missing**

Figure 3.3: Number of stations with river level data



Source: IWRM Project, 2006

Figure 3.4: Rating curve for Hadejia (IWRMP, 2006)

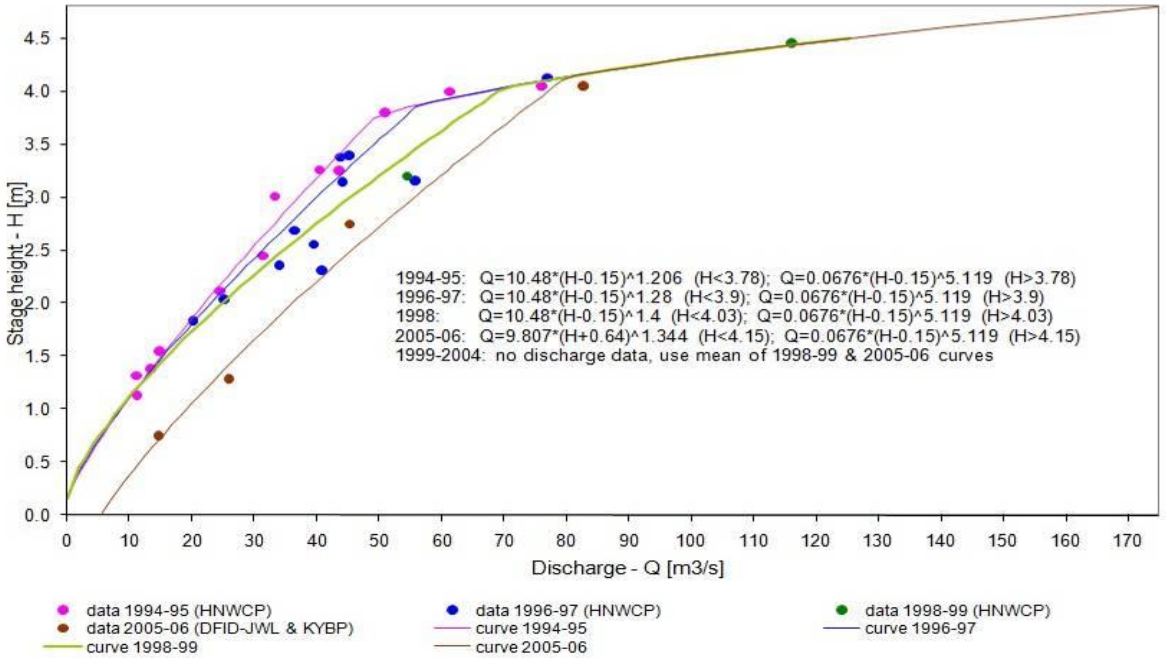


Figure 3.5: Rating curve for Likori (IWRMP, 2006

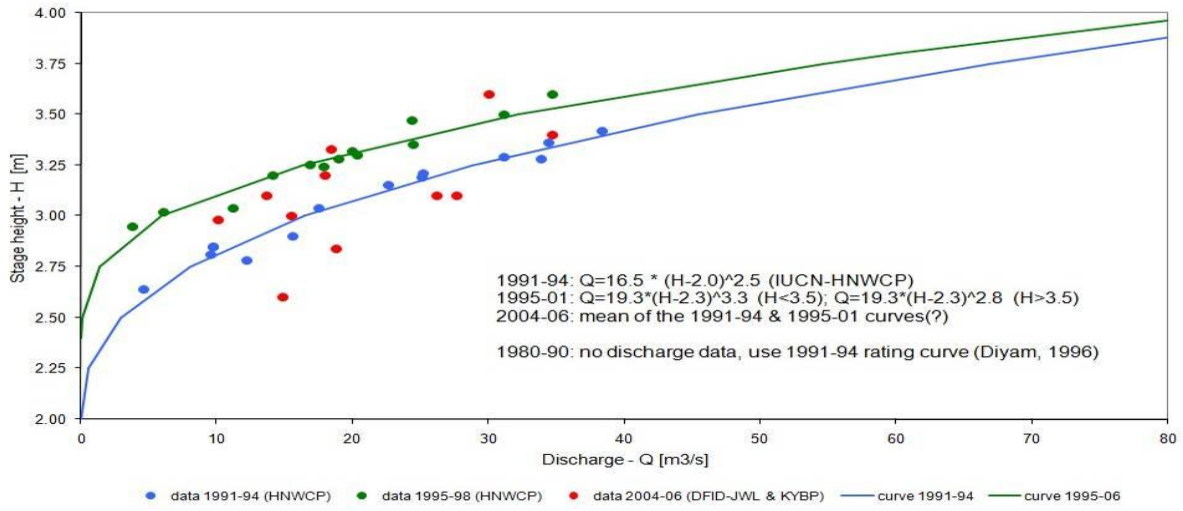


Table 3.8: Equation for rating curve in Wudil

Period of Applicability	Unit	Stage range	Equation 1	Stage range	Equation 2	Stage range	Equation 3
Source: WRECA/	DIYAM						
1963/64-1964/65	Ft	<0.5	$0.31*H^{0.65}$	>0.5	$230*(H-0.5)^{2.05}$		
1965/66-1966/67	Ft	>0.5	$0.31*H^{0.65}$	1.5-7.6	$152*(H-0.5)^{2.26}$	>7.6	$230*(H-0.5)^{2.05}$
1967/68	Ft	0.5-2.5	$4.8*H^{4.76}$	2.5-6.1	$76*(H-0.7)^{2.76}$	>6.1	$230*(H-0.5)^{2.05}$
1968/69-1969/70	Ft	<7.5	$5*H^{3.81}$	>7.5	$240*(H-0.8)^{2.02}$		
1970/71-1972/73	Ft			>0.8	$240*(H-0.8)^{2.02}$		
1973/74	M	0.26-0.446	$85*(H-0.26)^{3.7}$	0.446-0.935	$17*(H-0.02)^{5.41}$	>0.935	$38*(H-0.3)^{2.83}$
1974/75-June 1976	M	0.37-1.5	$41.4*(H-0.37)^{2.47}$	>1.5	$156*(H-1)^{1.48}$		
July 1976-1979/80	M	0.1-1.52	$9*(H-0.1)^{5.38}$	>1.52	$156*(H-1)^{1.48}$		
1980/81-Nov 1981	M	0.4-2.17	$9*(H-0.4)^{5.38}$	>2.17	$156*(H-1)^{1.48}$		
Dec 1981 - Oct 1982	M	0.9-2.94	$9*(H-0.9)^{5.38}$	>2.94	$156*(H-1)^{1.48}$		
Nov 1982 - 1984/85	M	0.54-0.91	$200*(H-0.54)^{2.5}$	0.91-1.85	$66*(H-0.44)^{1.8}$	>1.85	$156*(H-1)^{1.48}$
1985/86	M	<1.85	$66*(H-0.44)^{1.8}$	>1.85	$156*(H-1)^{1.48}$		
1986/87	M	0.54-0.91	$200*(H-0.54)^{2.5}$	0.91-1.85	$66*(H-0.44)^{1.8}$	>1.85	$156*(H-1)^{1.48}$
1987/88-1989/90	M	0.37-1.5	$41.4*(H-0.37)^{2.47}$	>1.5	$156*(H-1)^{1.48}$		
Source: IUCN/KYBP							
2005/06	M	>0.81	$59.64*(H-0.81)^{1.729}$				

Source: KYBP, 2006 and IWRM, 2006

3.3 Surface Water Resources

3.3.1 Rainfall

Rainfall is a principal source of water in the basin. However, the rainfall is concentrated into a few months, regular water shortages are invariably experienced during the later part of the dry season. High rainfall, at least above the

evapotranspiration demand, is concentrated at the upstream section (Hadejia and Jama'are sub-basins). Figure 3.6 shows the rainfall trend in NIMET synoptic stations within and around the project area. Each figure shows the annual rainfall, the 1931 – 1960 average (representing the climatic mean) and the five year moving average, For Maiduguri, there was low rainfall in early 1970s and 1980s. There was low rainfall between 2007 and 2010. The pattern in Potiskum shows that the rainfall since 1970s has been below the climatic mean, except few years in 1973 and 1990. The implication is that surface water contribution to the Borno and Ebeji sub-systems have been reduced since the 1970s. The rainfall patterns in Samaru, Kano, Jos and Nguru also confirms the persistent decline in rainfall since 1970s.

Rainfall in the basin is characterized by inter-annual variation. Table 3.9 shows annual rainfall of some stations in the project area. Annual rainfall at Hadejia sub-basin varies from 700 mm and 1,200 mm, while mean annual rainfall in sub-basin varies from 800 mm to 1,200 mm. Mean annual rainfall for the Yobe sub-basin varies between 250 mm and 600 mm. There was a persistent decline in rainfall in the 1980s and the rainfall did not recover until mid-1990. The declining trend in rainfall was more pronounced in the Yobe River sub-basin than the Hadejia and Jama'are sub-basins. In addition, the declining trend commenced earlier in the sub-basin which is attributed to the southward migration of the Sahelian drought.

Table 3.9: Annual rainfall at synoptic stations in LCB

Year	Tiga	Samaru	Potiskum	Nguru	Maiduguri	KRIP	Jos	Hadejia	Challawa gorge	Bauchi
1999	615	953	747	447	844	791	1148	481	854	1400.6
2000	615	1076	594	354	677	643	1161	788	661.9	1038
2001	704	1261	777	416	728	982	1089	712	807.65	1307.4
2002	587	999	700	455	444	541	1583	420	530.9	699.1
2003	659	1154	703	481	653	884	1308	539	694.83	989.5
2004		1019	571	294	604	756	1308	343	760.5	864.8
2005			632	449	917	905	1212			1047.3
2006			649	410	554		1204			1016.3
2007			673	483	731					1064.7
2008			608	320	566		1356			1133.3
2009			679	367	583		1302			1451.3
2010			593	470	393		1188			

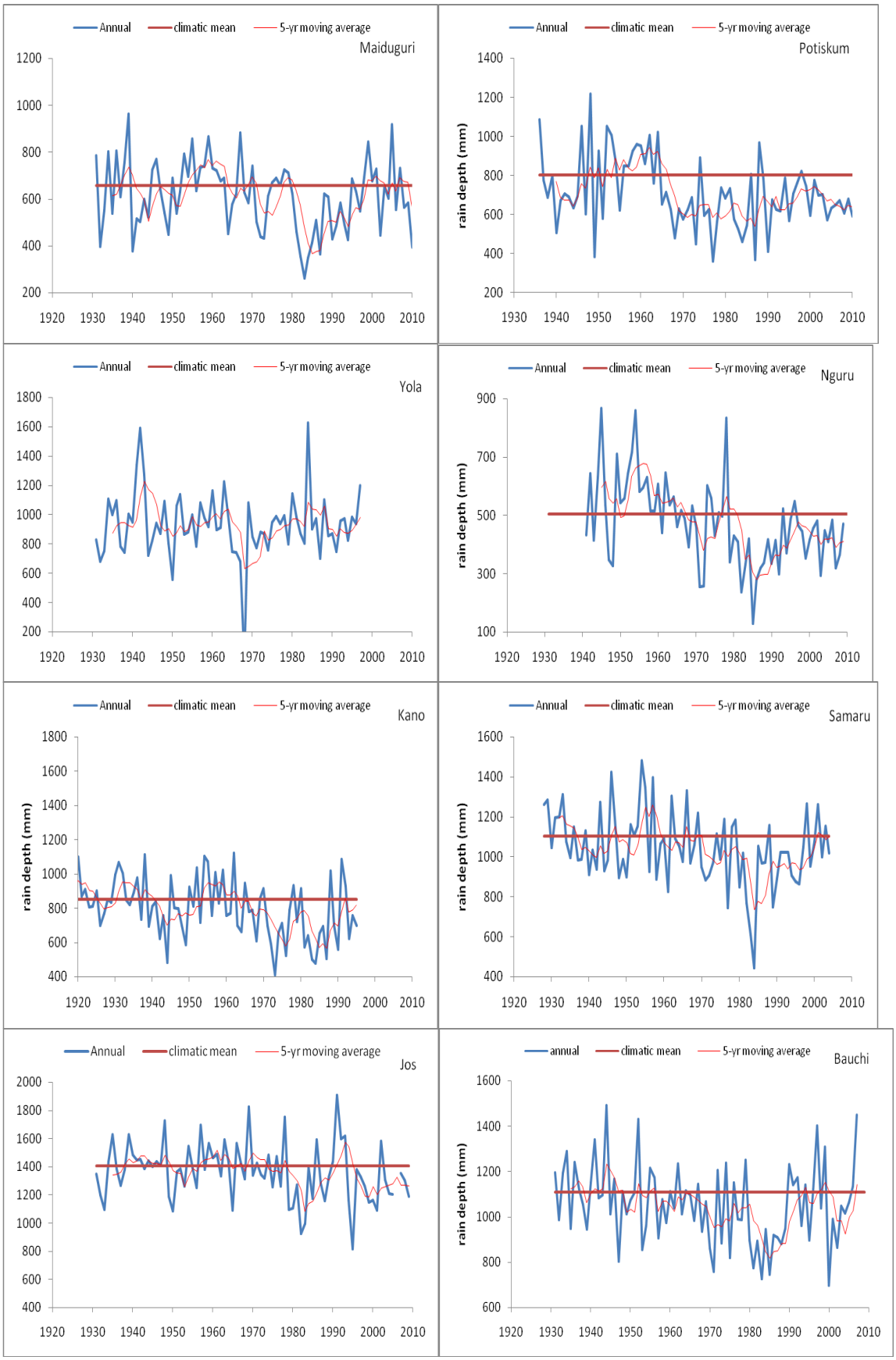
The period, 1931 to 1960, is classified as the period of climatic normal. The mean and standard deviation of the rainfall series of this period was used to standardize the rainfall series at each sub-basin. Figure 3.7 shows the standardized rainfall index of Tiga and Challawa sub-units in Hadejia sub-basin, as well as rainfall index in sub-basin. Typical characteristics of the anomalies are:-

(i) persistent low rainfall since the 1970s.

(ii) a few intermittent wet years was recorded. The index of wetness was not as high as that of dryness recorded in the basin.

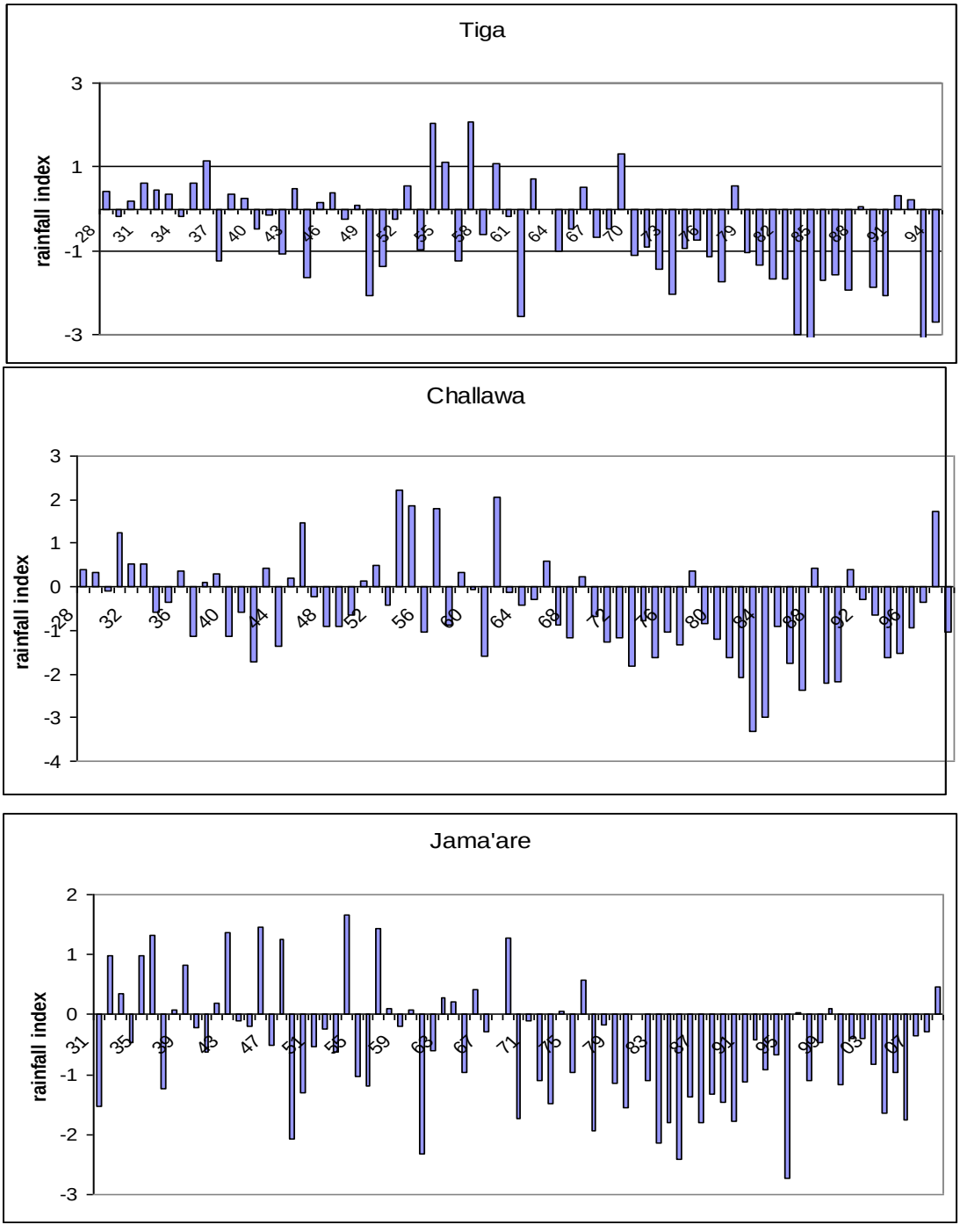
(iii) the implication of the rainfall situation is that while water demand is increasing due to increase in population, high social status and high technology; the supply is dwindling.

Figure 3.6: Rainfall trend in synoptic stations in LCB



The implication of the declining rainfall in the basin is that inflow into Tiga and Challawa Gorge reservoirs were based on high rainfall that occurred in the pre-1980s. Thus, the reservoirs would not be filled as expected during the planning stage. This observation is confirmed by the ratio of storage volume to average annual inflow of 2.5 and 1.6 for Challawa Gorge Reservoir and Tiga Reservoir respectively. Silt deposited in the useful storage zone of the reservoir gives a false impression of water stored in the reservoir, since elevation-storage and elevation-area characteristic curves of the reservoir did not account for such situation.

Figure 3.7: Normalised rainfall index of the basin



3.3.2 Streamflow

Available surface water resource was assessed based on the climate scenarios discussed earlier. The result is summarised in Table 3.10. Inter-annual variation in flow at Tiga and Challawa sub-basins as well as Jamaare sub-basin are presented in Figures 6.4, 6.5 and 6.6 respectively. The flow to the reservoirs is seasonal, occurring between May and September. Annual surface water resource in the basin varies between 868 Mm^3 and 6,258 Mm^3 per annum depending on climatic pattern. The average water potential is 3,360 Mm^3, with a coefficient of variation 1.6. On the average, Hadejia sub-basin contributes 60% (32% from Tiga area, 18% from Challawa and 12% from the unregulated area), while Jamaare sub-basin contributes 40% of the basin up to Gashua.

Table 3.10: Annual surface water potential (Mm^3) in KYB

Climate Pattern	Sub -basin					KYB
	Tiga	Challawa	Unregulated	Hadejia	Jama'are	
Very Wet	1736.8	1091.0	853.1	3680.9	2123.0	**6258.1**
Wet	1479.9	780.8	600.9	2861.6	1550.4	**4412.0**
Normal	1006.9	523.2	395.4	1925.5	1237.1	**3162.6**
Dry	761.1	307.6	219.7	1288.4	809.9	**2098.3**
Very dry	245.8	190.1	99.2	535.1	332.6	**867.7**

Based on the available records, the surface water resources of the KYB sector for pre- and post-dam era is summarised in Table 3.10. The table shows that the mean annual flow at Wudil reduced from 1,906 Mm^3 during pre-Tiga Dam to 1,264 Mm^3 during post-Tiga Dam. During the same period, the annual flow in Bunga reduced from 1,837 Mm^3 to 1,520 Mm^3. While Bunga had a 17% reduction, Wudil had 34%. If the reduction in flow at Bunga is mainly due to climatic variation, then the extra 17% reduction in Wudil could most probably be attributed to the operation of dams.

The inflow to either Tiga or Challawa Gorge is seasonal, and is represented in Fig. 3.8 and 3.9 respectively. Peak flow to each reservoir occurs between week 32 and 34, except in a very dry year when peak flow occurs two weeks earlier. Figure 3.10 shows mean streamflow at Bunga. The flow is unimodal with peak flow in week 34.

Table 3.11.: Overview of the annual surface water resources in the Komadugu Yobe Basin

River	Site	Catchment area[km^2]	Pre-Tiga Dam construction			Post-Tiga Dam construction		
			Mean annual flow		Mean annual rainfall [mm]	Mean annual flow		Mean annual rainfall [mm]
			[10^6m^3]	[mm]		[10^6m^3]	[mm]	
Hadejia	Wudil	16,380	1,906	116	1,046	1,264	61	883
Jama'are	Bunga	7,980	1,837	230	1,271	1,520	179	1,149
Gana	Kari	5,865	542	92		176	30	
Yobe	Gashua	62,150	1,118	22	570	925	15	460

The mean annual contribution of Komadugu Yobe to Lake Chad has been evaluated by FAO in 1972 as 450 x 10^6 m^3. In the critical drv years of 1973 and 1974, annual inflow to the Lake was 270.07 and 237.90 x 10^6 m^3 respectively (measured in the Yau profile). The swamp is estimated to have a surface area of 30km^2, and exerts

considerable routing effects on the runoff from the upstream catchments. In view of the hot climate of the area, a larger proportion of the inflow into the swamp is lost through evaporation and seepage. It was estimated that 487 Mm3 of water is lost per annum (TCIA, 1988).

Figure 3.8: Inflow to Tiga Reservoir

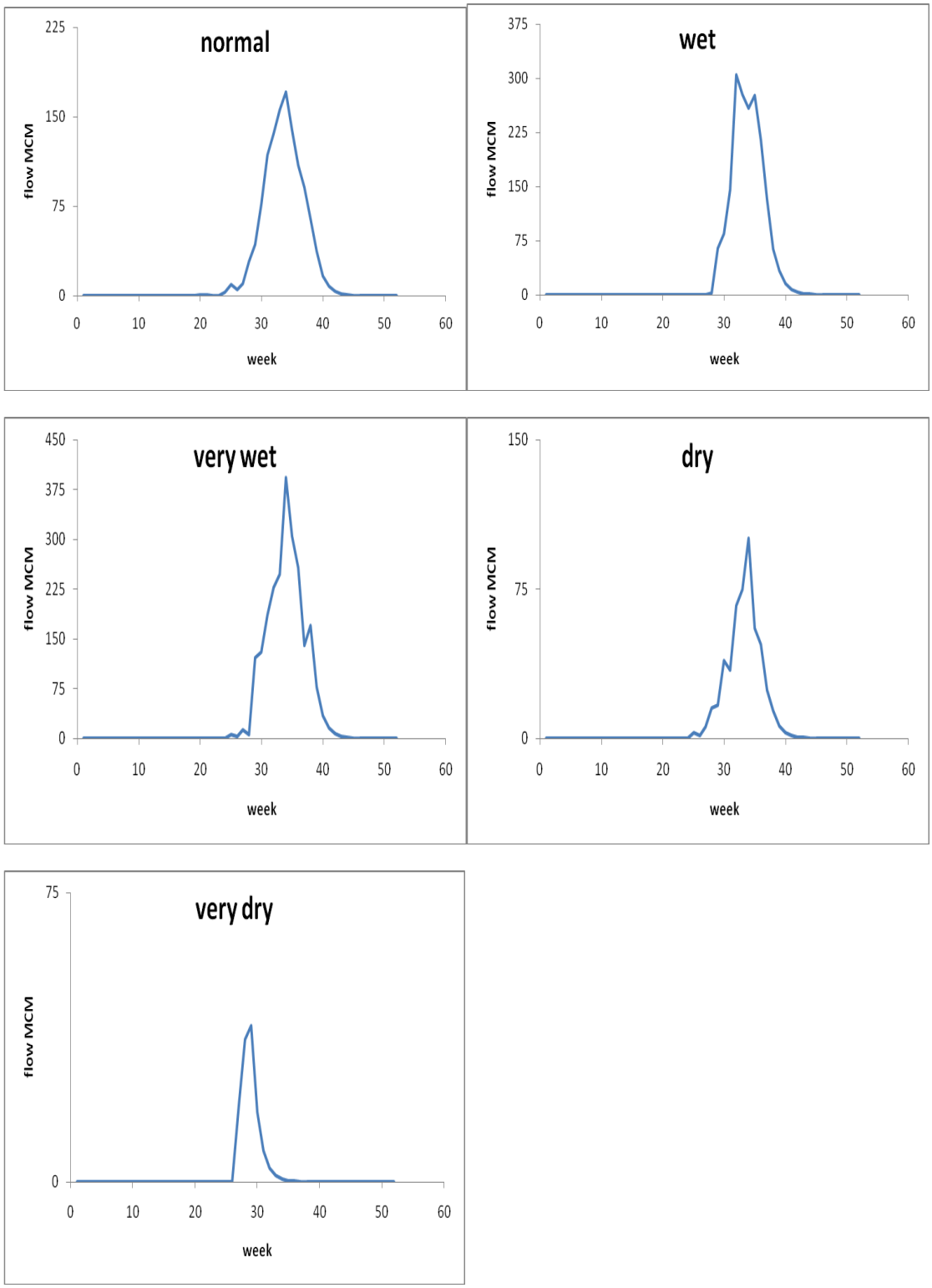


Figure 3.9: Inflow to Challawa Gorge Reservoirs

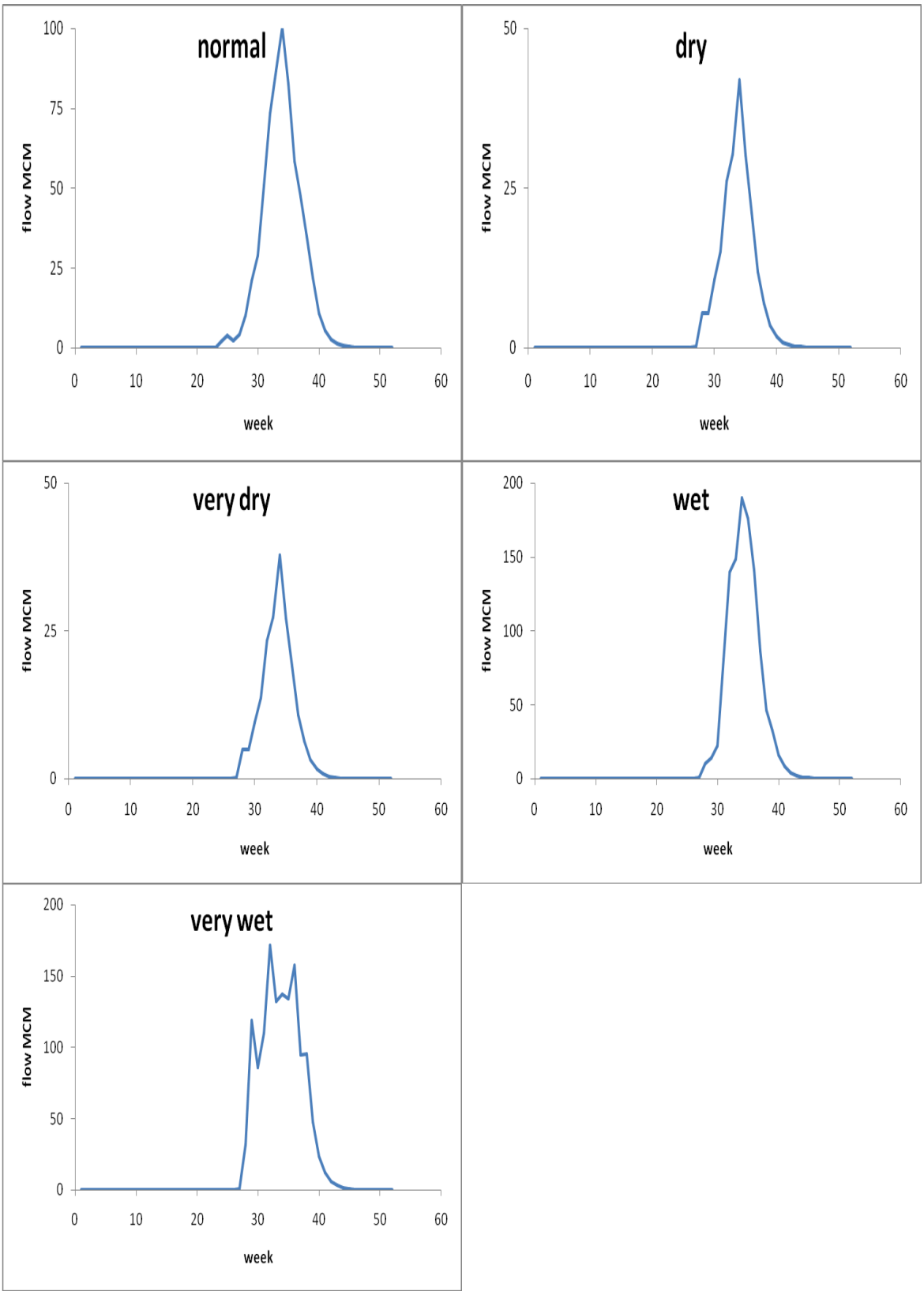


Figure 3.10: Mean Stream Flow at Bunga

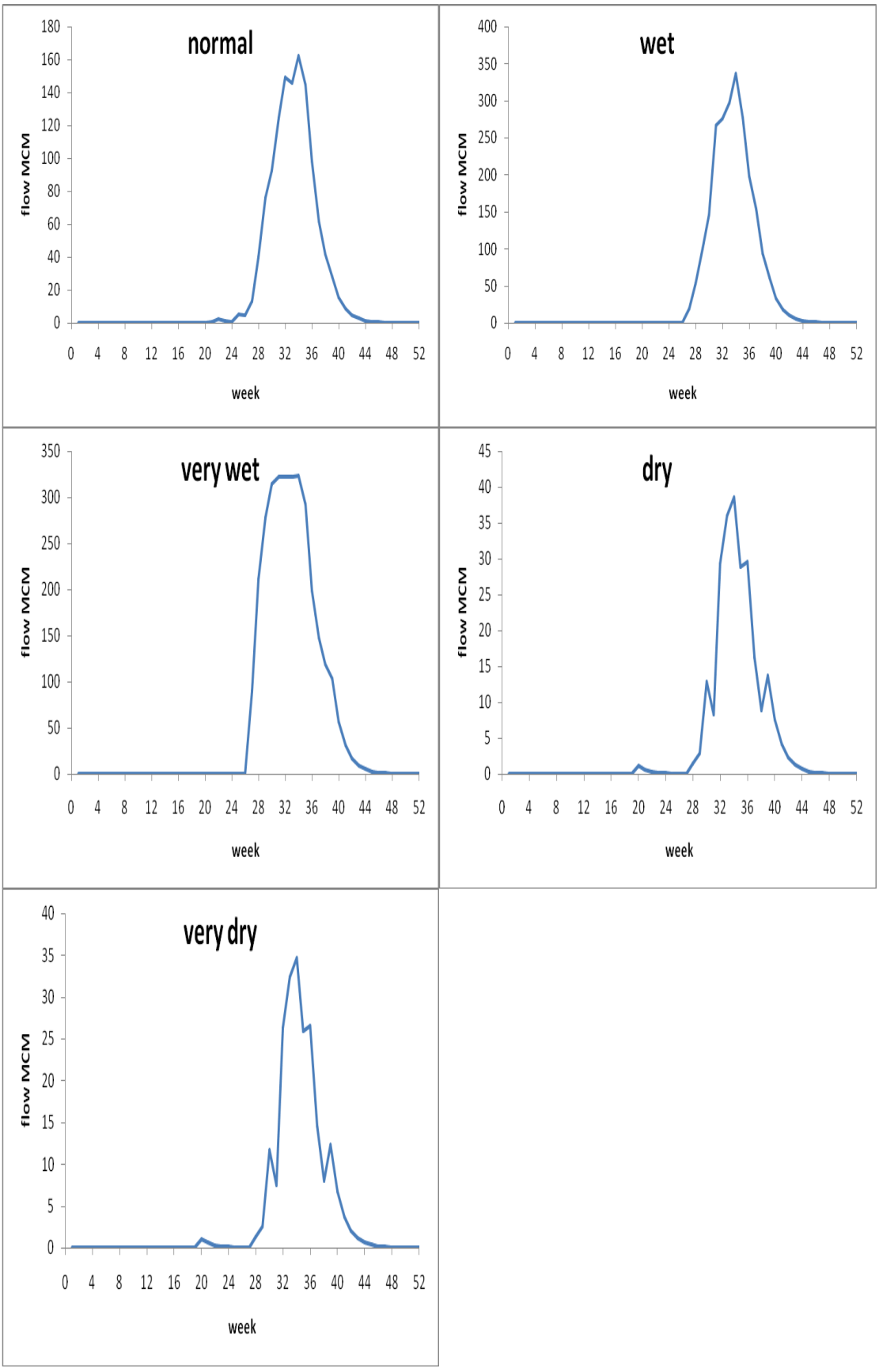
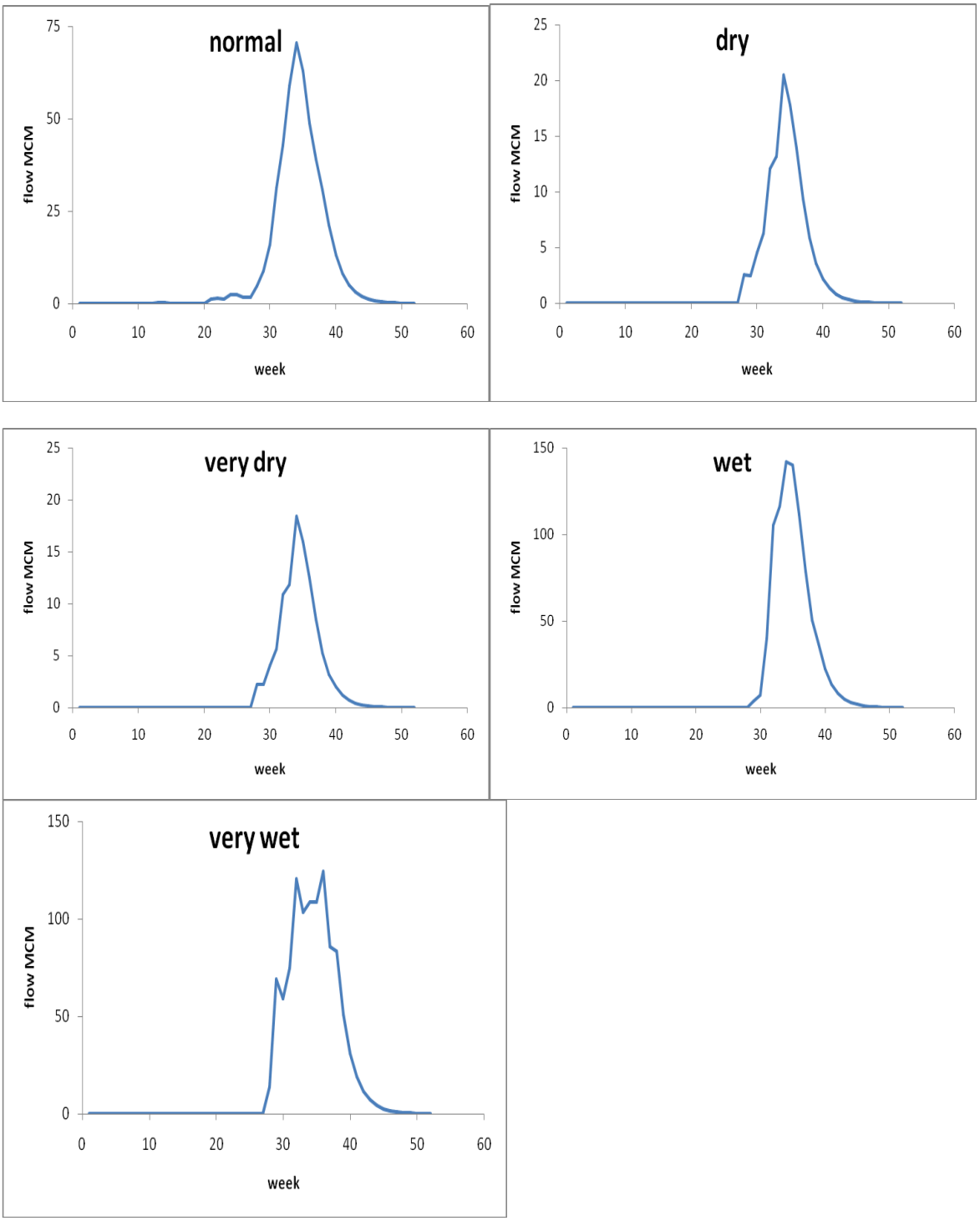


Figure 3.11:Flow from unregulated unit of Hadejia sub-basin



River Ngadda emerges from the swamp and directly discharges into the Alau reservoir, while Yedseram flows south eastward to meet River Bararam at Bama. There is considerable uncertainty as to the factors influencing the inflows into the two emerging rivers from the Sambissa swamp. Outflows vary widely from year to year due to the changing patterns of sedimentation in each channel.

3.3.3 Evaporation and Transpiration

Evaporation in the northern part of Nigeria is a function of location (radiation ratio), temperature and relative humidity. This hydro-meteorological parameter is of particular importance in the Lake Chad Basin and its quantification is essential for all water balance investigations. High temperatures are associated with high evaporation and transpiration rates in plants. Relative air humidity represents the evaporative demand of the atmosphere and is influenced by the advance and retreat of the rain belt as well as the large bodies of surface water. Consequently, high values of humidity are indicative of low evaporation, and these records consistently coincide with the peak rainfall months of August, with the average of about 80 percent. Conversely, the lowest values are recorded during the dry season (January-March) when the mid-day average is in the region of 15 percent. It is however, significant to note that the monthly, daily and at time even hourly variability of air humidity could be substantial (Kindler et al, 1989).

According to NWRMP (Sanyu, 1995), there were only 23 evaporation gages with long term record nationwide as at 1995, out of which only four were located in the Northern States. Obviously, the situation is unsatisfactory to achieve appropriate water resources management; consequently priority should accord the provision of Class A evaporation pan gages at all the meteorological observation stations should be accorded top priority. From the scanty data available the evaporation ranges from 3,000mm around Jos Plateau to as high as greater than 4,000 mm around the fringes of Lake Chad. These high rates of evaporation in the Basin has led to extraordinarily high water loss from the reservoirs and surface water development facilities, especially when compared with the limited water resources potential of the region. The evaporation losses in relation to available reservoir storage as reported by the JICA team are as shown in Table 6.6. This would suggest the selection of appropriate development options that would minimise evaporation losses.

Table 3.12 Evaporation Loss in Relation to Reservoir Characteristics

No	Description	Unit	Tiga	Challawa Gorge	Watari	Guzuguzu	Kafin Chiri
1	Reservoir Inflow	10^6 m^3	705	460	75	22	35
2	Active Reservoir Capacity	10^6 m^3	1,345	900	92	21.5	35
3	Max. Reservoir Area	Km^2	178	100	19.6	6.4	8.4
4	Evaporation Loss	10^6 m^3	250	130	30	9	12
5	Available Water	10^6 m^3	455	330	20	9	8
6	Ratio: (4)/(1)	%	35	28	40	41	34
7	Ratio: (5)/(2)	%	34	37	22	42	23

On the average, the computed rate of potential evapotranspiration, using Blaney-Morin-Nigeria equation (Duru, 1984) varies between 3.7 mm/day and 8.2 mm/day with a mean annual value of 2,200 mm. The estimates agrees with MacDonald (1973) estimate that average potential evapotranspiration SCIP is 2290 mm. The implication

of this is that the rate of evaporation in the basin, except Jos Plateau area is higher than rainfall. The phenomenon also accounts for high losses from impounded water in the Hadejia and Jamaare sub-basins (Table 3.12).

3.4 Groundwater Resources

The Nigerian sector of the Chad basin falls within the semi-arid region of Nigeria with average annual rainfall generally below 500 mm and evapotranspiration in excess of 2000 mm. Topographically the area is a monotonous plain, tilted towards Lake Chad at about 2 m per Km (du Preez and Barber, 1965), although in places dune ridges and the Bama ridge interrupt this flat plain. Surface water, in streams appears seasonally for a couple of months immediately after rainy season. Groundwater is thus the major source of perennial water supply for the people of the region. Groundwater occurs in the Plio-Pleistocene Chad Formation and the overlying superficial deposits. It occurs under water table condition, in perched condition, in semi-confined and confined conditions. Three well-defined arenaceous horizons within the argillaceous Chad Formation constitute the aquifers, and Barber and Jones (1960) named them the Upper, Middle and Lower aquifers (Fig. 3.12). The Upper aquifer in most of the study area is within the superficial deposits, and extends across the entire outcrop of the Chad Formation. It is composed of alluvium and aeolian sands and gravel lay down during recent times. However, around the type locality (Maiduguri) the Upper aquifer includes not only a surface zone of recent sands with an unconfined water table, but deeper layers of sands of the Chad Formation complexly intercalated between clays, and partially confined by these clays. Beacon Services Ltd. (1979) working in Maiduguri (the type locality) called the Upper aquifer a system, because of the three definable units, which they termed A, B and C unit. A unit is the water table aquifer largely within the superficial deposits; B unit is artesian to leaky artesian while the C unit is artesian with negligible leakage. These units seem to be restricted to Maiduguri and environs, which is an ancient shoreline of mega Chad; deposits of these units have been associated with beach or deltas. The units exhibit extremely variable thickness. Argillaceous deposits (100-150 m thick) confine the Middle and Lower zone aquifers, and boreholes drilled to these zones give rise to artesian wells.

The Chad basin has been referred to as an interior sag basin (Kingston et al., 1983), due to a sagging episode that has affected it before the onset of continental separation during which a rift system junction was formed providing appropriate site for sedimentation. It therefore lies at the junction of basins (comprising the West African rift), which becomes active in the Jurassic/early Cretaceous when Gondwana started to split up into component plates (Lees, 1952; Carter et al., 1963). The separation of South America and Africa started down near the Cape progressing up towards the Bight of Benin. At this stage trellis configuration of rifts developed, and the Chad basin forms at the intersection of two tectonic features known as the Tibesti-Cameroun and Teidet troughs, which trend northeast-southwest respectively (Schultz, 1976). This led to the development of major graben and sedimentation started. Cratchley and Jones (1965) believed the basin to be an extension of the Benue trough.

3.4.1 Depositional history

When the Chad basin formed, shallow marine sediments were laid down over localized fanglomerates and possibly fluviatile deposits, which lay, unconformably on the basement. This sediment is hereby designated pre-Bima sediments (Avbovbo, et al., 1986). The succeeding regression gives way to the deposition of a thick sequence of the continental Bima sandstone during Albian – Cenomanian times. The diverse lithology of the Bima sandstone indicates accumulation under widely varying conditions. These sediments range from poor sorted and thickly bedded feldspathic sandstones and conglomerates to fluviatile and deltatic sediments.

The Bima sandstone, which is the oldest of the Cretaceous sediments is overlain conformably by the transitional Gongila Formation. It consists of basal limestone overlaid by a sandstone/ shale sequence. The limestone is rich in mainly Ammonites and Mollusc (Reyment, 1965) the assemblage of which indicates an early Turonian age. The Formation has a maximum thickness of about 500m.

The Fika shales consist of blue–black shale which are occasionally gypsiferous (Baba, 1995) and which contain thin persistent limestone. They vary in thickness from 100m in Postiskum to about 500m near Maiduguri, which indicates increase in thickness northeast ward. The fossils of the Fika shales are mainly fish remains, Chameleon fragments and Reptilian remains. These indicate a Senonian-Maestischtian age. The Fika shales appear to have been deposited under a submerged (transgression) environment. It overlies the Gongila Formation conformably.

The Fika shale is overlain by the Gombe sandstone which is a continental sequence of estuarine and deltaic sediments deposited over the marine shales. Gombe sandstone does not show east-west trend, which is imposed, on the earlier Formations. There are sand stone/shales intercalation in the Gombe sandstone which is a continental sequence of estuarine and deltaic sediments deposited over the marine shales. Lenses of siltstones and mudstone occur with ironstone at the lower beds. The middle part is characterized by well-bedded sandstone and siltstone (Kogbe, 1976). The upper part of the formation contains poor quality coals and is represented by cross-bedded sandstone. The Gombe sandstone is thought to be Maastrichtian in age.

The end of the Cretaceous was marked by a period of uplift and erosion. The first deposits in the Nigerian sector of the basin after the Cretaceous period is the loosely cemented coarse to fine-grained sandstone, the Kerri-Kerri Formation. Massive claystone and siltstone with bands of ironstone and conglomerate occur locally. The sandstones are often cross bedded, and lignite (low grade coal) occurs near the base of the Formation. The Kerri-Kerri Formation rest unconformably on the Gombe sandstone. Angular unconformity was thought to exist between the Cretaceous and the Neogene sediments. The thickness of the Formation increases towards the basin centre and is overlain by Chad Formation. The Kerri-Kerri Formation is Paleocene in age and environment of deposition is lacustrine or fluvio-lacustrine.

Chad Formation (Table 3.13) is the Quaternary sediments which consist of fine to coarse grained sand, blue –grey with intercalation of sandy clay, clay and diatomite. The sandy sediments are often poorly sorted. Borehole data show that the Formation gently dip towards the centre of the basin. Maximum thickness of about 840 m has been recorded in the western shore of the lake Chad. This Formation was thought to be Pleistocene in age. A minor unconformity indicated by a plinth of laterite is identified in a borehole as separating the Kerri -Kerri Formation from the Chad Formation.

The dunes and alluvial deposits are superficial deposits lying on top of the Chad Formation. The longitudinal dunes or seif mostly common in the northern part of the basin, occur as parallel ridges trending northeast-southwest up to 10 m to 15 m in height and extending for tens of kilometres without interruption. The river alluvium deposits are common in the study area and consist of sands, silts and clays. Coarse sands and gravel occur along the present-day river channel. Less extensive alluvial deposits, mainly clay and silt, occur locally in interdunal depressions and semi-permanent ponds. Clays and silts also occur in oxbow lakes, abandoned channels and river flood plains. A summary of the stratigraphic succession is presented in Table 3.13.

Table 3.13: Summary of the stratigraphy of the Nigerian sector of the Chad basin

ERA	PERIOD	FORMATION	LITHOLOGY
QUATERNARY	Recent	Alluvium	Younger and older alluvium, with interbedded Aeolia sands up to 30 m
	Pleistocene	Chad Formation	Predominantly clays with interbedded sands
TERTIARY	Pliocene		
	Palaeocene	Kerri-Kerri Sandstone	Sandstone with interbedded gritstone and clays
MESOZOIC	Cretaceous	Various Formations from Bima to Gombe	Maiinly sandstone and shales
PRECAMBRIAN		Basement Complex	

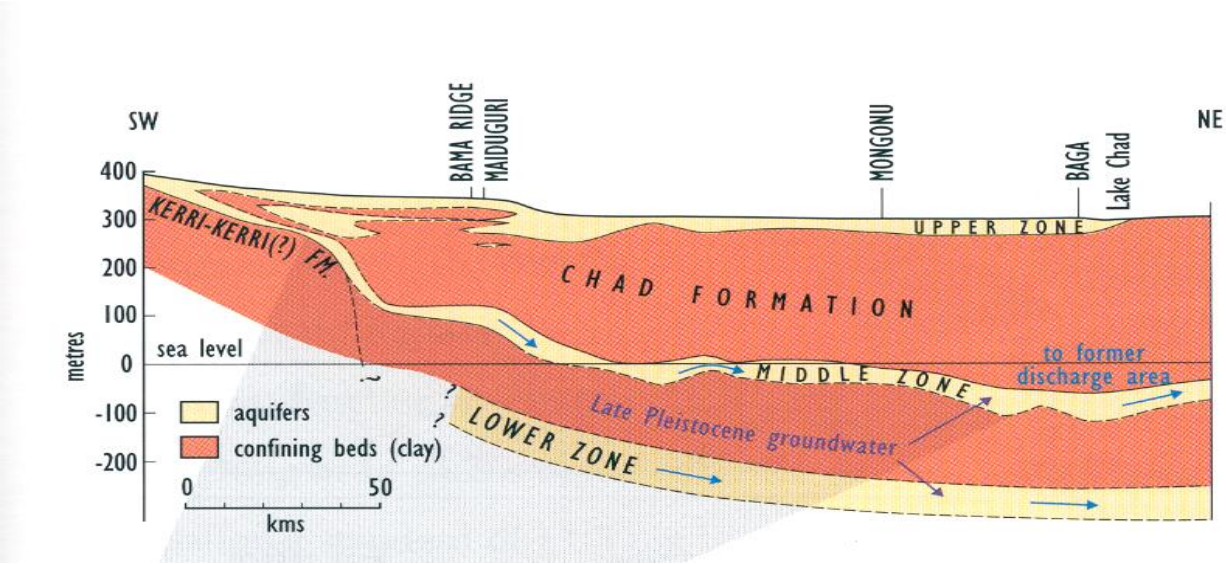
3.4.2 Hydrogeology

In the Borno drainages groundwater occurs in the arenaceous horizons of sedimentary Chad Formation and overlying alluvial deposits. The Plio-Pleistocene Chad Formation and the younger overlying Holocene sediments in the floodplains of rivers in the basin are the main source of groundwater. The Chad Formation is essentially an argillaceous sequence in which minor arenaceous horizons occur (Barber, 1965), and the Formation shows considerable lateral and vertical variability in lithology. Barber and Jones (1960) have named three clearly defined arenaceous horizons of the Chad Formation as the Upper, Middle and Lower Zone aquifers (Fig. 3.12).

The Lower and Middle Zones are confined, whereas the Upper Zone ranges from confined to semi-confined and unconfined in places. The Upper Zone sands are considered to be lake margin, alluvial fans or deltaic sediments related to sedimentation in and around Lake Chad, which has varied considerably in size

throughout the Quaternary (Durand, 1995). Around Maiduguri (type locality of the Chad Formation) the Upper aquifer includes not only a surface zone of recent sands with an unconfined water table but deeper layers of sands of Chad Formation, complexly intercalated between clays, and partially confined by the clays. Beacon Services Ltd. (1979) further subdivided the Upper aquifer system into three zones, an Upper A zone under water table conditions and underlying B and C zones which are semi-confined and/or confined. The alluvium deposits in the flood plains of major rivers are also source of shallow groundwater, which could be very important especially for agricultural purposes.

Figures 3.12: Geological cross-section showing the aquifers of the Chad



The major limitation in the study of water levels in this basin is the lack of monitoring wells or boreholes. Thus, static water level data from drilled boreholes at the time of completion and/or fragmented data of monitored wells obtained from intervention projects were used to study the water levels in the basin. However, in the last three years the Nigerian Hydrological Services Agency (NISHA) has drilled a monitoring borehole in Maiduguri (at the centre of the basin) fitted with automatic logger (see appendix I for data from this borehole).

Groundwater levels in the alluvial aquifer of flood plains in the basin range from 1 m to 3 m below ground level. Water levels in this aquifer show seasonal trends but no long-term decline or increase in groundwater level (Fig. 3.13). This agrees with the water level monitoring for the period (1991-97) by IUCN-HNWCP in the Hadeja Nguru Wetland (HNW) an area to the northwest of the present study. Also scarce water level data from the 1970s and 1980s do not indicate a consistent change in groundwater level in the HNW (Goes and Zabudum, 1998).

Groundwater levels in the Upper aquifer of the Chad Formation in the basin range from 20 m to 30 m below ground level, except around the Gubio hydrologic depression where levels as low as 70 m below ground level are recorded. Groundwater level in the aquifer also shows some seasonal and annual changes. Annual monitoring of four dug

wells in Maiduguri (Fig. 3.14 and appendix II) clearly shows seasonal fluctuations of about 2 m over 18 months period of monitoring. The Maduganari I and II wells show very little or no difference in depth to groundwater and water level trend. The water level for Kangadiri and Alhamduri is averagely 18 and 24 m; some 6 and 12 m respectively deeper than the Maduganaris. Elevation data, which is not available, will be quite useful to enable evaluation of relief factor. What is important in this is that seasonal fluctuation in water level does take place in all the wells, which could be attributable to groundwater recharge.

Figure 3.13: Hand dug wells' water level monitoring from Nov. 1993 to May 1995

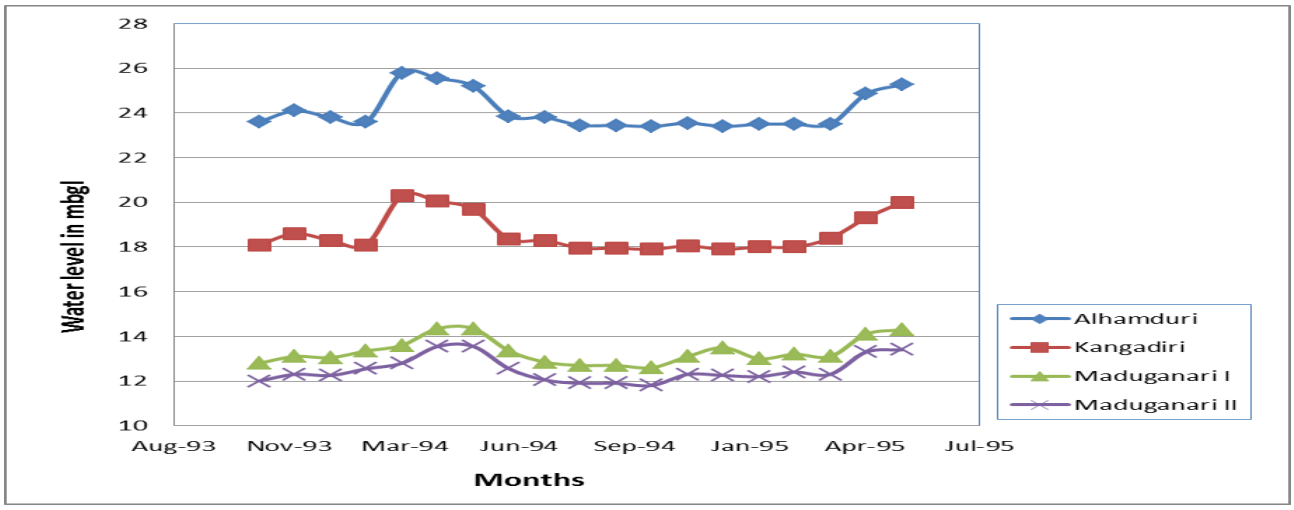
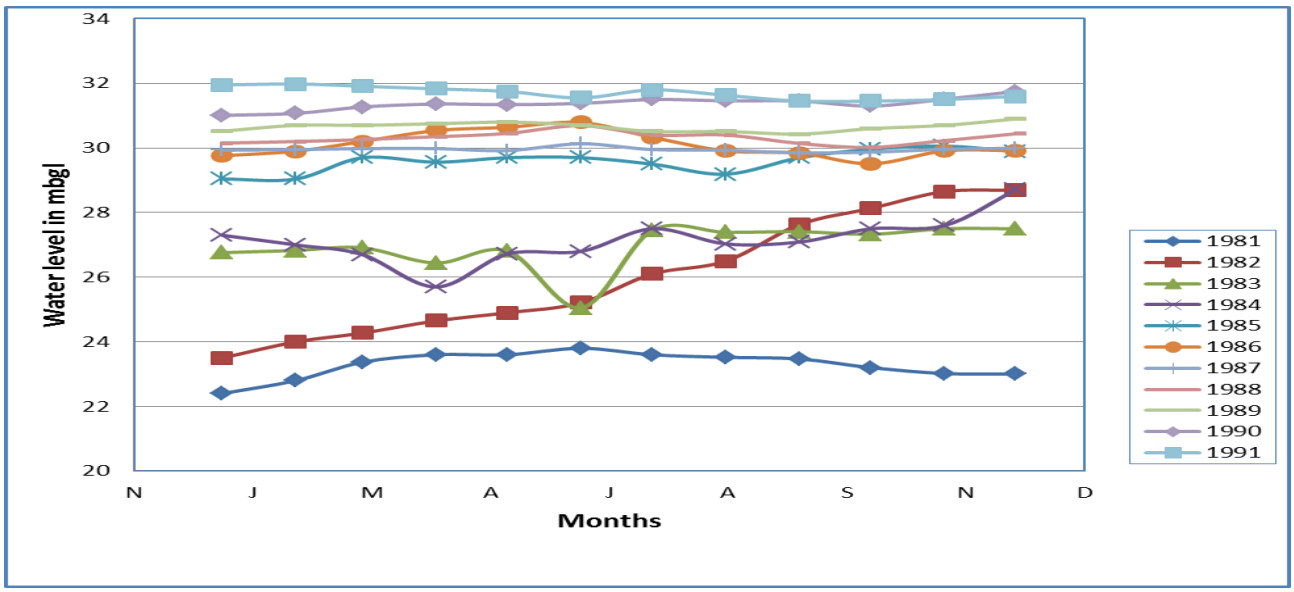


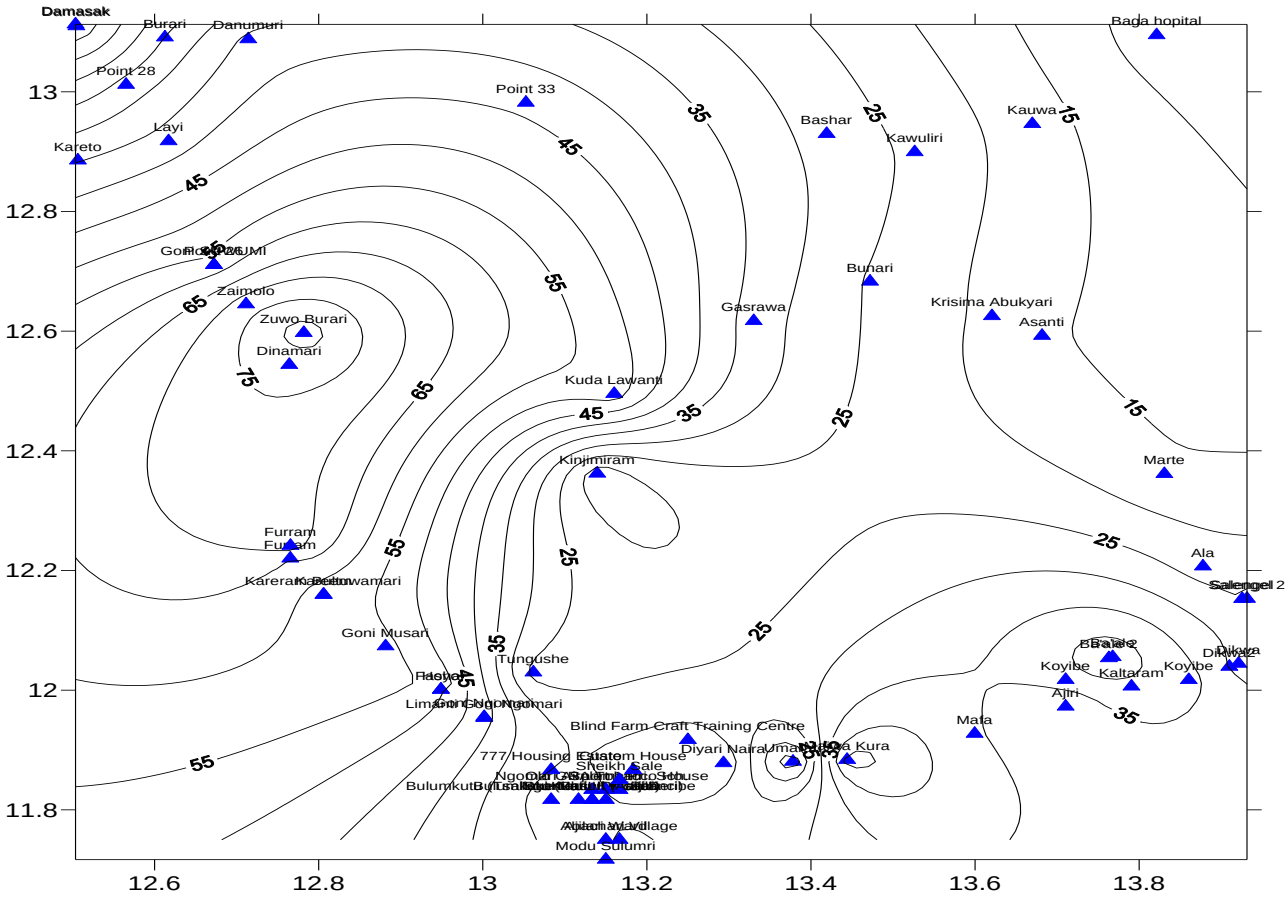
Figure 3.14: Monitoring of water levels for Upper aquifer borehole at Nursing Home Maiduguri (11°49'19" N and 13°08'53" E)



Ten years (1981 to 1991) monthly monitoring of Nursing Home borehole in Maiduguri (Fig. 3.14) tapping the Upper aquifer of the Chad Formation, indicate both seasonal and annual changes in the water level (Appendix III). The seasonal changes appear to be minor with no clear trends in some years, while annually about 10 m decline in the

water level (Fig. 3.14) is observed. This is very much in agreement with the decline of approximately 1 m y^{-1} reported for shallow groundwater in Jigawa State (western part of the same basin) from FMWR data collected for Fadama 1 project. Maduabuchi (2005) also reports a groundwater level drop in the phreatic aquifer. However, the NISHA data for three years with automatic logger on an Upper aquifer borehole at the Federal Inland Revenue Service (FIRS) office in Maiduguri did not show decline but seasonal changes (Appendix I). Water levels fluctuate between 26.7 m and 27.5 m over the three year period of data collection. In general groundwater levels in wells and boreholes tapping phreatic aquifer of the Chad Formation and alluvial aquifer dips away from major rivers and their floodplains, especially in the wet season, in agreement with the fact that they are infiltrating river systems. Static water levels of boreholes drilled in 2000 and in the 1950s & 1960s are show in appendixes IV and V. The data show that water level in the millennium is averagely 27 mbgl whereas in the 1950s & 1960s it is averagely 36 mbgl. This indicates a rise of about 10 m in the millennium, although the millennium data is more spatially restricted.

Fig. 3.15. Water level contour in mbgl for the Borno drainages – the Gubio hydrologic depression is seen at the western part with water level at 75 m below ground level.



The present day water level contour is shown in Fig. 3.15. This clearly shows the Gubio groundwater depression, where groundwater converges. Flow is from the Yobe river in

the north, Lake Chad in the northeast, Ngadda in the south, Yedseram in the south east and Ebeji in the east.

From the foregone, it is obvious that the alluvial aquifers in the flood plains of the rivers in the area show no change in water levels over the years. Water levels in the Upper aquifer of the Chad Formation show trends that are related to climatic conditions. That is, in periods of drought decline in water levels are observed and when rainfall improves water levels tend to rise.

3.4.4 Groundwater Recharge

The possible mechanisms for shallow groundwater recharge in the Borno drainages are: (1) direct infiltration of rain into the ground and (2) infiltration through riverbeds. In the Borno drainages, recharge via direct infiltration of rainfall is estimated at 58 mm/annum, which is about 10% of the average annual rainfall (Consulint, 1976). This is similar to the rate of 49 mm y^{-1} obtained for the sand dune area at the northern part of the Komadugu-Yobe Basin Carter et al. (1994). Edmunds et al. (2002) estimate recharge rates ranging from 14-49 mm y^{-1}, from a chloride mass-balance method using seven profiles from the unsaturated zone in the same area. Therefore, if 20% of the area of the Borno drainages is considered to allow for direct infiltration of rainfall, then a total annual recharge of 812 x 10^6 m^3 is obtained. Total area of the Borno drainages is estimated to be 70,000 Km^2.

Recharge to the shallow aquifers of the basin is also through seepage from rivers of the basin. This is supported by the slope of the piezometric surface away from the rivers. In addition to studies that show that river Ngadda's maximum flow at Maiduguri is about half that at the outlet from Lake Alo, a distance of about 12 Km (Barber and Jones (1960). This gives an indication of the volume of water lost to the river bed and banks. In Kumadugu-Yobe basin recharge through seepage from river beds has been estimated at 132 mm (Goes, 1999), which could be considered a reasonable rate for the rivers in the Borno drainages. Total recharge via seepage from all the rivers in the basin is estimated at 50.16 x 10^6 m^3, based on an approximate total river length of 380 Km for the basin. Total annual recharge to the Borno drainages from both mechanisms is estimated at 862.16 x 10^6 m^3.

3.4.5 Groundwater Abstractions

Abstraction of groundwater in the Borno drainages is by means of dug well, borehole, tube well and washbores. Except for the washbores, which is used for irrigation purposes, the other means are mainly for domestic supply and animal consumption. In this basin, there are approximately 200 Upper aquifer boreholes; about 400 tube wells tapping the Upper aquifer and about 1500 washbores on the alluvial aquifer of the flood plains. Dug wells are negligible.

Abstraction from the boreholes is estimated at 5.256 x 10^6 m^3/a based on 200 boreholes discharging at 2.5 l/s (Appendix VI) and pumping for 8 hours in a day; that of the tube wells is estimated at 3.154 x 10^6 m^3/a based on 400 tube wells discharging

at 1 l/s and pumping for 6 hours in a day. The washbores' annual discharge is estimated at 27.594 x 10^6 m^3 based on 1500 washbores discharging at 3.5 l/s and pumping for 4 hours in a day. As mentioned earlier, the washbores are largely used for irrigation and so about 75% is estimated to return to the aquifer. The net abstraction from this system therefore is approximately 6.899 x10^6 m^3/a.

Water demand projection 2005 for Maiduguri is put at 49.62 x 10^6 m^3/a based on a population of about a million people (TAHAL Consulting Engineers Ltd., 1995). This appears quite a lot compared to the discharge estimated above. It is worth noting that water supply to Maiduguri is obtained from treatment of Alo dam water, deeper aquifer boreholes, tube wells and wash bores.

3.4.6 Groundwater Management Problems

The management of the water resources in the basin is spread out over several institutions and unfortunately, there is little or no coordination between these institutions. Although, in the National Water Resources Act, which is presently at the National Assembly for legislation, it is hoped that it will have policy directive on coordination within the sector. The challenge will then be that, once passed, the stakeholders will have to be mobilised to understand and implement the law.

One of the major constraints observed in this work is the lack of reliable data. The role of data collection has regrettably either been underplayed or ignored by institutions in the region. Almost all monitoring of water levels in wells and boreholes are project based and most often, at the end of the project the activity stops. Good water policies and management depend upon the quality of knowledge available to decision-makers. Knowledge comes in many forms, but the significance of a database that provide minimum levels of hydrological/hydrogeological and resource use information cannot be overestimated. Actions to ensure that this database develop and survive require a clear policy base and the allocation of resources to operate the system. Emphasis here is on systematic monitoring of key hydrological parameters. Technological developments in data management, remote sensing, climate data and related fields mean that far better data in far greater quantities can be made available relatively cheaply (Goni, 2006).

3.5 Vegetation and Soils

The basin has two main vegetation zones, namely the Sudan-Savannah and Sahel; both are semi arid in nature. These are interspersed with woodland, riparian forests and seasonally flooded marshes and *fadamas*. Generally, the vegetation has been greatly modified by over cultivation, over grazing, deforestation and land degradation. The process of desertification has also been on the increase. The land mark droughts of 1973 and 1983 – 1984 led to floristic degradations (LCBC, 2006). The major human-related influences on plant-life in the Basin include: cutting trees for energy, timber and livestock browse; overgrazing and overbrowsing by livestock; trampling; clearing for agriculture, burning and cutting for hunting; clearing for human settlements.

Sudan Savannah area is characterised by shrubs and dense grasses with a sprinkling of trees. Much of the natural cover, however, has been tampered with by human activities, especially agriculture. Today the remaining woodland can only be found in the south-western parts of the basin (IUCN, 1997).

Six soil types (*Psamments or Regosols, Orthents*, *Fluvents or Fluvisols, Usterts, Ustalfs and Ustults)* in four major soil groups (*Entisols, Vertisols, Alfisols and Ultisols*) are found in basin. Soil degradation varies from place to place, between and within the two sub-systems of KYB and Borno drainages. In particular, Jigawa State has been tackling soil erosion through afforestation under the National Anti-desertification Programme. Soil conservation efforts on farmland, remains largely *laissez-faire* in character with declining crop yield from farm plots, which are a signal for soil fertility depletion (LCBC, 2006).

Several studies have revealed the following strategic ecosystem types in the basin:

- ***Floodplains:*** namely flooded grasslands (temporal), and flooded forests (zonal);
- ***Marshlands*** including grass/reed/sedge marshes (temporal)
- ***Swamps*** on shallow stagnant water or inundated soils,(herbaceous swamps (temporal) and shrub/tree swamps (zonal)
- ***Lakes and other water bodies*** including seasonal ox-bow lakes, ponds and pools (temporal) and permanent lakes (zonal)

The aquatic plants are zoned across the land/water ecozone, each zone with its unique plant community.

The salient characteristics of the major soil types are outlined in alphabetical orders, with some of the sub-types simply mentioned.

a) **Arenosols:** are sandy textured, well and sometimes excessively drained soils occupying shedding sites. The sub-types include Luvic, Cambic and Lithic Arenosols.
b) **Cambisols**: are generally well drained sandy loams overlying sandy clay loams or clays; may occupy any site but more frequently shedding and receiving than ponded sites. Sub-types include Dystric, Chromic, Eutric and Gleyic Cambisols.
c) **Fluvisols**: are deep, moderately well drained to somewhat poorly drained, stratified sands, silts and clays; occupying upland shedding sites and may be flooded by the river during the rainy season. Eutric Fluvisols are the common sub-types in the KYB.
d) **Gleysols:** are poorly to very poorly drained clays, occupying ponded sites (such as lakes) for most of the year. Eutric gleysol is the common subtype in the KYB.
e) **Lithosols:** are well drained, very shallow (about 10 cm) loams overlying ironstone.

f) **Luvisols:** are sandy loams overlying sandy clay loam; they occupy either shedding or receiving sites except the sub-type Gleyic Luvisols that may be in ponded sites. Other subtypes are Orthic and Chromic Luvisols.

3.6 Water Resources Infrastructure

The river systems in the Sudan Savannah areas, that constitute about 60% of the basin, are mostly shallow and flow only during the rainy season with several non-returning channels that carry away the water flow from the main streams. Along the Hadejia River from Ringim to Nguru and along the lower reaches of the Jama'are River there are extensive low lying fadamas that get flooded annually. The complexity of the hydrology is further compounded by the man-made controls imposed upon the river systems, as illustrated in the Hadejia River system being more than 80% controlled by the combination of Tiga Dam (completed in 1974) on Kano River and Challawa Gorge Dam (completed in 1992) on the Challawa River. The statistics of the storage and yield are summarised in Table 3.14. The Tiga and Challawa Gorge dams contribute raw water to Kano City Water Supply (about 6 million people) and feed two large, partly finished, formal irrigation schemes, namely the Kano River Irrigation Project (KRIP) and the Hadejia Valley Irrigation Project (HVIP). The KRIP was designed in two phases. Phase I (KRIP–I) has a total irrigated are of 27,000 ha while Phase II (KRIP–II) would add a further 40,000 ha. As at now only 13,700 ha of Phase I have been completed.

The outlet works at Tiga Dam are also deficient at present in that the valve release capacity is limited to a maximum of 47 m^3/s at full retention level. In response to seepage on the dam it has also been necessary to draw the spillway level down by 2.5 m to avoid excessive surcharging during floods. This change was made in 1992 and effectively reduced the live storage capacity to 1,283 million m^3, that is, about 70% of its former value. In an emergency situation, the limited capacity of the outlet works prevents the reservoir level being reduced rapidly, hence the need to keep the level down (Tahal, 1992).

Table 3.14: Storage and Yields of Tiga and Challawa Gorge Reservoirs

Reservoir	Total Storage Volume Mm^3	Annual Average Inflow Mm^3	Ratio Volume/Inflow	Average Annual Yield Mm^{3*}
Challawa Gorge	940	380	2.5	**267**
Tiga	1,345	900	1.5	**768**
Combined	**2,285**	**1,280**	**1.8**	**1,035**

* Losses from seepage and evaporation are put at 141 Mm^3 and 113 Mm^3 for Tiga and Challawa Gorge, respectively

Source of data: Parkman 2000

Challawa Gorge Dam, which commenced operations in 1992, has a live storage capacity of 900 million m^3 with a designed maximum valve release capacity of 86 m^3/s. There are operational problems with this level of release such that the effective limit of

release[1] is said to be in the order of 46 m^3/s. But it may well be a matter for major concern to the HJRBDA in terms of the flood attenuation capacity of the reservoir as well as the intrinsic safety of the dam structure itself. This may not be too dissimilar to the situation prevailing with respect to the limited release capacity of Tiga Dam outlet works where the reservoir water level cannot be drawn down rapidly in an emergency and where the situation warranted a reduction in spillway level to compensate for this[2]. It is assumed that a reservoir safety inspection at Challawa Gorge would consider this limitation and make the appropriate recommendations for increasing the release capacity or whatever other measures as are considered to be appropriate.

Table 3.15: Reservoirs in Komadugu-Yobe Basin

Dam name	River name	x_orig	y_orig	Status	Completed	Surface_km^2	Volume_MCM
Bagauda		8.380	11.588	E		3.8	22.1
Birnim Kudu		9.353	11.520	E	1970	6.5	1.2
Chalawa	Chalawa	8.030	11.734	E	2005	100	930
Galala	Galala	9.731	11.251	E	1982	4.1	23
Gari	Marke	8.321	12.449	E	1980	13.9	154
Gari		8.338	12.437	E	1980	3.7	60
Gulka	Gulka	10.251	11.206	P	-	83.7	597
Guzugozu		8.131	11.958	E	1979	6.4	24.6
Hadejia	Hadejia	9.745	12.320	E	1992	20	14
Ibrahim Adamu		8.424	12.643	E	1974	2.6	8
Jakara	Jakara	8.692	12.138	E	1976	16.6	65.2
Kafin Chiri	Jatau	8.854	11.612	E	1977	8.4	31.1
Kafin Zaki	Bunga	9.599	10.777	C	-	235	2700
Karaye	Mukagara	8.031	11.818	E	1971	2	17.2
Kawali	Bunga	9.754	11.224	P	-	27	72
Magaga	Magaga	8.045	11.952	E	1990	3.7	19.7
Maladumba		10.376	11.224	E		2	
Marashi	Marashi	7.828	11.931	E	1980	2.2	6.8
Misau	Zala	10.225	11.095	P	-	11.8	46
Pada	Pada	7.888	11.925	E	1980	4.1	12
Ruwan Kanya		8.454	11.515	E	1976	7.5	
Tiga	Kano	8.407	11.465	E	1975	180	1968
Tomas	Tomas	8.526	12.309	E	1976	15	60.3
Tudun Wada	Waina	8.424	11.276	E	1977	3.5	20.8
Warwade		9.215	11.749	E		5.3	12.3
Watari	Watari	8.153	12.175	E	1980	19.6	104.5

Notes: coordinates of dam central points in decimal degrees;
Status: E=existing, P=planned, C_cancelled
Sources: (NWRMP,1995; UNDP, 1989; HJRBDA, 2000):

[1] The records show that in the lead up to the 2001 flood the dam authorities tried to release as much as possible from the valves to reduce the load on the spillway. The daily discharge records for the period 31st August to 4th October 2001 show the valve release at 45 m^3/s which was indicated to be the maximum safe release

[2] It is understood that the situation at Tiga is compounded by high seepages through the dam structure which give rise to concern, whereas at Challawa Gorge there is apparently no indication of unduly high seepage losses through the dam structure

A barrage on Hadejia River at downstream of Wudil creates a pond that has capacity to regulate the fluctuations in the releases from Tiga and Challawa Gorge reservoirs 250 km upstream. The release to Hadejia Valley Irrigation Project (HVIP) is controlled at the barrage. The barrage has a maximum spillway capacity of 38.15 m^3/s while the storage capacity 1.4 million m^3. It cannot therefore, significantly change the water release rates or non-release by the two dams Tiga and Challawa Gorge, which have a combined storage capacity of 2285 million m^3 and combined maximum spillway [release] capacity of 111 m^3/s. The permissible water levels range from 37 m above mean sea level (amsl) [minimum] to full level of 38.75 m amsl with an average operational level of 38.25 m amsl. In the case of the HVIP, out of a design of 7,000 ha for Phase 1, an award of contract has been made for 4,000 ha, but only a gross area of 3,000 ha or a net area of 2,200 ha is currently under irrigation. Water is released downstream through 5 radial gates each with capacity of 30 m^3/s.

There is no system in place for the application of operational release rules from the dams that would match the integrated needs of the downstream users, either in terms of time or flows, nor is there currently adequate flow measurement at critical points in the basin, including the dam outlet points. A large amount of improvements would need to be made to the present defective and inadequate infrastructure in order to permit a reasonable degree of knowledge of flows, let alone their control in various parts of the basin.

There are also well over eighteen small to medium reservoirs mostly in Kano and Jigawa States (NWRMP, 1995). A dam is proposed on River Jamaare at Kafin Zaki. The purpose of the dam is to provide water for an area totaling 84,000 ha. Work on Kafin Zaki Dam has been started and then stopped a number of times, most recently in 1994. The summary of reservoirs in the basin is presented in Tables 3.15 and 3.16.

Table 3.16: Reservoirs in Yaere-Yedseram Basins

Dam name	River name	x_orig	y_orig	Status	Completed	Surface_km^2	Volume_MCM
Alau	Ngadda	13.283	11.717	E	1992	50	112.4
Maga	M. Tsanaga	14.933	10.832	E		400	600
Mokolo	M. Tsanaga	13.796	10.785	E		1	

Note: The larger portion of inflows to Maga reservoir is from Mayo Tsanaga; only a smaller portion is diverted from Logone River. Drainage from Maga is not to Logone but to Yaere /El Beid.

Alau dam was constructed downstream of the confluence of River Ngadda and Ngel Kondingel and consists of low embankment. The spillway is located within the embankment. Three other low embankments were constructed to confine the reservoir to high retention levels in order to reduce the surface area. A 3m diameter outlet work was constructed under the right embankment. The total length of the main embankment is 285m and a maximum height of 9.5m. The maximum fetch of the reservoir is 20km, with a live storage of 112.4 Mm3 and 50km2 area at normal retention water level of 329m. The main features of the dam are as follows:

a) Dam

Crest Elevation	331.5m
Maximum Height	9.5m
Length of Crest	285.0m

b) Spillway

Type: Gated	(4No lifting gates)
Crest Level	326.2m
Crest Length	4x4.6m

c) Irrigation Outlet Works

Minimum Capacity	12.5m^3/s

d) Operating Level of Reservoirs

	Elevation (m)	Volume x10^6m^3	Area Km^2
Normal Retention Water Level	329.0	112.4	50.0
Minimum Water Level	324.0	6.0	5.6

In view of the large surface area and small depth, losses due to evaporation and seepage are high. Seepage losses had been estimated at about 16Mm3 per annum, varying widely from month to month (Diyam, 1990). Evaporation depth over the shallow reservoir was estimated to be between 2700 – 2815mm. Considering mean annual rainfall of 700mm, the net evaporation may be between 2000 – 2100mm per annum. The evaporation loss ranges from 40.9 – 66.1Mm^3 per annum at a daily draft of 67,000m^3.

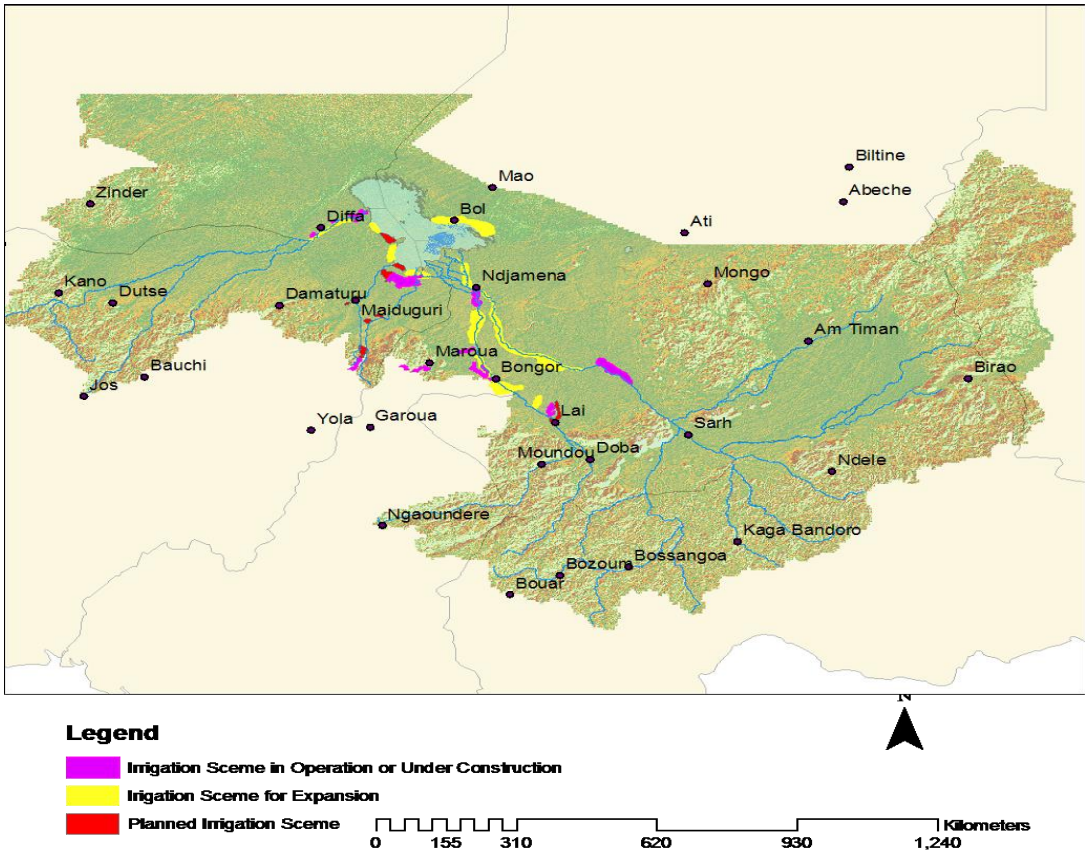
Table 3.17: Summary of irrigation activities in KYB sector

River System	Revised Potential (ha)	Developed (ha)	Cropped (ha)
Abir	1,000	130	**130**
Baga (Kirenowa)	1,000	500	**500**
Gashua	1,000	250	**500**
Gari	4,200	950	**1,900**
Galala	1,500	0	**0**
Jakarade	2,000	160	**160**
Tomas	2,300	400	**800**
Jakara	2,000	50	**50**
Jere Bowl	1,300	0	**0**
Yobe	1,600	700	**1,400**
South Chad	22,000	22,000	**7,000**
Kano River I	22,000	13,285	**24,000**
Kano River II	40,000	150	**0**
Watari	1,350	600	**700**
Kafin Ciri	660	0	**0**
Magaga	600	100	**0**
Hadejia Valley	12,500	2,075	**1,500**
Small Scale Yobe	1,000	120	**30**
Small Scale Borno	4,490	2,770	**2,720**
Small Scale Bauchi	500	50	**90**
Small Scale Jigawa	3,180	1,000	**1,200**
Small Scale Kano	1,000	500	**800**
ADP Fadama	140,000	12,500	**12,500**
Shadoof	10,000	10,000	**10,000**
Total	**277,180**	**68,290**	**65,980**

Source: Modified NWRMP (1995)

Several irrigation projects exist in the basin. The principal irrigation schemes are KRIP and HVIP. Withdrawals of the water requirements for KRIP and HVIP from Tiga and Challawa Gorge reservoirs follow rigid design prescriptions: fixed irrigation is done six days in a week with one day off. Releases from dams and diversions to cultivated areas are planned weekly. Local reservoirs control irrigation of fields. The estimated irrigation water demand per hectare for HVIP is much higher than that of KRIP Phase I. A high percent of rice cultivation in the cropping pattern, reduced rainfall and higher evaporation are held responsible for the situation. Gravity or surface irrigation method (a great water waster) is practiced both in the KRIP and HVIP. No sprinkler system is yet adopted. High cost of sprinkler equipment and their maintenance is accorded greater priority consideration in the choice of irrigation method than the low availability and high value of water in the basin. Table 3.17 highlights the irrigation activities in the basin.

Figure 3.16: Location of Major Irrigation Schemes in the Borno and Ebeji sub-systems.



In the Borno and Ebeji sub-systems, recurrent droughts and conflicts have caused migration resulting in a mosaic of different agricultural systems but all the systems have the following in common: mobility; integration with pastoralism, natural vegetation, and fisheries; as well as wise use of fluctuations (LCBC, 2006). Traditional farming systems are undergoing a transformation towards intensive systems. For instance several irrigation schemes were planned and executed between 1972–1985 but most of these failed due largely to recession of the Lake, high fuel cost and partly poor planning and management of the schemes. On the way to Lake Chad there are

two irrigation projects of Gamboru and Ngala, fed by water pumped out from the el Beid river (the total area 1200 ha). The river, however, is unable to supply all irrigation requirements during low water years. The construction of a 10 km canal connecting the Serbewel and El Beid rivers was proposed many years ago but as yet it has not been built. This canal would secure larger flow in El Beid from August to February.

Alau reservoir was also intended to provide irrigation water to Jere Bowl irrigation scheme. Feasibility studies by Enplan Group showed that over 900 ha of the bowl can be cultivated. The gross water requirement for paddy rice for 1000ha is 10.7 Mm^3 and 95 Mm^3 should the entire cultivable area is used. Thus the total water requirement is 195 Mm^3. This is a far cry from the total available water of 112 Mm^3 within the Ngadda river basin. This is the rationale for the augmentation of the inflow into the Alau Reservoir.Most of the water resources infrastructures in the basin suffer from a massive backlog of neglected maintenance. Periodic and routine maintenance, by far the most cost-effective form of infrastructure expenditure is almost nil. Instead, the norm is to wait for an infusion of capital for rehabilitation. In effect, it has become more convenient to replace than to maintain. But declining financial resources is making this less and less feasible.

3.6.1 Marawaji flow control structure

The increased proportion of the flows to the Marma channel and Nguru lakes has induced seasonal flooding of the HNWs, thereby adversely affecting the traditional pattern of land use. Traditional farming system was wet season flood rice cultivation followed by cultivation of dry season crops on the residual moisture from the flood recession. The flood recession also provided extensive areas of dry season pasture. Conversely, the more easterly oriented Burum Gana channel, at the Likori bifurcation, has become progressively more deprived of wet season flows.

The on-going flow division structures at the upstream of the Hadejia and Burum Gana rivers where the flow has tended to favour the more northerly oriented Burum Gana River, leaving the Hadejia River virtually dry. At the bifurcation of Hadejia and Kafin Hausa rivers, the pattern is repeated. The structures will permit the reclamation of some 13,500 hectares of land around Marma and Nguru lakes. About 5,100 hectares shall benefit from the reclamation through irrigation along the Burum Gana channel while the potential benefit along Old Hadejia River is in the range of 20,000 hectares.

3.6.2 Structures Ebeji/El-Beid

There are two irrigation projects of Gamboru and Ngala, fed by water pumped out from the el Beid river (the total area 1200 ha). The river, however, is unable to supply all irrigation requirements during low water years. The construction of a 10 km canal connecting the Serbewel and el Beid rivers was proposed many years ago but as yet it has not been built. This canal would secure larger flow in el Beid from August to February. The Serbewel peaks about 2 months earlier than the el Beid, but it is still at low flow during the critical months of May and June at el Beid.

At the outlet of Lake Alau, a storage reservoir of 108 x 10 m^3 capacity is being built by the Chad Basin Development Authority. The reservoir will stretch from the existing lake to Konduga, occupying about 6,000 ha. The reservoir shall provide drinking water for Maidiguri and irrigation water for the Jere Bowl Project (8,000 ha), just north-east of Maiduguri.

Also under consideration is construction of a water transfer canal approximately 120 km long (about 7 m^3/s capacity) connecting the Alau reservoir with the Hawal River inflowing Borno from the southern Adamawa State. Taking into account that the Borno groundwater resources are being rapidly exhausted, this idea does not come as a surprise.

3.6.3 Water supply to Borno State

It was reported (Ayoade, 1981) that in 1976, only seven towns in Borno, with the total population served of about 370,000, have been served by the modern public water supply systems. Total volume of water supplied at that time was slightly less than 30,000 m^3/day. By 1988, Maiduguri alone was supplied with about 35,000 m^3/day of groundwater (mostly from the Continental Terminal aquifer). The percentage of city population served by private connections and public standpipes was 26 and 74 respectively (Anyaeche, 1988). The population of the state capital is growing, and current population is estimated to be about 960,000. The city water demand is expected to be about 226,250 m^3/day, which is 90 percent of population served by private connections.

3.7 Water Rights

Article 25 of the Universal Declaration of Human Rights provides that "Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family…". This recognises the fact that nobody can survive for more than a few days without water, while he/she also requires it for basic needs of growing food and for sanitation. Similarly, the right to certain standard of living dictates that some right be vested in individuals to live in an uncontaminated environment, with clean air and access to clean water. The National Governments are also charged by article 24 of the 1989 Convention on the Rights of the Child to "strive to ensure" that no child is deprived access to clean water.

Such a responsibility must entail that at least the Federal government and indeed the upstream State Governments do not deny the States downstream the ability to discharge the foregoing rights and obligation to its citizens, by denying them adequate resources from interstate rivers. This is, however, predicated on the condition that this would be possible under the natural flow of the watercourse. Federal Government, therefore, needs to create an institution where aggrieved parties suffering from such denials could have neutral and perhaps regional platform to report and seek redress.

The Water Resources Decree 101 of 1993 is based on the principles of riparian right. The water rights will, therefore, depend on existing land rights. Consequently,

establishing equitable security of tenure of land would guarantee equity of water rights which is critical in ensuring access to and active participation in conservation and protection of water resources for all groups in the society. This is particularly important for the poor and women who are generally excluded from access to land in traditional tenure and who are critical to effective land and water resources conservation and protection.

The Water Resources Act of 1993 Cap W2 LFN 2004 postulates that the right to use flowing water arises from ownership of adjoining land. It is, however, ambiguous on certain issues. For instance, section 2 of the Act which guarantees water right reads as follows:

a) any person:
- *i) may take water without charge for his domestic purpose or for watering his livestock from any water course to which the public has free access;*
- *ii) may use water for the purpose of fishing or for navigation to the extent that such use is not inconsistent with any other law for the time being in force; or*
- *iii) who, has statutory or customary right of occupancy to any land, may take and use from the underground water source or if abutting on the bank of any water course, from that water course, without charge for domestic purposes, for watering livestock and for personal irrigation scheme.*

Some of the controversial aspects of these clauses are with respect to what constitutes "water courses to which the public has free access". Could this include lakes, rivers and even public irrigation canals? Another controversy is with defining what constitutes personal irrigation schemes.

The water resources decree, however, requires as obligation for all to register all new water rights in terms of quantity and quality of water flow required. The Water Regulations (that is yet to be enforced) - which seeks to provide interpretation of the Act demands that water rights permits be issued seasonally for direct abstraction purposes or annually for impoundment. It, therefore, follows that those that have no land and hence no water rights cannot partake in its conservation or protection.

It is important to note that section 6 of the Act clearly recognises the principles of integrated land and water resources management and enjoins the Minister to produce a Master Plan, current and detailed, for the development, use, control, protection, management and administration of all water resources. The Master Plan is to be reviewed periodically in the light of prevailing socio-economic and technological situation to affect activities, plans and proposals of public authorities relating to water resources development. It is thus in this section, that the relationship between the national water resources master plan and the comprehensive river basin plans to be developed by RBDAs would have to be contextualised given the background of the need for integrative management of land and water resources for sustainable development. This would be revisited in the evaluation of RBDAs in Chapter 6.

Meanwhile, it is worthwhile to observe that the importance of the master plan to integrative management for sustainable development is underscored by the provision of section 7 of the Act, which grant powers to the President to stop the release of funds for any water project not included in the Master Plan. The provision would however appear to conflict with the constitution especially as it relates to the rights of the federating units over their statutory releases. Even without this lacuna, the expectation is that the Minister of Water Resources would submit memorandum inviting the President to exercise such powers with regard to projects that are not included or that are at variance with the Master Plan. In reality, however, nothing like that has been done. The Master Plan is rarely consulted and certainly it has not been updated since it was first produced in 1995.

The Water Resources Act in section 19, stipulates the powers to formulate and implement legal measures for Nigeria's interstate water resources in all its facets including watershed management, resources protection and preservation. Although the Minister has comprehensive authority to develop water resources policy, he has not been able to fulfil this legislated mandate for three reasons. First, the Act did not include the mechanism for implementation and the rules and regulation are yet to be approved for implementation by Federal Ministry of Justice, Federal Executive Council, National Council of State and the National Assembly. Secondly, the National Inland Waterways Act and indeed FEPA Decree contradict some of these mandates. Thirdly, the reality is that water resources policy formulation is currently exercised more by the National Water Resources Council in contravention of the Act. Overall, the Act is yet to be enforced eighteen years after it was promulgated.

Nevertheless, the regular review, updating and enforcement of a National Water Resources Master Plan envisaged in section 6 of the Act remains the most strategic in the conception and execution of integrated management of land and water resources for sustainable development. The significance of this becomes all the more compelling against the background of the realisation that sustainable development which presupposes preservation of natural resources should necessarily be achieved by deliberate public policies.

3.8 Land Use

Climate and physiography are two of the major variables influencing the pattern of land occupance in any given location. In the first place, they constitute two of the five soil formation factors and secondly, they determine the magnitude and character of water resources available to that location. And of course, it is the combination of available soil and water resources endowments of the location that dictates the uses to which its land can be put.

Nearly all the upland areas of the Sudan Savannah zone have been cultivated for many centuries. Naturally, cutting, fire, cultivation and grazing have modified the native vegetation profoundly. The flooding problems along the river floodplains of Hadejia and Jama'are rivers, especially on the flat lowlands at the downstream end of the basin to

the northeast, have made over one-fifth of the basin land area unsuitable for dry land farming (Class II). This includes the Hadejia-Nguru Wetlands. Instead they are extensively used as grazing land and limited dry season recession farming.

Moderately and marginally suitable lands for dry land farming, Classes III and IV constitute more than 65% of the basin area. On these, sorghum, millet, cowpea, groundnuts and such other crops as vegetables are extensively cultivated. Figure 3.8 shows a southwest-northeast trend and distribution of the various crops. Millet hectarages increase from 24% in the southernmost (wettest) to 62% in the northernmost (driest) end of the basin. This is because of its greater drought tolerance than the other crops commonly grown there. In contrast, sorghum accounts for less than 10% of the crops grown in the low rainfall (less than 500 mm/yr.) area to the north whereas it accounts for up to 35% in the wetter area to the south.

Prior to the development of large-scale irrigation projects on Kano River and in Hadejia Valley, small-scale irrigation activities were taking place at several locations within the basin. The one at Yau in Borno State at the lowest reaches of the basin is one of them. Another one was at the Burum Gana floodplain. Others were along the Jama'are River floodplain.

Apart from agriculture, other occupations engaged in by the basin's inhabitants have been fisheries, livestock rearing, and potash harvesting and doumpalm collection. KYB (2006) reviewed the land use development changes in Kano, Jigawa, Bauchi, Yobe and Borno States from 1976/78 to 1993/95. It was reported that agriculture increased by 20,000 km^2 from 120,000 km^2 in 1976/78 to 140,000 km^2 in 1993/95. On the other hand, woodland, grassland and shrubs decreased by about 24,000 km^2 from about 94,000 km^2 in 1976/78 to about 70,000 km^2 in 1993/95. Degraded land has increased by 578% of the 1976/78 area, reaching 6,565 km^2 by 1993/95. Forestland has declined from 2,600 km^2 to 1450 km^2 during the same period. Forest water swamp area had also declined from 12,000 km^2 to 7,000 km^2 during that period (Table 3.9).

In recent past with the advent of large-scale irrigation schemes, dry land agriculture and these other occupations have been facing increasing threat of failure even total extinction. Problems arising from the projects, both of which are upstream of Hadejia-Nguru Wetlands, are: (a) releases of water where and when it is not wanted downstream of the projects, and (b) withholding of water where and when it is needed.

3.9 Land Capability

Schultz (1976) identified (see Table 3.18) about 8,000 km^2 of the basin land as being suitable, to varying degrees, for irrigated agriculture (Classes I, II and III). About 62% of these is marginally suitable. The same reported that about twice that size (16000 km^2) was highly, moderately and marginally suitable for dry land farming (Classes I, III and IV). That means that about 3,000 km^2 of Classes I and III are suitable to some extent for both irrigated and dry land agriculture. Class I includes the best agricultural

soils, which are highly suited to irrigation and to intensive dry land farming. A large part of this Class of land is flat terrain consisting of well-drained upland soils which are sandy loams overlying sandy clay loams. These soils have low natural fertility, which is normal for the region, but can be expected to respond well to fertilization and other scientific management practices. A wide variety of crops such as sorghum, millet, wheat, groundnuts, and many vegetables and legumes, can be grown on these soils. During the rainy season there is usually sufficient rainfall for most crops. Irrigation is ordinarily being practiced during the dry season.

The upland soils have moderate permeability and moderate water holding capacity. Salinity and alkalinity problems have not being very serious problems yet with the introduction of irrigation. Low-lying regions, on the other hand, which comprise a small part of Class I lands, usually have sandy clay loam to sandy clay textured, somewhat poorly drained soils. Rainfall flooding is widespread because of a lack of natural surface drainage. As a result, these soils are now used mainly for gazing, but are also being used to produce cultivated crops where adequate artificial drainage has been provided. Poor aeration is a limiting factor, therefore, they are capable of carrying crops like rice, sugar cane and cotton, which can tolerate flooding during the rainy season. Diversified crops can be grown during the dry season, since water additions can be regulated. Subsurface horizons in some of the soils are moderately alkaline, although it will be wise to carry out further investigations to ascertain the extent and seriousness of this problem. Permeability rates are slow to moderate; water storage capacity is moderate.

Class II lands in the basin are characterized by widespread river and rainfall flooding making them ordinarily unsuitable for extensive dry land farming without drainage works. They are better left as natural woodland and used mainly for dry season grazing. With proper flood control, irrigation and drainage, much of these lands are capable of being cultivated during both the rainy and dry seasons. Many different soil types occur, but the most extensive are somewhat poorly drained sandy clay loams. These are developed on older alluvial deposits. About 70% of them have normal chemical properties; the remaining 30% are characterized by moderately alkaline or saline subsurface horizons. Lands in this Class are capable of carrying such rainy season crops as rice, cotton and sugar cane, which are tolerant to flooding and poor aeration. They can also carry a fairly wide range of crops during the dry season. Surface and internal drainage are critical, so the success of any irrigation project has so far depended and will in future depend to a high degree on the design of the flood control and drainage systems. Soils with serious alkalinity or salinity hazards should be avoided.

The recent floodplain deposits found in the present meander belts of the rivers consist of stratified sands, silts and clays with variable drainage. Water-holding capacities and permeabilities are moderate and chemical properties are considered normal. Many 'shadoof' irrigation schemes are already established on these soils as they are well suited to small irrigation projects and a wide range of crops could be grown throughout the year. Dykes are needed to control river flooding during peak flows, otherwise soil

drainage is not expected to be a problem. With few trees growing on these soils, land clearing and land levelling are minimal.

Clay and heavy clay textured, somewhat poorly and poorly drained soils are also included in Class II lands. They normally occur in depressional basins within the floodplain and they turn out to be swamps or lakes during the rainy season. These soils have very low permeabilities and moderate to high water storage capacities. Thus, they are suitable for crops such as rice, cotton and sugar cane, which are tolerant of these conditions. Chemical properties are normal but poor aeration is logically a limitation, even with proper surface drainage. Isolated longitudinal dunes with deep sandy soils are also found in Class II lands. General characteristics and uses of these soils are the same as described for the dunes in Class IV lands discussed later.

Class III lands are moderately suitable for dry land farming and at present are mostly cultivated. Textures are usually moderately coarse, therefore the soils are considered only marginally suitable for irrigation. The main soils are deep, loamy sands and sandy loams. Natural fertility of these soils is low and in some instances aluminium toxicity and nutrient deficiencies related to low pH may be present.

A significant portion of Class III lands is comprised of irregularly distributed soils that are similar to those in Class II above but underlain by ironstone within a depth of one metre; similar to the upland soils discussed under Class I; or somewhat poorly drained sandy clay loam to sandy loam soils similar to the low-lying soils of Class I lands. Priority should be given to improving agricultural production on the better soils, which are the well-drained, deep sandy loams and the sandy loams over sandy clay loams. A wide variety of crops can be grown, including sorghum, millet, groundnuts, vegetables, and legumes.

Class IV lands consist of dune fields and small river floodplains. These soils are generally considered marginally suitable for dry land farming, however, a small percentage are well suited to dry land farming and irrigation. The crests and upper slopes of the longitudinal dunes are characterized by sand and loamy sand, somewhat excessively drained soils. Well-drained sandy loams are common on the lower slopes. All these soils have low natural fertility and low cation exchange capacity but no serious problems related to chemical properties, such as alkalinity or extreme acidity. Because of their coarse texture, they are rapidly permeable and have low water-holding capacity. The dune soils are subject to drought, and in the northern part of the basin drought hazards are severe. Only drought tolerant crops, such as millet, and cowpeas can be grown successfully. Fertilizer losses due to leaching are high. The soils commonly occurring on the lower slopes of the dunes are comparable to those of Class III lands. Similar crops and management practices apply.

Table 3.18: Land Use Development Changes in the Basin

Land Use Category (km^2)	Bauchi*		Borno		Jigawa		Kano		Yobe		Total		
	1976/78	1993/95	1976/78	1993/95	1976/78	1993/95	1976/78	1993/95	1976/78	1993/95	1976/78	1993/95	Change
1. Intensive(crop) agriculture	20,026	27,338	9,606	10,681	8,496	15,940	17,470	15,691	7,826	7,879	63,424	77,529	**14,105**
2. Extensive (grazing) agriculture	11,049	12,050	19,392	25,885	7,746	561	574	538	10,334	10,583	49,095	49,617	**522**
3. Floodplain Agriculture	882	1,163	-	-	1,795	2,341	274	258	1,272	1,824	4,223	5,586	**1,363**
4. Extensive Agriculture with Denuded	26	137	242	871	1,265	832	-	772	1,433	4,379	2,966	6,991	**4,025**
Sub-total Agriculture	31,983	40,688	29,240	37,437	19,302	19,674	18,318	17,259	20,865	24,665	119,708	139,723	**20,015**
5. Shrubs/Grasses	14,833	15,593	27,981	17,477	1,201	473	460	909	14,240	8,674	58,715	43,126	**-15,589**
6. Trees/Woodlands/Shrubs	14,754	3,571	-	-	-	-	817	171	-	-	15,571	3,742	**-11,829**
7. Discontinuous Grassland	683	956	1,830	3,641	692	1,122	-	-	3,024	2,841	6,229	8,560	**2,331**
8. Grassland	-	470	127	2,082	-	-	-	-	744	415	871	2,967	**2,096**
9. Grasses	-	-	8,742	6,466	48	556	-	-	3,735	4,578	12,525	11,610	**-915**
Sub-total Woodland/Grassland/Shrubs	30,270	20,590	38,680	29,666	1,941	2,151	1,277	1,080	21,743	17,508	93,911	70,005	**-23,906**
10. Shrub/Sedge/Graminoid Freshwater mash/Swamp	770	622	4,200	4,029	1,075	701	176	347	1,344	782	7,565	6,481	**-1,084**
11. Graminoid/sedge/ Freshwater Mash	-	-	4,200	482	251	45	-	-	-	-	4,451	527	**-3,924**
Sub-total Freshwater Swamp/Mashland	770	622	8,400	4,511	1,326	746	176	347	1,344	782	12,016	7,008	**-5,008**
12. Gullies	-	1,403	-	1,023	-	-	-	803	123	609	123	3,838	**3,715**
13. Sand Dunes	-	-	429	892	-	-	-	-	416	1,835	845	2,727	**1,882**
Sub-total Degraded land	-	1,403	429	1,915	-	-	-	803	539	2,444	968	6,565	**5,597**
14. Disturbed Forest	-	1,322	-	-	-	-	-	-	-	-	-	1,322	**1,322**
15. Undisturbed Forest	2,367	125	-	-	260	3	-	-	-	-	2,367	128	**-2,239**
Sub-total Forest	2,367	1,447	-	-	260	3	-	-	-	-	2,627	1,450	**-917**
16. Urban	-	-	57	140	-	-	-	-	-	-	57	140	**83**
17. Reservoir	-	175	-	-	-	45	250	335	-	-	250	555	**305**
18. Irrigation Project	-	-	27	411	-	-	46	109	-	-	73	520	**447**
Sub-total Miscellaneous	-	175	84	551	-	45	296	444	-	-	380	1,215	**835**
Total Land Area (km^2)	66,034		74,363		23,089		20,430		44,716		**228,632**		
Population (1991)	4,291,000		2,595,000		2,832,000		5,638,000		1,411,000		**16,767,000**		
Population Density (persons/km^2	**65**		**35**		**123**		**276**		**32**		**73**		

*Only part of Bauchi State is in the basin

Interdunes and included floodplains contain a wide variety of soil types. Within small geographic areas, textures vary from sand to sandy clay loam while drainage ranges from somewhat excessive to somewhat poor. Rainfall ponding occurs frequently on the depressional, usually finer textured soils, and river flooding is widespread on the floodplains. Most of the soils have normal chemical properties but some have moderately alkaline subsurface horizons. Interdune and floodplain soils are either sandy, in which case they are practically the same as dune soils, or they are loams and sandy clay loams subject to frequent flooding. The flooding usually precludes dry land farming and the feasibility of large-scale drainage and flood control schemes has not been confirmed. In suitable areas, grazing and dry land farming have been going on.

Most soils in Class V lands are unsuitable for cultivation. Isolated tracts of arable soils are scattered throughout the basin. Generally, the Class V lands carry shallow soils, underlain by laterite or bedrock, which are common on the slopes of the undulating plains. Depressions and low-lying regions are frequently flooded and the soils may be alkaline and/or saline. The upper slopes and crests frequently have rock outcrops. Extensive mountainous areas occur and the soils on these rocky lands are shallow. Soils in Class V lands are being and should continue to be utilized for wildlife, forestry, watershed and grazing purposes. The isolated tracts of good agricultural soils are similar to, and can be managed in the same way, as those of Class III.

3.10 Land Tenure

The land tenure situation in Nigeria is based on the imposition of modern legal tenet on the customary laws. Traditionally, land titles could be acquired in two ways: by cultivating virgin land or where the initial title is relinquished to another person who thus acquires the right to exploit it. However, such rights are not exclusive; rather these land tenure systems are based on the understanding that land was a community and rarely family property. Consequently, land control resides with the community head but individual could apply and be granted rights to cultivate or use the land not belonging to any clan or family, provided it is for beneficial purposes. Generally, authorization to occupy available land is given to men and rarely women who have family relationship, mostly from the paternal side with the community. Such individuals could continue to possess such lands for as long as they use them to the benefit of society. Furthermore, land could be passed on to heirs or pledged to satisfy a debt, but could not be sold or mortgaged (Geomatics International, 1998).

This arrangement remained until 1978, when the problem of lack of uniformity in the laws governing land-use and ownership, population pressure and increased urbanisation, as well as trends towards uncontrolled speculation in urban land led to the promulgation of Land Use Decree No 6 of 1978. The Land Use Act of 1978 as it is now referred to, approaches these issues via three related strategies: the nationalising of propriety rights in land; "the granting of usufructuary rights in land to individuals; and the use of administrative system rather than market forces in the allocation of rights in land" (Uchendu 1979; Francis, 1984). Part I sub section A.49 of the Act state that:

> *subject to the provisions of this Decree, all land comprised in the territory of each State in the Federation are hereby vested in the military Governor of the State and such land shall be held in trust and administered for the use and common benefit of all Nigerians.*

Apart from the vesting of all land in the State, the Act also distinguishes two types of land, namely; urban and other lands (presumably rural lands). The urban lands were placed under the control and management of the State Governors to be advised by a 'Land Use and Allocation Committee'. On the other hand, the 'other lands' were placed under the control and management of the Local Government in which the land is situated with a 'Land Allocation Advisory Committee' as the advisory body. Consequently, the community's trusteeship of land were denied or frozen and the Act replaced these local sovereignties with a single national sovereignty (Uchendu, 1979).

The part II of the Act provided a new tenure system that is not only contractual but also dependent. It is such that while Governor is empowered to grant statutory rights of occupancy within his State, the Local Governments may only grant customary rights of occupancy essentially for agricultural purposes which shall not exceed 500 hectares or 5,000 hectares for grazing land after cumbersome process. As a result of these, rural land which although inherited on the basis of customary rights, could be claimed on the basis of occupancy (Renne, 1995). Part V of the Act, however, empowers the Governor to revoke rights of occupancy for reasons of overriding public interest, which may arise from unauthorised alienation of the land by the occupier or requirement of the land for public purposes. In such cases, compensation would be paid, but only for 'unexhausted improvements' on the land, but not for the land itself (Mamman, 2000).

The Land Use Act administration has proved complicated, and as a result many transactions go unreported and undocumented, and customary tenure has continued to prevail in many localities. Land development and management, especially for agriculture, have been identified as the major constraints that face Nigerian farmers, particularly the small-scale farmers owning 2-5 ha per family (Lombin, 1996). The constraints of customary laws and practices include lack of security of tenure, land fragmentation, distinction between the rights to trees and land, as well as unfavourable legislative treatment of customary tenure for forest and grazing land. The security of tenure is an important incentive to farmers to invest in the land. Consequently, the lack of recognised title on customary tenure means that the land which is the farmer's most important asset cannot be used as equity for raising credit through formal financial institutions.

Clearly, the legal, institutional and technical frameworks for land management should be linked based on clear policy choices. It is important to note, however, that the Land Use Act, institutional and technical frameworks alone should not and do not determine the policy choices, but rather these should define the framework with which to design appropriate system of land management. Obviously this has not been the case in the foregoing.

It is also significant to note that the provisions of the Land Use Act of 1978 have been enshrined in the Constitution of the Federal Republic of Nigeria 1999. Consequently, the provisions of the Act cannot be amended or expunged, altered or repealed except as provided in the constitution, and these conditions are stringent.

3.11 Invasive Water Weeds

The changes in flow regime of the Hadejia-Jama'are and Gana-Yobe Rivers have in recent times witnessed an explosive growth of aquatic weeds. The invasive weed is particularly visible at the Hadejia-Nguru Wetlands and the flow contributing channels. The water bodies have become overgrown by the *Typha* spp or 'cat-tail' particularly the *Typha domingenis* (Goes, 2001). *Typha* is not an exotic species of weed to Nigeria. It is found all over the country, where the environmental conditions are favourable for its survival. The rapid invasion is probably due to its reproductive characteristics which is both sexually (through seed dispersal and colonization) and asexually (through rhizome which takes place within the immediate area) resulting in denser coverage.

The history of *Typha* invasion in the Hadejia-Jama'are and Gana-Yobe River sub-systems could be traced back to the early part of the 1990s when it was first observed in the Hadejia barrage. The weed thrives well in shallow (less than 1.5 m deep water) but more permanent water bodies. It hardly survives in seasonal rivers with marked period of dryness. It has been observed that the construction of dams, which diverts wet season flows for releases during the dry season, has created favourable condition for the development of the invasive weed. Goes (2002) reported the following circumstances as favouring the development of the invasive weed.

- The absence of fast flowing water (due to silt blockages and aquatic vegetation growth).
- Continually moist soil (due to wet season diversion and dry season releases from dams).
- Relatively nutrient rich water (due to nutrient rich irrigation water from the fields).

All the above circumstances occurred at various points and stretches within the Hadejia-Jama'are and Gana-Yobe Rivers, hence the rapid invasion.

3.11.1 The Impacts of Invasive Water Weeds (Typha spp.)

The invasions by *Typha* spp. in the Hadejia-Jama'are and Gana-Yobe rivers have produced visible impacts on the ecology and socio-economic activities in the basin. The noticeable hydrological impacts include blockage of river channels (which reduces and diverts river flow), increased siltation, over flooding and loss of farmland and settlements, extension of riverbanks and reduction of river channels. These have resulted in less water contribution by the Hadejia River to the Yobe River sub-system within the last two decades (Goes, 2002).

The invasion of the water bodies by the *Typha* grass, which leads to flow reduction, particularly, at the downstream sectors of the Komadugu Yobe Basin prevents access to farmers, pastoralists and fishermen to open water. It, thus, constitutes a serious

threat to the ecology as well as economy of the area as large parts of the river channels, lakes, fadamas and potential grazing lands have been taken over by the weeds.

Furthermore, the proliferation of the weeds provides habitat for mosquitoes, snails and birds leading to diseases like malaria, bilharzias, liver fluke (in livestock) and crop damage. In the Hadejia-Jama'are and Gana-Yobe Rivers, infestation by quelea birds and damage to farmlands and other infrastructures have reached alarming proportions so much so that the local communities have continuously laid their complaints to the relevant authorities or agencies for intervention.

3.11.2 Control of Invasive Water Weeds (Typha spp.)

Various methods of controlling the water weeds (*Typha* spp) have been identified. These include biological, chemical, physical and mechanical control. The use of *biological* control method involving the use of species of fish that grazes on *Typha* is found to be ineffective in many trials in West African invaded water bodies, though no evidence of such trials have been made in the Hadejia-Jama'are and Gana-Yobe rivers.

Regarding the use of c*hemical* control method, to date no specific herbicide for *Typha* control has been identified. This difficulty is partly expressed due to the nature of the weed, which thrives in water, and the fear of causing more damage to other life forms in water bodies in the process of controlling the weeds. However, the possibility of using non-selective herbicides such as "Round-up under drained and dry conditions" is there and may yield positive results.

The *physical* measures to control *Typha* include the use of fire, hand cutting and shading. Shading involves replanting cleared sites with trees or covering up irrigation channels to create dry conditions that is not favourable for the survival of the weeds. These measures, particularly, that of cutting and burning, have been attempted in the Hadejia-Jama'are and Gana-Yobe rivers but achieved virtually no success.

Mechanical control of *Typha* can be very expensive especially in terms of acquisition of the necessary machines and accessories. It can be controlled by mowing, excavation and dredging which require the use of boats, excavators and dredgers. The use of this method has not yet been tried in the Hadejia-Jama'are and Gana-Yobe rivers.

For proffer utilization of the land and water resources of the Hadejia-Jama'are-Gana-Yobe Basin and realizing that the challenge posed by *Typha* is too enormous for individual, communities, Local Government Areas and State Governments to control, the need for concerted action with the Federal Government towards these efforts is most desirable. This calls for a revisit of the suggestions arrived at the "*Typha* Roundtable" held in Hadejia on 17th July 2003 (DFID-JWL, 2003). Specifically, the call for integration of mechanical-physical control of *Typha* and the need to tackle the problem in stages as follows:

- Opening up of existing water channels to increase flow rates and reduce unwanted flooding (this was discovered to be responsible for the siltation/blockages and development of *Typha*).
- Structural changes in the river system in form of control mechanism to distribute water more evenly along different channels (this can be achieved by river training).
- Management of dam releases integrated into mechanical control of *Typha* through dyke construction, drainage, burning, cutting and re-flooding.

3.12 Water Quality

The result of the water quality test carried out by KYBP Office during the year 2005 and 2006 is presented in Table 3.19. Except for one small tributary on the Hadejia River, all nitrate values are above the accepted WHO limits of 10 mg/l. The rivers with the least population and the least agricultural activities, the Jama'are and the Gana Rivers, have the lowest nitrate content (20 to 30 mg/l). The Hadejia and Yobe River (at Gashua) have slightly higher nitrate content (generally ~40 mg/l). The highest nitrate contents were measured in upstream part of the Hadejia River sub-system (50-65 mg/l at Wudil, Kano-Kura Bridge, and in Challawa Gorge Reservoir) and in the main drainage canal from HVIP (70 mg/l). Upstream of Challawa Gorge Reservoir are a lot of small-scale farms. Wudil and Kano-Kura Bridge are downstream of KRIP and Kano. These results indicate that the large and small scale irrigation projects and most likely also urban waste are contributing to the deterioration of the water quality in the basin. The nitrite values are low in all the tests (<0.5 mg/l).

The Electrical Conductivity is low (<100 µS/cm and often even <50 µS/cm). In some of the samples the pH is a bit low (slightly acidic. pH=6.4). The pH value is similar as measured in the rivers by Schultz (1976). The hardness is well within the recommended limits.

Table 3.19: Water quality parameters in 2005/2006 for KYB

Water quality parameter***	Explanation	Results of field tests	Accepted limits
Electrical Conductivity (EC)**	indication for the amount of ions in the water	< 200 µS/cm	750 to 1500 µS/cm*
pH	acidity of the water, 7 is neutral	6.4 to 7	6.5-8.5 (WHO)
Nitrite (NO_2)	indicates the presence of biological waste such as manure, nitrite is broken down by bacteria into nitrate	<0.5 mg/l	0 mg/l (WHO) 0.5 mg/l (EU)
Nitrate (NO_3)	indicates the presence of biological waste such as manure	10 to70	10 mg/l (WHO) 50 mg/l (EU)
Total hardness	sum of ions which can precipitate as 'hard particles'; calcium, magnesium and sometimes iron	< 90	
Carbonate ($CaCO_3$) hardness	sum of calcium ions which can precipitate as 'hard particles'; influences pH and CO_2	18 to 179	500 mg/l (WHO)

* or roughly 500 to 1000 mg/l Total Dissolved Solids
** measured with an EC meter from Hanna Instruments (USA)
*** measured with HS test strips

The potential sources for surface water pollution in the KYB are mainly in the Hadejia sub-basin, which has the largest irrigation projects, most industries and the most densely populated areas. The potential pollution sources are:

- Drainage water from large (KRIP and HVIP) and small-scale irrigation projects may contain insecticides and nutrients from fertilisers. Especially rice and cotton require a high dosage of fertiliser.
- Waste water discharges from urban areas. Organised sewage collection and/or wastewater treatment is virtually non-existent. The largest urban areas near the rivers are: Kano, Wudil, Ringim, Hadejia, Nguru (Hadejia River System), Gashua, Geidam, Damasak and Diffa (Yobe River). The towns along the Komadugu Gana and Jama'are River are relatively small.
- Industries, especially tanneries, textile mills and abattoirs, in Kano and other urban areas. About 70% of Nigeria's tanneries are located in Kano (World Bank, 1995). At Kano's three industrial estates industrial sludge and liquid waste are routinely deposited in open drains, sewer systems and watercourses without treatment. The waste treatment facilities that do exist are either inadequate or not functioning (Binns *et al*., 2003). The waste by-products from tanneries have high concentrations of the heavy metals chromium and cadmium.

It should be noted that pollution of surface water with nutrients (nitrate, phosphate) is a favourable factor for the development of aquatic weeds such as *Typha*.

Ahmed (1998 cited in Doody, 2000) reported that there are concentrations of trace elements, such as copper, cadmium and iron that were higher than permissible levels for irrigation in the Hadejia River sub-system. He concluded that this was as a result of industrial discharge upstream of the river system. A 1989 study, which monitored the activities of 15 tanneries in Kano, found that in all cases permissible levels for effluent discharge were violated, with the exception of pH and temperature (World Bank, 1995). Binns *et al*. (2003) measured the surface and groundwater quality at different times at four sites in and near the Jakara River in Kano (40 samples in total). The analysis revealed extremely high (sometimes more than 100 times the WHO limits) levels of toxic waste in most of the surface water and in some of the shallow groundwater samples (e.g. Cd up 28.9 mg/l and Cr up to 49 mg/l). Although, the Jakara River does not directly drain into the Hadejia River it is not likely that the water quality of the tributaries to the Hadejia River originating from Kano will be much better. The KSWB reported that the intakes for KCWS are upstream of the drainage canals from Kano. Still, the shallow (~10 m) tubewells in the bank of the Hadejia River for the domestic water supply of Wudil are downstream of the drainage canals.

Further downstream in the Hadejia River System, Doody (2000) carried out a surface water quality survey at the end of the dry season (May/June) covering 20 sites in the Marma Channel and Nguru Lake in the HNW. The conductivity varied between 100 and 210 μ cm^{-1}. Nitrate (<2.5 mg/l) and phosphate (<1 mg/l) levels were low at all the sample sites. Arsenic (mean 0.018 mg/l, maximum 0.03 mg/l) was the only trace

element recorded in concentrations higher than the WHO limit (0.01 mg/l). The most likely source was pesticides on crops or birds (*Quela quela*). The conclusion of the study was that the surveyed waters were unpolluted but that there are indicators of threats to the water quality of the wetlands from agrochemicals such as fertilizers and pesticides.

The most important factors that can cause deterioration in the groundwater quality in the basin are:

- the presence of natural minerals especially in the deeper aquifers;
- the use of fertilisers and agrochemicals for large and small scale agriculture;
- leakage due to poor sanitation and waste dumps in densely populated areas; and
- leakage from industrial waste.

A shallow groundwater quality field survey on 72 hand pump equipped wells in and around the HNW had the following worrying conclusion (Goes and Zabudum, 1998). More than half (57%) of the surveyed wells in Nguru and Gashua, and 11% of the surveyed village wells were polluted (nitrate content: 50 to over 500 mg/l, EC 600 to 3,000 µS/cm). The high nitrate concentration, which exceeds 5 to over 50 times the accepted WHO drinking water limit (10 mg/l), is a potential health hazard. The most important cause of the high nitrate levels in the surveyed wells is probably poor sanitation because, generally, the wells in densely populated areas are the most polluted. Nitrate contamination of shallow aquifers in northeast Nigeria was also observed along the Yobe River by IWACO (1985b). Out of 85 samples taken from mainly open wells in the phreatic aquifer north and south of the Yobe River, 51 samples showed nitrate level of 10 to 100 mg/l. In 7 samples values above 100 mg/l were measured. Even the eight village wells in the basin measured in 1974 showed that nitrate content varied between 7 and 374 mg/l with a mean value of 90 mg/l (Schultz, 1976). In shallow boreholes used for irrigation at the HVIP also high nitrate levels were found indicating groundwater contamination from fertilisers (Essiet and Ajayi, 1995 cited in Doody, 2000).The water from some of the boreholes from the deeper aquifers have a high (natural) iron, sulphate and/or manganese content (Bunu, 1999; Oteze and Fayose, 1988; Maduabuchi, 2005).

The water quality from the El Beid River is the main source of water for the SCIP irrigation project. The El Beid has high sodium and potassium concentrations at different moments of the flood cycle. The high concentrations in the south-western corner of the Lake could cause severe soil damage and lowering of crop yields (MacDonald, 1973). The impacts of sewage disposal through septic tanks on groundwater in Maidiguri are not known but could be severe.

Socio-economic Characteristics 4

4.1 Introduction

In addition to quantitative and qualitative assessment of the physical conditions (temporal and special availability and use of water), an assessment of the present socio-economic characteristics is also necessary before any intervention directing to IWRM can be made. A understanding of these situation are prerequisite for assessment and analysis of institutional framework and the potential water use conflicts between stakeholders that would done in the next chapter.

The Communities in the Lake Chad basin of Nigeria have over the past eked out a living through exploitation of natural resources. The principal economic activities of the basin are agriculture, fishery, animal husbandry, and commerce. All of which are invariably dependent on access to water. Water is life – safe drinking water is essential for health but increasing the level of access to water is also important for income generation. The occurrence of repeated drought and expansion of Sahel, has led to increased southward migration of human and their domesticated animal in search of fundamental natural resources for survival. The conventional wisdom therefore suggests that water is a major constraint to the basin's rural economic growth (finite land and water resources versus growing demand). These have escalated the natural resources degradation arising mainly from overexploitation. The river systems have been the refuge and thus the main victim of degradation (UNEP, 2004). Consequently, the predominant concentration of the population is in the south western parts of the basin, where most of the economic developments are also centred.

4.2 Population Dynamics

According to 2006 population census, the total population of five out of the six riparian states that made up the Lake Chad Basin of Nigeria is 24,881,580. The World Bank (2002) stated that the population growth rate of the region has ranged between 2.5% and 3.0%, but the popularly used growth rate is 2.8%. Table 4.1 shows the distribution of population among the five states. Kano has the largest concentration of population in the basin representing about 38% while Yobe has the list representing about 9%. According to Aminu *et al*. (2006), the population statistics of the five riparian states are predominantly rural. He explained that the percentages of the total population leaving in rural areas in mid-2000 were 84.0, 64.4, 93.1, 60.1 and 75.7 for Bauchi, Borno, Jigawa, Kano and Yobe states, respectively. The primary occupation of the rural inhabitants is agriculture. Agricultural activities in the basin overwhelmingly depend on access to water in the rivers and the Lakes. The implication is that if proper

and effective water management system is not put in place, the dwindling livelihood of the population in the basin will further be threatened.

The distribution of the population by sex across the seven states shows that males are slightly higher than females. The result in Table 4.1 reveals that males are 51.5% while females are 48.5%. According to Aminu *et al*. (2006) most of the population in the KYB are below 60 years. This assertion is confirmed by the findings of the UNIMAID Consult (2011) in Borno Basin, where only about 20% of the populace are above 45 years (see Fig. 4.1).

Table 4.1: Population of the 7 Riparian States of the Lake Chad Basin in Nigeria for 2006

State	Female	%	Male	%	Total	%
Adamawa	1,561,978	49.30	1,606,123	50.69	3,168,101	**10.14**
Bauchi	2,250,250	48.12	2,426,215	51.88	4,676,465	**14.98**
Borno	1,990,036	47.94	2,161,157	52.06	4,151,193	**13.29**
Jigawa	2,132,742	49.04	2,215,907	50.96	4,348,649	**13.93**
Kano	4,539,554	48.38	4,844,128	51.62	9,383,682	**30.05**
Plateau	1,585,679	49.88	1,593,033	50.12	3,178,712	**10.18**
Yobe	1,115,588	48.05	1,206,003	51.95	2,321,591	**7.43**
Grand Total/ Basin Average	**15,175,827 -**	**48.55**	**16,052,566 -**	**51.45**	**31,228,393 -**	**100.00**

Source: Computed from NPC (2006).

The demography of the riparian communities in the basin is characterized by changing population patterns, with many people migrating from other communities to the settlements on the shores of the lakes and rivers in order to engage in the productive activities provided by the basin resources. Many young people within and without the basin migrate to various segments of the basin during the dry season to be gainfully engaged in recession and irrigation cropping on the fertile shores of the Lake Chad and flood plains. Similarly fishermen and nomads also migrate to the riparian areas for fishing and for rich pasture to their livestock. This has in recent times resulted in high population, depletion of resources and conflict among different users of the basin's natural resources.

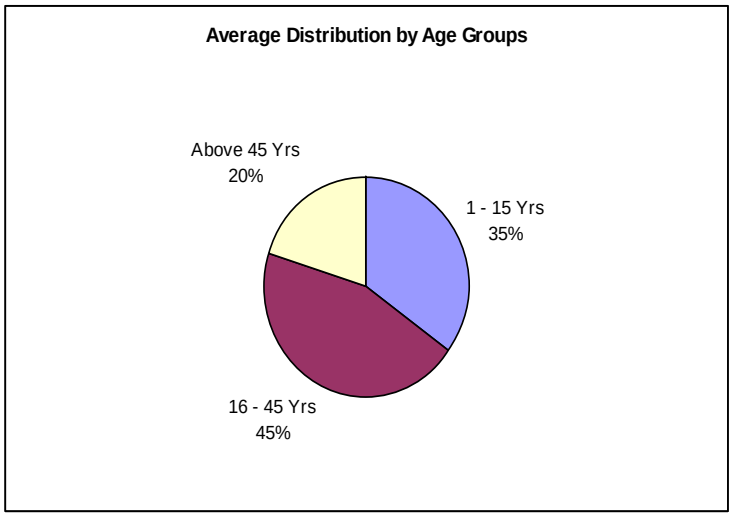


Figure 4.1: Age Distribution communities in the Borno Basin.

Source: UNIMAID Consult, 2011.

4.3 Social and Cultural Aspect

The basin exhibits a socio-cultural unity based on shared history by the established population groups of Hausa and Kanuri (Kindler *et al*., 1990). Hausa is the dominant language in most of the communities, especially around Kano, Bauchi and Jigawa States, but in Yobe and Borno States and some few communities around the downstream of Jigawa State the use of Kanuri language prevails over Hausa (Aminu *et al*., 2006). The old Islamic States (the Kanem-Borno and the Sokoto Caliphate) are largely responsible for present distribution of populations in the basin. Migration during the latter part of the millennium has brought Shuwa Arabs from the east and Fulani pastoralists from the west (Neiland and Verinumbe, 1990).

The Borno sub-system of the Lake Chad Basin of Nigeria has a rich and diverse historical and cultural heritage. Tijanni (1980) has noted quite aptly the larger ancient Kanem-Borno region to which the present Borno state belongs was, and still is, the 'abode of a human population characterised by considerable ethnic and cultural diversity'. The state is pluralistic in ethnic composition, with most of the languages belonging to the Chadic language classification. Some of the major linguistic and cultural groups in the state include the Kanuri, Babur/Bura, Marghi, Shuwa-Arab, Mandara, and Fulfulde. The northern and central part of the Borno basin area are mostly dominated by the Kanuri and Shuwa-Arab ethnic groups; the southern part of the basin are dominated by Babur/Bura, Marghi, Chibok, Mandara, Gwoza and other minor ethnic groups.

It is important to note that there are other numerous pockets of ethnic groups, each attracted by the opportunities to exploit the natural environment through a range of activities. The majority of the populations speak Hausa and an official language. The main languages used in the area reflect the political roles exercised during the pre-colonial period. The English and French colonial powers have also imposed their languages, legal and administrative systems, upon the traditional ones in Nigeria and Niger portion of the basin, respectively. Nevertheless, customary laws, regulations and structures still determine land use systems in large measure.

4.4 Economic Activities

The principal economic activities of the basin are mainly water dependent: agriculture, fishery, animal husbandry, and commerce. The ecosystem of the rivers and lakes and other floodplains adjoining the communities in the basin yield a wide range of goods and services, many of which have a high economic value. Consequently, the economic costs of upstream water diversion can be substantial, particularly in a semi-arid environment where downstream uses of water are critical to the economic livelihoods of a large number of rural households. The study carried out by Kwaghe *et al*. (2008) among riparian communities in HJKYB and that of Borno basin by UNIMAID Consult (2011) represented by Figures 4.2a&b, depicts the primary economic activities of the populace in the Lake Chad Basin of Nigeria. The results of the 2 studies shows that

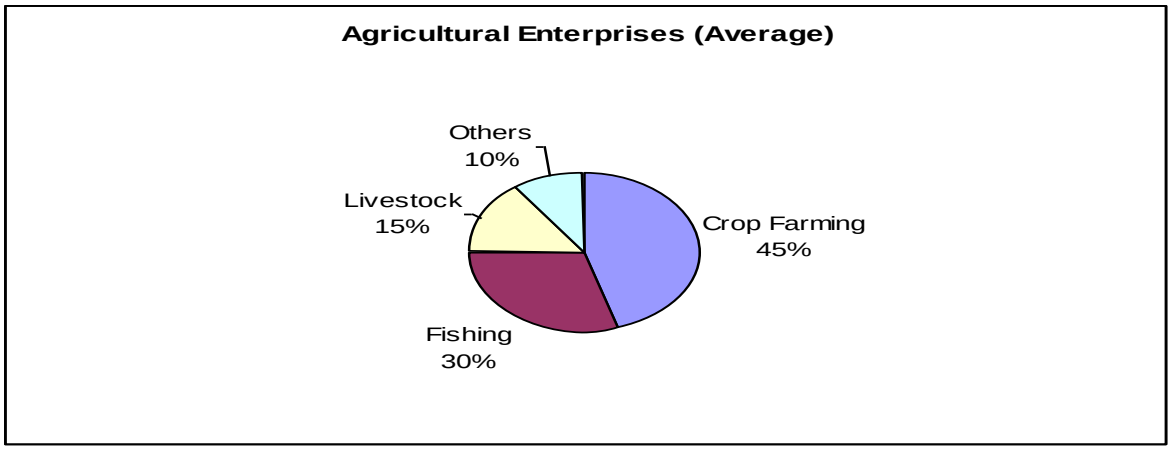
crop farming is the major economic activity followed by fishing, animal husbandry and others. Other in these studies refers to civil servants, traders, artisans and some commercial activities. The summary of economic activities across the basin is also presented in Table 4.2.

Table 4.2: Summary of economic activities in Lake Chad Basin of Nigeria

Communities	Locations	Main Economic Activities	Main Agricultural Outputs Produced	Other Economic Activities
Runa, Tsakuwa, and Muras	Dawakin Kudu LGA: Kano Upstream	Crop production And fishing	Onion, sugar cane, tomato, carrot and Pepper in dry season. Sorghum, millet cowpea and cassava in wet Season	**Livestock rearing; Trading and Hunting**
Katai, Kausani and Tsibiri	Wudil LGA: Kano Midstream	Crop production And fishing	Sugar cane, onion, pepper, tomato, garden egg in dry season. In the wet season: rice, maize, cowpea and millet	**Commerce**
Katirshe, Kadiri and Cincimi	Agingi LGA: Kano Downstream	Crop production And fishing	Tomato, onion, pepper, carrot, wheat in dry season. In wet season rice, millet, sorghum	**Livestock rearing; Trading**
Miga, Hanzu, And Kware	Miga LGA: Jigawa Upstream	Crop and livestock production, and fishing	Rice in the wet season, tomato, pepper, sugarcane dry season	**Commerce**
Auyo, Gamsarka and Zumoni	Auyo LGA: Jigawa Midstream	Crop production, fishing and livestock	Rice, sorghum, millet and maize in wet season. In dry season, tomato, onion, pepper, garden egg, maize	**Commerce**
Kardigi, Saleiri and Bulinceri	Kirikasanmma LGA: Jigawa Downstream	Crop production	Cassava, but before flooding and *Typha* spp. invasion millet, G/nut and cotton in the upland and livestock.	**Potash sale (obtained as a deposit due to flood)**
Garbi, Zabarmawa and Araro	Nguru LGA: Yobe upstream	Crop production, livestock and fishing	Millet, sorghum and Groundnut before flooding, but now flood overtakes 90% of the farmland.	**Commerce**
Wusir, Asbak and Kazir	Bade LGA: Yobe Midstream	Fishing and Crop production	Rice in the wet season, vegetables such as tomato, onion, and pepper in dry season but dry season cropping and fishing have decline due to water stress	**Commerce; Government work**
Dambaram, Balle and Canlori	Geidam LGA: Yobe Downstream	Crop production And fishing	Rice, okra, G/nut in wet season, onion, tomato, pepper in dry season. Fishes resources decline due to water shortages	**Livestock production**
Livestock Production	Damasak LGA: Borno upstream	Crop production And fishing	Pepper, Wheat in dry season. Rice, millet, cowpea in wet season.	**Livestock production; Commerce**
Jabulam, Yau and Fogwa	Abadam LGA: Borno Midstream	Crop production And fishing	Rice in wet season. In the dry season rice, wheat and vegetables in the Yau irrigation project	**Livestock production**
Abadam, Doron- Baga and Malamfatori	Abadam LGA: Borno Downstream	Crop production And fishing	Maize, cowpea using residual mixture (Lake Chad), rice in rain fed. Pepper, tomato, onion, sweet potato, in dry season	**Livestock production; Commerce (local and cross-border); Transportation using canoes across the borders**
Durfada, Gombole Dam, Dekeke	Konduga LGA: Gombole/Sambisa Midstream Ngadda catchment	Crop Production and fishing during rainy season	G/nuts, Beans, Sesame, Cassava, Pepper, Onion, Tomatoes, Maize, sorghum, Millet	**Livestock, Hunting and Commerce**
Khadamari, Zabarmari, Gongolan	Jere LGA: Borno downstream Alau Dam	Crop production and fishing during the rainy season	Rice, tomatoes, pepper, onion, mango, cashew, citrus.	**Livestock production and commerce**
Gamboru, Dambore, Wurge, Wofio,	Ngala LGA: Borno – River Ebeji	Crop production and fishing during the rainy season	Rice, onion, pepper and carrot	**Livestock production and cross border trade**
Uba, Lassa, Maikadiri, Izge	Askira/Uba LGA: Borno Upstream of Yederman	Upland crop production few vegetables in dry season	Rice, maize, sorghum, cassava, mango, citrus and vegetables	**Livestock and commerce**
Kari, Pastoralist community and Pastoralist community	Darazau LGA: Bauchi Upstream	Livestock rearing, fishing in wet season, upland crop production and few vegetables in dry season	Sorghum, rice, maize wet season. Tomato, pepper in dry season	**Sales of drinking water using tube wells along the shore of the river**
Zigau, Desina and Tsibiri	Shira LGA: Bauchi Midstream	Crop production and fishing in wet season	Rice, maize in wet season. Sweet pepper, hot pepper, tomato in dry Season	**Livestock rearing**
Jama'are, Yola and Aniferi	**Jama'are LGA: Bauchi Downstream**	**Crop production And fishing**	**Sorghum, rice in wet season. Sugarcane, onion, tomato, garden egg, lettuce, wheat in dry season**	**Livestock rearing**

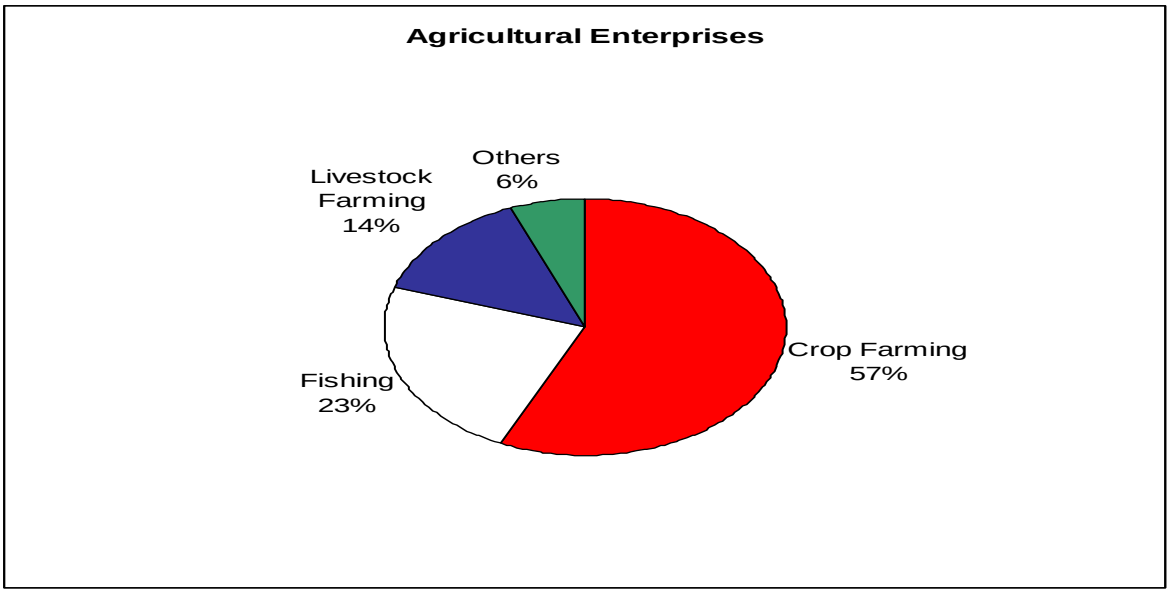
Source: Aminu *et al.*, 2006 and Field Survey, 2011.

Figure 4.2a: Distribution of Households by Agricultural Enterprises in Borno Basin



Source: UNIMAID Consult, 2011.

Figure 4.2b: Distribution of Households by Agricultural Enterprises in HJKYB



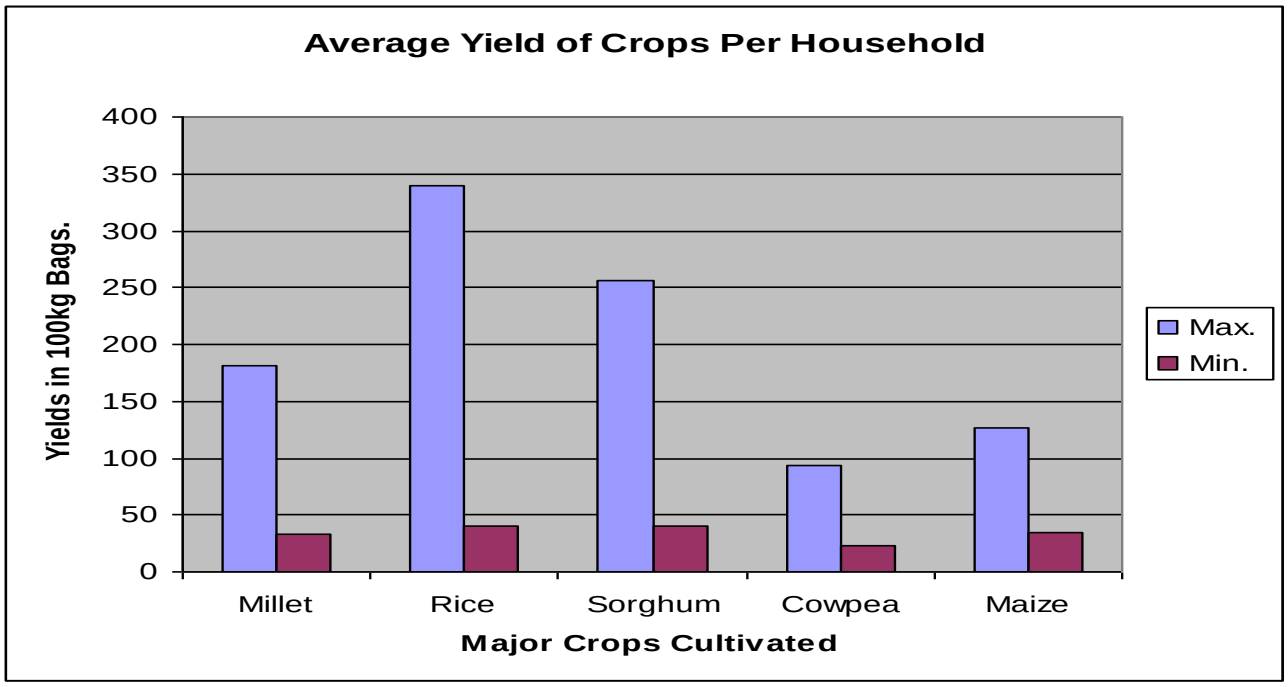
Source: Kwaghe et al. (2008)

4.4.1 Crop farming

The dominant crops cultivated in the basin are rice, millet, maize, sorghum, cowpea, pepper, onion, tomatoes, potatoes, cassava and water melon. These are in rhythm with the three methods of crop production in the area namely rainfed, flooding/recession and irrigation. The main crops produced by rainfed or upland cropping are food crops such as millet, sorghum, maize, cowpea and groundnuts. In recent time, maize and cowpea are produced on large scale as recession cropping in the shores of Lake Chad and adjoining flooded low lands when they recedes. Other crops that are produced by flooding/recession are rice, wheat, water melon, cassava and potatoes. Irrigation farming used to be by drawing water through canals from surface sources, but in recent time the use of underground water because of the dwindling water situation in the basin is becoming the main source of water for

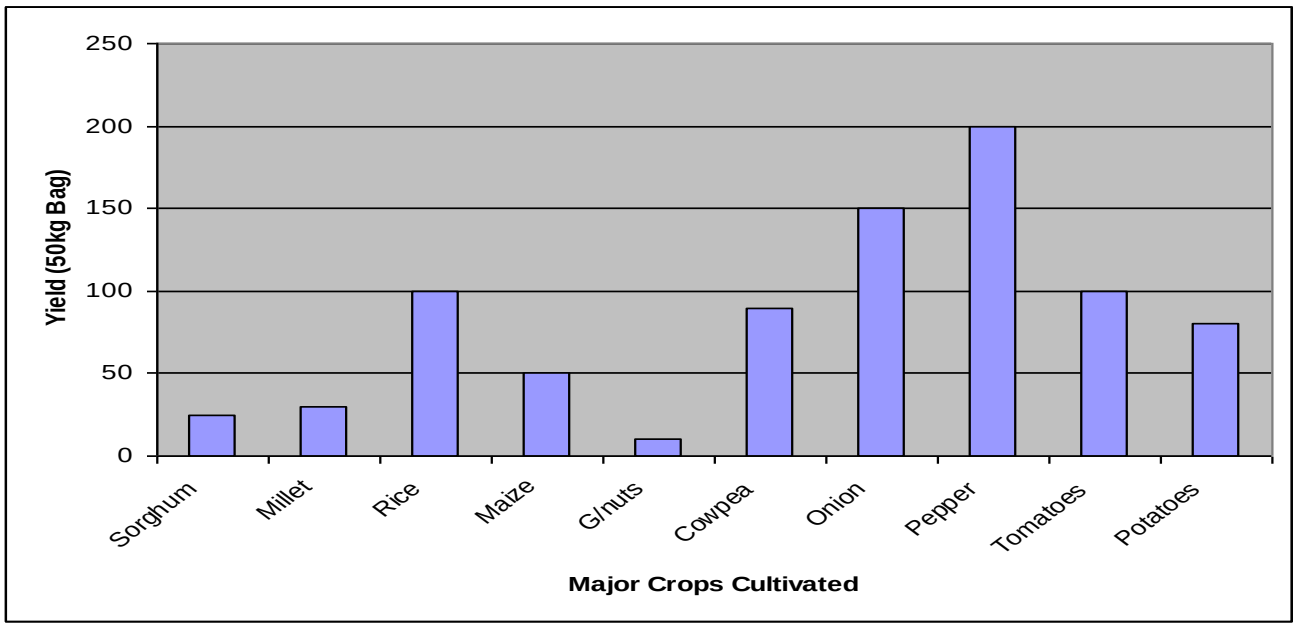
irrigation. However, water from surface sources are still used for irrigation around Lake Chad, Lake Nguru, Lake Alau as well as Challawa and Tiga dams. The major crops grown by irrigation in the basin are hot and sweat peppers, onion, tomatoes, garlic and other vegetables, these are mainly cash crops. Figures 4.3 and 4.4 shows some of the major crops cultivated in the basin and their average yields per households.

Figure 4.3: Average Yield of Major Crops per Household in KYB



Source: Kwaghe *et al.* (2008)

Figure 4.4: Major crops and their average yields per household in Borno Basin

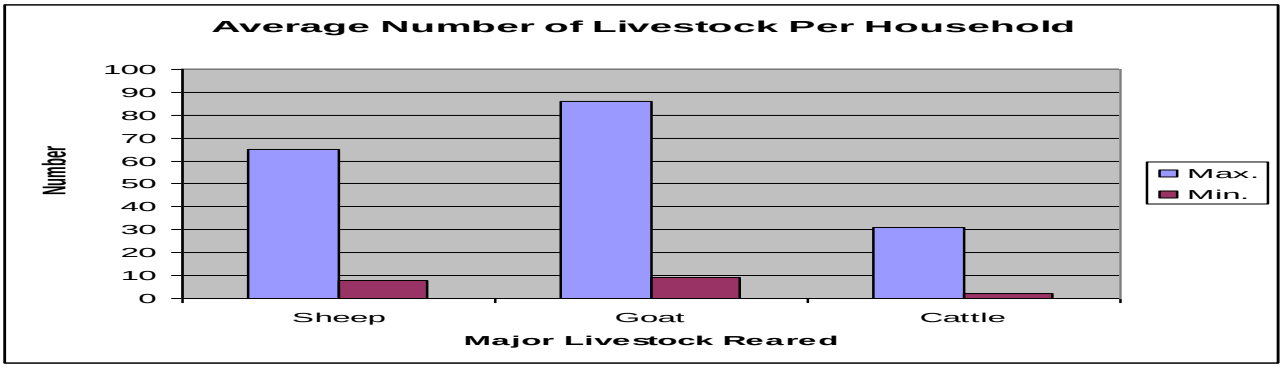


Source: UNIMAID Consult, 2011.

4.4.2 Animal husbandry

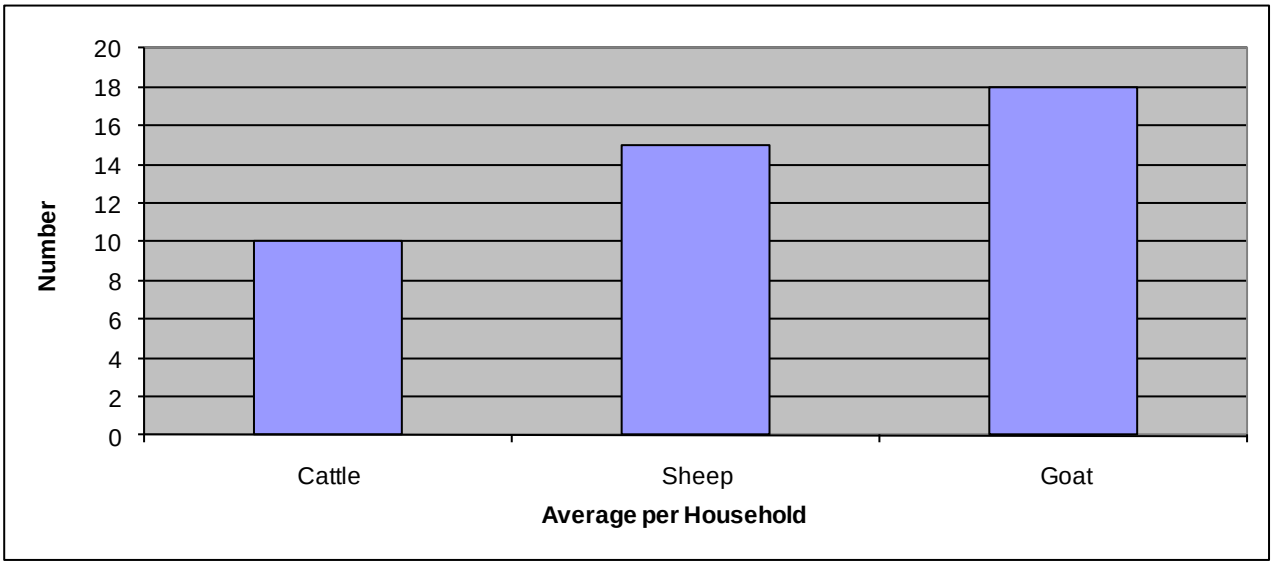
The basin form a vital part of the region's livestock production system. Hundreds of thousands of nomadic stock, as well as the resident stock, graze the wetlands, fadamas and surrounding uplands of the basin in the dry season. One source (ICRA, 1992) reported that 90% of the stocks are owned by Fulani pastoralists. Resident livestock reared in the basin are kept primarily for their economic values, especially during dry season. They are normally brought out for sale as coping strategies; during periods of hardship. The major livestock kept by the communities are goats, sheep and cattle. The average of the major livestock reared per household in the HJKY basin and Borno basin are presented in Figures 4.5a&b respectively.

Figure 4.5a: Average number of livestock per household in HJKYB



Source: Kwaghe *et al*. (2008)

Fig. 4.5b: Average number of the major livestock per household in Borno Basin



Source: UNIMAID Consult, 2011.

4.4.3 Fishing

As with livestock, little detailed information, especially quantitative data, is available on Wetlands fisheries. Though formerly very important, it seems clear that it has

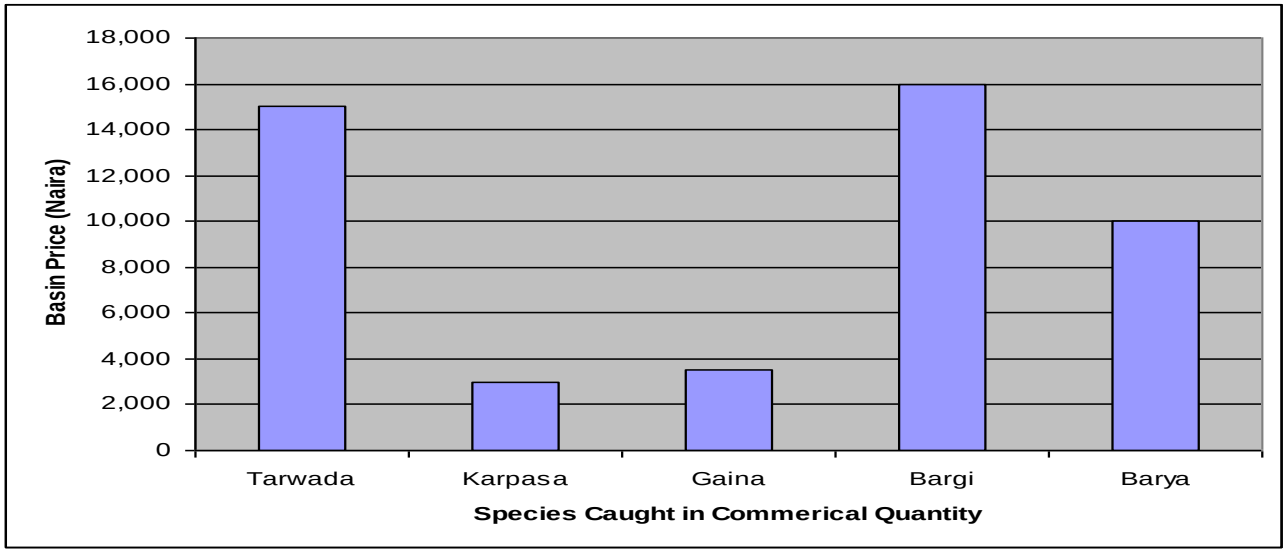
declined in recent decades. This is probably due to a combination of the reduction in seasonal flooding and increasing overfishing. Species diversity has declined.

Even without fishing, only 10% of the basins fish biomass normally survives the dry season, in the limited area of permanent pools (lakes) and rivers, so theoretically up to 90% can be removed by fishing each year without seriously harming the basic stock and the long-term sustainability of the fishery.

A change from seasonal flooding due to over-abstractions of water up streams and drought combined with widespread overfishing appears to result in a change in the species balance, with an increase in the less valuable species. As a consequence of these two factors, fishing returns over the years has decreased significantly

Fishing is an important economic activity in the basin communities, where majority of households participate either as full time or part time fishermen. It was reported across the Borno basin communities that daily catch or the value of daily catch has drastically fallen. It is also reported that species of economic importance are lost, the available species that are caught in commercial quantities now include *Tarwada, Bargi, Karpasa, Gaina,and Barya.* As reported across the communities on the average, about 4 basins are caught by a fisherman daily during the peak fishing periods. The average prices per basin of the common species caught are as presented in Figure 4.6 (UNIMAID, Consult).

Figure 4.6: Common Species in the Borno basin and their Unit Prices



Source: UNIMAID Consult, 2011.

4.5 Access to Water Supply, Sanitation and Health

Access to safe drinking water supply as reported by KYBP (2006) is essential for health but increasing the level of access to freshwater is equally critical for livelihood. Water uses in the basin include domestic, industrial, agricultural (flood cropping, recession farming, small and large-scale irrigation), livestock, fisheries and ecological. More than

70% of the freshwater withdrawal in the basin is used for agriculture followed by domestic use. The indiscriminate discharge of effluents into the river has restricted the use of river flow for economic productive purposes, while safe drinking water is obtained mostly from dug wells and or boreholes. The river flow is however an important source of recharge of the underground water. Although, the general believe is that the river flows are unsafe for domestic uses even by upstream communities (Kano, parts of Jigawa and southern Borno), yet the use of water in the irrigation canal was rampant by communities adjoining these structures. The explanation was that they were using the raw water as a last resort because they have no other option.

The sanitary conditions for rural dwellers are particularly poor. The sanitation rate was barely up to 40% in 2000 and has not improved by much since then. The development of disease vectors in swamps and irrigation fields coupled with deterioration of drinking water quality as a result of some hydrological changes and improper conservation has resulted in health concern in basin. The health status of the people in most communities (particularly those that suffer less severity of flood) can be described as average. Most of the population (estimated at about 80%) were judged to be healthy enough to work in the farms and also engaged in other economic activities such as fishing and livestock rearing (Aminu *et al.,* 2006). Around Hadejia Nguru wet lands, the problem of flooding has resulted in water logging and severe salinity of the soil, which has affected the quality of the underground water. Consequently, even though water is readily available from tube wells and local wells, the quality has been impaired by the excess potash and sodium. In those communities, especially where severity of flood has been more (such as those around Jigawa downstream and Yobe upstream (Hadejia-Nguru Wetlands areas) the health status of the people was weak (Aminu *et al*., 2006). Many of the inhabitants of these communities suffer from cold related illnesses such as rheumatism and pneumonia and this seems to affect their livelihood.

The sources of potable drinking water as reported by the communities visited in Borno basin are motorized boreholes, free flows boreholes, wash boreholes, tube wells and mud and cement wells. The free flows boreholes were drilled since 1960s but most of them are still functional. The main sources of potable water in most of the communities are private tube wells and wash boreholes where water vendors buy and re-sell to members of the communities. Few communities reported that some of their members collect water directly from open sources and this is dangerous and unhygienic.

The major sources of water as reported by Kwaghe *et al*. (2008) in the communities surveyed in the HJKY basin are hand pumps, cement wells, and motorized boreholes. Even though members of the communities complained that the numbers of sources of drinking water are not sufficient in their communities, most of them are functional. The survey revealed most of the communities fetch their drinking water from hand pumps. On the average each community have 3 hand pumps.

4.6 Access to Market and Marketing

Availability of market in a community and the participation of her members in marketing activities is a sign of a booming community. One of the bottlenecks to agricultural development and economic break through is lack of market where farmers can dispose their produce and buy inputs and other livelihood necessities. One of the major problems hampering the rural communities living along the shores of the lakes, rivers and low lands access to market and marketing is poor road networks. Out of the 22 communities surveyed in HJKYB only 13 are accessible year round while the remaining 9 are seasonal or partially seasonal (Kwaghe *et al*., 2008). Similarly out 17 communities visited across the Borno basin, only 8 of the communities are accessible year round without any difficulties while 9 are seasonally accessible or partially accessible only with powerful 4 wheel drive vehicles. In some communities around the Lake Chad in Borno State (Alahgarno, Abadam, Mallam Fatori and Mallam Konari) the road leading to them are bush roads and it is very difficult to navigate as you just have to find your way through the bush (UNIMAID Consult, 2011).

One of the contributing factors to high poverty rate registered in the rural areas and among farming households in particular is subsistent production. As long as there are no market facilities available to rural areas, their production will continue to be subsistent. To help farmers to produce tradable commodities or to produce in commercial quantity their access to market and marketing facilities needs to be developed or enhanced by the local authorities. One of the ways to do that is to provide markets with marketing facilities and access roads.

4.7 Poverty

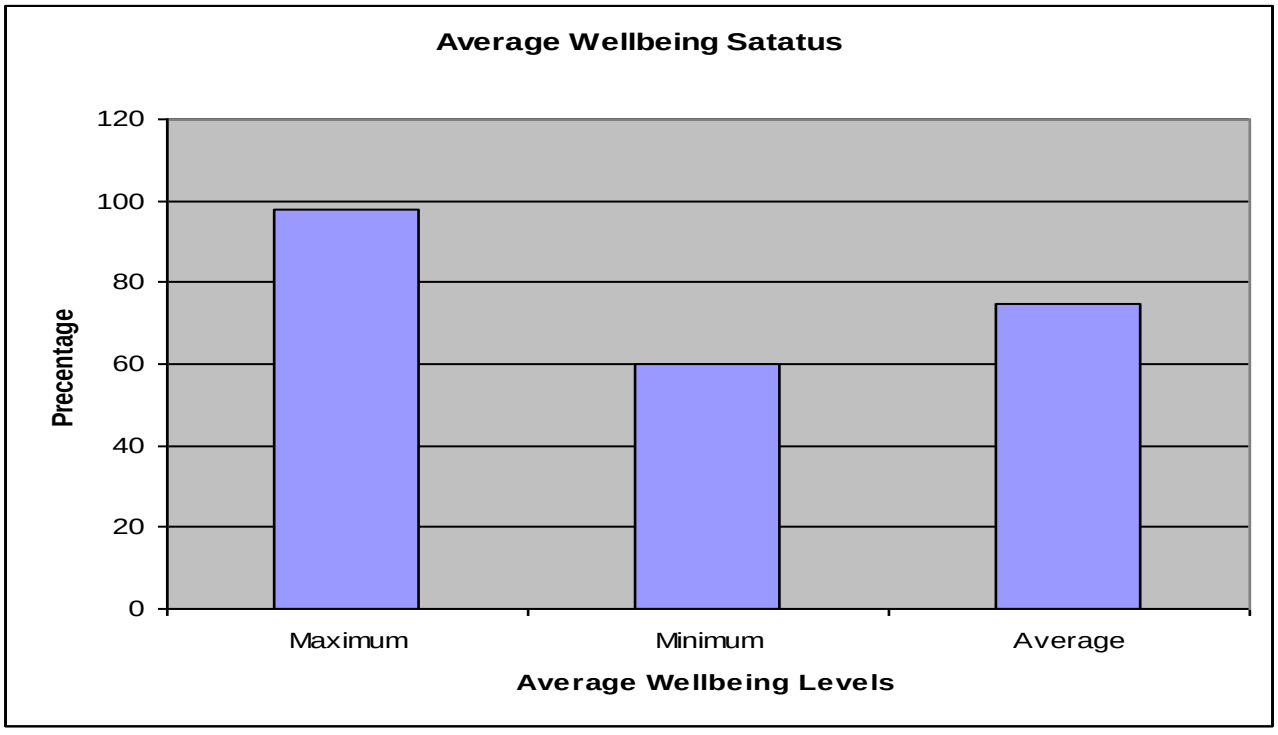
As reported by Afremedev Consultancy Services Ltd (2006) Level of access to water determines the productive activities and livelihood the communities in the basin can pursue. For instance, the upstream communities in KYB whose access to water was boosted with the construction of hydraulic structures and development of public irrigation schemes such as the Kano River Irrigation Project (KRIP) and Hadejia Valley Irrigation Project (HVIP), have higher per capita income and enjoy higher standard of living when compared to their counterpart downstream. Communities downstream especially in Yobe and Borno states have complained seriously over their increasingly poor access to water (Aminu *et al*., 2006). Accesses to water by communities downstream have slightly improved in the recent years through some project implemented by HJKYB-TF. These projects varied with peculiarity of the problem hampering the access to water by the communities; it included channel clearance, dyke and embracement construction, flood control or retention gates etc. Communities that had excess water were alleviated and those without water have started seeing water. It is expected if these projects continued on sustainable basis, poverty in the basin will be reduce.

Similarly, in the communities upstream of the river Ngadda around Alau Dam in Borno basin have higher income than the downstream communities? The Jere bowl, popularly

known for production of rice was impoverished for 7 years after the construction of Alau Dam. The seasonal flow that floods their rice fields was blocked by the dam and this affected their productivity until water sharing formula was negotiated after 7 years of being impoverished.

The unsatisfactory and uncoordinated management of the reservoirs coupled with profligate operation and maintenance of the irrigation schemes as well as Kano city water intake structures has led to over-abstraction and at time destructive river-flow. The fresh water scarcity in the basin has not prompted authorities to manage the utilisation of the resources that are available more efficiently. There is general lack of incentives and other economic instruments to promote environmentally sound practices. Farmers on the KRIP and HVIP as well as Lake Alau have no incentive to conserve water, as the water charges are low and often the farmers do not pay and they are not sanctioned. These factors have contributed in making access more difficult downstream, which in turn has affected the productive activities and the general ecosystem as well as the human settlement dynamics. Some communities have been temporarily migrating to other places where access to water for productive purposes is more readily available, especially for dry season cropping.

Figure 4.7a: Average Levels of Wellbeing in Borno Drainage Basin

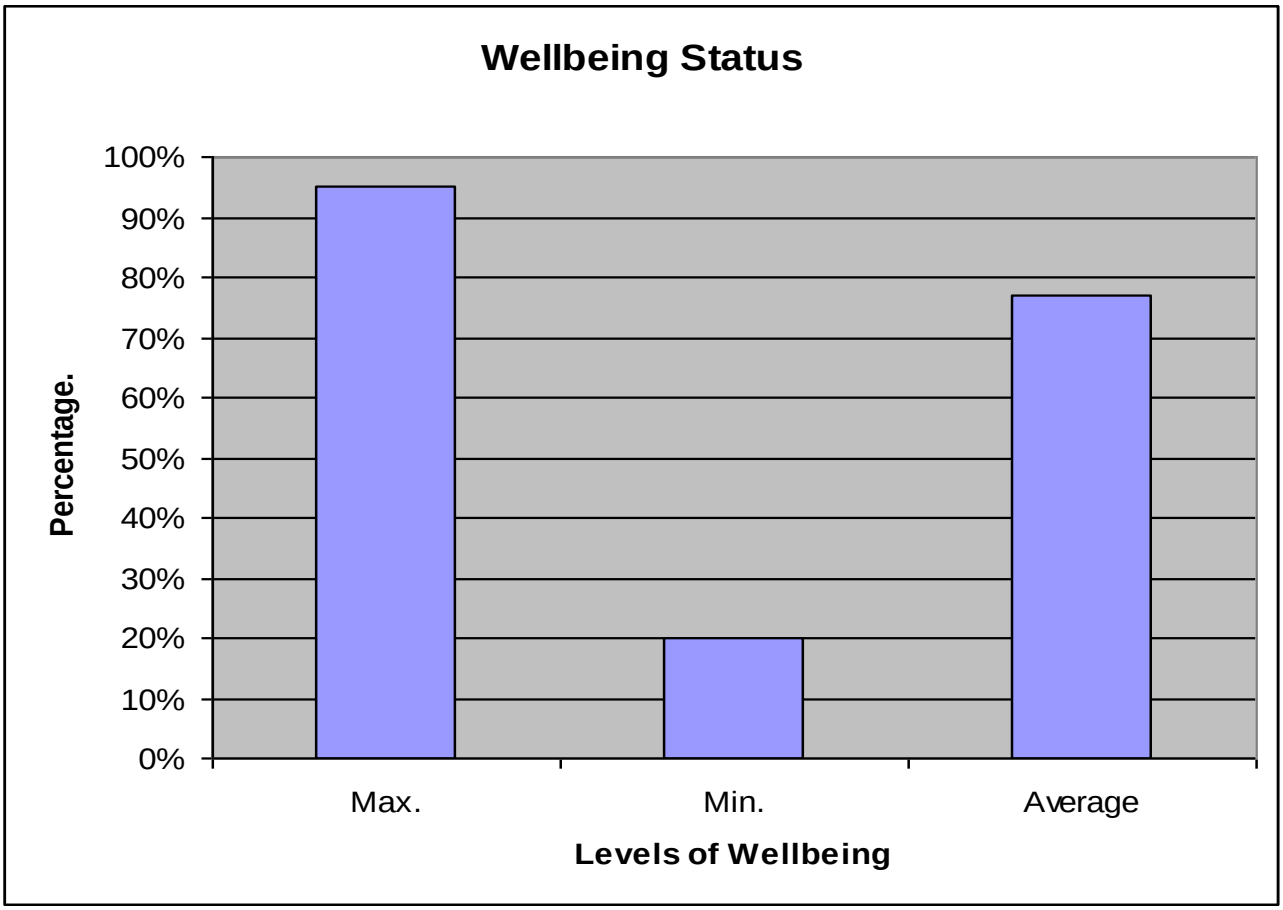


Source: UNIMAID Consult, 2011.

The people of Komadugu Yobe and Borno Basins are facing endemic poverty. This has been the catalyst for environmental degradation. They resort to unsustainable exploitation of natural resources for their short-term survival. For the last forty years most communities have endured the effects of freshwater shortage largely caused by unsatisfactory management of the water resources of the basin (UNEP, 2004).

Increased diversion to meet the need of the upstream communities has led to many people residing downstream experiencing freshwater shortage. The prevalence of endemic poverty in the basin especially the downstream communities requires special attention to be paid to improving water allocation.

Figure 4.7: State of Wellbeing of Households in the HJKYB



Source: Kwaghe *et al.* (2008)

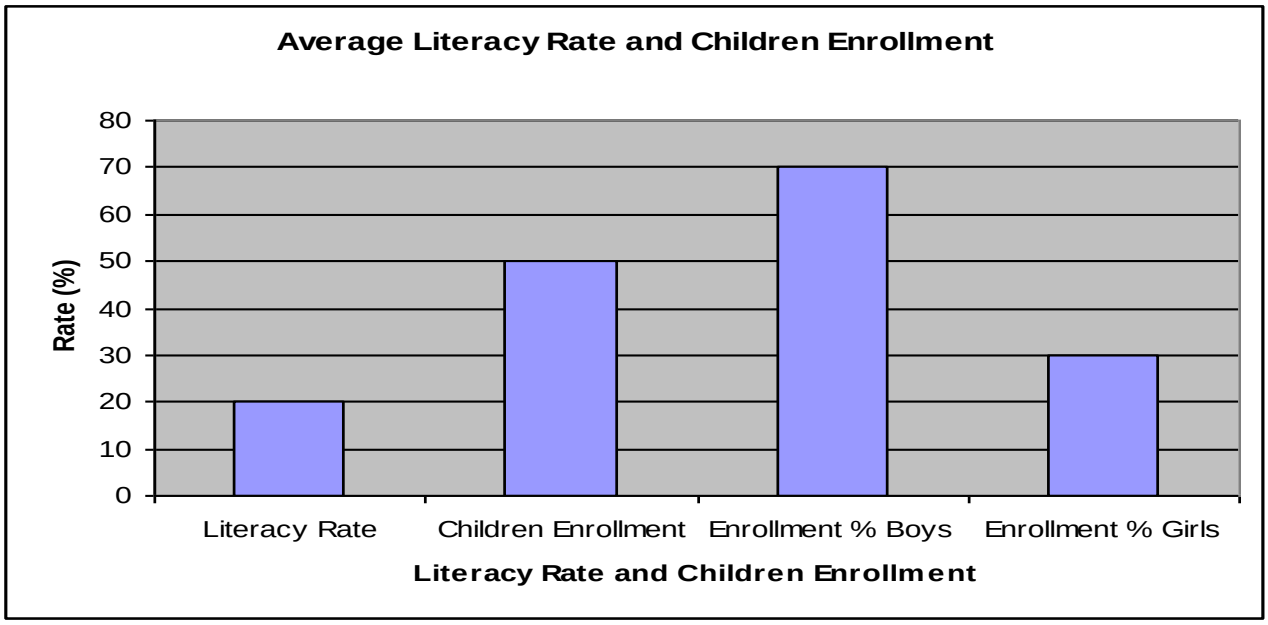
Some of the indicators of wellbeing investigated among the communities visited in the HJKY and Borno Basins were the ownership of assets and level of adoption of coping strategies. It was reported in all the communities interviewed that before the year runs out many families experience food shortage and adopt some coping strategies. The average of families that adopted coping strategies as reported by the 2 studies are 75% and 77% respectively for Borno Basin and HJKY Basin (Kwaghe *et al*. 2008 and UNIMAID Consult, 2011) The minimum, maximum and average of families that adopted coping strategies are presented in Figure 4.7a&b.

4.8 Education

Illiteracy is a hindrance to development in the basin. In terms of literacy in the HJKYB, the adult members are generally illiterate in terms of western education, but majority can write in *ajami* (writing in Hausa using Arabic alphabets). Primary school enrolment

rate is generally low (around 60%) with the exception of Kano State, consequently, the literacy rate is among the lowest. In a few communities around upstream Kano where access to primary school is difficult the level of primary school enrolment was as low as 20% only. There is also a sharp disparity between literacy levels of girls from boys. Among the factors that discourage primary school enrolment are the long distance to the few schools, falling standard of education and the problem of unemployment of graduates. The children who attend school have to cope with little resources and dilapidated facilities. The poor literacy level has made many of the communities disadvantaged, as a result of their inabilities to liaise or negotiate effectively with their elected local administrators, State and Federal government agencies, NGOs and donors. It may also be responsible for the weak advocacy group,

Fig 4.8a: Average Literacy Rate and Children Enrolment in Schools in Borno Basin



Source: UNIMAID Consult, 2011

The findings of the study conducted in the Borno Basin, except Jemu a community in Kukawa LGA, all the communities visited have at least a primary school and an Islamiyya. Literacy rate that is those that can read and write in one of the major languages (English or Hausa or Arabic) is about 20% in the basin. The enrolment of children of school age is on the average 50% of which boys' percentages are 70% and girls 30% (UNIMAID Consult, 2011). Similarly, the survey conducted by Kwaghe *et al*. (2009) in HJKYB, out of 22 communities only 4 (Yusuri, Joka Juriye, Bulagana Chira'a and Landa Mada) are reported to have no educational facilities. Literacy rate, that is those that can read and write in one of the major languages (English or Hausa or Arabic) are on the average 59 per cent of the interviewed populace. The enrolment of children of school age is on the average 62 per cent of which boys' percentages are higher (68%) while girls are lower (32%). Though the studies were conducted at different time period with exception of the illiteracy rate the children enrolments in schools are similar, the results are presented in Figures 4.8a&b.

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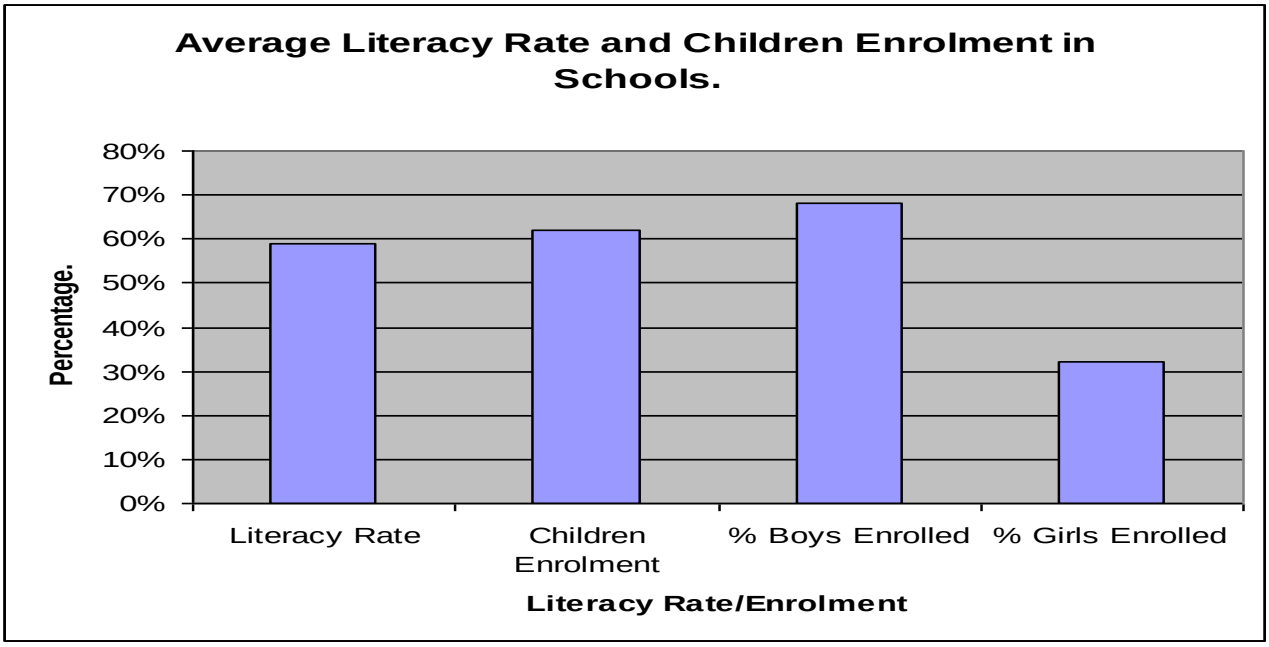
Figure 4.8b: Average Literacy and Children Enrolment in Schools in JHKYB



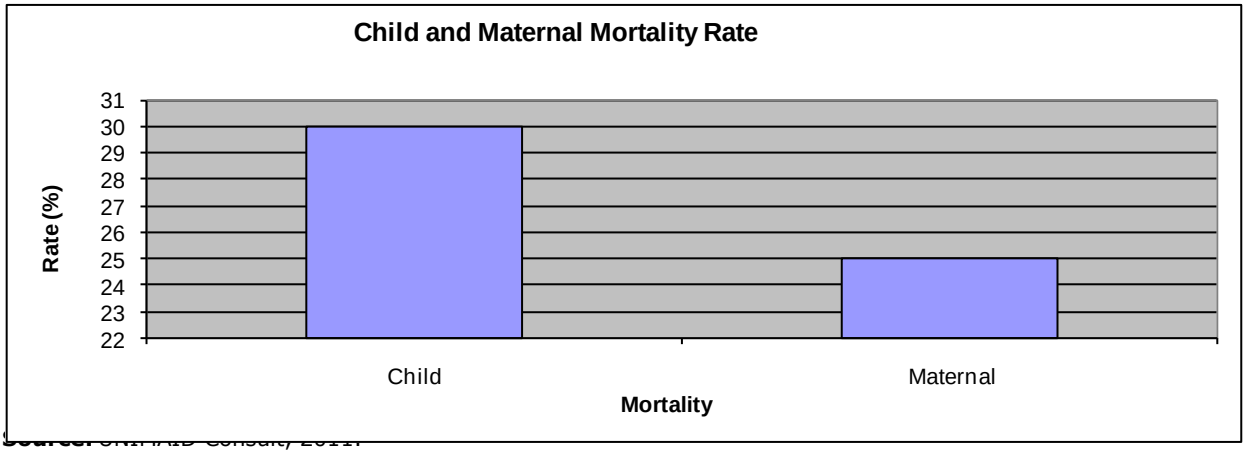
Source: Kwaghe *et al*. (2008)

4.9 Health

The health problems experienced across the Lake Chad Basin of Nigeria is somehow associated with the environmental conditions, poor accessibility, lack of health facilities and personnel and poverty. The development of disease vectors in swamps and irrigation fields coupled with deterioration of drinking water quality as a result of some hydrological changes and improper conservation has resulted in health concern in the basin. The health status of the people in most communities (particularly those that suffer less severity of flood) can be described as average. Most of the population (estimated at about 80%) were judged to be healthy enough to work in the farms and also engaged in other economic activities such as fishing and livestock rearing (Aminu *et al.,* 2006).

All the communities visited during the field survey in the Borno basin have at least one health facility with staff. Most of the facilities available though are empty; the health personnel will only attend to patients while they buy their medicine from private medicine stores where available. In serious and complicated cases, particularly pregnancy complications, patients are referred to nearby hospitals. The common diseases as reported across the communities are malaria, measles, typhoid, whooping cough, skin infections, STDs, HIV/AIDS and pregnancy complications. Less than 5 years child mortality and maternal mortality in the Borno Basin is relatively high. On the average in the basin, child and maternal mortality rates as reported by the communities are 30 and 20 percent respectively (UNIMAID Consult, 2011)(see Figure 4.9a).

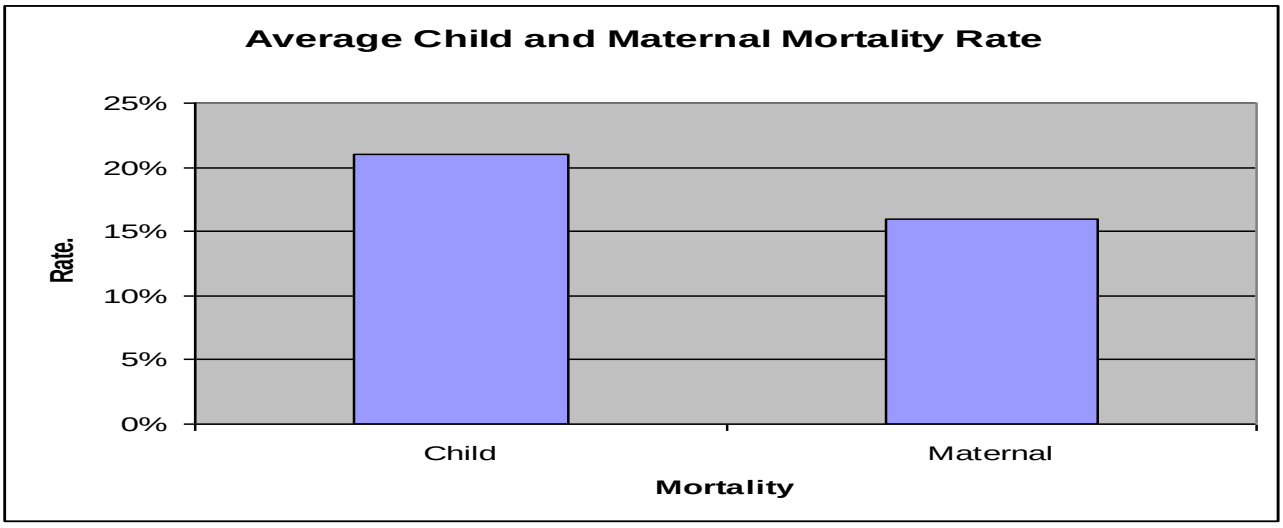
Figure 4.9a: Average Child and Maternal Mortality in Borno Basin



Source: UNHAB Consult, 2011

In a similar study carried out in HJKYB, the findings revealed that there are no health facilities and personnel reported in 11 out of 22 communities interviewed. Villagers have to travel to the nearest hospital close to them to receive medical treatment. Because of the unavailability of health facilities and personnel, villages are highly vulnerable in emergency cases, particularly pregnancy complications and high fever in the case of children. The common diseases as reported across communities in the HJKYB are malaria, measles, chicken pox, typhoid and pregnancy complications. Less than 5 years child mortality and maternal mortality in the basin is relatively high. On the average in the basin child and maternal mortality rates are 21 and 16 percent respectively (Kwaghe *et al*. 2008)(see Figure 4.9b).

Figure 4.9b: Average Child and Maternal Mortality Rate in HJKYB



Source: Kwaghe *et al*. (2008)

4.10 Gender Role and Participation in Decision-Making

The roles and responsibility of women and men varies among the communities. In most of the communities except around Yobe (midstream) and southern Borno along rivers Yedseram and Ngadda the participation of women in economic activities is

restricted to food processing and handicrafts aspects. For instance, fish drying, the fabrication of local fishing tools, baskets making and threads for tying farm produce, as well as threshing and winnowing of harvest of crops are women dominated activities. The main economic activities are being dominated by men and this is not unrelated to the social and cultural norms of the people based on religious considerations. In midstream Yobe and southern Borno, most women, especially the middle aged, owned and manage their farms especially in the dry season, in addition to partaking in fishing. The dwindling access to water resources is gradually changing the pattern, with women are now less actively involved in fishing because of the inadequate water in the river which has made the enterprise less economically attractive and more tasking. In places where the effects of flood have led to salinity soil, women have resorted to collecting the potash deposit for sale to outside communities. The problem of potash intrusion has created another enterprise even if it is economically less promising than the farming under previous condition.

The ownership of land and land –based resources among women was observed to be high across the basin. In the focused group sessions, the female respondents revealed the various arrangements or means by which women can have access to land include inheritance, borrowing, tenancy, gift and pledging. The discussion also revealed that women's access to land is neither independent nor secure. Women often lose their land rights on divorce. The few women who actually own lands independent of their husbands acquired such lands through purchase and few through inheritance.

The general level of women's participation in farming activities was observed to be high in the entire basin. Farming activities in which women are involved include planting and trans-planting, watering, harvesting, processing and marketing of farm products. However, the most physically demanding tasks such as construction of canals, spraying of weeds, land clearing and ploughing are generally considered as men's activities. Some of the men during the group discussion consented that farming will be impossible without the participation of women. Pastoral women in the across the basin are mainly involved in tendering of livestock as well as processing and marketing of dairy products; while women of the fishing communities also engage in processing and marketing of fish.

In addition to being responsible for many of the above agricultural activities, women are also the major providers of fuel wood and domestic water to their households—two activities which, in combination with cooking, child care and other domestic work, exert much strain on women and occupy a great part of their daily chores.

Though women participate actively in almost all the farming activities as well as in domestic work, women's involvement in decision making appears to be very low. Analysis of the group discussions showed that women have limited involvement in decisions regarding the use of production resources in view of the fact that such resources are actually considered, first and foremost, men's resources. Women

participate in the various producers groups but are mostly in 'women only' groups such as those engaged in groundnut oil processing. This means that women's perspectives, needs, knowledge and proposed solutions are often not taken into account regarding the wider use of production resources.

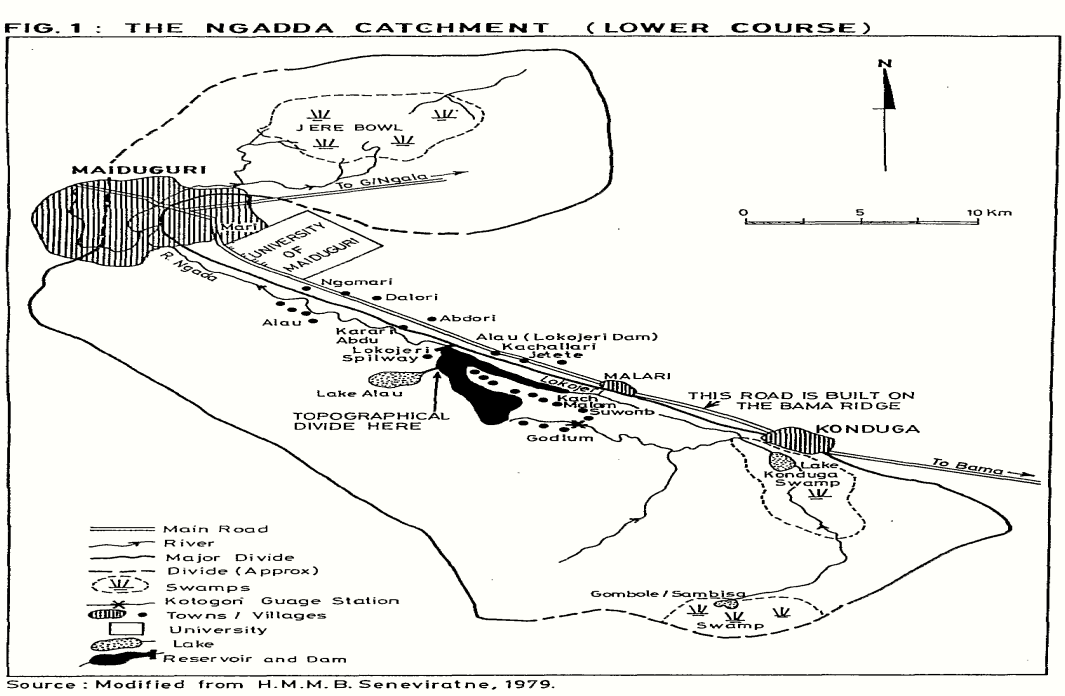
4.11 Needs and Priorities

The needs and priorities of the communities across the basin varies from maintaining a steady and adequate flow of water along the rivers particularly in the dry season, to control of excessive and persistent flood events and the issues of water recession and desertification which had effected the ecosystem and economic productivity (Aminu *et al*., 2006 and Kwaghe, et al., 2008). The needs and priority issues were obtained based on preference ranking by the communities. The upstream communities in Kano and some parts of Jigawa States, where access to water is reasonably adequate, the major problems cited include that of maintaining a steady and adequate flow of water along the river particularly in the dry season and controlling the direct effluent discharge from tannery into the river that deteriorated the quality of water (killing fishes), harming the environment and the health of the people. The problems associated with flooding events which usually destroyed crops and houses, was chosen among the priority issues by the communities (Landa Mada and Wudil in Kano).

Similarly the needs of communities in the upstream Yedseram and Ngadda at Gombole and Sambisa swamp are flood control hydraulic structures to control floods during the rainy season while during the dry season they need drilling of tube wells and water pumps for irrigation. Other communities along the river Ngadda such as Konduga, Malari and settlements around Lake Alau needs irrigation facilities such water pumps and wash boreholes to facilitate their productivity. The needs of communities downstream Alau Dam at Jere bowl is well defined water sharing formula by timely release of water to flood their rice farms. One of their needs also is the control of flood that comes at the time not required from river Gadabul which joined river Ngadda below Alau dam and undermines the production based on the arranged water release from Alau dam (see Fig. 4.10).

According to Aminu *et al*. (2006) the communities around downstream Jigawa and upstream Yobe (Hadejia-Nguru Wetlands), their priority issues were regulation of excessive and persistent floods which has overtaken more than 70% of their farmlands including the upland area. This was reported to have made agricultural production almost impossible for both wet and dry seasons. The flood was also reported to have caused the emergence of *Typha* grass that not only block river flows but serves as habitat for quelea birds, and worsening salinity and high water table in the area. As a result of these issues a number of the people in this area have had to migrate to other places within and outside their locality to get access to farm lands. Though, noticeable improvements have been made by the activities of HJKY-TF and the Wetland Development Initiative, more efforts is required to bring the situation to pre-flooding and desiccation periods.

Figure 4.10: River Ngadda Catchment (Lower Part)



Source : Modified from H.M.M.B. Seneviratne, 1979.

In communities downstream (from midstream Yobe and up to around mid stream Borno) the priority issue and need was that of water recession and desertification which had affected their ecosystem and economic productivity. The flow of the river even during the wet season was inadequate and in many cases is no more than a flash flood and thus farmers had to use tube wells and water pumps to secure water for supplementary irrigation and such process is cost intensive. The intensity of dry season cropping has declined seriously in these communities and fishing which was one of the major economic activity has also declined thus affecting the income level of the people especially the women who were participating intensively in fishing during periods of water adequacy in the past. In the rainy season the main crop grown hitherto was rice but because of the decline in the annual floods, the productivity of rice fields have declined. Consequently, maintaining adequate river flow in both dry and wet seasons is the most important needs among these downstream communities.

Following from above, it is clear that the greatest needs of the people in basin vary according to their local situation, but they are associated to access to water for their livelihoods. In some cases it is flooding, other desiccation of former ponds, rivers and lowlands used for farming, fishing, and livestock grazing. Still other is lack of resources to exploit the shallow underground water as an alternative to surface water used in time past. All these needs can adequately be handled with an effective and coordinated water management plan for the whole basin.

ASSESSMENT OF IWRM FRAMEWORK IN THE BASIN 5

5.1 Preamble

Protecting and conserving the shared water resources in a coordinated manner, while reconciling sometimes conflicting social and economic needs and demands are at the heart of integrated water resources management for sustainable development. In essence, it requires a 'big picture' perspective and keeping all stakeholders in all sectors and at all levels, in both the public and private sector, adequately informed and involved. The key issues in integrated Water Resources management are:

- Water is often a sensitive political issue, and therefore needs all those interested in, and who will be affected by decisions on water resources to be involved (i.e. effective all stakeholders' participation). This has to be backed by a sustained strong 'voice' and high-level commitment at national and basin decision-making level.
- Basin management is governed by national water resources policies and legislation as well as international treaties and agreements, which are implemented at the basin and local level.
- The basin organisations require suitable enabling environment (policy and legal framework), institutional arrangement with clear allocation of roles and responsibilities, and appropriate management mechanisms to operate satisfactorily.
- Basin management systems require adequate, reliable and sustained financing not only for developing, operating and maintaining infrastructure and the basin organisation themselves but also for effective stewardship of the resources.

Box 5.1: The Integrated Water Resources Management Framework

Enabling environment	Institutions	Management
Laws and policies • Frame water resources management within Nigeria and between riparian countries **Water user dialogues** • Cross-sectoral and upstream-downstream dialogues • Basin committee **Budgets** • Financing organisations and investment **Cooperation** • Within international river basins	**Roles and Responsibilities** • Of basin and other water sector organisations at different levels in the government, non-government and private sector agencies • Effective coordination mechanisms • Planning process • Financing	**Structures to** • Assess water resources (availability and demand) • Set up communication and information systems • Resolve conflicts in water allocation • Establish regulations • Establish financing arrangements • Establish self-regulation (voluntary actions) • Research and develop • Undertake development works • Ensure accountability • Develop organisational capacity • Coordinate.

Based on Global Water Partnership 2009

IWRM emphasises active involvement of all stakeholders in national policy and legislative processes, good governance and creating effective institutional and regulatory arrangements as routes to more socially equitable, economically efficient and sustainable decisions. Moreover, the insight provided by the Global Water Partnership (GWP) that 'the water crisis is mostly a crisis of governance', emphasises the fact that technical and organizational solutions need to be in line with prevailing and realistically achievable governance capacities. Therefore, it will not be sufficient to build stakeholder involvement for consensus with respect to water resources development to be pursued (e.g. building a dam or irrigation scheme), it has to also involve identification of public concerns and values, as well as solutions through an open, inclusive process. In the absence of transparency and accountability, where there is no stakeholder participation, or where corruption is allowed to become endemic, it would be ineffective nay impossible to put the IWRM approach into practice. The 'pathways' towards IWRM approach therefore, require us to scrutinize, and assess these key issues in integrating water resources management in the basin. In this context, therefore, special consideration will be given to issues of governance.

Box 5.2: Brief History of Water Resources Related Institutional Changes

Period	*Development*
1959	Creation of the Inland Waterways Division of the Federal Ministry of Communications based in Lokoja with responsibility for monitoring levels in the Niger/Benue system.
1960-66	Formation of Hydrological Unit under the First Republic.
1960s	Creation of Water Resources Division in the Ministry of Agriculture and Formation of the Geological Survey Department of the Federal Ministry of Mines and Power.
1970s	Creation of State Water Boards or Corporations
1970s	Creation of Kainji Lake Development Commission and the Chad Basin and Sokoto-Rima River Basin Development Authorities in the Second National Development Plan.
1975	Creation of the Federal Ministry of Water Resources (FMWR).
1976	A further nine (9) RBDAs (including HJRBDA) were established (3rd National Development Plan)
1977	FMWR disbanded and absorbed into Federal Ministry of Agriculture.
1979	Re-creation of the Federal Ministry of Water Resources.
1984	FMWR merged with the FMA&NR to form Federal Ministry of Agriculture, Water Resources and Rural Development.
1984	Creation of 18 RBDAs , and change of name to River Basin and Rural Development Authorities (RBRDs) with one for each State except Ogun and Lagos that shared one.
1987	Mergers of 18 RBRDAs to the former 11 and the name reverted to RBDA with reduction of functions to only provision of water for multipurpose usage.
1989	Re-creation of FMWR again.
1990	Partial Commercialization of RBRDAs by Technical Committee on Privatisation and Commercialisation (now Bureau of Public Enterprises (BPE))
1992	Re-merger of FMWR with FMARD
1994	Re-creation of FMWR which was merged with Directorate of Food Road and Rural Infrastructure (DFFRI) thus renamed FMWR&RD.
1994	Change of the name from River Basin Development Authorities to River Basin and Rural Development Authorities and creation of Upper and Lower Niger RBRDAs out of Niger RBRDA.
1999	The Department of Rural development was transferred to FMANR renamed FMARD, and bearing FMWR without the "& RD" appendage.
2007	The FMWR was merged again with FMARD to form FMAWRRD
2009	The re-creation of FMWR, the establishment of Nigeria Integrated Water Resources Management Commission (NIWRMC) and Nigeria Hydrological Services Agency (NIHSA)

The chapter will assess the political will and stakeholders' participation; national policies and legislations as well as international agreements, basin organisations, financing, and the challenges posed by all of these in the context of the chequered history of water resources management as exemplified in Box 5.2 below.

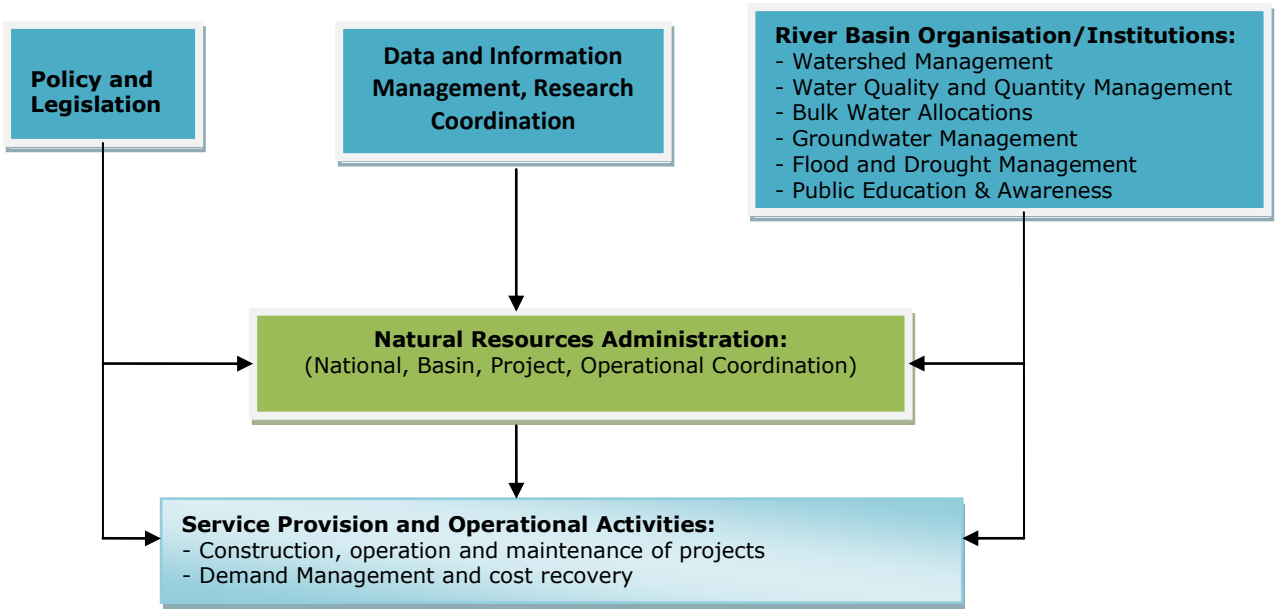
5.2 Stakeholders Participation in Basin Management Systems

5.2.1 Integrated Water Resources Management Functions

The major integrative water resources management functions can be categorised as follows:

- Policy, legislation, institutional development and capacity building.
- Coordination, guidance, dispute resolution
- Monitoring, data/information management and auditing (Knowledge base)
- Research and research coordination
- Bulk water allocation and water rights authorisation/administration
- Integration of resources management and interests in various sectors
    - National and multi-basin
    - Basin/sub-basin/catchments long range
    - Multipurpose project planning, design, construction and operation (seasonal and real-time) and maintenance
    - Environmental Impact Assessment
- Demand management and cost recovery
- Environmental Conservation and resource quality management (protection, restoration) - watershed management
- Groundwater management
- Development and management of multipurpose projects
- Public Safety and disaster prevention and management such as floods and drought management
- Public education and awareness
- International and intra-national cooperation

Figure 5.1: Relationship of the Integrative Natural Resources Management Functions



These can further be grouped into three main functions, namely: policy and legislative functions (i.e. providing enabling environment), river basin organisational[3] functions (i.e. providing institutional framework for water resources administration) and water services operational functions (i.e. provision and management of water services). These functions are interrelated, with general flow of activity from one category to another leading to specific decisions and actions. Figure 5.1 illustrates these relationships.

5.2.2 Stakeholders, Agencies and Interest Groups

Integration of water resources management must be both vertical - across different levels of government and authority – and horizontal – to cover all water users and stakeholders groups. A key element of these integrations is bringing together representative of the three tiers of government from across different ministries responsible for activities that impact on water – ministries of water resources, environment, finance, planning, agriculture, transport and energy – as well as those with social and environmental responsibilities such as ministries of health, poverty alleviation and environment. This however would only be effective if the representatives (Ministers, Commissioners and Chairmen of LGAs) are committed and are backed up at highest level (e.g. by the President and State Governors) and private sector and community representatives are allowed to fully participate. This takes the form of National Councils that facilitate coordination of actions across portfolios and the federating members.

Stakeholders in the process of integrated water resources management for sustainable development comprises of actors involved in decision making at various levels; all interested and affected parties as well as those others such as water users, who may sometimes be ignorantly considered not to be a factor in policy-making. To ensure sustainability, integrated water resources management requires holistic approach, balancing the competing demands on the resource which for example could be for domestic use, agricultural uses, hydropower generation, recreation, industrial, and environmental protection, as well as those issues related to pollution and modification of the flow regime. In the case of Lake Chad Basin which is a transboundary basin (i.e. shared with other countries), it requires the involvement of heads of state to discuss and coordinate water resources management issues.

Although there is a large number of water management agencies, administrative units, water users and other stakeholder groups, not all of these play a significant role in the allocation and conservation of water resources. Such institutions would therefore not be strategic to the success of the integrative arrangement of water resources at operational level even though they should be consulted when formulating policies and programmes. A general distinction could, therefore, be made between **operational partners** who are involved in the integrative processes and the **consulting partners**

[3] River Basin Organisation is used as a generic term to refer to all types of institutions that are flexible and work at all levels and collaboratively to monitor, investigate, coordinate, regulate, plan, finance, develop and manage shared water resources.

that should be consulted in the decision-making process on policy, legislation and plan/programme development as well as in the provision of relevant data and information for IWRM. Both groups of stakeholders are listed in Appendix 2, and they are all important in the shared responsibility for integrated water resources management for sustainable development. It is also pertinent to state here that it is not very easy to come out with a complete list of the institutions' involved in all aspects of water resources management in a complex basin like the LCB. Water is a pervasive resources and its management and uses touch almost all aspects of society, the economy and the environment.

In addition to the list of stakeholders listed in Appendix 2, there are currently at least eight apex organs of government which have statutory responsibility for policy/legislative formulation, approval and/or coordination for water and related resources management throughout the federation. These include the National Assembly, the National Council of State and at least six National Councils of Water Resources; Housing and Urban Development, Transport, Environment, Aviation as well as Agriculture and Rural Development. The advisory role and the day to day implementation of the decisions of National Councils of Water Resources, Environment, Housing and Urban Development, Transport, Aviation, as well as Agriculture and Rural Development are vested in the Federal Ministries of Water Resources, Environment Housing and Urban Development, Transport, Aviation, and Agriculture and Rural Development respectively. Due to the dependence of other sectors of the economy on these critical resources, several other statutory and non-statutory institutions are active in either policy, organisational, and operational aspects of the management of water resources. These other institutions include:

- State Houses of Assemblies of Adamawa, Bauchi, Borno, Jigawa, Kano and Yobe;
- Federal and State Governments' Executive Councils of Adamawa, Bauchi, Borno, Jigawa, Kano and Yobe;
- Federal Ministries of Solid Minerals, Finance, Economic Planning, Industry, Culture and Tourism;
- National Emergency Management Agency (NEMA), and Office of Minister for Special Duties (Ecological Funds).

5.2.3 Political leadership and Commitment in the Basin Management systems

To put in place the desired IWRM framework (i.e. appropriate policies and laws, robust institutional framework, adequate financing for water management) requires sustained strong political will and commitment at the highest level of government. The strong political leadership matters a lot, but neither will integrated approach work without effective stakeholder participation and freedom of information exchange. For IWRM to work effectively as we have seen in Komadugu-Yobe Basin requires sustained political will. Although the memorandum of understanding signed at Damaturu in 2007 by the President and the Governors of the five riparian states of Bauchi, Borno, Jigawa, Kano, Plateau and Yobe was monumental, it still, however, failed to translate into sustainable water resources management, because the political will and commitment was not sustained beyond that landmark.

The Komadugu-Yobe leaders' summit approved a catchment management plan, and guaranteed seed money for its implementation, but the desired rules and regulations, and the appropriate institutions to fully implement the plan were not put in place and those that existed were not monitored to ensure that they manage water effectively, efficiently and equitably. Neither the Leaders' summit nor the Coordinating Committee of the basin has met since then. Consequently, the 'water charter' that was painstaking prepared, remains not approved; and the Trust Fund has never submitted report of its activities to the body. Meanwhile, the gains that were recorded have systematically been eroded by lack of adequate monitoring and evaluation.

Most of the State IWRM fora no longer meet regularly, because the sponsorship they enjoyed from DFID-JEWEL project was not sustained at the end of the project. It is however instructive to note that before then, they had collectively identified common areas of concern where action is needed. This informed the preparation of the Catchment Management Plan for sub-basin. Unfortunately, they are no longer active to play active role in the preparation of the larger Catchment Management Plan for Lake Chad Basin. Nigeria Integrated Water Resources Management Commission (NIWRMC) would need to urgently establish platforms for cross-sectional and upstream-downstream dialogues.

Another critically important element of integration is that of harmonizing various sectoral views and interests in decision-making, with special attention to upstream–downstream relationships. The establishment of the Hadejia-Jama'are-Komadugu-Yobe Basin Coordinating Committee (HJKYBCC) was intended to accomplish this in the sub-basin. It was however observed, that not enough cross-sectoral integration was discernable during the field work. The HJKYBCC was a fall-out of the recommendation of the workshop jointly organised by NIPSS and the IUCN-HNWCP in 1993 in response to the growing tension and conflicts in the sub-basin. The National Council on Water Resources (NCWR) accordingly established HJKYBCC during its sitting in 1999. The HJKYBCC held its first meeting in 2000 during which it established a Technical Advisory Committee (TAC). Both the HJKYBCC and TAC have not met since 2007, and many of the far reaching decisions taken at these meetings remain unimplemented, because no budget has been provided for that purpose. Above all, governments have not established the context and framework for action by non-governmental entities. This is a critical element within the enabling environment that should be created by governments at all levels. Accordingly, policies and legislations have to be supportive of private sector participation to integrate the sector in the management of water resources that is critical to almost every economic activity.

Accordingly, the now dormant HJKYBCC should urgently be resuscitated and expanded to cover the entire Lake Chad Basin and to include all ministries, departments and agencies across all portfolios related to water resources management. However, experience has shown they will only work well when ministers and commissioners are

committed and are backed-up by the President and Governors respectively. The Lake Chad Coordinating Committee should have their representative always included in the national team to summits or conferences of head of state of Lake Chad Basin Commission.

5.3 Status of Policies and Legislations

The national, state and local water laws and policies provide the rules of the 'game' (i.e. the roles, responsibilities and accountability) that guide how the stakeholders (both the public and private sectors actors) participate in the development and management of water resources. There are several basic policies, rules, regulations, laws and factors which influence the governance of water resources management. These range from specific federal government policies, to non-statutory documents, such as NV20-2020 report and UN conference reports, both of which influence the IWRM and decision making process. All of these are however, fairly recent development, dating back to1992 on wards[4].

Box 5.3: Fundamental Requirements of Policy and Legislation in Integrated Basin Management

Laws and policies establish the framework for integrated water resources management, and should include the following:

- Clearly identify the functions, structure and funding of basin organisations and basin management.
- Specify management roles and jurisdictions.
- Ensure fairness and accountability in decision making.
- Avoid fragmentation and overlap of responsibilities.
- Spell out regulatory and enforcement processes for sharing water, abating water pollution, protecting ecosystems or fighting against natural hazards and determining entitlements to water.

Based on Global Water Partnership 2009

Formal articulation of water resources management policy in Nigeria was commenced in 1990. This culminated in the promulgation of a Water Resources Act, 1993, Cap W2 LFN 2004 (formerly Water Resources Decree 101 of 1993). The Act vests the strategic control and policy roles for all inter-state rivers on the Minister responsible for Water Resources. It failed, however to provide institutional framework for its enforcement, nor did it advocate IWRM, nor even provide for private sector and stakeholder participation. Attempts were made from 1994 to incorporate the IWRM principles in the policies but it mostly ignored holistic water resources management instead they were skewed towards sectoral issues, most especially water supply and sanitation.

The current water related policies and legislations have been oriented to specific resource or institutional mandate. Furthermore, the policies are for specific water-using sub-sectors. Although these sub-sectoral policies remain important, they have not been coordinated under national water resource policy and legislation. Each Federal Ministry is responsible for the development of the necessary policy and legislation, mostly on the basis of specific sub-sectors within its mandate. For instance, there are specific

[4] Afremedev Consultancy Services Limited, 1999: RLWRDPS ReportR2/2: Institutional and Human Resource Arrangements for integrated natural resources management. PTF, Abuja, Nigeria.

policies on water supply and sanitation; irrigation and drainage; flood, erosion control and drought management among others. Furthermore, most of the sub-sectoral policies were developed after the promulgation of Water Resources Act 101 of 1993, but with little or no reference to its provisions.

The National Water Resources Policy of 2004 is still a draft document as it has not been properly enacted notwithstanding that it has gone through extensive national consultation. It is a blueprint document which provides the framework for IWRM to address key challenges of water resources management in Nigeria. Several IWRM best practices are contained in the policy. These include:

a) Clear and coherent regulation.
b) Clear definitions of the functions and relationship of sector institutions.
c) Coordination
d) Finding solution to the problem of dwindling funds.

Box 5.4: Legislative List on Land and Water Related Functions as Contained in the Constitution

1979 Constitution

State Legislative List:

- Fishing and fisheries in rivers, lakes, waterways, ponds and other inland waters in the State.
- Land that is to say, rights in or over land, land tenures including the relation of landlord and tenant, and the collection of rents.
- Production, supply and distribution of goods.
- Public health sanitation and hospitals.
- Water, that is to say, water supplies, irrigation and canals, drainage and embankments, water storage and water power, subject to the provisions of the Federal Legislative list.

Federal Legislative List:

- Fishing and Fisheries other than fishing and fisheries in rivers, lakes, waterways, ponds and other inland waters within Nigeria.
- Maritime shipping and navigation including:
  c) Shipping and navigation on tidal waters, and
  d) shipping and navigation on River Niger and its effluents any such other inland waterways as may be designated by the National Assembly to be international waterway or to be interstate waterways etc.
- Meteorology
- National Parks being such areas in a State as may with the consent of Government of that State be designated by the National Assembly as National Parks.
- Water from such sources as may be declared by the National Assembly to be sources affecting more than one State.

Concurrent Legislative List

- the regulation of the right of any person or authority to dam up to otherwise interfere with the flow of water from sources in any part of the Federation.
- Environment.
- Tourism

1999 Constitution

Concurrent Legislative List:

- The generation, transmission and distribution of electricity.

Federal Legislative List:

- Fishing and Fisheries other than fishing and fisheries in rivers, lakes, waterways, ponds and other inland waters within Nigeria.
- Maritime shipping and navigation including:
  a) Shipping and navigation on tidal waters, and
  b) Shipping and navigation on the River Niger and its effluents any such other inland waterways as may be designated by the National Assembly to be an international waterway or to be interstate waterways; etc
- Meteorology
- National Parks being such areas in a State as may with the consent of Government of that State be designated by the National Assembly as National Parks.

e) Reliable and adequate data for planning and projections.
f) Decentralization in order to boost efficiency, performance and sustainability.
g) Autonomy of water supply agencies.
h) Regarding water as an economic good.
i) Creating public awareness about water conservation and management.
j) Provision of stable and adequate power supply.
k) Accountability.
l) Technical and financial capacity building to manage water delivery system.
m) Human resource development.

The National Water Resources Policy post-dates many policies such as National Water Supply and Sanitation Policy, 2000 and even National Water Sanitation Policy, 2004. Consequently, there are some provisions in these earlier policies that appear inconsistent with IWRM principles and indeed the National Water Resources Policy. Furthermore, the National Policy on the Environment of 1999 although it contains provisions that seeks an integrated approach to addressing environmental issues it however gave diverse organizations and institutions roles and responsibilities that should be placed under a coordinating institution like NIWRMC.

5.3.1 The Constitution of the Federal Republic of Nigeria

The constitution is the supreme law of the nation and therefore any law or conduct that is not consistent with the constitution is invalid. Essentially, therefore all provisions and especially constitutional obligations must be mandatory. The present constitution says that all natural resources belong to the Federal Government no matter where they are located. More specifically; the Federal Government has exclusive rights to: "Water from such sources as may be declared by the National Assembly to be sources affecting more than one State." Unlike the 1979 Constitution that was in tandem with integrative principles and the Water Resources Act, 1993, Cap W2 LFN 2004 (Water Resources Decree 101 of 1993), the current constitution is silent on many aspects of provision of water services and on water resources management. The legislative list on aspects of water resources development and management contained in 1979 and 1999 constitutions are contained in Box 5.4.

5.3.2 Land and Water Resources Related Policies and Legislations

Water Resources Act cap. W2 of 2004 was first promulgated and published in the supplement to official Gazette No. 27, Vol. 80, September 1993. It is the highest extant legislation governing water resources management in Nigeria. It confers on the Federal Government represented by the Federal Ministry of Water Resources (FMWR) the responsibility for controlling the use of both surface and groundwater resources **traversing more than one state** throughout the Federation. It is based on three important principles:

- a link between the right to use water and the ownership of land adjacent to that water (the riparian principle),
- a separation between private (water drawn from small streams or wells which gave too little water to have potential for communal benefit) and public water; and between water in the rivers that are restricted to a state and those traversing more than a state, and
- the African customary law which saw rivers and the water in them as common good which belongs to the nation as a whole and are available for common use by all citizens, but which should be controlled by the state in the public interest.

In its present form, Water Resources Act cap. W2 of 2004 has been difficult to administer, because it vests all the powers on the Minister of Water Resources. Meanwhile, the River Basins that were statutorily empowered to comprehensively plan and develop the Nation's water resources are not delegated any residual powers.

Another fundamental flaw of the Act is that it did not flow from any policy or from public debate. It also has no clear provision on quality control, water right transfer and groundwater control, nor did it define criteria within which the Minister would be committed to carry out the public trust obligations bestowed on him by the law.

Table 5.1: A List of Statutes on Water Resources in Nigeria

No.	Name of Statute	Key Provisions
1.	The Waterworks Act of 1915	Colonial Nigeria (shortly after Amalgamation in 1914) passed the law specifically to keep water from being polluted. It prohibits the pollution of water in Nigeria by obnoxious or harmful matters.
2.	The Minerals Act of 1917(as amended), now Minerals and Mining Act 1999, Cap. M12, LFN 2004	This law vests the Head of State of Nigeria with power to make regulations for the prevention of pollution of any watercourse. It grant the Minister in charge of mines powers to issue mining lease and the lessee a water license to obtain and convey water as may be required for mining operations.
3.	The Public Health Act of 1917	It prohibits the fouling of water and vitiation of the atmosphere.
4.	The Oil in Navigable Waters Act, 1968	It prohibits water pollution by oil spillage.
5.	The Petroleum Act, 1969	It covers prevention of pollution by inland waters, rivers, lakes and watercourses.
6.	The River Basin Development Authority (RBDA) Decree 25 of 1976 (repealed by No. 87 of 1979 and also latter by RBDA Act of 1987, Cap R9 LFN 2004)	In its present form Cap R9 spells out diverse functions and objectives for these Authorities to ensure a Pan-Nigerian programme for water resources development.
7.	The Environmental Impact Assessment (EIA) Act, 1992, Cap E12 LFN 2004.	The law seeks to protect the physical and aquatic environment.
8.	Water Resources Act, 1993, Cap W2 LFN 2004	It vests the right to use and control all surface waters and groundwater and of all water in any water course affecting more than one state in the Federal Government, with provisions that any person may take water without charge for his domestic or livestock watering purposes (in any watercourse to which the public has free access).
9.	National Inland Waterways Authority Act, 1997, Cap N47 LFN 2004	Establish the Agency with specific powers to grant permit for water intake; provide hydraulic structures for rivers and dams, bed and stabilization barrages, groynes; erect permanent structures within the right-of-way or divert water from a declared waterway.
10.	The 1999 Constitution of the Federal Republic of Nigeria.	The Constitution puts in the Exclusive Legislative List (ELL) shipping and navigation on the River Niger and on any of its effluents and on any such other inland waterway as may be designated by the National Assembly to be an international waterway or to be an interstate waterway. The ELL also includes water from such sources as may be declared by the National Assembly to be sources affecting more than one state.
11.	National Environmental Standards and Regulations Enforcement Agency (Establishment) Act, 2007 (NESREA Act) No. 25	Established and vest the agency with responsibility for the protection and development of environment and Nigeria's natural resources, and to enforce compliance with water quality environmental health and sanitation standards including pollution abatement.

Source: Modified Federal Ministry of Water Resources, Legal & Regulatory Framework Theme Group – 2001

Tables 5.1 and 5.2 contain the list of water-related legislation (statutes) and regulations[5]. Many of these water related legislation, have some provisions that overlaps, or are duplicated or even contradictory and sometime in conflict of one another. These include the following:

[5] As modified from the list prepared by the Legal and Regulatory Framework Thematic Group of the FMWR Water Resources Management Strategy Programme.

- Water Resources Act, 1993, Cap W2 LFN 2004 and the Minerals and Mining Act, 1999 Cap M12 LFN 2004: Under S.5 of Water Resources Act 1993, the "Secretary" (which imply the Minister) charged with responsibility for matters relating to water resources, has power to issue water license, power to order removal of hydraulic work, power to impose license fee, pollution control, and power to impose other fees, rates and charges; such powers are similarly conferred on Minister responsible for Mine under part IV (section 46 – 63) of Mineral Act. Meanwhile, nowhere is "resolution of conflict" provided for in the event of dispute or disagreement arising from the exercise of powers duly granted under the laws.
- The National Inland Waterways Authority Act, 1997, Cap N47 LFN 2004 is perhaps the most extensive in terms of conflicts and overlaps with the extant Water Resources Act which it post-dates, but to which it makes no reference or acknowledgement. The Act grants the Agency powers to issue permit and licenses for water intake. This power extends over all Federal Navigable Waterways mentioned in the second schedule of the Act. These watercourses are virtually the same watercourses over which the Minister of Water Resources has power to grant water intake licenses under the Water Resources Act of 1993. Furthermore, it is observed that under S.9(o) of the NIWA Act, the Authority has power to provide hydraulic structures for rivers and dams, bed and bank stabilization, barrages and groynes. Similar power is vested in the RBDAs under S.4 of the RBDA Act Cap. R9 LFN 2004. Besides, under S.13(b) of Water Resources Act of 1993, the Minister of Water Resources is empowered to impose a fee on any person or public authority seeking to construct, operate, maintain, repair or alter any hydraulic works in or adjacent to any water source. "Public authority" as interpreted under S.20 includes "any commission, authority or statutory corporation established by the Government of the Federation". This represents another instance of conflicting statutory powers and demonstrates further the incidence of lack of inter-sectoral coordination and lack of conflict resolution mechanisms in Nigeria's water sector.
- Provision of water services and regulatory functions are often combined in a single institution; thus making such institutions the referee and player in the same game. This goes against the transparency and accountability principles of IWRM. This is especially true of all RBDAs, as well as all SWAs.
- Under present laws, different agencies at all tiers of government pursue different water agenda. This approach has led to fragmentation of water resources development policy issues, including licensing abstraction, charging fees, pollution control and watershed management.
- The regulatory framework within the water sector has been diverse, diffused and weak. Enforceability in such circumstances has become lax.
- Virtually all laws on water resources (both federal and state) are rule-oriented and fail to recognize the place and role of the private sector and communities as important stakeholders.

- Present water-related legislation lack adequate provisions and mechanisms of inter-sectoral coordination, tariff setting and conflict resolution.

Furthermore, the Land Use Act of 1978 gives the State Governors and Local Governments the responsibility for control, regulation and allocation of land. On the other hand the Water Resources Act cap. W2 of 2004 gives the Minister of Water Resources the powers and responsibility of control, regulation and planning of development of water resources; prevention of pollution and formulation of national policies relating to the control and use of water resources for multipurpose as well as short and long term provision of water for various sectoral purposes. Both resources are closely linked but are currently not closely coordinated and laws have largely remained inadequately enforced.

Table 5.2: A List of Other Regulations on Water Resources in Nigeria

No.	Name of Regulation	Key Provision
1.	National Policy on Environment 1989	Protection of the environment.
2.	National Guidelines and Standards for Environmental Pollution Control in Nigeria 1991.	Pollution control in watercourses as part of the environment.
3.	National Effluent Limitation Regulation 1991.	Control of discharge of industrial waste and sewage into watercourses.
4.	Pollution Abatement In Industries And Facilities Generating Wastes Regulation 1991	Control of industrial pollution.
5.	Waste Management Regulation 1991	Waste management.

Source: Modified Federal Ministry of Water Resources, Legal & Regulatory Framework Theme Group – 2001

It is noteworthy to observe that many of these water resources related legislation and regulations in Nigeria predate the Dublin Conference when IWRM Principles was widely accepted and thus most of them do not reflect IWRM approach. Overall most provisions in the legislations and regulations although applicable but they are not enforceable because of the some of the constraints discussed above as well as these other reasons:

- Most of these laws were made without adequate consultation and participation of the stakeholders, as they were made during the military rule in Nigeria.
- The laws were not followed up with required advocacy and public awareness campaign. Furthermore, they are written in English and rarely are they translated into local languages.
- The laws in most cases lack clarity and coherence.

Overall, the policy and legislations for managing water resources are essentially fragmented, un-harmonised and scattered in the statute documents. Furthermore, they are narrowly oriented to meet sectoral needs and are in some cases contradictory or inconsistent on some aspects of the resources usage. These serious deficiencies have been aggravated by lack of coordination of the agencies within the sector, and the fact

that most legal framework did not flow from comprehensive policy. Meanwhile, these policy and indeed the legal instruments have not provided sufficient basis for institutional and technical intervention and action. Accordingly, most of the laws are not enforced, and the IWRM policy options of providing economic incentives, user-pays, polluter-pays strategies have not been sufficiently articulated.

5.3.3 Transboundary/ International Charters, Treaties and Agreements

The river systems in LCB cover parts of the territory of Republic of Niger and Cameroon and in respect of Komadugu-Yobe Sub-system parts of the system in Nigeria, are both upstream and downstream. Being the downstream riparian (especially in respect of Borno drainage basin), Nigeria is vulnerable since the water in some of the river the basin depend on, does not originate within Nigeria. The Lake Chad Basin Commission (LCBC), of which Nigeria was a founding member and the greatest contributor, as well as the bilateral initiative of the Nigeria-Niger Joint Commission (NNJC) and the Nigeria-Cameroon Joint Commission for Cooperation (NCJCC) have provided the required special conflict resolution mechanisms with our neighbours.

Alarmed by the shrinking of the Lake Chad, the LCBC with the assistance and cooperation of UNEP, UNSO and FAO prepared a Master Plan for environmentally sound management and development of the natural resources of the Lake Chad conventional basin in 1993. The NNJC with its headquarters in Niamey, Niger Republic was established under a bilateral relation to monitor and recommend the development options within the following four major drainage basins common to both countries: the Komadugu Yobe Basin, Baggia Lamido Basin, Gada Goulbi de Maradi Basin, and the Tagwai El Fadama Basin.

There are two major flaws in the LCBC statutes: non-prescription of any water allocation rule and no provision for pollution control and the control and prevention of harmful agricultural practices. Little efforts have been made to harmonize legal frameworks in Nigeria's shared basins in order to protect the use of shared water resources. The progress made in the adoption of IWRM approach and water policy reforms in Nigeria's shared basins may lead to the development of some measure of harmony in legal and regulatory framework especially among the Member States and Contracting Parties of LCBC.

Nigeria is also a member of the following regional organizations for cooperation and integration in water related matters that could relate to Lake Chad Basin –the New Partnership on African Development's (NEPAD), the African Ministerial Council on Water (AMCOW) and the Economic Commission for West African States (ECOWAS). At regional level, ECOWAS has established the Permanent Framework of Coordination and Monitoring of IWRM implementation in the member states. It intends in consultation with all stakeholders to harmonize and integrate the diverse policies in the region with a view to preparing a water policy framework directives for the ECOWAS.

5.3.4 General Policy-Making Framework

Federal Government has the critical role of providing enabling environment for water resources management. IWRM however, presupposes that the usual prescriptive central approach to development and management of natural resources be replaced by the creation of a framework by the government within which participatory, demand driven and sustainable development of water resources can take place.

Government currently combines the functions of policy-making, planning, allocation, monitoring, enforcement and conflict resolution in the natural resources management with that of a service provider. As the private sector become developed, more operational functions associated with provision of water services delivery would be devolved to it. The regulatory and control role of government requires political will, data, decision support system and adequate resources and means to enforce the existing legislation. The biggest problem is not therefore, the absence of adequate legislation but the lack of the political will and these other factors.

There have been growing competitions between sectors for scarce resources, against the backdrop of increased pressure for cuts in the budget of the governments, and increasing competition for scarce development assistance resources. When these are weighed against the role of Federal Government to ensure and facilitate the overall investments needed to adequately manage the natural systems, the challenges become increasingly difficult to meet. This situation calls for greater private sector involvement in financing of water resources related development projects. This can only be achieved, however, if legislation provides for investment security and incentives. Other stakeholders that need to be integrated are the Community-Based Organizations (CBOs). They could also invest in the development and management of these systems, if appropriate legal empowerment were in place.

The land titles and water rights have to be clearly delineated and government or NGOs would have to facilitate the development of effective community institutions and provide catalytic financial assistance. Capacity of community to take on added responsibility has to built and appropriate incentives provided to make it attractive for the community to do so.

In summary, therefore, none of the existing institutions and ministries is responsible for holistic and integrated management of basic natural resources, notably soils, water and vegetation. Although the natural system makes environment, land and water resources inseparable, their policy and legislation are being formulated and implemented in isolation and without adequate coordination and participation of all stakeholders. Ideally, the policy should be handled within one government institutional framework. However, this may not be feasible because virtually every sector of the economy depends on these critical resources and as a result, for a single institution to hand all aspects of their policy may be too cumbersome and over centralized.

Box 5.5: Responsibilities for Managing, Regulating and Provision of Water Services

Monitoring, investigating, Coordinating and Regulating (Federal Ministries of Water Resources, Environment, Health, NIMET, NIHSA, NIWRMC, NIWA, NWRI, HJRBDA, LCBDA and NESREA)

- collecting, managing and communicating data on water availability, water demand (including environmental flows) and water quality to support different basin functions;
- develops and implements pricing regulations;
- develops water quality standards and guidelines,
- develops policies and legislation for standards on groundwater extraction and environmental stewardship
- authorises and controls withdrawals and discharges, defining mechanisms and criteria by which water is apportioned among user sectors including environmental flows including works modifying river flows and ecosystems;
- audits the performance of the water sector for compliance with standards and providing mechanisms for negotiation and litigation.

Managing (NIWRMC and its Lake Chad Catchment Management Office in Dutse, NESREA, HJRBDA, LCBDA)

- undertakes strategic knowledge base assessment (to develop Decision Support Systems);
- develops water charter (policies and strategies) to comply with regional or national objective and standards in a context specific manner;
- facilitates strategic water research and development;
- formulates medium- to long-term plans for developing and managing water resources in the basin;
- allocates water;
- mobilises financial resources by collecting water taxes or polluter pay fees to ensure adequate financing of catchment management plan and water stewardship;
- manages surface water and groundwater quantity and quality – to ensure that they remain within accepted limits as well enforcing relevant laws and regulations to prevent degradation/overexploitation and to restore ecosystems;
- coordinates inter-agency policies and community actions undertaken in the basin by state and non state actors;
- ensures that dams, navigation and water distribution infrastructure and waste treatment plants are properly operated; that allocated water reaches its point of use; and that surface and ground water are conjunctively managed;
- prepares against water disasters by coordinating provision of protection from floods and developing emergency works, flood/drought preparedness plans, and coping mechanisms;
- defines priorities and implements actions to protect ecosystems;
- develops programmes to build capacity in the water sector;
- promotes public participation and awareness.

Operating services (RBDAs, State WBs, State ADPs, other public, private or public-private utility)

- designs, constructs, operates and maintains water infrastructure for water supply, sewerage, waste water treatment plants, drainage and irrigation systems;
- provides technical advice and assistance;
- charges and collect fees for services;
- operate s under some form of legal agreement usually with the regulator for operating rights and the resource manager for utilisation of the water resources.

Based on the Comprehensive Assessment of Water Management in Agriculture 2008 and Global Water Partnership 2009

From all of the foregoing it is obvious that water resources management is currently fragmented. The subsequent sections would describe the current status of the discharge of these functions.

5.4 River Basin Organisations

Renewable freshwater resources are those found in the lakes, rivers, wetlands and underground aquifers. A basin is the area bounded by the watersheds of river systems and their tributary that flow towards the same outlet – generally the sea, but in this case to Lake Chad – an inland water body. River or lake basin[6] has globally been recognized as a practical hydrological unit for organisational functions of integrated land and water resources management. The basin seldom concurs with administrative and/or political boundaries. River or Lake Basins are characterised by relatively homogeneous land, soil and water resources.

Box 5.6: Main functions of River Basin Organisations

Monitoring, investigating, coordinating and regulating

- *Collecting data*: Collecting, managing and communicating data regarding water availability, water demand (including environmental requirements) and water quality to support different basin functions.
- *Prevention, monitoring and enforcing*: Monitoring and control of water pollution, salinity levels and ground water extraction – ensuring that they remain within accepted limits; and enforcing relevant laws and regulations to prevent degradation/overexploitation and to restore ecosystems.
- *Coordinating:* Harmonising policies and actions undertaken in the basin by state and non-state actors relevant to land and water resources management.
- *Resolving conflicts:* Providing mechanisms for negotiation and litigation.

Planning and Financing

- *Allocating water:* Defining mechanisms and criteria by which water is apportioned among user sectors, including the environment.
- *Planning:* Formulating medium-(3-6 years) to long-term (10-20 years) plans for developing and managing water resources in the basin.
- *Mobilising resources:* Ensuring financing, for example, by collecting water user and pollution fees or water taxes.

Developing and Managing

- *Constructing facilities:* Designing and constructing water infrastructure.
- *Maintaining facilities:* Maintaining water infrastructure.
- *Operation and management:* Ensuring that dams, navigation and water distribution infrastructure and wastewater treatment plants are properly operated; that allocated water reaches its point of use; and that surface and ground water are conjunctively managed.
- *Preparing against water disasters:* Protecting from plods and developing emergency works, flood/drought preparedness plans and coping mechanisms.
- *Protecting and conserving ecosystems:* Defining priorities and implementing actions to protect ecosystems, including awareness campaigns.

Basedon the Comprehensive Assessment of Water Management in Agriculture (CA), Global Water Partnership (GWP) and the International Network of Basin Organisations (INBO) 2008

The GWP have defined IWRM as a process that *"promotes the co-ordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems."*[7] National IWRM strategy and

[6] Catchment and watershed are used interchangeably with river basin.
[7] GWP TAC 2000

Water Efficiency Plan and other IWRM approach at national level are complementary and indeed essential input for basin management; most especially transboundary basins. Within the constraints of the basin, it is required to integrate land uses and management (such as planning, forestry, industry, agriculture, energy generation, transportation and the environment) and water resources management. In reality however, these land use management are governed by policies not connected to water resources policy and by various institutions.

Accordingly, the three main functions of river basin organisations (see Box 5.6) are therefore: 1) monitoring, investigating, coordinating and regulating; 2) planning and financing; and 3) developing and managing. They can take many forms, from statutory decision making and/or advisory bodies (i.e. National Council on Water Resources, Coordinating Committee of HJKY Basin), management bodies (i.e. NIWRMC), development entities (i.e. RBDAs) and regulatory bodies (i.e. FMWR, NIWRMC, NESREA). Generally, responsibilities for managing water, regulating water and providing water services should not be assigned to the same agency, so as streamline operations and ensure accountability (see Box 5.5). RBDAs are therefore, not the only institutions responsible for organisational functions at river basin levels.

5.4.1 River Basin Development Authorities (RBDAs)

The number of RBDAs in Nigeria have risen to 18 and fallen to 11 over the years and to the current 12, and their functions expanded or contracted to include rural development according to prevailing political thinking and other extraneous considerations. In spite of their name, the boundaries of the RBDAs do not correspond with watersheds or catchments of the major river basins. Instead, their boundaries have been determined arbitrarily with concession made to ensure that they coincide closely with the administrative/political boundaries, rather than the hydrological reality. This is responsible for the current situation where Lake Chad hydrological basin, is split between two RBDAs, namely CBDA and HJRBDA.

The operational area of HJRBDA comprises the upper reaches of the catchments falling within parts of Bauchi, and the whole of Kano and Jigawa states, while that of the CBDA comprises the lower basin in the catchments falling in parts of Adamawa, and the whole of Yobe and Borno states. They both have responsibility for water management in the basin but with little co-ordination. If the river or lake basin criteria had strictly been observed, only a maximum of eight river/lake basins[8] would have been created in Nigeria and not twelve as is the current situation (NWRMP, 1995).

This clearly reveals lack of awareness of the concept, philosophy and principles of IWRM in contiguous natural system (the river basin) by policy-makers. This flawed situation is made even more tenuous by lack of reliable and regular hydro-

[8] The strict hydrological basins are *Niger-North, Niger-Central, Upper Benue, Lower Benue, Niger South, Eastern Littoral, Western Littoral, and Lake Chad*. Some even suggest that Niger-North and Niger-Central should ideally be Upper Niger, while the Upper and Lower Benue should equally form one basin thereby reducing the basins to six.

meteorological information on the basin for effective resources assessment. The monitoring networks which used to be effective up till late 1970s, have become inoperative (IUCN, 2003). Meanwhile, the subsisting enabling legislation on the RBDAs is Decree No. 35 of 1987. In spite of several fundamental changes and reforms thereafter - including the global concept of integrated water resources management approach in the 1990s, the partial commercialization of their activities in 1990, the increase in their number from 11 to 12 and change of name to River Basin and Rural Development Authorities (RBRDAs) in 1994, signifying increased scope of their mandate, - the enabling decree has remained the same. The transfer of the Department of Rural Development to FMA in 1999, brought with it a dilemma of whether they were to continue with their role in rural development or not? This situation remains unresolved, and further illustrates the lack of coordination and the inappropriate institutional framework at this level. In addition, their functions are distorted and out of tune with the fundamental element for success of a basin as would be shown subsequently. The functions in the said decree are as follows:

- to undertake comprehensive development of both surface and groundwater resources for multipurpose use, with particular emphasis on the provision of irrigation infrastructure and control of flood and erosion, and for water management;

- to construct, operate and maintain dams, lakes, polders, wells, irrigation and drainage systems for achievement of the Authority's functions and to hand over all lands to be cultivated on irrigation schemes to farmers;

- to supply water from completed storage schemes to all users for a fee to be determined by the Authority with approval of the Ministry;

- to construct, operate and maintain infrastructural services, such as roads and bridges linking project sites, provided that such services are included and form an integral part of the list of approved projects; and

- to develop and keep up-to-date a comprehensive water resources master plan, identifying all water resources requirements in the Authority's area of operation, through adequate collection and collation of water resources, water use, socio-economic and environmental data of the River Basin.

Experiences have identified a number of common features that are essential for the success of river basin organization (GWP TAC 2000). Where these elements are lacking or flawed the RBOs would lack political legitimacy and sustainability. These are:

- A high level of autonomy of the enterprise management and organizations;

- Transparency, accountability and active stakeholder participation in the decision making;

- Availability of reliable information, a good decision-support system and the capacity to use it to anticipate developments; and

- Adequate, reliable and sustained financing.

It is common knowledge that although the RBDAs were supposed to be autonomous entities with high level of administrative and financial autonomy, in reality they are not. Each RBDA is suppose to have a Board of Directors comprising a Chairman, the representative of the FMWR, the Chief Executive Officer of the RBDA and some other members, all to be appointed by the President, and answering only to the Minister for Water Resources. In reality however, the Boards are hardly ever appointed and when they do, rarely do they last more than three years, nor do they meet regularly. In most cases they do not comprise of technocrats who have idea of the principles governing IWRM, and are therefore not conversant with the role of RBDA in attaining IWRM approach. The Boards rarely meet except to award contracts or to deliberate over mundane issues. The RBDAs have practically no financial autonomy as the currently depend entirely on allocations from federal government budgets, which often fluctuate from year-to-year in deference to other government priorities.

According to the 1987 commercialization programme of Federal Government, HJRBDA and CBDA were classified as category A-RBDAs, along with Sokoto-Rima RBRDA. They were to have been granted complete autonomy and be weaned-off the treasury dole out by 1995. Federal Government reneged on their responsibility by failing to provide the seed capital and the required enabling environment. Consequently, the performance agreement was voided, but not without debilitating destabilisation of the already fragile institutional structure. It eroded their revenue base and the ability to render services while making their overhead even the more burdensome, without improving their autonomous sources of finance nor did it improve their services.

Secondly, to ensure transparency and accountability, it is particularly important to separate the role and institution of '**referee**' namely the water resources management institutions/regulator from those of '**players**', i.e., the water services delivery functions. Currently, the RBDAs are both water resources managers/regulators as well as water services providers. Importantly, funds and indeed activities of the organisation have to be administered within clear legal framework and accountability by transparent external audit. The current enabling law of RBDAs fails to spell out clearly the rights of stakeholders and how they are to administer their responsibilities. It is critically important to not only spell out their mandate, but to clearly define the boundaries of the mandate, spell out the reporting lines and who sets the 'rules' for decision-making and stakeholder participation (GWP/INBO, 2009)

There is insufficient stakeholder participation in decision-making processes. For instance, although their enable law requires each RBDA to convene advisory committee meeting at least once annually: to consult them over their annual programme and serve as forum to harmonise their needs and expectations; the committees have not been constituted in the past 20 or more years. The advisory committees are supposed to include the following:

- heads of the Federal government agencies involved with water resources development in the authority's area of operation (to include relevant representative of universities and polytechnic but these are rarely, if ever considered); and

- heads of departments of States Agencies in their domain responsible for agriculture, irrigation, fisheries, forestry and livestock.

The situation was such that during the interviews, most respondent from the RBDAs did not know they were mandated to have one. The few, who were aware of the provision, complained of inconsistencies of their boundaries and insufficient funds as the reason why they were not constituted. These have denied them the needed coordination with other agencies in water resources management and development.

One of the critical tasks of basin water management is to develop and then subsequently implement the basin master plan (i.e. a catchment management plan). To develop an effective catchment action plan it is vital to have adequate and reliable information as well as models and decision-support tools to predict outcomes of alternative plans and programmes. The enabling law of the RBDAs require them to have Master Plans, to collect, collate, analyse and disseminate reliable information, update the master plan regularly and develop suitable decision-support system that would facilitate decision making that are systematic and consistent with sustainable development of their basin. Today, however, only Hadejia-Jama'are River Basin Development Authority has a master plan, which is out of date, as it was prepared in the 1970s and has not been updated (Afremedev, 1999).

Government has been rhetorical to this very vital function of RBDAs. Inadequate funds are provided for collection and collation of vital hydro-metrological data necessary for such an exercise. It is interesting to note that Kano State Water Board (KSWB) and Water Resources Engineering Construction Agency (WRECA) have well-developed network of hydrological data collection stations while HJRBDA that has the primary mandate for this has been relatively less involved in the state. On the other hand, the situation in Bauchi State is the reverse; the state government agencies have no hydrological data collection stations, and therefore rely on Upper Benue RBDA for their data.

The interview with officials of both RBDAs also revealed that all of their existing dams and irrigation projects were developed without Environmental Impact Assessment (EIA) study, and of these only the KRIP phase 1 has been subjected to environmental impact audit. This was done under the auspices of a World Bank grant to prepare ground for the completion of KRIP phase1 and to identify the problems with existing system and suggest remedial measures to alleviate them. It is significant to note that IWRM approach requires that sectoral development be evaluated regularly for possible impacts on the resource-base, identifying the measures necessary to protect the resources and the related ecosystem and ensuring that such measures are

implemented. Hence, EIA is central to the cross-sectoral integration. Obviously, the absence of environmental impact audit as a routine and the inability to implement measures recommended even on the only audit concluded in 1992, both represent significant flaws in the current institutional arrangement.

Risk assessment and management also touches the heart of the need for cross-sectoral integration. Risks in this basin are floods, drought and environmental damage in addition to business related risks. While it is never possible to eliminate or avoid all possible risks, it is however essential, at the minimum, to at least observe the precautionary principle. In spite of recent repeated occurrence of floods and observed wetlands damage downstream arising from poor reservoir operation; nothing has been done to avoid this potentially irreversible environmental damage. The shrinking of Lake Chad and its effect on South Chad Irrigation Project (SCIP) and Baga Polder Project has been ignored, with the projects being operated as if nothing has changed. The explanation that scientific research was yet to fully establish the causal link and potential damage, neglected the precautionary principle which requires preventive measures rather than remedying the damage after the event. This further underscores the need for institutional reforms to align it to regional and national contexts change, such as climate change, ecosystems protection, basic data acquisition and collation, among many others.

In summary, therefore, although the establishment of RBDAs between 1973 and 1976, was no doubt a significant stride in entrenching coordinated water resources management and development in Nigeria, the advantages of the policy have however, been grossly curtailed by the distortions in their structure and functions. They are now almost entirely service oriented without adequate regard to stewardship of the resource. Meanwhile, as was illustrated, there is also little or no coordination between HJRBDA and CBDA except through the FMWR, even though they manage water resources in the same hydrological basin. It remains to be seen whether some other institutions such as Nigeria Integrated Water Resources Management Commission – Catchment Management Office (NIWRMC-CMO), the Federal Ministry of Environment, and NESREA - the successors to FEPA, are currently filling this gaps.

5.4.2 Federal Ministry of Environment/NESREA

FEPA was abrogated in 1999 and replaced with Federal Ministry of Environment. Several departments and agencies were transferred from other Ministries to it. These included: department of forestry including wildlife, forestry monitoring, evaluation and coordinating unit (FORMECU) formerly in Ministry of Agriculture and Rural Development; Flood and Erosion and Desertification Control, formerly in Ministry of Water Resources; and the environmental health and sanitation unit of the Ministry of Health. Others are the oil and gas pollution control unit formerly of Department of Petroleum Resources and the coastal erosion unit, environmental assessment division and sanitation unit both formerly of the Ministry of Works and Housing. In 2007 the National Environmental Standards and Regulations Enforcement Agency (NESREA) was

established by an act of parliament ((Establishment) Act, 2007 (NESREA Act) No. 25) which vest the agency with responsibility for the protection and development of environment and Nigeria's natural resources, and to enforce compliance with water quality environmental health and sanitation standards including pollution abatement.

The defunct FEPA commissioned a macro-economic study on EIA of the water resources development projects in the Jemaare River sub-basin, arising from the controversies surrounding the development of Kafin Zaki Dam. Federal Ministry of Environment is the apex institution of Federal Government responsible for the management and protection of the nation's environment; it inherited the study, which has remained uncompleted. It was understood that the study stalled due to insufficient funds but that it was primarily intended to identify suitable strategies for the management of natural resources in the basin that would be economically beneficial, environmentally safe, as well as socially and politically acceptable.

The Federal Government's four-year (2000-2003) programme that was designed to tackle ecological problems in Nigeria at a total cost of N11.25 billion was equally frustrated by poor funding, even though a system of cost sharing was adopted. Federal Government was to have contributed 60% (about N 6.75 billion) of the amount, the State governments to contribute 15%, the local governments 15% and the private sector, including the local communities, NGOs and CBOs 5%. It was not possible to obtain the status of the contribution of stakeholders and the progress of the projects.

Each State has an Environmental Protection Agency (SEPA). These are supposed to be responsible for the preservation and management of the environment in the state but instead they are mostly preoccupied with urban sanitation and solid waste disposal. Consequently, neither the defunct FEPA, nor the FME, nor NESREA, nor SEPA is filling the gaps of the regulatory role required to ensure sustainable development and to integrate the development of water resources at Lake Chad basin level. This may have played a part in influenced the establishment of Nigeria Integrated Water resources Management Commission as well as other related organisations.

5.4.3 Nigeria Integrated Water Resources Management Commission (NIWRMC)

The GWP in association with Cap-net and UNDP[9] gave the following template for institutional arrangements that are needed to bring IWRM into effect:

- Government to co-ordinate the national management of water resources across water use sectors.
- Water resources management based on hydrological boundaries;
- Organisational structures at basin and sub-basin levels to enable decision making at the lowest appropriate level;

[9] As contained in page their joint publication titled "Integrated water resources management plans - Training manual and operational guide" of March 2005

- The functioning of a consortium of stakeholders involved in decision making, with representation of all sections of society, and a good gender balance;

Nigeria with one giant swoop managed in principle to meet all these criteria with the creation of Nigeria Integrated Water Resources Management Commission. For many reasons, Federal government of Nigeria consider water resources management to be a responsibility of government - as a facilitator, regulator and a catalyst for implementing projects. Accordingly, t**he core mandates of NIWRMC are as follows:**

a) "To assist the Federal Government of Nigeria (i.e. The Hon. Minister responsible for water resources management) **to regulate and control the rights by all persons or public authority to develop**, **take or use water affecting more than one state** from any water course (surface water) or any groundwater as described in the schedule to Water Resources decree 101 of 1993"

b) To regulate development, inefficient utilisation, wrongful diversion and harmful practices and discharges into water affecting more than one state (bring sanity to the indiscriminate and perilous practices which have been wasteful of investment, led to loss of life and endangered environment).

c) To promote an integrated approach to water resources management that would facilitate the attainment of the MDGs

d) To provide core technical competence and advice on best practices for FGN to meet its obligations and receive its entitlement on international transboundary river basin commissions and bilateral bodies.

Among the key functions and responsibilities of the NIWRMC are:

- *Utilize policy instruments to regulate institutional and management activities of all water exploitation for private and public water services delivery so as to ensure:*
  - Equitable allocation between all uses and between upstream and downstream communities;
  - Optimum efficiency in all uses of water resources;
  - Conservation of the ecosystem for environmental sustainability;
  - Integration of quantity and quality of water resources;
  - Integration of land and water resources uses (manage both surface and groundwater at level of hydrological basins);
  - Integration of freshwater system and coastal waters
  - Prevention and resolution of conflicts between Stakeholders.
  - Effective administration of water on behalf of all Nigerians so as to guarantee fundamental basic needs and rights of all citizen;

- *License exploitation of water resources;*

- *Develop and enforce Integrated Management Resources Management Plan and Water efficiency;*

- *Provide forum for shared vision, program, plans and their financing that would enable all stakeholders to participate in decision making to protect their needs and interests;*

- *Enable and regulate private sector participation in provision of Water Services to safeguard the society*

- *Provide technical support to FGN on matters of international transboundary shared water. implement instrumental legal tools such as: International Convention, Bilateral or multilateral treaty or agreement, Constitutional and National Legislative requirements on water resources management.*

The challenge has been with mutually accepting the level at which government responsibility should cease, and at what stage to partner with autonomous water services management bodies and/or community-based organisations to deliver services. Integrated water resources management has always been associated with promotion of the river basin as the logical geographical unit for its practical realisation. The river basins or catchment units offer strategic advantages for planning of shared resources, particularly at higher levels of government, although groundwater aquifers frequently cross catchment boundaries, and could pose unique problems. As we have seen river basins rarely conform to existing administrative entities or structures.

It is in conformity with these that, NIWRMC will operate Catchment Management Offices (CMOs), which hopefully, would be a prelude to full fledge River Basin Organisations (RBOs) in future. The 8 Catchment Management Offices as provided in the bill passed by the National Assembly establishing the NIWRMC are based on Hydrological Basins as defined in the National Water Resources Master Plan. Out of the 8 CMOs expected to be established, that of Lake Chad has been opened although it is not operating fully. The Catchment Director was deployed to NIWRMC headquarters, thus effectively crippling its effective take-off. Essentially the CMOs are to provide the following water governance services:

- Suitable platforms for decision making to solve conflicting demands on the use of the land and freshwater resources in the basin.

- Facilitate both horizontal interaction between agencies, and vertical between the governing bodies and local, actual or potential users of these resources, i.e. both top-down and bottom-up interactions.

- Allocate water resources in appropriate quantity and quality to different uses and monitor based on a water charter to be agreed by the stakeholders;

- Effectively assess the resources basin-wide and put in place IWRM plan and water efficiency strategies to provide basis for water charter and sustainable water resources exploitation.

The primary function of NIWRMC is to ensure that water organizations and agencies at all levels and across sectors are participating and talking to each other. They are required to do so by

- anchoring coordination
- create coordination bodies at catchment level (hydrological basins not political entities) and
- devolving responsibility to the lowest level.

To achieve these, would require significant capacity building and increased autonomy to assume the regulatory authorities on all water related matters within the river basins. The Catchment Management Councils, which will be a significant step in stakeholder participation, have been provided in NIWRMC bill but there don't appear to be a concerted programme to establish them as of today.

Fourthly, the NIWRMC previously was under the Ministry of Agriculture. A Ministry of Agriculture is generally considered the most inappropriate place to house a water resources management organisation because of the obvious conflict of interest. Thankfully, good reason prevailed, and in accordance with the international best practice, it is now properly housed in the Ministry of Water Resources.

The main weakness of NIWRMC and indeed the FMWR is that water governance activities are poorly underfunded to the extent that they cannot effectively carry out their mandates on water resources management. This was partly due to the merger of the Ministry of Water Resources and the Ministry of Agriculture, but also due to the lower priority given to water resources management generally. In the past, the bulk of the funds for water resources management have come from Technical Assistance from multilateral and bilateral development partners.

As had been stated earlier, the 2003 draft National Water Resources Policy contains many elements which adhere to the principles of IWRM. The first and biggest step in improving water governance is to approve and commit to implementing the National Water Resource Policy. If implementing the Water Policy is taken seriously by all the Governments, the details of putting IWRM into practice will follow more easily.

The new National Water Resources Policy will when implemented provide the necessary framework for integrated water resources management. With respect to the water supply sub-sector there is already National Water Supply and Sanitation Sector Reform Programme which aims to focus on the following:

- Sustainable water supply to all socio-economic groups;
- Optimal involvement of private operators for investment and management;
- Tailor-made reform for rural, small towns and urban water supply and sanitation; and
- Review of Water Resources Act of 1993.

Ongoing exercise by the FMWR Legal section concerning holding of discussions with other institutions that have conflicting provisions to those of the Water Resources Act with a view to streamlining water laws and removing conflicting sections.

5.4.4. Hadejia-Jama'are Komadugu Yobe Basin Trust Fund (HJKYBTF)

The Hadejia Jamaare Komadugu Yobe Basin (HJKYB) extends from west of Kano downstream to Lake Chad. It covers 84,138 km2 (Finney and Kwaghe, 2006). Since early 1970s when the Tiga dam was completed, ecological changes in the basin began to manifest, attaining their heights during the late 1990 – early 2000s. The implementation of the second dam, the Challawa in 1992, further compounded the ecological problems that brought hardship and livelihood challenges to communities in the Basin. The consequences of these have been loss of farmlands, settlements, fish, grazing lands etc, leading to migration and increased poverty in the basin (JWL, 2003). The gravity of poverty in the Basin has increased to about ten folds in the last couple of years. This resulted into unilateral intervention by farmers, governments, and donor agencies to mitigate the effect of the flood and desiccation.

Since the problem is all over the basin, it calls for articulated intervention which was speared headed by JWL and the governments of the States in the Basin (Bauchi, Borno Jigawa, Kano, Plateau and Yobe). The governments of these states through a Memorandum of Understanding set up a Trust Fund (the Hadejia-Jama'are Komadugu Yobe Basin Trust Fund) with Headquarters at Damaturu. This drive was supported by the Federal Government of Nigeria by the provision of matching grant for the uptake of the Trust Fund during a Summit of the key Stakeholders on June 9, 2006.

Since 2008, the Trust Fund has been identifying specific projects for interventions, each with its peculiarities and at various locations within the Basin. Interventions by the Trust Fund, which plan began in November 2007 (and implemented from May 8, 2008) take the forms of weed/channel clearance, construction of dykes (both earth and concrete) and flood retention gates at some selected communities within the basin.

5.4.5 Other Institutions

The FMWR-IUCN-NCF KYB Project commissioned Afremedev Consultancy Services Limited to prepare Water Audit and Catchment Management Plan for KYB, as was requested by TAC of HJKYBCC which recommended a water audit. The project comprised of socio-economic and environmental situation analysis, water balance study, development of water management options and development. This was followed with the drafting water charter for management of the basin. The FMWR-IUCN-NCF KYB Project also implemented some of the pilot projects of the LCBC/GEF sponsored Komadugu Yobe Basin component of the Lake Chad Basin Initiative. All these were intended to address many of the following challenges identified at a Stakeholders Consultative Workshop convened in January 2003:

- Capacity-building of the stakeholders for optimum utilisation of the resources in the basin

- Data collection, rescue, update and dissemination
- Stakeholders participation, commitment and coordination
- Establishment and implementation of enabling legislation and policy
- Establishment of the necessary institutional framework for the integrated natural resources management and sustainable development of the basin
- Establishment and enforcement of environmental quality standards for planning, design, construction and operation of dams as well as for special multiple uses of water

Another significant development was the Lake Chad Basin Commission Initiative, which was a collaborative programme of LCBC with the World Bank, UNEP and UNDP that implemented a GEF-supported programme for integrated management of Lake Chad and associated river systems. One of the components of this programme was the preparation of Transboundary Diagnostic Study, National Action Plan and Strategic Action Programme for the entire LCB. All these would be helpful in preparing CMP for LCB in Nigeria.

5.5 Water Services Providers (Operating Services) (public, private or public-private utility)

5.5.1 River Basin Development Authorities

The RBDAs, initially had a very wide mandate, but this was whittled down over time and today in reality the function of the RBDAs has been reduced essentially to developing and managing water storage, primarily for irrigation, and carry out some borehole drilling for rural water supply. As such they are purely implementing agencies of the Government and, to a considerable extent, specifically irrigation development agencies.

The three RBRDAs (CBDA, HJRBDA and UBRBDA) in LCB have independently been harnessing and abstracting water in the catchments principally for irrigation in their domain. Currently, HJRBDA has developed Tiga, Ruwan Kanya and Challawa Gorge reservoirs, as well as Kano River Irrigation Project – Stage 1 of Phase I (KRIP 1-1). Meanwhile the development of Hadejia Valley Irrigation Project Stage 1 of phase 1 (HVIP 1-1) and the stage 2 of KRIP 1 as well as Completion of Watari Irrigation Project (Bagwai Sector) are on-going. The development of Kafin Zaki and Kawali Diversion structures along with their downstream irrigation development although planned, have remained controversial and have generated considerable tension. The proposed dam would lead to the control of flows in the Jama'are River system, and Yobe and Borno States believe that it would exacerbate their water scarcity, as the upstream states (Bauchi, Kano and Yobe) would utilise the water without any regard to their needs and aspirations.

On the other hand, CBDA has most of its development on the fringes of Lake Chad. To date, it has developed South Chad Irrigation Project (SCIP) phases 1 and 2 and Alau Dam but without downstream irrigation development - that is currently on the drawing board, and has partially developed Baga Polder Irrigation Project. UBRBDA has little or no presence in the Basin, because the basin area under it, are on the marginal fringes of its territory.

As part of the consequences of the foregoing, a large gap exists between irrigation potential and actual utilisation of the available irrigation water. Reservoirs and waterways are being damaged by heavy siltation, sedimentation and weed infestation. Most of these projects with possibly the KRIP as the only exception are not performing satisfactorily, for three main reasons, namely: poor planning and design from the onset; poor funding and attention to operation and maintenance; and finally insufficient beneficiary participation in their development and management. Poor planning and design was as a result of insufficient and unreliable information used, which led to wrong decisions. Afterwards, the situation was compounded by paternalistic approach to the management of these schemes. The hasty programme to transfer management of these formal irrigation schemes to the farmers without adequate capacity building, only made the situation worst. Many of the RBDAs have built sizable but insufficiently trained manpower that is not in tandem with their low achievements.

The following major constraints that are also militating against effective provision of irrigation services by the RBDAs:

- Shortage of staff with capability in operation, maintenance and management (OMM) of irrigation schemes.
- Severe funding constraints. They hardly receive any funds other than for salaries. The last subvention received being that of October 2001.
- Lack of effective extension services on their schemes arising from policy inconsistencies.
- Absence of effective mobilisation of farmers' resources towards OMM.
- Inadequate tractors and implements that would enable them ensure compliance with cropping calendar.
- Scarcity of spare parts, especially for SCIP with high electromechanical components, while scarcity and high cost of AGO (diesel) has led to the frequent failure of the system and hence poor performance.

5.5.2 The North East Arid Zone Development Programme

The North East Arid Zone Development Programme (NEAZDP) is an integrated rural development project, for the northern fringes of the semi-arid zone of Yobe State. It covers 20,000 km2 in 9 Local Governments Areas with estimated population of 1.2 million people as at 1992. It started as a joint FGN-Yobe State Government-Euporean Union (EU) project with linkages to University of Maiduguri, through its Centre for Arid

Zone Studies (CAZS), and Ramat Polytechnic in Maiduguri. EU, however, suspended their aid in 1996 as part of the economic and political sanction by the body. Since then the Federal Government has been responsible, although not satisfactorily, with funds not being released as and when due and not fully. This has drastically affected the performance of the project.

The mission of the programme has been "to motivate and assist the rural population to improve their standards of living through proper use and management of natural resources". The programme has encouraged villages to prioritise their needs; has given credit, technical assistance and advice to owners of productive projects such as irrigated agriculture; and has provided support to social projects such as provision of hygienic and reliable water supply, and improved nutritional and health standards under full management of the communities.

NEAZDP operates 19 hydro-meteorological stations out of which 14 are manual gauging station installed along the Komadugu Yobe river system while 5 automatic gauging stations are installed at bridges at Hadejia, Katagum, Gashua, Geidem and Dapchi. Thus, they are essentially engaged in organizing and assisting farming communities within its operational area to abstract both surface and groundwater for irrigation and domestic use.

5.5.3 State Government Agencies

The State Ministries of Agriculture and Natural Resources (SMANR) and Ministries of Water Resources and Rural Development (SMWRRD) play similar roles in land and water resources management to those of FMARD and FMWR respectively at the State level. The operational difference is in the emphasis of their activities on service provision rather than on regulation, control and natural resources management. The State Irrigation Department (SID) and the ADPs belong to SMANR in some States, while in some others SID and state-wide coordination of water resources development and management belongs to SMWRRD (e.g. Kano and Katsina).

Like elsewhere, the advent of HJRBDA, CBDA and UBRBDA has eclipsed the role of SIDs in their area of jurisdiction. These SIDs however, continue to maintain sizable staff, in spite of the limited funds that has rendered them virtually idle. Kano State government has nonetheless managed to remain relatively active. It has developed several dams, including the Bagauda, Gari, Tomas and Watari medium and small-scale dams for domestic and agricultural water requirements. It would appear that an informal division of responsibility exists in which irrigation projects of more than 500 ha are generally handled by the RBRDA, while those that are less are managed by SIDs. Even then, there is apparently no forum for formal discussion and coordination of activities between the RBRDA, ADPs, WBs and the SIDs within any of the states in the basin. Although, the approved organisational structure of the ADP requires the Chief Executive Officer of the RBDA of that domain to be a member of the governing board of the project, in reality this has been ignored for the past fifteen years or more.

Furthermore, the new centralised agricultural extension policy requires ADPs' to provide all extension services, both for rainfed and irrigated agriculture including RBDA schemes, but this too has been observed more in breach.

The Agricultural Development Project (ADP) hitherto deals mainly with rainfed agriculture but more recently they (particularly those of Adamawa, Bauchi, Kano and Jigawa States) are all involved in the National Fadama Development Project (NFDP) and Special Programme for Food Security (SPFS). These four and, to a lesser degree, those of the Yobe and Borno are now promoting small scale, farmer owned and managed irrigation using petrol-driven pumps to exploit shallow aquifers of the *fadama* under the auspices of the World Bank through NFDP and FGN for SPFS. The farmer acquires the pumping systems on loan, but the washbores and tubewells are drilled by the ADPs. This project has been tackling some of the institutional issues faced by HJRBDA, CBDA and UBRBDA such as cost recovery and provision of credit for small farmers, and some of these farmers are also participants in the schemes operated by the HJRBDA, CBDA and UBRBDA.

The responsibility for provision of municipal and rural water supply and sanitation services lies with the State governments. It was indicated that one of the conditions before the World Bank intervention in the National Water Supply Rehabilitation Programme (NWSRP) was the existence of a state agency that was solely responsible for water supply, while the requirement of the FMWR Nationwide Rural Water Supply Programme was the responsibility of an agency for the development, operation and maintenance of rural water supply schemes.

Consequently, almost all the states in the basin now have State Water Boards (SWBs) for urban water supply and Rural Water and Sanitation Agency (RUWASA) for rural water supply and sanitation. The SWBs are involved in water resource development and have some reservoirs, and treatment plants with reticulation networks to provide water supply services to towns with population of more than 1,000. They are also involved in hydro-meteorological data collection and have monitoring network.

The SWBs degree of interaction with the FMWR varies, depending on whether the State is a beneficiary of the NWSRP. The FMWR coordinates the funds and by implication this has improved harmonization and cooperation with the SWBs that are beneficiaries of the Fund. Unfortunately, because FMWR itself does not seem to recognize the resources management functions of RBDAs, they were not consulted on the NWSRP. This has tended to further distance the SWBs from the RBDAs.

5.5.4 Other Institutions and Agencies

More than 149 Local Government Authorities have their domains within the KYB. It was gathered that they are all involved in one way or the other in the abstraction of water for small scale irrigation purposes. Nonetheless, even if it were not so, the involvement

of the Local Governments and District Authorities in irrigation development projects would be vital especially in the mobilization of farmers.

Other stakeholders involved in land and water resources management and development are shown in Table 4.1. Many of these institutions operate independently of each other and from the FMWR except for limited and ad-hoc inter-ministerial and inter-departmental fora which are often restricted in scope and depth of discussion.

5.5.5 Water-Related Functionality of Village Level Institutions

Evidence exists that village level institutions in the form of Water Users Association (WUA) have been formed in the basin, especially at the two major irrigation projects. However, either that the formation had been haphazardly done or they were not empowered enough at the very beginning because they are not active now. The participation of water users and other village level institutions must be thorough to be effective. One does not expect the water users to accept new added responsibilities without any privileges attached to it. The leadership must be fully involved in planning, designing, operation, maintenance, financing and policy matters if the aim is to transfer complete responsibility to users in the long run.

Outside the major irrigation projects, several village level institutions are also springing up as a result of several disasters facing communities. Water scarcity, flood and *Typha* grass invasion have all forced communities to rise up and formulate ways of solving their problems.

Most donors require that the grassroots lay some foundations before coming in to assist them to strengthen such foundations. As such, the worst affected members of any community in the basin are now forming self-help groups for the various problems. In this regard DFID and the DFID-JWL Project are assisted communities to form such groups. Groups such as Marma Channel Flood Protection Groups and Pastoralists Group now abound. The DFID-JWL Project assisted such groups to identify and articulate their goals. Critical areas of action were also identified. The opportunities, such as helping factors and constraints, hindering factors and group workplans were all identified and articulated.

In one community, a group with flood and *Typha* control as their ultimate goal, priority was given to the clearance and opening up of the main river channels blocked by floating grasses, *Typha* grasses and siltation. The group worked tirelessly for three months and thereby cleared the mouth of their channel at the Gubusum bifurcation. All this was done manually. Occasionally, a group of more than one hundred able-bodied men, would work from sunrise to sunset. There is need to complement and empower such CBOs, by helping them out with the work that is beyond them and handing it over to them as their property after proper training in Operation and Maintenance (O&M) for sustainability. Public authorities must do it because NGOs are too few in the basin.

To achieve Integrated Water Resources Management (IWRM) in the KYB, the management of land, water and human society, governments, NGOs, local groups, private companies and donor agencies in consultation with all other stakeholders in the basin must jointly develop and implement an ecosystem based catchment management plan. For the sake of conservation, this approach will promote the protection and rehabilitation of the catchment.

5.5.6 Functionality of State Level Participatory Fora

The tasks and goals they set by the village level groups mentioned above, are enormous and cannot be achieved by manually through self-help effort alone. They were encouraged to seek support from state level participatory forum, local government authorities, regional political representatives and numerous other stakeholders for assistance. This for instance led to some of these groups securing mechanical excavators from the state ADPs. The state level participatory forum also attracted worksite visits by commissioners, deputy governors and emirs. They also facilitated media coverage of the community problems and efforts. For instance, news correspondents from Radio Jigawa, DW of Germany, British Broadcasting Corporation and Voice of America were reported to have visited some of the site of the work being done by CBOs and reported the on-going community level activities.

The states' level participatory fora (SLPF), have also facilitated the identification of more permanent solutions to the CBO problems. For instance it was during deliberation of a state level participatory forum that the construction of flow proportioning structures at critical positions in the river system was identified among several other options. Through the operation of these structures, water flows can be proportioned between the various channels in order to mitigate lack of water in some channels, and control excess in others. These structures may also help control *Typha* as well as arrest potash intrusions and restore regular seasonal flows into Yobe River and the Lake Chad.

The some of the SLPF are also planning the replication of these structures elsewhere if the first two prove successful and also planning to establish suitable joint local management arrangements of the structures. The Jigawa State forum in particular also worked towards the establishment of good working relations with the managers of HJRBDA who control the upstream structures of Tiga and Challawa Gorge dams. They also made attempts to establish regular information channels on upstream water releases and to influence the planning of dam operation procedures (i.e. by way of establishing basin-wide water sharing arrangements) which will serve the purpose of controlling floods and *Typha*. These fora are however less active today compared to when they were receiving assistance from DFID-JEWEL Project. DFID-JEWEL Project failed to provide exit strategy that would enable these State-level fora to be self-sustaining.

5.6 Financing

A good basin management system requires adequate funds for its operation so it can fulfil its mandate. Many of the foregoing institutions and policies were put in place with unrealistic objectives especially when compared with their funding allocation. This is in part responsible for the under-performance of the basin management system. All the basin organisations have limited financial autonomy and depend almost exclusively on treasury dole out, the size of which depends on other government priorities. Basin management covers three distinct areas of developing and maintaining infrastructure, stewardship of the resource and operations of the basin organisation. It is therefore an essential 'public service and good' and irrespective of whether or not a formal umbrella basin organisation exists, governments need to sustainably fund development and management of water resources. This is because of the public nature of water. NIWRMC that was recently created to provide overall basin management should not duplicate, but coordinate the activities of all other agencies and address new functions that are not being implemented. This would require adequate funding which must clearly be designated to specific functions. The CMP will need to be complemented with articulate financial plan that would set out exactly how implementation of CMP would be funded – detailing where the funds will come from and what it will be spent on.

All finances of basin management come from a combination of three sources, namely: taxes, tariffs (in form of charges, tariffs and fees) and transfers (the so called three Ts)[10]. The taxes are generally an indirect source of funds. Federal Government makes allocation from treasury funds which include tax revenues to basin organisations A more sustainable and sound basis tax budget allocations is however required. The Trust Fund that was commenced in the basin is a good start, but it is arbitrary. It has been suggested that this be transformed into **Catchment Debt for Nature and Stewardship Trust Funds** to finance the implementation of stewardship, conservation and general water resources management in each catchment. This should come from local government, state and federal government allocating some percentage of the tax revenue received from land ownership.

The River Basin organisations (i.e. NIWRMC, RBDAs, and NESREA) are provided subvention directly by FGN, but these are seldom adequate to cover their costs. Increasingly, they are being required to augment these with tariffs and fees to directly recover cost from the beneficiaries of their services at least their operating, renewal and managing of resource costs. It is projected that with the exception of Lake Chad Basin and Western Littoral areas, constraint to food security will not be from water availability but will rather lie with insufficient infrastructures to store and deliver water to the farms. Financing infrastructure to secure enough water in a sustainable way for all uses and users would therefore pose enormous challenges in the Basin, especially because of water scarce. For instance, although significant public and private investment in irrigated agriculture in the past five decades has contributed significantly

[10] Water markets are not considered here because they are not used in the basin nor are they generally used worldwide because of their complexity.

to close the food security gaps, particularly in the KYB, the performance of most schemes have been unsatisfactory. Funding has been the main constraint to provide additional infrastructure and to sustainably operate and maintain existing schemes. Meanwhile, public-private partnership has not been vigorously explored to utilise several dams that are without irrigation facilities. A substantial increase of water efficiency and productivity through investments in the rehabilitation or modernization involving restructuring of both the physical facilities and the institutions of existing systems, as well as development of new water resources are clearly needed.

Currently, the capital cost of public sector irrigation schemes in Nigeria ranges from N1.5million (US$10,000) to N2.3 million (US$15,000) per hectare. This is significantly higher than farmer-owned and operated schemes with investment costs of about 5% of public scheme[11]. Operation and maintenance (O&M) costs are estimated at N8,000-9,000 per hectare per season (approximately US$60/ha) for gravity-fed schemes and N80,000-85,000 per hectare per season (US$530/ha) for schemes using pumps. In contrast, a 3 HP pump to irrigate about 1 ha, has an annual operating costs of about N45,000 per hectare per season (US$280/ha). Currently RBDAs charge on average N500/ha/season (US$3/ha per season for irrigation water supply (with exceptions of few schemes)), and even this very low fees have proven difficult to recover[12]. The low irrigation water pricing is in part responsible for the cycle of poor services leading to lack of willingness to pay by the user. Consequently, few of the public schemes are operable and all are beset with O&M problems including the supply of and access to spare parts. There is urgent need to develop and implement and appropriate financing system, based on 'polluter-pays' and 'user-pays' principles.

Critical issues in cost recovery are the capacity and willingness of the beneficiaries to pay. For instance, the capacity of payment for irrigation is influenced by the value addition of irrigation (increase income); insurance against extreme events such as floods and drought; the quality of irrigation service provided; and such other considerations like improved farming techniques, availability and cost of inputs, credit and marketing facilities, among others. Crop budget analysis reveals that farmers realize enough income to pay the charges currently levied. Probably, the factor responsible for the lack of willingness to pay may not be unconnected to the perception that water should be free. In any case there is need to experiment differentiated fees based on ability to pay.

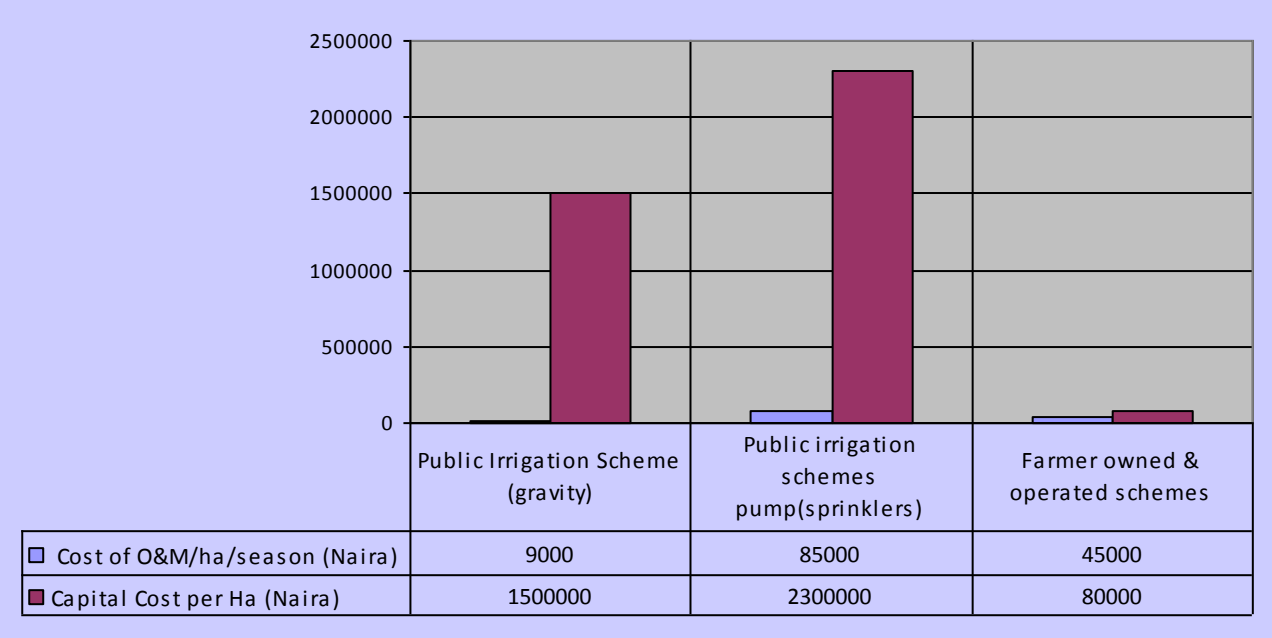
Another strategy would be to examine the high cost of developing infrastructure generally. A careful examination to discern where society can derive optimum benefit from the infrastructures would enable the society prioritize those that would give maximum returns. For instance, irrigation would then have to service agriculture, rather than an end in itself by redirecting irrigation from a supply to a demand-driven

[11] It is significant to note that the public irrigation schemes include a substantial portion for rural development infrastructure not necessarily directly linked to irrigation, like rural roads, bridges, water supply component, storage facilities, workshops etc. They also generally have longer life-span. If these are discounted, the difference in cost becomes less significant.

[12] Costs recovered vary from scheme to scheme but in any case cover only a small fraction of the O&M costs.

activity and ensuring that this complements rain-fed agriculture. Traditionally many farm families in the basin had cultivated small areas in fadamas during the dry season, using water manually drawn from shallow wells or streams using a calabash or similar container to irrigate 0.01-0.05 ha. Some use manual lifting using a Shadouf or treadle pump to irrigate 0.05-0.1 ha. The use of Shadoufs is however declining with the introduction of small-motorized pumps and treadle pumps are generally not liked[13] by both men and women. Costs for a pump and well are estimated at N750-3,000 (US$5-20) for the Shadouf and N10,500 (US$70) for the treadle pump.

Figure 5.1: Capital and recurrent cost for public and private irrigation schemes (Naira)



	Public Irrigation Scheme (gravity)	Public irrigation schemes pump(sprinklers)	Farmer owned & operated schemes
Cost of O&M/ha/season (Naira)	9000	85000	45000
Capital Cost per Ha (Naira)	1500000	2300000	80000

Major fadama areas are located along the flood plains of Yobe rivers. The promotion of mechanized lifting (3.5-5.5 HP petrol driven motor centrifugal pumps) and tubewells to irrigate 0.5-1.5 ha costing between N75,000-105,000 (US$500-700), depending on the water source, allow for the extraction of greatly increased amounts of water. The pilot programme began in the late 1980s through Agricultural Development Projects (ADPs). By 1992, more than 80 000 pumps had been distributed. From 1993 onwards, the National Fadama Development Project (NFDP) funded by the World Bank built on the ADPs' achievements and by the end of the phase 1 of the project in 1999, over 55 000 pump sets had been distributed with an equipped area of about 1 ha per pump.
Extraction from a river is the cheapest and from a tubule the most expensive option.

Before the 1980s, water sources were mostly rivers or open wells in fadamas, in contrast today, washbores and tubewells are most common. A more cost effective system involves single-cylinder water-cooled diesel motor pump and a tubewell in a

[13] The low patronage for treadle pump is as a result of negative experience with them in some States due to bad publicity and poor performance of the first set of pumps.

fadama or in alluvial plains. This could irrigate 0.5-2.0 ha and is estimated to cost about N142,250 (US$950) but the cost of its operation is significantly lower. This technology is however not widely found and usually installed by well-off farmers for multipurpose use, because diesel is difficult to find in rural areas, while petrol is readily available. Overall, the NFDP provide loan packages that do not reflect the full capital costs, as a result of which it has worked against the introduction of lower cost options such as the treadle pump. The truly resource-poor farmers still do not have easy access to lifting equipment.

Private sector irrigation in Nigeria is small-scale with the exception of two sugar estates, which were sold to private companies but receive token government support. About two-thirds of the irrigated area of the private sector is small-scale, mostly for cultivating commercial vegetable, horticulture and flower around large cities. The remaining is classified as fadama irrigation.

The Special Programme for Food Security (SPFS) of the FAO commenced in 1999 with a pilot phase including 280 ha in three villages in Kano State, where farmers were provided with motorized pumps and tubewells to enable them to engage in irrigated agriculture in the fadama lands. The project adopts a participatory community development approach, where farmers' groups themselves are primarily responsible for planning and have ownership of the project. After the success of the pilot phase, the project has now been extended to cover all States of the federation.

The area under irrigation appears to have stabilised but this is still far short of planned areas and only a third of the actually equipped area. The overall state of public irrigation schemes is generally poor, although there are some 'bright spots' especially the interest and commitment of the farmers in a few of the schemes. Some three schemes in the Basin account for 60-70% of the irrigated area in Nigeria, namely: Kano River Irrigation Project, Hadejia Valley Irrigation Project and South Chad Irrigation Scheme.

Finally, the transfers include grants and charitable and voluntary contributions. The Trust Fund was primarily intended to increase these components of financing especially in regard to stewardship, unfortunately the grants from development partners have dwindled in the recent past. Trust Fund should more rigorously pursue water financing program and grants from African Development Bank, World Bank as well as bilateral sources. Although funding from non-governmental sources remain modest when compared with other sources, it nonetheless, is also important not to neglect them.

5.7 Summary of Challenges of Lake Chad Basin Management Systems

The sum total of all of the foregoing is that there are now many public institutions involved in the planning, financing, construction, operation and maintenance of water resource systems at various levels - Federal, State and Local. The establishment of NIWRMC notwithstanding, this has resulted in uncoordinated and fragmented decision-

making, inconsistent policies, overlapping and duplication of functions, or even competition for same water as has become manifest in the basin in recent times. There were no clear priorities in the basin and sub-basins that are formally recognised by all stakeholders. In many cases the integrated water resources management principles are not known to many of the stakeholders. Data and information management are very poor and conducted for the needs of individual agency and without harmonization of procedures. While this was not entirely a bad arrangement, they were irregularly done and without coordination or exchange of data.

Table 2.6: Summary of Legal and Institutional Framework

INSTITUTION	ROLE AND RESPONSIBILITIES IN WATER RESOURCES MANAGEMENT	REGULATING ACT
National Council on Water Resources	Overall national water resources policy formulation	
Federal Ministry of Water Resources	Responsibility of overall water resources management and development Controls the provision of water supply and sanitation service delivery Responsible for planning and irrigation development	**Water Resources Act of 1993**
Nigeria Integrated Water Resources Management Commission	Water Regulation, Allocation and Management through CMP, and issuing of water rights for all purposes on behalf of HMWR	**Bill is yet be signed into law**
Nigeria Hydrological Services Agency		Bill yet to be signed into Law
Chad Basin Development Authority **Hadejia-Jamaare River Basin Development Authority** **Upper Benue River Basin Development Authority** **Lake Chad Basin Commission (LCBC)**	Gives effect to the inter-state Agreement relating to the utilisation of shared Rivers for economic, industrial and social developments. In addition, hydrological and environmental data is collected and used for dam operations	The River Basin Development Authority Act of 1987
Federal Ministry of Environment **Department of Forestry** **NESREA**	Environmental management and enforcement of legislation Manages the protected areas as National Monuments. It in addition manages unique water bodies such as lagoons, geophysical sites such as hot springs; and all major waterfalls throughout the country, which are protected as National Monuments National Heritage Conservation Controls, manages, co nserves and administers national and local forestry Provides participation of local communities, traditional institutions and NGOs, preventions of pollution or fouling of public water	
Federal Ministry of Agriculture and Rural Development **National Food Reserve Agency** **Department of Fisheries**		
Federal Ministry of Transport **Nigeria Inland Waterways Authority**	Provides for the survey, registration and safety of certain vessels used on inland waters, and for the safety of passengers and cargo, as well as for the competency of masters and crews of shipping vessels	
Ministry of Foreign Affairs **Nigeria-Niger Joint Commission (NNJC)** **Nigeria-Cameroon Mixed Commission (NCMC)**		
National Parks Authority	Responsible for all National Parks and Game Management Areas. It is largely responsible for the management of wildlife but is also responsible for the management of forests and water catchment areas found in national parks	
Presidency **MDG**		

Federal Ministry of Energy **Power Holding Company of Nigeria**	Responsible for planning, designing, constructing and operating hydropower facilities. In addition hydrological and environmental data is collected and used for dam operations	
National Planning Commission **North East Arid Zone Development Programme**		
Federal Ministry of Solid Mineral **Nigeria Geological Services Agency**	To advise the Minister on geological matters, to undertake the geological mapping of Nigeria and undertake prospecting and exploration operations, and generally assist members of the public seeking information concerning geological matters Provides for environmental protection during prospecting, mining, decommissioning and abandonment of mines Important partner in the development of groundwater resources and in mapping out the groundwater aquifers	
Federal Ministry of Aviation **Nigeria Metrological Services Agency**	Responsible for provision of meteorological data and information	
Federal Ministry of Culture and Tourism **National Tourism Development Council**	Broad mandate for tourism and environmental monitoring; and enforcement of legislation and improvement of watersheds through control of soil erosion and deforestation	
Federal Ministry of Health	Responsible for monitoring sanitation; health education; monitoring of drinking water quality; setting standards and general sanitary supervision throughout the country	
State Ministry of Agriculture **State Agricultural Development Projects** **Department of Irrigation** **Department of Fisheries**	Development of water resources for aquaculture	
State Ministry of Land and Physical Planning	Responsible for urban planning and demarcation of areas for development, the preparation, approval and revocation of development plans, the control of development and subdivision of land. These features are important in that the impact of development on natural resources is an important component of town and country planning, and this includes water The preparation, approval, and revocation of development plans subject to their impact on natural resources	
National Infrastructure Concession Commission		
State Ministry of Local Government **Local Governments Authorities**	Responsible for implementing the decentralisation policy of government (through Cabinet Office)	
State Ministry of Trade		
State Ministry of Water Resources **State Rural Water Supply and Sanitation Agencies** **State Water Boards**	Domestic urban water supply policy and investment projects. Is responsible for rural water supply and sanitation Support to planning and implementation of projects	
State Ministry of Agriculture **Agricultural Development Project**		
Academic and research Institutions including National Water Resources Institute, Lake Chad Research Institute, Centre for Arid-zone Studies (CAZS) UNIMAID, Centre for Trans-sahara Studies (CTS) UNIMAID etc	Provide human resources capacity building and knowledge through training, research an consultancy services	
Private Sector	Provide various services such as investment, consultancy services and constructing	
Farmers, Industries etc	Utilise water resources for different purposes and contribute to the management of water resources by the formation in some areas of water users' associations (WUAs)	Currently the Water Users' Associations (WUAs) are not recognised under the Water Act. Function as cooperative only
Non-governmental Organisations.	They usually support MDAs and State and Local Governments on public awareness and mobilization of stakeholders to manage water supply and sanitation in their areas	

Overall, the institutional challenges to IWRM in the LCB can be summarised as follows (Musa, 2003):

- ***Improving land and water governance:*** The water resources situation when compared with the population and socio-economic situation, suggests that water crisis may be eminent, arising primarily from poor water governance[14]. The strategic improvement required involves governments at all level creating an enabling environment and introducing appropriate institutional reforms that would facilitate mobilisation of all stakeholders' knowledge and resources for effective management of natural resources to meet all needs and interests.

- ***Creating awareness and greater stakeholder participation:*** Ignorance prevails as to the importance of stewardship and the need to accommodate the interest of all stakeholders. To create institutional harmony would require applying useful experience and knowledge in pursuit of IWRM for sustainable development of all sectors and raising awareness of its importance.

- ***Tackling conservation, achieving water for food and sanitation while improving flood management as urgent priorities:*** Stewardship is a major challenge and integrated management of the basin is required to conserve the limited available water resources. Measures have to be taken to protect the rivers, aquifers, aquatic ecosystems from pollution, invasive aquatic weeds, siltation and overexploitation and to use water sources optimally for all uses. For instance, flood management and protection of some delicate ecosystems used for traditional methods of flood recess agriculture would have to be better managed. Sustained dialogue between upstream and downstream communities would enable mutually agreeable ranking of these urgent needs.

- ***Generating the required investment for future:*** Tackling these challenges and issues would require substantial increase in investment for integrated management of the basin, which would have to be harnessed from various sources – public and private sector; domestic and international; individual and institutional – and will have to be pooled in financing a more secure basin for the future.

As the situation is at present, there are many public institutions involved in the planning, financing, construction, operation and maintenance of land and water resource associated systems at various levels - Federal, State and Local. This has resulted in some uncoordinated and fragmented decision-making, inconsistent policies, overlapping and duplication of functions, or even competition for same water as has become manifest in the basin in recent times.

NIWRMC need to provide coordination in watershed management and public education and awareness while ensuring bulk water allocation through water entitlements which was hitherto not being performed satisfactorily.

[14] **Water governance** is the process of managing and developing water resources by engaging and interacting social, political, economic and legal aspects.

Box 5.5: Organisation of water management in Lake Chad Basin in Nigeria

Functions	The Institution Responsible
Water policing –authorization (discharges, withdrawals)	NIWRMC (LC-CMO) /NESREA (RBO)
Registry of users	NIWRMC (LC-CMO) (RBO)
Strategic long-term planning (master plan)	FMWR (National Water Resources Master Plan)
	NIWRMC (National IWRM Strategy and Water Efficiency Plan) (RBO)
	HJRBDA/CBDA (Regional Master Plan)(RBO)
Manage concessions to big developers (raw water sales)	NIWRMC (LC-CMO) (RBO)
	HJRBDA/CBDA (RBO)
	State Governments
Water charges (pollution, abstraction), basin action plan	NIWRMC/NESREA (RBO)
	HJRBDA/CBDA (RBO)
Drinking water supply and sanitation (community)	State Governments
	Private
Irrigation (community)	HJRBDA/CBDA (RBO)
	State Governments
	Private
Monitoring, data	HJRBDA/CBDA/NIWRMC (RBO)
	State Governments
	HJKYTF
	Private

RBO: River Basin Organisation

6 DECISION SUPPORT SYSTEM

6.1 Climate Scenarios

Availability of water in the LCB depends on rainfall, which is highly variable due to climate dynamics. Rainfall affects streamflow or inflow to reservoirs, and groundwater recharge. Water demand in the Hadejia sub-unit accounts for over 60% of the current water demand of the KYB sector (KYBP, 2006). This is satisfied by release from the two big reservoirs (Tiga and Challawa Gorge) in the basin. Inter-annual variation in rainfall results in low or high inflow to the reservoirs and affect the operation and the reliability of the system. A Decision Support System (DSS) was developed in 2006 (KYBP, 2006) to aid the operation of the reservoirs. The DSS shows the weekly water balance under very wet, wet, normal, dry and very dry climate scenarios. The structure of the DSS is well documented in KYBP (2006) but the procedure for installation and usage has been modified. This is documented in the DSS Manual. Effective use of this model depends on the ability to forecast the rainfall or flow pattern. The on-going study by Federal Ministry of Water Resources on the development of optimised reservoir operation model for the reservoirs is expected to address this area (Jimoh, 2011). The water balance analysis for the 2010, 2030 and 2050 is discussed herein.:

6.2 Analysis of Options

The current water uses at the upper part of KYB includes water requirements of two large irrigation projects (KRIP and HVIP) and that of KCWS. At the middle part, we have the HNWs demand. There are also demands for agricultural and domestic needs in the lower part of the KYB. As at now, the groundwater development of the basin has been uncoordinated and there are insufficient records to assess the rate of abstraction and its contribution to water requirement of the basin. Current water requirement of the basin are as follows:

Upstream section of KYB

- 14,500 ha command area in KRIP requires 257 Mm^3/year.
- Kano City with a population of 6,000,000 requires 196 Mm^3/year.
- 2,000 ha command area in HVIP requires 24.2 Mm^3/year.
- Evaporation loss from Tiga and Challawa reservoirs is 445 Mm^3/year

Middle section of the basin

- Proposed 10,000 ha command area in Kawali Irrigation scheme requires 80.2 Mm^3/year.
- Proposed evaporation loss is 175 Mm^3/year

Downstream section of KYB

- Considering the Marawaji control structures and demand for 6,000 ha dry season farming and 16,000 ha wet season flooding, ecological requirement at Hadejia-Nguru Wetlands is 500Mm^3/year.
- Water supply for communities from downstream of Kano to Hadejia with a population of 1,107,574 requires 27.3 Mm^3/year.
- Water supply for communities from downstream of Hadejia to Damasak requires 1.3 Mm^3/year.
- Water supply for communities from downstream of Damasak to Yau requires 1.5 Mm^3/year.
- Livestock requirement from Hadejia to Damasak requires 10.5 Mm^3/year.
- Livestock requirement from Hadejia to Damasak requires 5.3 Mm^3/year.

The Borno sub-system

- Maiduguri Water Supply : 45.3 Mm^3/year
- Maiduguri environment requires 24 Mm^3/year
- Jere Bowl Irrigation Project -Enplan (1991) showed that Jere Bowl has a gross land area of 15,820 Ha suitable for irrigated agriculture. Of these, 6,936Ha are lowland fadama, while 8,884Ha are in upland areas. . Adopting gravity irrigation system, the current demand is 139 Mm^3/year.
- Seepage and evaporation losses from Alau reservoir 75 Mm^3/year
- Environmental flow is 14 Mm^3/year

Table 6.1: Estimated water demand for LCB

Purpose	Estimated demand (mM3/year)		
	2010	**2030**	**2050**
Upper Hadejia			
KRIP*	257.0	257.0	257.0
KCWS	196.0	321.2	526.3
HVIP*	24.2	24.2	24.2
Evaporation losses from Tiga and Challawa Gorge	445.0	445.0	445.0
Middle Hadejia			
HNWs	500.0	500.0	500.0
Jamaare			
Proposed Kawali Irrigation Scheme	80.2	80.2	80.2
Evaporation losses from proposed Kafin Zaki	175.0	175.0	175.0
Downstream KYB			
Regional demand for domestic need	30.1	49.3	80.8
Regional demand for agricultural need	15.8	17.0	17.0
Borno drainage system			
Maiduguri water supply	45.3	81.8	147.8
Maiduguri environs water supply	24.0	35.7	53.0
Jere Bowl Irrigation	139.0	139.0	139.0
Seepage from Alau dam	75.0	75.0	75.0
Environmental flow	14.0	14.0	20.0

*no further expansion

The projected water demands for the year 2030 and 2050 are presented in Table 6.1. The total water requirements for the upper and middle Hadejia sub-units are 1422.2, 1547.4 and 1752.5 Mm^3/year for 2010, 2030 and 2050 respectively. The annual surface water yield for the Tiga, Challawa and unregulated units is 1925.5, 2861.6 and 3680.9 M^3/year for normal, wet and very wet years respectively. The available surface water resource in the sector in a normal year is sufficient to meet the current demand and the demand for year 2050, given that irrigation demand is not increased beyond the current level. However, in a dry (1288.4 Mm^3/year) or very dry year (535.1 Mm^3/year) the current demand cannot be satisfied. An available surface water resource is under stress. There is a need to promote conjunctive use of surface and groundwater resources. Quantitative assessment of the groundwater resources should be addressed.

The reliability analysis of Tiga Reservoir system was carried out and the result (Table 6.2, detail in Appendix) study that available water in the unit could be meet the KCWS requirement and 80% of the irrigation requirement (optimum level) for 15,000 ha. If the cropped area is increased to 20,000 ha, the reliability of the system is 0.77, which is below optimum level.

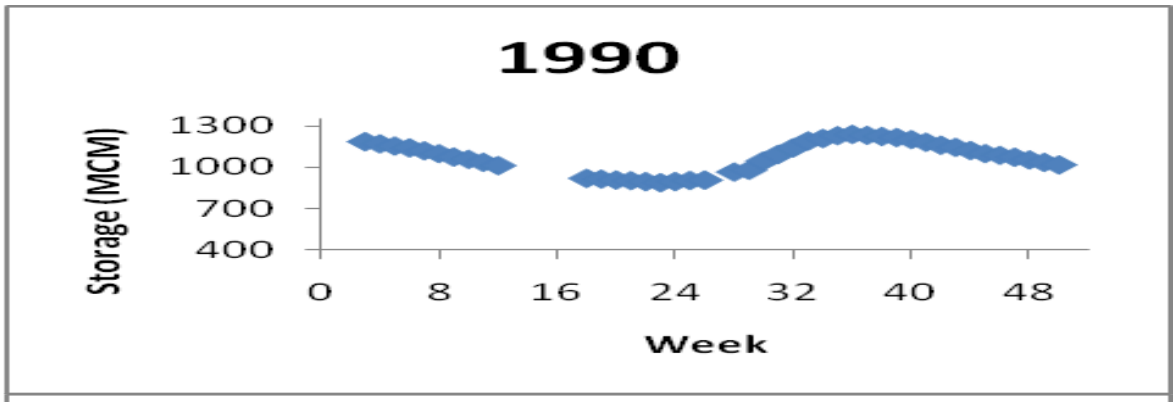
Probability analysis of flow series in the upper Hadejia unit showed that the probability of occurrence of a normal climatic year is 0.65. The probability of occurrence of both dry and very dry years is 0.17, for wet and very wet years, the probability of occurrence is 0.17. Extreme event (either dry or wet) occurs one in every three year.

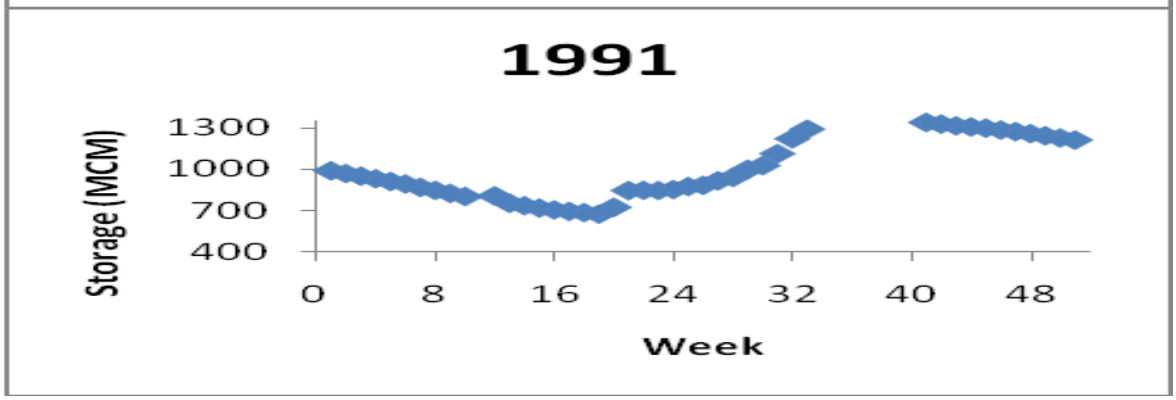
Table 6.2: Reliability of area under irrigation

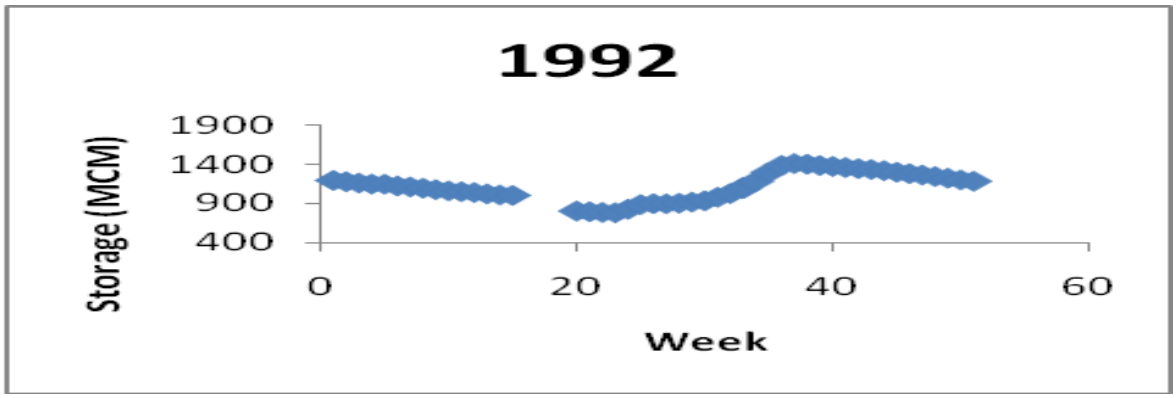
No	Area under irrigation (ha)	Reliability
1	42,000	0.70
2	36,000	0.73
3	30,000	0.75
4	25,000	0.76
5	20,000	0.77
6	15,000	0.80

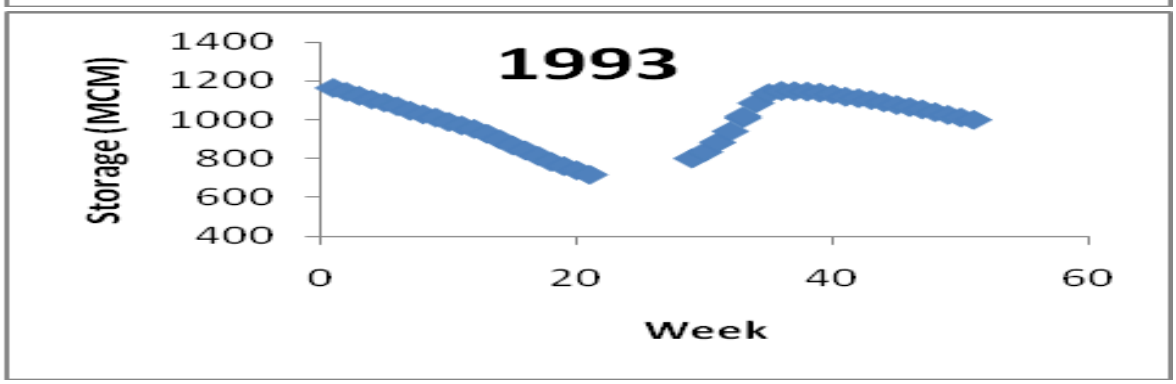
6.3 Reservoir Operation

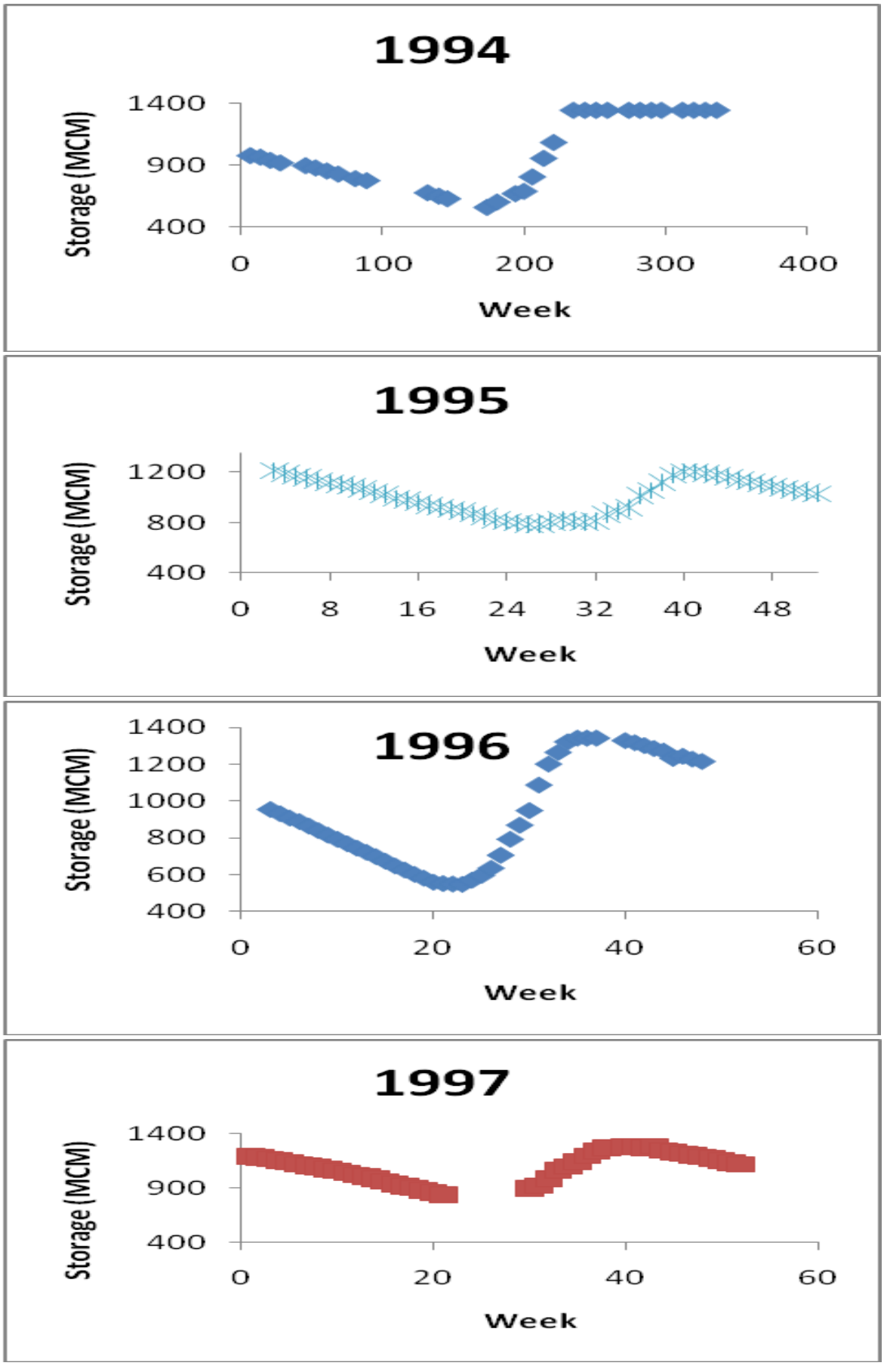
Earlier investigations (Afremedev, 1999 and IUCN, 1999) reported that there are no operation manuals for Tiga and Challawa Gorge dams. Figures 6.3 and 6.4 show the variation in reservoir storage at Tiga and Challawa Gorge respectively. The operation varies with season. The characteristics of the reservoir storage is summarised in Table 6.4, while the reservoir storage under optimised condition is presented in Figure 6.5 the finding underscore the need for the use of optimised reservoir operation system. The reservoir optimisation model being developed by Federal Ministry of Water resources would be a useful tool for this exercise.

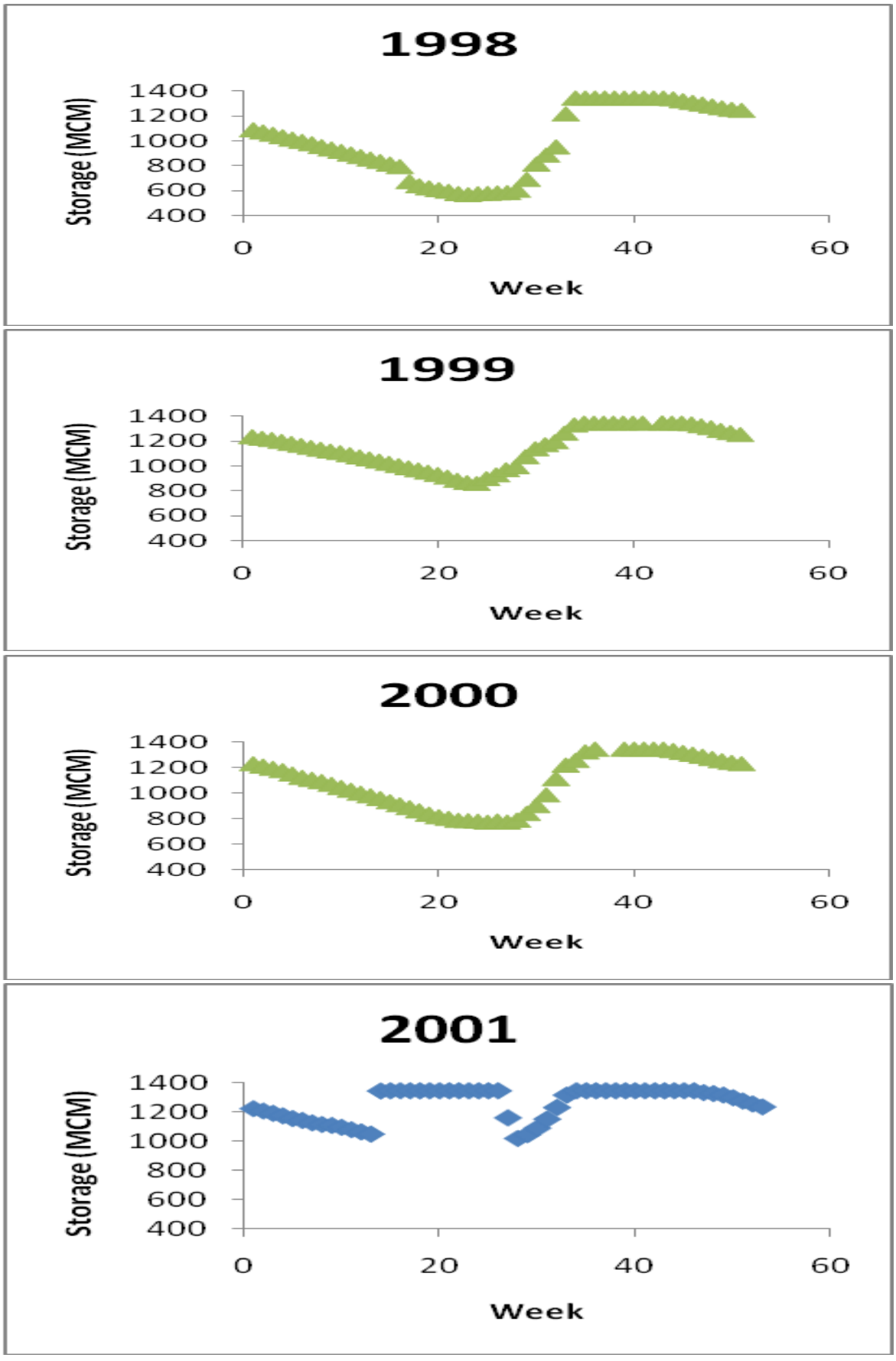

1990
Storage (MCM)
1300
1000
700
400
0
8
16
24
32
40
48
Week


1991
Storage (MCM)
1300
1000
700
400
0
8
16
24
32
40
48
Week


1992
Storage (MCM)
1900
1400
900
400
0
20
40
60
Week


1993
Storage (MCM)
1400
1200
1000
800
600
400
0
20
40
60
Week


1994
Storage (MCM)
1400
900
400
0
100
200
300
400
Week
1995
Storage (MCM)
1200
800
400
0
8
16
24
32
40
48
Week
1996
Storage (MCM)
1400
1200
1000
800
600
400
0
20
40
60
Week
1997
Storage (MCM)
1400
900
400
0
20
40
60
Week


1998
Storage (MCM)
1400
1200
1000
800
600
400
0
20
40
60
Week
1999
Storage (MCM)
1400
1200
1000
800
600
400
0
20
40
60
Week
2000
Storage (MCM)
1400
1200
1000
800
600
400
0
20
40
60
Week
2001
Storage (MCM)
1400
1200
1000
800
600
400
0
20
40
60
Week

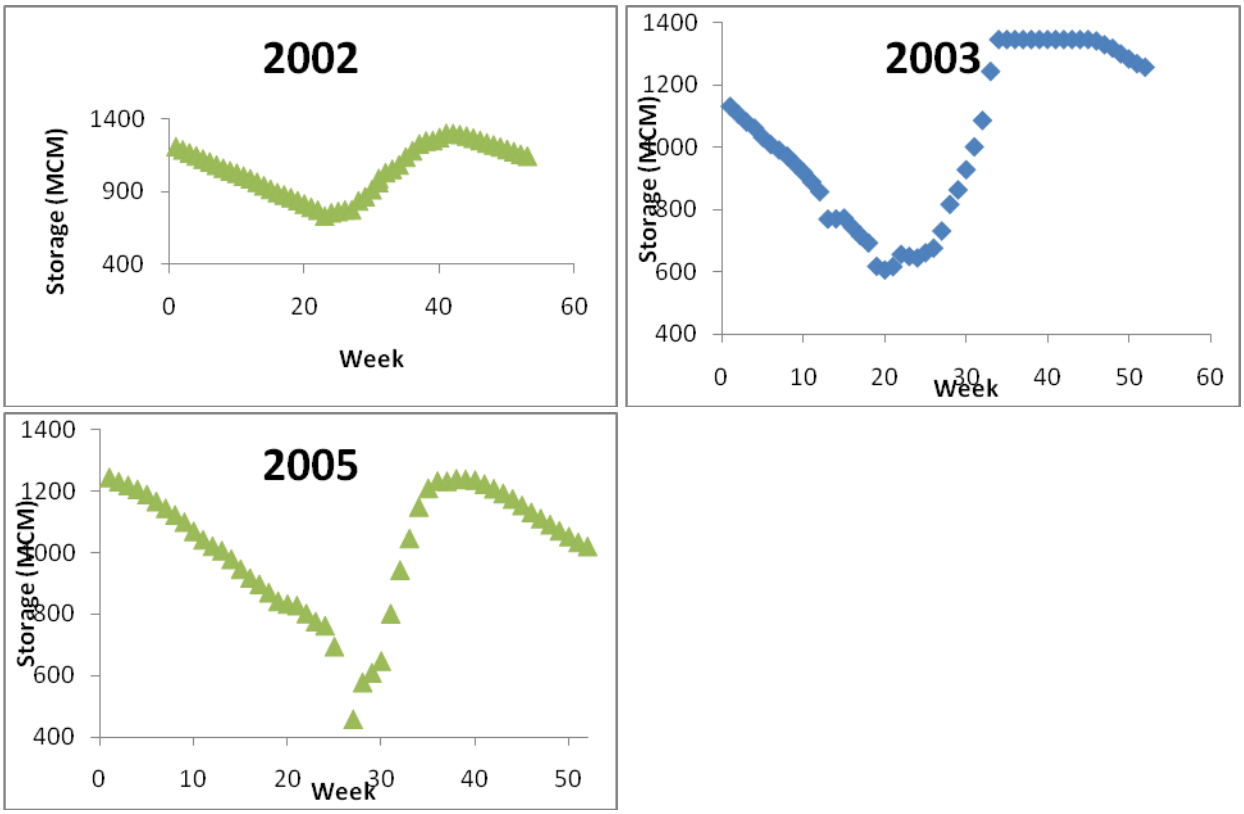
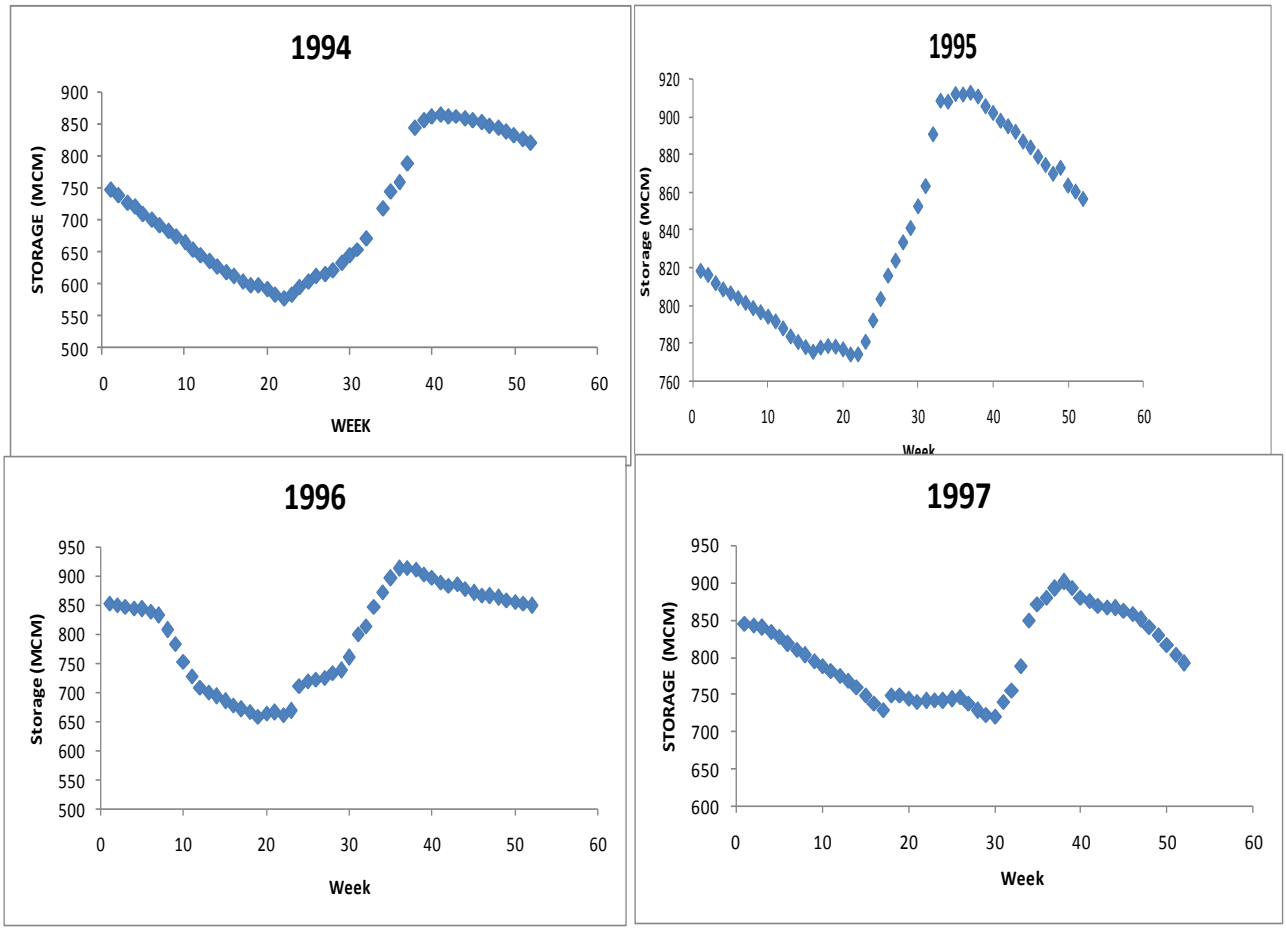
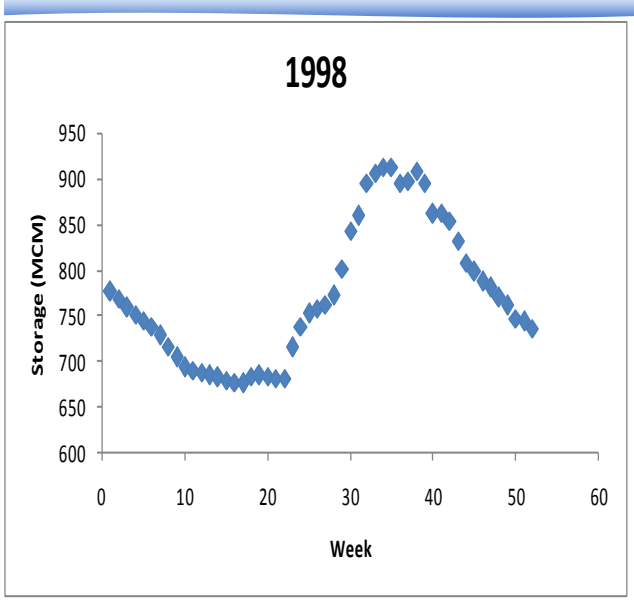
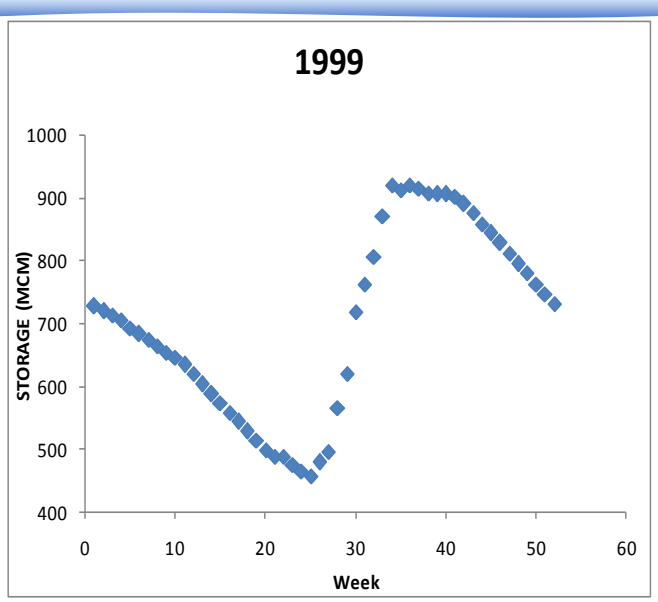
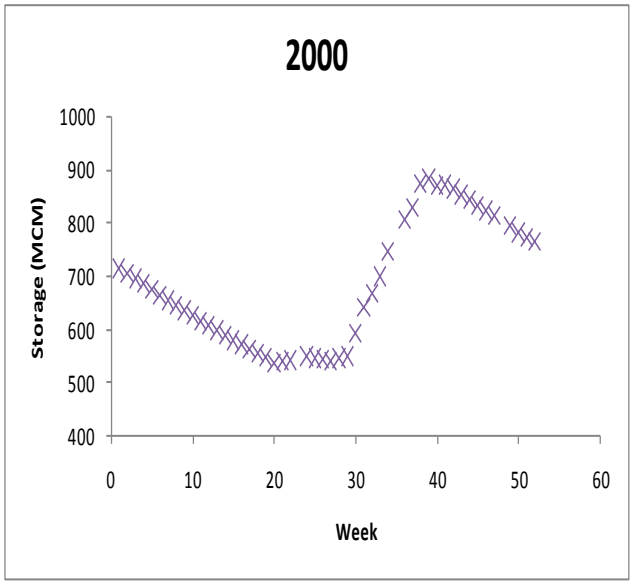


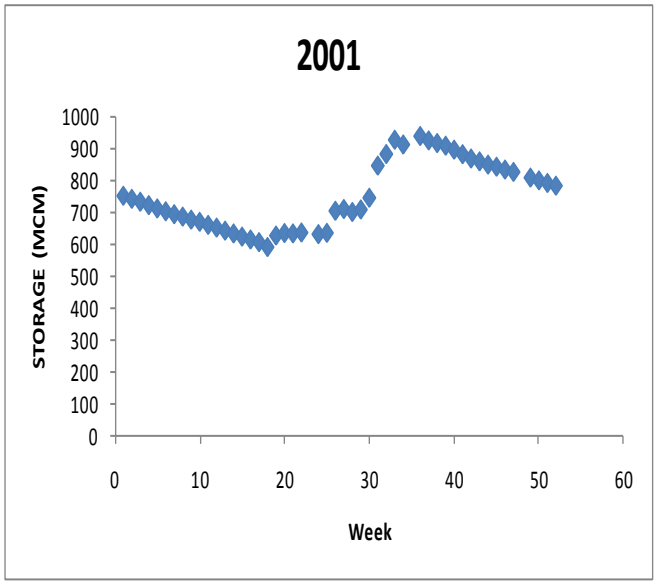
Figure 6.3: Variation of storage in Tiga Reservoir

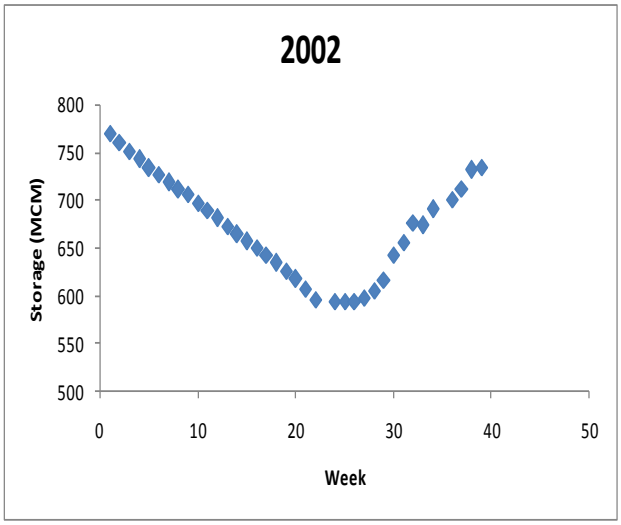


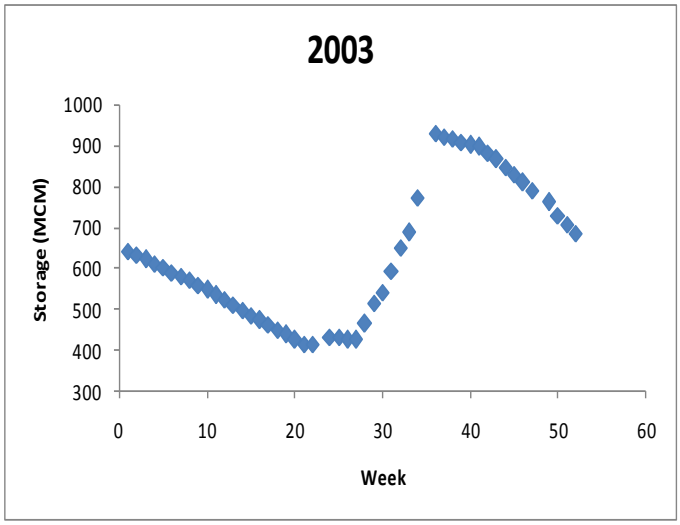

1998
Storage (MCM)
950
900
850
800
750
700
650
600
0
10
20
30
40
50
60
Week


1999
STORAGE (MCM)
1000
900
800
700
600
500
400
0
10
20
30
40
50
60
Week


2000
Storage (MCM)
1000
900
800
700
600
500
400
0
10
20
30
40
50
60
Week


2001
STORAGE (MCM)
1000
900
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
60
Week


2002
Storage (MCM)
800
750
700
650
600
550
500
0
10
20
30
40
50
Week


2003
Storage (MCM)
1000
900
800
700
600
500
400
300
0
10
20
30
40
50
60
Week

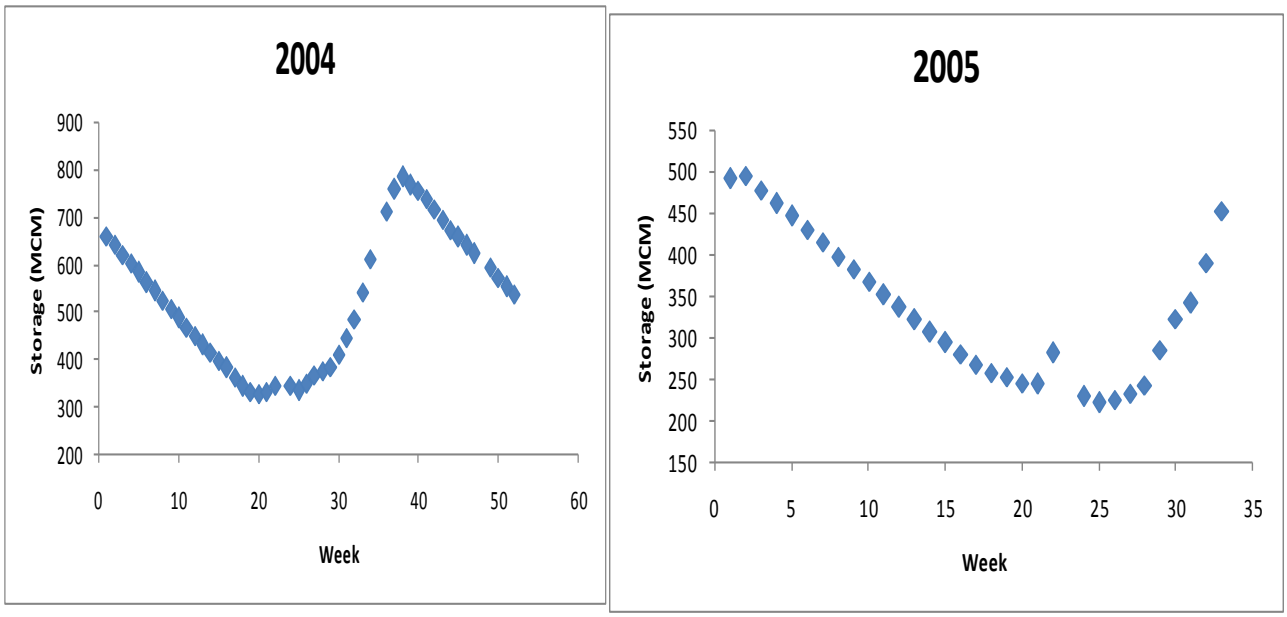
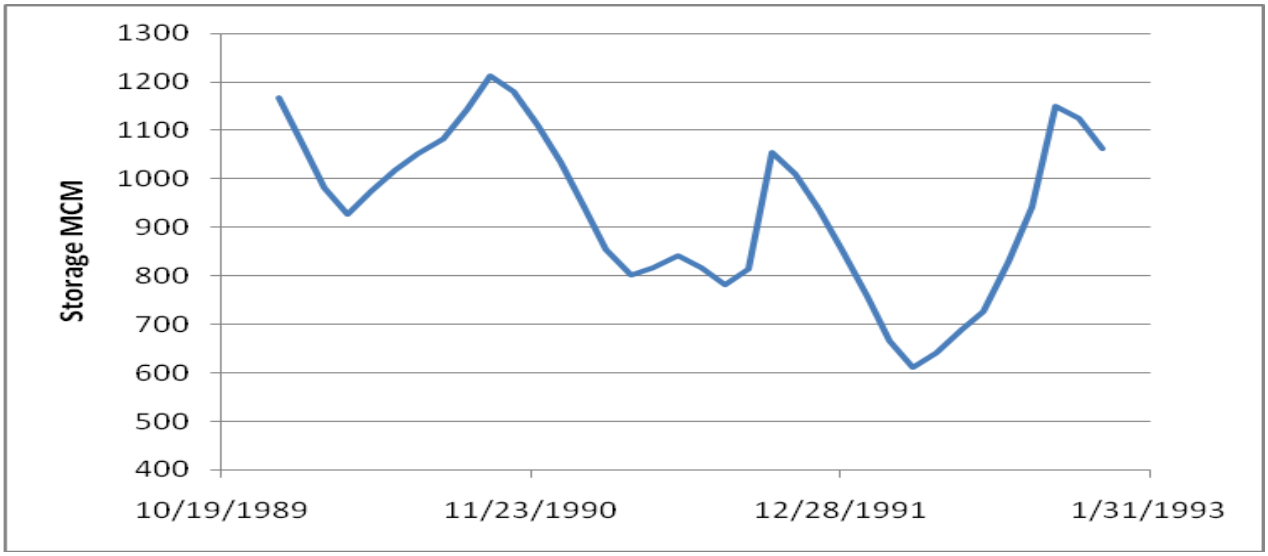


Figure 6.5: Optimised storage forTiga Reservoir



7 WATER CONSTRAINTS AND RISKS

7.1 Water-Related Constraints

Two of the broad challenges facing water management in the Lake Chad Basin were noted as being: (i) how to control unsustainable water consumption; and (ii) how to enhance the water allocation mechanisms. Many of the root causes were identified, and recommendations made in the LCB-CMP. However, to successfully implement projects/policy actions aimed at alleviating these challenges, the water related constraints and risks need to be addressed as a priority.

Constraints that limit the number of resource-focused options that could and should be promoted by the CMP for KYBP and similar projects include (not in order of importance) as below.

For example, sometimes farmers within flood plains have a set of crop varieties adapted to the soil conditions. Each peasant has several plots of land: one upland plot devoted to early rice varieties, providing food in times of scarcity; and one or several larger plots sown with semi-late or late varieties. This staggering of varieties is primarily used for safety reasons. Unable to predict the amount of rainfall or the flood water level, the peasant uses a wide variety of cultivars each requiring specific growing conditions. There is not much interest in varieties with very specific water requirements, even if they produce higher yields. Farmers know how to adapt to the extremely irregular hydro-meteorological conditions. A proven early warning system for flood height, areal extent and duration would greatly increase labour and natural resource efficiency.

7.1.1 Climate and Extreme Events

The climate of the Komadugu-Yobe Basin is predominantly semi-arid and, consequently, rainfall is extremely variable in time and space. Hence, groundwater recharge and runoff into reservoirs would also be extremely variable, as is the productivity of rainfed arable and non-arable lands. Meanwhile, meteorological drought and floods are recurring natural phenomena that have had a relatively greater impact on the poor and vulnerable in the basin.

The GIWA (2004) assessment attributed recent climatic variability to be primarily to these long-term climatic cycles but which may have been exacerbated by recent human induced Sea Surface Temperature (SST) and land surface anomalies. It referred to anthropogenic global change and therefore it was considered as having a moderate impact. Nevertheless Birkett (2000) concluded that the seasonal fluctuations of the

Lake Chad level has been primarily controlled by climate, not water management practices. However, stream diversion is still a key factor in the extent of freshwater shortage downstream of the large dam constructions and there is a concern regarding the use of what water supplies that is available in the basin during periods of low precipitation.

7.1.2 Water Resources Availability

In many sub-catchments, current usage of water resources approximates and even exceeds annual replenishment. In the absence of inter-basin transfers, the scope for augmenting water resources by developing additional ground and surface water resources is limited. The availability of freshwater is one of the most critical environmental issues of the basin and is particularly true in lower reaches that is essentially arid or semi-arid and the precipitation is highly variable. With increasing population and development we can expect that the pressures on existing water supplies in the basin and the vulnerability of the populations dependent on these resources will continue to grow (UNEP, 2004).

Despite the freshwater shortage concerns in the basin, water is still utilised inefficiently. Isiorho *et al*. (2000) estimated that in Maiduguri, 10 to 25% of water is used inefficiently. Similarly, agriculture is the largest user of water in the basin; in the Hadejia river system, irrigated agriculture accounts for approximately two-thirds of the total water requirements, and most of these irrigation projects, are utilising water resources inefficiently (Bdliya *et al*., 1999). Irrigation channels are unlined and open resulting in infiltration and evaporative losses. Although, there have been no studies that accurately quantify the level of water wasted in the sub-system, there are empirical reasons to believe that the recent trends have been exacerbated by the diversion of water by dams for irrigation projects such as the KRIP. Furthermore, the level of water use has been unsustainable in the climatic scenario of the past 40 years.

By implementing water conservation measures less water will be needed to produce a unit of crop, regrettably, even in the light of water shortages there are no clear strategies or incentives for the farmers to conserve water; farmers are not compelled to pay appropriate charges for the water, neither is the rate based on quantity of water usage, consequently by saving water they do not achieve any personal gain. Education programmes and incentives may therefore be necessary to promote water conservation.

There is also the issue of the pollution of existing water supplies, which at the moment is considered as having a slight impact due to limited industrial activity in the basin (except around Kano City). However, pollution of water supplies either directly from the industries and other non-point pollution sources such as from agricultural activities or by the increased urbanisation in the basin could increasingly become a concern in future.

Overall, the concern of freshwater shortage was considered as being severe due to its driving almost all environmental concerns in the basin. The ecological impacts on the wetlands and lake's environment have been severe. For example, since the 1960s, the Hadejia-Nguru Wetlands have been reduced by almost 50% (Barbier *et al.*, 1997) and the Lake Chad was reduced since the 1990s to just 10% of its size prior to the 1960s. Freshwater shortage has had severe economic impacts on the fisheries, flood-recession agriculture, livestock rearing and other wetland industries.

7.1.3 Demographic

Population growth: Increases in the basin's population has led to greater pressure on the natural resources of the basin most especially its water resources. The population of the basin is estimated to be 23.8 million representing over 55% of Lake Chad Basin's population. Such a concentration of population has led to extreme pressure on the diminished water resources.

Migration: There has been a large influx of immigrants from the northern fringes into the Komadugu Yobe Basin. This has been attributed to drought and desertification forcing communities to leave this increasingly arid environment. This has increased competition and aggravated conflicts between livestock-breeders who have been moving southwards and the sedentary farmers (LCBC, 2000b).

As a result of the foregoing, year by year a larger proportion of groundwater recharge and surface water storage is needed to meet rural and urban water requirements. As a consequence, the water available for other uses especially agriculture, is reducing. In addition, with increasing population and in the absence of improvements in water use productivity, there will be a decrease in the proportion of the population that can rely on landbased activities as a main source of income.

7.1.4 Poor Reservoir Management and Water Use Inefficiency

The scarcity of water in the basin has not prompted improved reservoir management to utilise resources that are available in a more efficient manner. The inefficient gravity irrigation methods are still being employed in place of more efficient methods such as drip or sprinkler irrigation systems. Irrigation channels are open and unlined, and therefore prone to infiltration and evaporation losses. There are no immediate incentives for the upstream farmers to conserve water, as they seldomly pay the token irrigation fees, which consequently has encouraged farmers to grow water intensive crops such as rice and sugar cane. It also has to be questioned whether it is appropriate for some state government to be deliberately encouraging growing such crops in a basin prone to freshwater shortages.

An international dam safety specialist recruited by the World Bank as part of the GEF project has reviewed the Tiga Dam (Hadejia River sub-basin). The main threats were identified in decreasing order of probability: internal erosion due to arching of fill material over the cut off trench, internal erosion caused by a fracture of one of the two secondary outlet pipes, and slope failure under seismic load. The probability of failure

was considered high for the 8 km zoned earthfill embankment, with the main threat coming from piping i.e. water creating channels through the dam. Tens of thousands of people would be at risk from Tiga Dam. The Challawa Gorge Dam is newer and was not considered to pose an immediate threat (World Bank, 2002). Although the Tiga Reservoir has approximately twice the inflow of the Challawa Gorge Reservoir, the maximum capacity of the main Tiga Dam outlet is just a third of the maximum of the two outlets of Challawa Gorge Dam. The operation of dams remains highly uncoordinated (Bdliya *et al.*, 1999).

The Greater Kano Water Supply (GKWS) intake is located on Kano River before the confluence between the Challawa and Kano rivers. It has a sump that is easily silted, so that constant dredging is necessary. A canal had to be constructed on the Kano River to bring water to the sump. Sandbagging was also used to simulate a weir structure, but it was eroded with time, particularly with varying water releases. The Challawa intake is expected to have an even more severe problem with silting. The water at this intake is very turbid as a result of severe erosion upstream in the Watari and other tributaries. The siltation decreases the inflow by diverting water to the other bank. There are reasons to believe that inadequate sediment studies were made when situating the intakes. The discharge in the Hadejia River from the Tiga and Challawa Gorge dams towards the end of the dry season is maintained at higher than optimal levels to ensure that the sumps of Kano Water Supply are filled (Diyam, 1996 in Bdliya *et al*., 1999). The Kano State Government puts pressure on the HJRBDA to release more water in order to meet the requirements of Kano City. This consequently results in the flooding of downstream farmland (JEWEL, 2003). This is highly wasteful particularly during periods of low water availability (Bdliya *et al*., 1999).

Stream flow conveyance is hampered by the proliferation of blockages from weeds and siltation in the Hadejia river system. The blockages in the Old Hadejia River have prevented the Hadejia River from contributing to the Yobe River. These have not been cleared and have consequently continued to impede freshwater from reaching the main river channels. The water is instead restricted to the wetlands of the Hadejia-Nguru and does not reach downstream users.

7.1.5 Governance

Governance issues (political, legal, policy and institutional) and in particular utilization of IWRM instruments in the Basin raises special concerns, because it is at the heart of all the water resources management problems of LCB. Good governance, requires transparency and accountability, appropriate participatory mechanisms, effective policies and laws, and an appropriate institutional framework to implement the policies and enforce the laws as well as informed stakeholder who respect these laws. All stakeholders agreed (LCBC/GEF TDA report for Nigeria, 2007) that addressing governance issues would be critically important in addressing many other priority issues affecting the land and water degradation in the basin. For instance, the various

threats to water security[15] lies in the failure to respond to challenges of protecting the natural resources while sustainably balancing the various needs and uses of land and water in the Basin, through effective institutional frameworks that allocate and manage these natural resources based on legitimate policies, laws and an efficient and responsive administration.

The major aspects of governance issues that have been identified include the following:

- Lack of awareness of Integrated Water Resources Management (IWRM) among decision-makers;
- Poor coordination,
- Lack of transparency and insufficient stakeholders participation
- Institutional weaknesses including legal and policy aspects which often are not aligned to IWRM.

These would be briefly elaborated herein.

7.1.5.1 Lack of awareness of IWRM principles and strategies

Although, considerable effort has been made in introducing IWRM principles in the Basin when compared to all other basins in Nigeria, yet the result has not matched the efforts; in that the society is still yet to enjoy transparent water allocation and management at all levels. It is awareness that give rise to trust that would be engendered by transparency that would propel and secure effective participation of water users. Corruption on the other hand has led to problems of misdirection of investments and stifling of needed partnership between policy makers, services providers and users. The combination of lack of awareness, insufficient transparency and corruption has resulted in opportunistic behaviour; with decisions in water resources management having no meaningful participation of relevant stakeholders, which in turn has exacerbated potentials for conflict.

It was not until 2007 that there emerged an overall environmental management strategy for the Lake Chad Basin. Unfortunately this national action plan remains restricted in scope and content, and is not generally recognised and accepted by all stakeholders. Other isolated and restricted strategy exist, such as the 1989 Nigeria-Niger Joint Commission brokered agreement on the equitable sharing of the water resources common to the two countries. On the other hand, although the FMWR-IUCN-NCF KYB Project developed a Catchment Management Plan for KYB that was generally recognised and even approved by Summit of Leaders of the Basin led by the President, and that included the establishment of a Trust Fund to catalyse its implementation, it however did not cover the entire LCB. The LCBC-GEF Project also prepared transboundary diagnostic analysis followed by a strategic action programme and national action plan to implement the transboundary environmental issues. None of these comprehensively provided for integrated water resources management strategies and water efficiency plan for the entire Lake Chad Basin and in all of these there has

[15] Water security here refers to access to adequate water of appropriate quality as a productive input and protection against the vulnerabilities associated with uncertainty in water flows.

been no institutional capacity to promote implementation and compliance/enforcement of the agreements.

7.1.5.2 Poor coordination

The Nigeria-Niger Joint Commission provides an interface between the two countries that enables concerns to be discussed and conflicts to be resolved. However, this only tackles issues concerning the last 160 km stretch of the Komadugu Yobe that forms the border between Niger and Nigeria. The major water developments, which are located in the upstream States are not represented at these meetings. The Commission therefore does not enable integrated management of the entire Komadugu Yobe sub-system. The Lake Chad Basin Commission also has several deficiencies which the strategic Action Program recognised but which remain substantially unattended to, even as of to-date. Consequently, the two commissions' meetings serve only as forum to discuss problems, rather than long-term solutions for the water resources management issues that confronts the entire region. The most acute obstacle to management of water resources in the past was the absence of a coordinating mechanism to harmonise the activities of the water uses and users; but which was partially resolved with the establishment of Nigeria Integrated Water Resources Management Commission (NIWRMC) in 2007. However, four years later it has not been statutorily empowered, nor has it the requisite capacity to effectively operate its Catchment Management Office in the Basin. The Catchment Management Office of NIWRMC has to be adequately staffed with competent hands. It also would need a mutually agreed Catchment Management Plan for LCB backed with Water Charter and adequate funding to function effectively.

Policies and actions that are being undertaken by governments and non-governmental organisations relevant to land and water resources management are not being harmonised, and the only previous mechanisms that was provided for negotiation and consensus building has not been effective. Even within the same government, water resource sector is treated as a distinctly different sector to the environment. The environment ministry is rarely consulted during the planning of water infrastructure projects. On the other hand the ministry of environment and its departments and agencies have concentrated on managing toxic substances. When environmental problems from water resource projects did arise, the environment departments are invited to assist; they rarely have the requisite expertise in water-related environmental issues. Consultants are often hired to assess the concerns, but the departments still lack the expertise to analyse the results of the consultancy studies and to turn the recommendations into policies. Meanwhile, there is a potential conflict brewing over water quality control with several institutions (i.e. Federal Ministry of Health, NESREA, NIWRMC) vying for the same task and none doing it. The current arrangement would negate IWRM principle, as it separate water quantity management from water quality management; because they are two faces of the same coin. Coordination should be provided by NIWRMC; while NESREA should regulate the overall

environmental aspects and Health concentrate on the aspects that are harmful to human health.

The Hadejia-Jama'are-Komadugu-Yobe Basin Coordinating Committee chaired by the Minister of Water Resources also includes representatives of the ministries of environment and health as members, but it rarely sat. As a matter of fact it has not sat in last eight years. There is a lack of coordination and cooperation between riparian Nigerian States during planning and implementation of water projects (Bdliya *et al*., 1999). Water developments (e.g. the completion of the Hadejia Valley Irrigation Project) are being implemented without execution of an Environmental Impact Assessment throughout the basin, which is exacerbating the inequitable water allocation and environmental damage. As a result of all of the foregoing, natural resource conflicts are dispersed, and are often not considered as important as political, ethnic or religious conflicts (Blench, 2004). In addition to the much recognised conflicts between pastoralists and farmers, there are also those involving hunters, fishermen and even brick-makers, and between upstream and downstream communities. General studies indicate that these other conflicts are extremely limited compared to herder-farmer conflicts, which has been exacerbated by recent marked expansion of *fadama* (riverine valley-bottom) cultivation in the Basin in the last two decades (Blench, 2004).

Traditional institutions undoubtedly play the most significant role both in managing the conflicts informally and arranging peaceful resolution when the situation becomes dire. According to Blench (2004), the traditional rulers are more accountable and responsible than any other group, but that they get little support from state governments. Their powers are increasingly subverted by local government officials. They however are still able to enforce resource-sharing agreements especially as they relate to Common Property Resource (CPR), such as restraints on fisheries.

Although there are NGOs who claim to be involved in conflict resolution, such as *Miyetti Allah* – little evidence of their practical involvement was seen in the field. Mechanisms of conflict resolution works best where there is mutual trust between different stakeholder communities. This can be facilitated through confidence building and provision of suitable forum that would facilitate mutual trust to be built. Despite considerable interest by donors and government on the issue, much of which often follows major skirmishes, sustained support to communities is still insignificant. All things considered, the donors still have better records. Demographic growth and increased pressure on fertile land and limited water resources would exacerbate the present situation. Government commitment to water security targets, confidence building and conflict resolution based on all stakeholder participation will be essential and critical in institutionalising IWRM.

More significantly, the governance problems and the failure to deploy IWRM instruments also derive from structural flaws in the current decision-making process. There are currently two RBDAs within the basin (Chad and Hadejia-Jema'are River Basin Development Authorities), with no coordination except through Hadejia-

Jema'are-Komadugu-Yobe Basin Coordinating Committee (HJKYBCC), which is neither a statutory body nor has it been able to have any decisive influence on their activities todate. There is also fragmentation and often conflicting responsibilities among many players engaged in water resources and environmental management in the basin. Their programmes are often not harmonized nor coordinated. Consequently, these problems have impacted on the capacity of the communities to participate effectively in basin management. Their lack of capacity is responsible for their reluctance to assume the role of agents for change, by shunning responsibilities and adopting a narrow mind-set that makes them opposed to all attempts at instituting sustainable management practices in the basin. This situation and the uncoordinated operation of the large dams has contributed significantly to environmental degradation and increasing potentials for resource allocation conflicts.

In view of all of the foregoing, renewable and sustainable resources management would best be achieved with active involvement of traditional rulers and Local Government Area (LGA) officials. The emphasis should be on traditional rulers because throughout the basin, the natural resources (fisheries, forest, water and land resources) are customarily vested in them. All the enacted legislations reviewed tend to recognise this position by providing in most cases that consultation with traditional rulers regarding customary law practices and LGA officials representing grassroot level administration be carried out before any resource base is brought under any legislation.

There is also need to build upon the recent display of political will and motivation, exemplified by Summit of Governors of the Riparian State government to reverse public apathy at all levels. This momentum should be used to facilitate measures necessary for strengthening environmental and water resources management institutions in the basin. Three prong approaches was suggested (Afremedev, 2006). Information sharing would foster convergence between the demands of users and the action of managers and decision-makers. Capacity building of the key agencies responsible for developing and implementing public policy would further enhance convergence between stakeholders' interests and decision-makers' actions. While, public participation is the best means of ensuring that outcomes would encompass the full array of pertinent issues, fears and interests at stake.

7.1.5.3 Lack of transparency and insufficient stakeholders' participation

Community participation is a key factor for reinforcing executive and legislative actions. Reluctance on the part of communities to fully participate in the implementation of key programmes, projects or activities is indicative of failure of stakeholders to exercise citizenship rights. Such communities also forego opportunities to provide their democratic representatives and managers with vital information, views, demands and priorities for incorporation into management plans and government appropriation act. For example, the upstream dam developments had minimal stakeholder involvement. Decision-making and consultations were only made at the state and federal levels in Nigeria. Lobbying from communities and state officials for large dams have continued

at the Federal Government level as capital required to finance the projects often exceed state governments' financial capacity. Niger Republic, which is located downstream of the basin were not sufficiently consulted or considered during planning; except through LCBC. There was no effective involvement of the public in the planning or implementation stages including the communities of the Hadejia-Nguru wetlands.

At the Nigerian national level, the National Council on Water Resources (NCWR), which is comprised of the state water authorities under the chairmanship of the FMWR, is responsible for coordinating water use policies. The NCWR is served by a technical committee chaired by the Permanent Secretary in the FMWR, and is comprised of several technical sub-committees. There have been concerns of late that only limited stakeholders are represented in the technical sub-committees who make recommendations to the NCWR. Additionally, the Federal authorities dominate the decision making process at the Nigeria-Niger Joint Commission and Lake Chad Basin Commission with little interaction with, and inadequate involvement of the State governments or local populations.

Among the solutions to the water resources governance problems of the LCB is the effort to ensure active participation of all stakeholders. Indeed the present state of water resources management in the basin requires an equitable apportionment of water between the various sectors which includes irrigation, domestic and industrial water use, traditional food production systems and the ecosystem on one hand, and between the regions (upstream and downstream state and communities) on the other. If long term damage to ecosystem and water engendered conflicts are to be avoided then greater stakeholders' participation must be promoted. The basin and indeed the Nigerian nation must embrace an IWRM, which is anchored on active participation of stakeholders, so as to attain efficient and sustainable use for natural resources of the basin for the present and future generation.

7.1.5.4 Institutional weaknesses including legal and policy aspects which often are not aligned to IWRM.

a) Institutional weaknesses: Out of the several government agencies and a couple of non-government organisations in the Lake Chad Basin that have interest in the management of water resources, only four government institutions, namely;

(i) the Federal Ministry of Water Resources (FMWR);
(ii) Nigeria Integrated Water Resources Management Commission (NIWRMC);
(iii) National Environmental Standards and Regulations Enforcement Agency (NESREA); and
(iv) the Federal Ministry of Environment (FME), and one non-government organizations (the FMWR-IUCN KYB project and the Stakeholders Consultative Forum) are concerned with the sustainable utilisation of the water resources of the basin.
(v) All the other institutions are inward-looking concerned only with meeting their water requirements, with minimal or no concern for the impacts of their activities on other users.

The three River Basin Development Authorities (RBDAs), which are implementing agencies of the FMWR, are called the Chad Basin Development Authority (CBDA), the Hadejia-Jama'are River Basin Development Authority (HJRBDA) and the Upper Benue River Basin Development Authority (UBRBDA). They act independently of each other and their development-oriented mandates do not take responsibility for environmental protection. While the River Basin Development Authorities are required to control pollution in the projects, there is no specific provision for Health Impact Assessment (HIA), or for the mitigation and control of vector-borne diseases. Although Nigeria is known to have endemic schistosomiasis and other water-related diseases, the institutional arrangements for water resources development have not taken health issues into consideration (Ofoezie, 2002). Consequently, until recently following the establishment of NIWRMC and to a lesser extent NESREA, there was no agency to regulate and manage the water uses over the entire basin. Furthermore there are overlaps in the roles and mandates of the various governmental institutions in the basin. This scenario clearly called for a coordinating and control mechanism (Bdliya *et al.*, 1999). Consequently, the National Council on Water Resources accordingly set up the Hadejia-Jama'are- Komadugu-Yobe Basin Coordinating Committee. It however lacks statutory powers and has remained in effective. NIWRMC should hasten to constitute the Catchment Council on Water Resources and Basin Stakeholder Advisory Forum.

Legal aspects: Two current national water-related legislations are relevant to IWRM issues in the Basin. These are the Water Resources Act, Cap W2, 2004 and the River Basin Development Authority (RBDA) Act, Cap R9, 2004. The text Water Resources Act, cap W2 of 2004 (Decree 101 of 1993 of Federal Government of Nigeria (1993)), predate the 1992 Dublin Conference which set the firm stage for IWRM approach. The Act therefore does not promote integrated basin management. The most significant import of the Water Resources Act, however, is that it reaffirms Federal ownership of interstate water courses, which include the river systems in Lake Chad Basin. On the other hand the RBDA Act under which the Hadejia Jama'are River Basin Development Authority (HJRBDA), Chad Basin Development Authority (CBDA) and Upper Benue River Basin Development Authority (UBRBDA) operate emphasizes development of irrigated agriculture without imposing any concomitant legal responsibility for pollution control and watershed management. Furthermore, it did not separate the regulatory and user functions. Both were combined in the RBDAs (Goldface, 2005). The law as it presently stands make no clear distinction in their roles as water resources managers and as developers thus, simultaneously clothing them with the gab of both referee and player. This lacuna has thus inhibited and compromises the principle of transparency and accountability.

Water Resources Act W2 of 2004 confers on the Minister of Water Resources the responsibilities for controlling the use of both surface and ground water resources throughout the Federation. However, most of the water resources activities are

organised in a fragmented manner such that each type of water use is literally managed by a separate agency or department for example, irrigation, municipal water supply, power, transportation, quality and pollution control, health and environmental concerns; with each being controlled as a separate agency responsible for its own operation and independent of the others. To facilitate co-ordination and harmonise decision making, a National Council of Water Resources was establish as the highest policy making institution but no function was allocated to it in the Act W2 of 2004 nor was it even mentioned. The most significant achievement of the Council has been its coordination of the National Water Rehabilitation Programmes. There are however several other legal instruments which although on the face value should be complementary, but they are indeed contradictory or in conflict with provisions of Water Resources Act W2 of 2004. Please see Chapter 5 section 5.3 for the review of the conflicting and contradictory legal instruments.

Furthermore, the provisions of Water Resources Act, cap W2, 2004 are yet to be implemented or enforced as the regulations and rules for its administration and enforcement have not been published, and many of the governing "Rules" have been found unsuitable. In addition pollution studies will be required to monitor the impact on water availability and distribution, and to assist in the formulation of regulations regarding pollution, which are lacking in the current legislative framework. Additionally, the Water Resources Act, and the RBDA Act suffer from lack of provision requiring their operators to undertake watershed management responsibility as part of the their programme for resource sustainability(Afremedev, 2006).

It is however significant to note that prior to Decree No. 101 of 1993 (National Water Resources Act, cap w2 of 2004), water users in Northern Nigeria have had customary rights, which had the force of law, permitting anyone to make use of water where available for his personal needs and for his livestock and agriculture. Meanwhile, the statutory legal instrument establishing the NIWRMC, should be put in place urgently, to provide them the instrument to enforce some of the regulations that are required to sustainably harness the water resources of the basin.

Overall, there is need to harmonise the Water Resources, the RBDA and NESREA laws and to make them IWRM-compliant. Under the present rule-oriented Water Resources Act, the place and role of stakeholders in the administration and management of the nation's water resources is not provided. Currently, there is no formal platform other than those facilitated by donor sponsored ad-hoc projects as part of theirs stakeholder mobilization efforts, to involve upstream and downstream communities throughout the LCB in watershed management to take care of environmental degradation which threatens the economic life of downstream investments and undermine sustainability. It was in recognition of these defects in the law by the government and the major stakeholders that the NCWR created a Coordinating Committee for HJKYB to reach-out to all governments, stakeholders identified in the basin including NGOs, Community-Based Organisations (CBOs), the private sector communities and institutions as well as

the other line ministries and professional groups, pending the enactment of a more appropriate law. The bodies are, however, weak in the absence of a budget and of any statutory provision on their composition and functions.

***b) Government policy*:** Overall, poorly enacted and implemented laws and lack of awareness on the part of decision-makers with regard to IWRM principles in water resources legislation and policies has caused and exacerbated water resources problems that, in turn, has hampered the implementation of actions required to halt resources degradation in the Basin. Currently, there are few incentives or disincentives to encourage individuals or groups of water users to maximise water use efficiency and/or productivity. This is despite there being an active debate on this topic.

Nigeria currently has no approved comprehensive policy document on transboundary water resources. It has however made several concerted efforts over the past decade, but none has been conclusive. There were suggestions on strategies and programs in the NWRMP prepared by JICA but it lacked depth as it was not based on any clear objectives and principles. The key transboundary water issue of Nigeria repeated in many official government documents has been the equitable access to the transboundary water resources. This may have been necessitated by the rather peculiar location of the country, being situated at the tail end of many transboundry drainage basins. It has therefore tended to show great concern about any stream flow modifications upstream. In the recent government draft water policy document, FMWR expressed the need to institutionalise equitable and sustainable sharing of the water resources of all transboundary water bodies and the Lake Chad in particular. This is in the light of the huge investment it has in the region coupled with the increased demand for water and the reduction in rainfall in the basin since the early 1970s.

Meanwhile, recently a comprehensive Water Resources Policy that harmonises all the sectoral policies and accommodate IWRM concept was developed. This followed the realisation that the Water Resources Act cap W2 of 2004, was not based on any comprehensive water resources policy and did not contain IWRM principles. However, the policy is yet to be formally approved by NCWR and National Council of State. It is instructive, to note however, the following objectives, principles and strategies for Nigeria's transboundary water resources as contained in the draft National Water Resources Policy document:

Objectives

- To promote rational and optimal use of the shared water resources for the development of Nigeria;
- To strengthen co-operation among riparian states in their efforts to find solution to development problems, thereby promoting cordial relationship among the people of the border regions to live as good neighbours.
- To improve the living conditions among the people of shared basins in order to avoid cross border exodus.

Principles

- Nigeria shall strive to promote equitable and beneficial use of shared water resources based on generally acceptable principles of international law.
- Nigeria will seek to co-operate with other riparian countries for the development, optimum use and protection of transboundry waters wherever possible and in her national interest without compromising her sovereignty.
- Shared water resources among riparian countries shall be used to strengthen socio-economic and political relations.
- Nigeria shall respect all clauses of all international agreement reached on management of shared basins and shall be guided by international conventions and treaties that are in force.

Strategies

- Establish an effective dispute resolution mechanism in consultation with co-riparian states within the regional commission and authority.
- Establish comprehensive monitoring system for water resources in collaborations with co-riparian states in all its boundary basins for essential data collection using a uniform format collation, analysis and Charing.
- Review all international treaties and agreement on shared basins to reflect the key issues raised in the United Nations (UN) Convention.
- Support the regional agencies' activities, meet its own commitment and exert influence to ensure protection of her interests as a vulnerable downstream riparian state.

Although, there is a policy of the National Water Resources Council, which stipulates releases of water from the Federal Government/River Basin Authority dams at a prescribed charge per m^3 to State Water Agencies downstream, the charges are neither paid nor even demanded by the RBDAs. For example, releases from the Tiga and Challawa Gorge dams to Kano State Water Corporation. There is however no water allocation policy between Nigerian States or between Nigeria and Niger. The inadequate water for the downstream states has fuelled disputes between the downstream states of Borno and Yobe about who has the right to this diminishing resource. With no water allocation agreement or policy framework for the entire basin, the uncertainty over water rights also transcends national boundaries. It has been argued that since Nigeria uses a large share of Lake Chad's water for irrigation, they have special responsibility in ensuring the long-term sustainability of water use for all riparian countries (Isiorho *et al*., 2000).

c) Poor water resource environmental planning: The Federal Government of Nigeria with increased revenues from oil exports during the period 1970-1980, focused on general expansion in all areas of the economy. Concerns over the food security for the rapidly expanding population resulted in agricultural policy focusing on increased production. It invested in large-scale agro-projects that included large dams for irrigation particularly in the Hadejia river system aimed at producing maximum yields in the shortest time (Neiland and Béné, 2003). The poor operation of these hydro-agricultural schemes is now posing a threat to the wetland ecosystems and downstream economies. The projects were planned with insufficient data (only those gathered during the wet periods in the 1960s), consequently, not much consideration

was given to the climatic variability that has been demonstrated throughout the Lake Chad Basin's history. It was estimated by Hollis *et al*. (1993) that droughts lowered the flow at Gashua by 23% while the Tiga Dam lowered it again by a similar measurement. The consequences of reduced flows on populations in the downstream Nigerian States and Niger, whose productive systems are highly dependent on the river flow, was not sufficiently taken into account. Meanwhile, the governments of the riparian State Governments have continued to demonstrate insufficient political commitment, especially at the leadership level, with no long-term goals and objectives to solve freshwater shortage concerns.

Among the many other undesirable consequences of the prevailing governance problems cited by Afremedev (2006) are:

- The absence of basin-wide water management agency and the RBDAs' inability to constitute their advisory committee as provided in their enabling legislation;
- Insufficient trained personnel and dwindling financial resources made available to the RBDAs to meet demands and priorities, as well as inadequacies in terms of operational equipment and infrastructure required to conserve and regulate water allocation and utilization;
- Poor appreciation of and compliance with Environmental Impact Assessment (EIA) laws, even among those responsible for deploying IWRM instruments, along with a lack of systematic process for mobilizing the society, applying water-use charges, and in enforcing environmental and water resources regulations; and
- Insufficient exchange of information on environment, water resources and socio-economic management issues.

Several of these institutional weaknesses have been traced to cumbersome decision-making process; lack of continuity of government policies, and regular review of legislation and policies which in turn, have led to constraints and insufficient human capacity to implement programmes; the inadequate funding of management and knowledge based programmes; excessive concentration on short-term actions and emergency response, to the detriment of more effective medium and long-term planning. Another issue is the need to hasten the inter basin water transfer to improved the available water in the Lake. Additionally there is also the issue of near absence of up-to-date data on quantity and quality that has rendered planning impossible.

7.1.6 Capability

***Specialist knowledge*:** Although specialist knowledge and experience exist, there are not always readily available to, or used by, communities and the implementors of watershed development or water resources infrastructure programmes. Careful targeting of context specific interventions to particular physical, social and institutional group or community are rarely practiced. Consequently, the tendency is to fund and implement the same interventions everywhere, regardless of the context or priority needs.

Capacity to promote compliance and enforce agreements and policies: The LCBC and even the recently established NIWRMC lacks the capacity to enforce issues under their mandate. For instance, the Bagauda Agreement which emerged early after the construction of Tiga Dam in 1974 - stipulated the long-term average annual flow releases as minimum guaranteed flow at Gashua in the Komadugu Yobe sub-system from the Hadejia river sub-system for downstream communities - has not been implemented (IUCN, 2003a). NIWRMC need to effectively revisit these agreements and in particular redraft and update the water charter to cover the entire Lake Chad. This should tabled for approval of Summit of Leaders and be firmly implemented.

7.1.7 Knowledge

Public awareness: Information is only disseminated amongst the scientific community and to governmental departments and agencies. This information seldom filters down to the communities such as those in the Hadejia-Nguru wetlands, partially due to poor communication infrastructure and a lack of consideration by policy makers of local management systems. The Water Audit has also shown that, in general, there is a lack of awareness at all levels, of the severity and complexity of water resource problems in the basin.

***Poor quality information*:** Much water-related decision-making are based on official statistics that are incorrect and/or out of date.

Information sharing: There is weak information sharing networks between the Federal agencies and the State governments as well as between the two riparian countries. The Nigeria-Niger Joint Commission has meetings where some information is exchanged verbally; however these meetings primarily resolve disputes it does not have a clear information dissemination mechanism. Environmental and hydrological data are rarely widely dispersed among various Federal ministries and their agencies, and thus they are difficult to access (Lemoalle, 1997). For instance, the water resources Master Plan was scantily disseminated and is rarely used nor has it been updated since it was produced in 1995.

An insufficient knowledge of water resources and the functioning of aquatic ecosystem: Although the basin is the most studied region of the Lake Chad Basin yet it still lacks a comprehensive model that is able to predict the hydrodynamic reactions of proposed water projects. The current models could be significantly improved with the provision of and up-to-date application of remote sensing and GIS. There is a lack of hydro-meteorological information to support decision-making in the region and monitoring networks have not been operating since the late 1970s (IUCN, 2003a). Information networks on river flows and sediment loads are particularly weak. There is presently a lack of knowledge regarding future climate changes and its impact on water infrastructure, ecology and socioeconomic status of the basin.

Scientific resources: Nigeria and Niger authorities place inadequate importance on scientific and technical research, which can be partly blamed on financial difficulties.

The region lacks adequate professional human resources and monitoring and evaluation facilities. The Federal Ministries do not disseminate or coordinate research efforts.

7.1.8 Miscellaneous Socio-Economic Issues

***Irregular Energy supplies*:** Frequent shortage of petrol encourages farmers to over-irrigate when petrol is available. Frequent and prolonged power cuts, particularly during summer months, as well as power surges that often damage transformers and, thereby, causing disruption of water utilities operation leading to shortages of treated water for domestic use.

***Short-termism*:** There is a belief, generated in part by watershed development propaganda, that there are quick fixes to the water-related challenges facing communities in the downstream communities: simply stop all further water resources development works upstream but do so without regards to the others further downstream.

***Water-related myths*:** A number of water-related myths have become accepted wisdom at the policy level in Nigeria, the most damaging being that by ignoring the matter it would go away or by stopping all water resources development the situation would be improved or that government must do all things. Subscription to these myths has led to poor decision-making, ineffective policies and wastage of financial and human resources.

***Small and fragmented land holdings*:** In general, farmers have holdings that are becoming increasingly fragmented. This makes good land husbandry and good water management difficult.

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7.2 Water-Related Risks

Experience in the basin has shown that there are a number of water-related risks associated with watershed management and with the resource protection measures implemented as part of improving water governance programmes. These include the following below.

7.2.1 Unsustainable Use of Deep Aquifers

The issue of changes in water table although regarded as having a moderate impact due to the reduction in the wetlands and lake and therefore their aquifer recharge function, the indiscriminate sinking of boreholes that are often uncapped and free flowing is considered to be unsustainable. There is however a lack of adequate information on groundwater reserves and the full impacts of abstraction are not fully known.

Increased borehole drilling by individuals**:** In most cases, the prime motivation of such individual is to become self sufficient in potable water supply, but it is also encourage profligacy in water use. At the watershed scale, this is justified only if the resources that are being "harvested" do not have a higher value if they are put to other uses.

Deterioration in some village water supplies**:** There is a high risk that some project interventions will reduce runoff into wetlands or other structures that are important sources of recharge of the aquifers that meet rural water requirements. Some project interventions have also led directly or indirectly to increased pumping of groundwater for irrigation in urban and peri-urban areas, thereby, increasing the risk

of failure of village water supplies during the summer months. Finally, some of such project interventions are leading to increased consumption of water: per household, by livestock, by horticulture within the village and by land and non-land-based activities.

7.2.2 Exploitation of Shallow Aquifers

Increased tubewell and washbore construction and increased irrigation by "poor" landowners: Successful water development projects often improve the financial status of relatively poor farmers. Consequently, the National Fadama Development Project has been providing loans for constructing tubewells and washbores and installing pumps. This is fine as long as the water they "harvest" is renewable i.e. does not exceed the annual recharge rate and have no alternative higher-value uses (e.g. as a source of domestic water supply).

7.2.3 Conflict Between and Within Communities

Large dam developments in the upstream of the basin have had potentials to cause conflicts due to downstream users receiving insufficient amounts of water to meet their requirements. There has also been significant migration from the north of the basin as "environmental refugees" have fled drought, increasing the pressure on natural resources and inciting social tensions.

Some interventions, that involve changing land use or patterns of water availability and use, result in distinct winners and losers. If there is a risk of this happening, conflicts should be managed by ensuring that losers are compensated in some way. As above, decisions on whether an intervention should take place should be based on economic and social value.

Reduction in net productivity: There is a risk that promotion of interventions with a high social value will lead to reductions in net productivity at the village or watershed scale. For example, use of water for irrigation on marginal lands (usually owned by poorer farmers) will tend to be less productive than use of the same water on better quality land (usually owned by relatively richer farmers). Ultimately, determining the balance between acceptable social and economic value is a political decision.

Lack of water leads to displacement of people and sometimes conflicts. In addition to fishermen and farmers, pastoral communities have also been affected by the abstraction of water upstream, drought and the recession of Lake Chad. The conflict in the Lake Chad basin mostly results from use of shared resources. Such conflicts are often civil and can therefore have the tendency to manifest in violence, as for example, in the recurrent conflict between farmers and pastoralists. In particular therefore, multiple-resource use conflicts present the greatest non-military security threat in the Lake Chad basin.

According to Afremedev Consultancy Services Limited (2006) large dam developments in the upstream of the basin have had potentials to cause conflicts due to downstream users receiving insufficient amounts of water to meet their requirements. There has also been significant migration from the north of the basin as "environmental refugees" have

fled drought, increasing the pressure on natural resources and inciting social tensions. Some interventions, that involve changing land use or patterns of water availability and use, result in distinct winners and losers. If there is a risk of this happening, conflicts should be managed by ensuring that losers are compensated in some way. As above, decisions on whether an intervention should take place should be based on economic and social value.

There exist several mechanism of conflict resolution in the Lake Chad Basin including traditional, political, judicial, educational, bilateral and multilateral commissions and diplomatic initiatives. For example, Cousins (1996) in extensive review of literature on conflict in multiple-resource use systems has argued that whereas a situation of chronic or endemic conflict is a central feature of non-equilibrium settings, there are several mechanisms to deal with such conflicts. Some of such mechanisms emphasize a shift in administrative focus from regulation and control of resource use to mediation and arbitration between the conflicting interests of individuals and groups. This further suggests that legal frameworks should focus on procedural rather than substantive law, which cannot easily codify customary law without losing its internal complexity, flexibility and adaptability to change. Procedural law would: -- specify the framework within which interested parties could legitimately put forward process claims, the criteria for choosing between opposing claims and enforcement procedures. Improved grazing and watering conditions will enable livestock owners in the basin to increase the size of their herds/flocks to bigger, more easily reached markets bolstered by a growing demand for higher standards of nutrition of the Lake Chad basin teeming population. It therefore suggested that conflict be explicitly addressed and accepted as inevitable rather than being ignored or treated an incidental or removable feature. For a multiple resource use environment, like the Lake Chad Basin, recommendation is to establish formal institutional arrangements for negotiation, arbitration and resolution of conflict. In this light, for Lake Chad Basin, a major role for crop farmers, fishing folks, the pastoral organizations and the traditional institutions in conflict resolution is recommended.

7.2.4 Environmental Degradation

It is generally assumed that an increase in forestry equates to environmental improvement in watersheds and that this is sufficient in terms of meeting environmental sustainability targets. In many cases, increased forestry will lead to significant improvements in biodiversity, particularly if indigenous tree species are planted. There are risks, however, that changing patterns of land and water use and, hence, the hydrology of watersheds will lead to reduction in biodiversity in areas other than forested areas (e.g. in wetland areas, in ephemeral streams, in and around reservoirs). There is also a risk that some project interventions will adversely affect water quality (e.g. pollution resulting from: increased use of agro chemicals).

Lack of incentives promoting environmentally sound practices: There is an absence of economic instruments, incentive measures, and specific programmes to promote and support local initiatives (World Bank, 2002). For example farmers have no incentive to conserve water, as they do not pay economic quantitative rate for the resource. This

has encouraged farmers to grow crops such as rice, which fetch high market prices, yet are water intensive.

Inadequate valuation of environmental goods and services: Water diversion as part of the Komadugu Yobe irrigation projects e.g. the Kano River Irrigation Project supplied by the Tiga Dam, did not take into account the essential income and nutrition benefits in the form of agriculture, grazing resources, non-timber forest products, fuel wood and fishing provided for local communities around the Hadejia-Nguru wetlands. The wetlands also serve other wider regional economic purposes, such as providing dry-season grazing for semi-nomadic pastoralists, agricultural surpluses for neighbouring states, groundwater recharge of the Chad Formation aquifer and 'insurance' resources in times of drought (Barbier *et al*., 1997).

According to the Ramsar Convention on Wetlands the present value of the aggregate stream of agricultural, fishing and fuel wood benefits were estimated to be around 34 to 51 USD per ha (1989/90 prices based on the maximum flood inputs) (Barbier *et al*., 1997). The Hadejia-Nguru wetlands have declined by 210,000 to 230,000 ha. It is therefore estimated that decline in this wetland has had an economic cost of between 7.1 million and 11.7 million USD. However, it must be noted that this has been a result of both upstream water developments and climatic variability.

7.2.5 Deepening of Poverty

Endemic poverty faced by the population of the basin is a catalyst for environmental degradation. For their short-term survival the communities exploit natural resources at an unsustainable level. The people suffer greatly from the effects of freshwater shortage that has prevailed over the past 40 years. The prevalence of poverty in the basin requires special attention regarding water allocation. There has consequently been severe food insecurity in some part of the region and a proliferation of diseases.

In the basin, the rural population is highly differentiated and the poor, critically, do not have access to fishing and farming resources (Bene *et al*., 2002). This can be attributed to the predominance of traditional management systems at a local level (83% of Nigerian villages) and the absence of strong modern systems, which results in the majority of the benefits from water resources, such as the fisheries, being retained by a powerful elite minority, including local leaders, their extended families, and other prominent people and their associates (Neiland and Béné 2003).

POLICY OPTIONS AND RECOMMENDATIONS 8

8.1 Preamble

The water audit is a situational analysis of the physical and institutional components to identify the water resources problems. In recognition, therefore, of the fact that IWRM aims primarily at achieving sustainable management of water resources, the question arises as to how to identify the appropriate strategy that should be put in place. In response to this we must seek answers to the following questions: What are the key issues? Since we do not have limitless resources, how do we prioritise them? Only then can we address the question of what are the management options?

Regardless of the approach policy options should aim at nothing less than institutionalizing water resources management changes that will promote more strategic and coordinated decision-making on an on-going basis. For this reason this chapter will address the following:

- Identify the key issues;
- Prioritise them;
- Identify IWRM change areas and the appropriate policy options.

A combination of Water Resources Issues Assessment Method (WRIAM) and Causal Chain Analysis was used to identify the key issues and to prioritize them. The WRIAM method as the name suggests, focuses on water resources issues, and was used to asses and identify the key issues. The Causal Chain Analysis (CCA) is intended to support WRIAM and the decision support system (DSS) to identify priority policy options and make recommendations that would be considered in the preparation of the CMP. It should be noted that DSS is primarily a simulation of the natural environment, and by using CCA to identify the root causes of the environmental and socio-economic impacts resulting from those issues and concerns that were prioritised, namely water shortages, irregularity in stream river flows, equity of allocation of water among others, stakeholders would be better placed to develop and select appropriate policy options and interventions.

CCA is based on procedures employed in the UNEP/GEF Global International Waters Assessment (GIWA) and involves the development of an analytical model based on available information. On the basis of the CCA, feasible policy options that target the key issues aimed at minimising future impacts on the environment were recommended. The key criteria used in selecting recommended interventions from a wide range of potential policy options proposed by stakeholders, key political actors and experts were institutional capacity to implement, and appropriateness, as well as

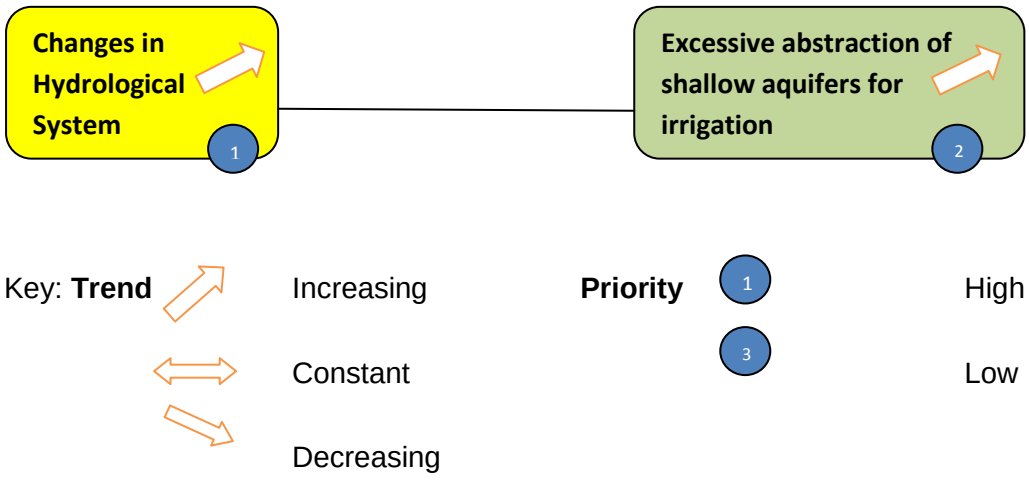
political and social acceptability. The policy options and recommended interventions presented here would be further analysed in the process of developing the Catchment Management Plan (CMP). The recommendations are therefore intended as broad contribution to policy processes and general debate among stakeholders in the basin.

For each area of the key issues, commencing with matrices showing the linkages between critical problems, a causal chain model was formulated. The causal elements cited in the matrices were considered and the relationships among them determined, starting with the establishment of the primary, secondary, tertiary and root causes. To facilitate the analysis the following guidelines, based on the perception of the nature of the causes were employed as the broad criterion:

- Primary causes are those of a technical nature,
- Secondary causes are those of an economic nature;
- Tertiary causes are those of an institutional nature; and
- Root causes are those of a socio-political nature.

A graphic representation was also used to facilitate easier identification of the causal elements and their attributes. Moving always from the right to left, from the root causes towards the problem, the causal-effect relationships are represented by means of connecting lines with their attributes, in terms of priority and trends. Furthermore, values were assigned to each one of the elements and their attributes, in order to facilitate the final analysis of recommended strategic actions.

Figure 8.1: Typical representation of connections in causal chain analysis



The primary concern of the water audit is to address the water allocation; consequently attention was focused on those issues that relate to socio-economic losses associated with water use constraints, deficiencies in the institutional frameworks and human activities and their limitations.

8.2 Identification of Critical Themes and Priorities for Action

The preparation of the CCA was intended to serve as a bridge linking the water audit (knowledge base) and preparation of catchment management plan. Although the analysis used was built on the outcome of various stakeholder discussions as the primary baseline, it nonetheless was an embodiment of a professional multidisciplinary consultant work that took into account biodiversity, water resources, agriculture, teaching and research as well as the regional and inter-institutional cultures of governance of the basin.

It also utilised outcome of several knowledge-based studies, the assessment from the water audit study and subsequent discussions at the state levels with senior government officers, line department specialists, senior researchers, NGO staff and KYBP staff. This led to the identification of the principal critical problems. The field interviews with stakeholders also made it possible to identify the causes of critical problems, and served as inputs for establishing their causal chains. In assembling the causal chain, the causes of each critical problem were analyzed by our team of consultants to ensure that it was consistent with the outcome of the decision support system.

The Lake Chad basin is under severe environmental stress due principally to natural causes that have been exacerbated by human pressures (Bila, 2005). Previous knowledge base studies in the Lake Chad Basin have identified the following hydro-environmental issues whose impacts are trans-boundary in nature.

a) ***Issues due to Stress caused by Climate Change***. This include the following:
   - Lake Level Decline - due to persistent drought of over 3 decades;
   - Decline in vegetation cover and increasing vulnerability to erosion
   - Trans-boundary migration of human populations
   - Increased ecological stress on upstream resources and abandonment of traditional, effective resource management practices.
   - Falling lake levels and problems of fishing access for two of the riparian states, Niger and Nigeria
   - Nigeria also experiences increased problems accessing surface water resources for its large-scale irrigation projects
   - Decrease in wet season flooding, with the consequent effect of a decline in reception capability of natural habitats dependent on water

b) ***Issues due to Human Pressure*** such as increased competition for scarce water resources, land degradation, water pollution and loss of biodiversity.

c) ***Persistent Rural Poverty***: A combination of deforestation, bush burning, unsustainable agricultural practices and drought is creating a circular relationship between environmental degradation and poverty among the rural population. The consequence of inaction against the threat of human pressure and rural poverty is likely to lead to the following;
   - Heightened potential for mis-allocation of scarce water resource base, that short change the natural system.

- The formation of spirals of degradation, with one harmful action having a cascading effect resulting in other harmful effects.
- Increased competition for the natural resource base between users and uses that could increase the potentials for disputes and possible conflicts between communities and among various countries and interests.
- Environmental diminution.
- May increase pollution from such sources as oil drilling and production, mining, unsustainable agricultural practices, and increasing pesticide use.
- Further deterioration of the environment unless effective policy and institutional framework are put in place.

d) ***Short-Term Policy Focus*** that results in unsustainable interventions that is responsible for the following:

- Absence of an integrated approach to water resources management at the national and basin levels
- Costly investment that are underperforming or are abandoned because of unforeseen changes in water availability
- Construction of large dams upstream without consideration to downstream requirements and needs;
- Mining operations and other land resources activities are often not sufficiently co-ordinated with regional water and environmental policies
- Failure of development strategies in rural areas that is deepening poverty in the basin
- Development of agricultural and industrial activities at the expense of environmental sustainability
- Insufficient scientific knowledge base on prevailing situation of water resources generally and of the functioning of aquatic systems specifically, as well as neglect of local knowledge and initiatives.
- No effective system for monitoring the quantity and quality of freshwater resources as well as water quality protection frameworks
- Ineffective management of water demand and little attention paid to adapting production methods to natural resource limitations and to economic instruments and incentives
- Too little value accorded to water and the environment in economic policies

e) ***Poor stakeholder participation and Inter-sectoral Coordination***, which has manifested in the following:

- Low-level public participation and inadequate mechanisms to reverse it;
- insufficient co-operation between and among sectors within, between and among the governments
- Absence of public awareness on environment and water resources management issues
- insufficient harmonisation of legal frameworks at all levels to protect and sustainably use the shared water resources
- slow response of national and regional organisations to adapt to rapidly changing circumstances.
- donors sponsored projects have historically been the only providers of technical assistance for the creation of stakeholder forum that have not been sustained beyond the projects.

Arising from the preliminary analysis, the foregoing issues were aggregated into the following principal problems related to the three main themes, namely: (1) those associated with changes in hydrological system, (2) those related to socio-political organization, and (3) those associated with human activities. Each of these themes was further subdivided into priority challenges as detailed below:

(1) Issues associated with the hydrological system
- Emerging potential conflicts over water use;
- Economic and social losses including those associated to water related disaster events (such as droughts and floods)

(2) Issues associated with socio-political organization
- Political and institutional weaknesses and Poor utilization of IWRM best practices and instruments

(3) Issues associated with human activities
- Land degradation and water pollution
- Loss of biodiversity

These major concerns were analysed to determine the degree of relative importance (priority assessment) for each cause, during which a value of between 1 for the most important causes, to 2 for moderately important causes and 3 for the least important causes. Consideration was given to available knowledge base study reports and information. Cross-referencing was made between the causes, under each critical theme and its characteristics, ranging from technical, economic, and institutional/socio-political. Furthermore, the status of the evolving trends of the causes under each critical theme were assessed and categorized as increasing, decreasing or constant. Accordingly, each block contains a trend assessment and a priority assessment. These indicators are to serve as a basis for determining priority actions under each critical problem and in future will serve as a basis for operation of the decision support system.

The causal chain flow charts for each critical problem, with the root causes, tertiary, secondary and primary causes represented by blocks and lines that shows the logical relationships between them are as shown in Figures 9.2 to 9.6. For ease of referencing, each block has been assigned identification codes: R for root causes, T for tertiary causes, S for secondary causes and P for primary causes. Each of the critical problems identified would be elaborated below.

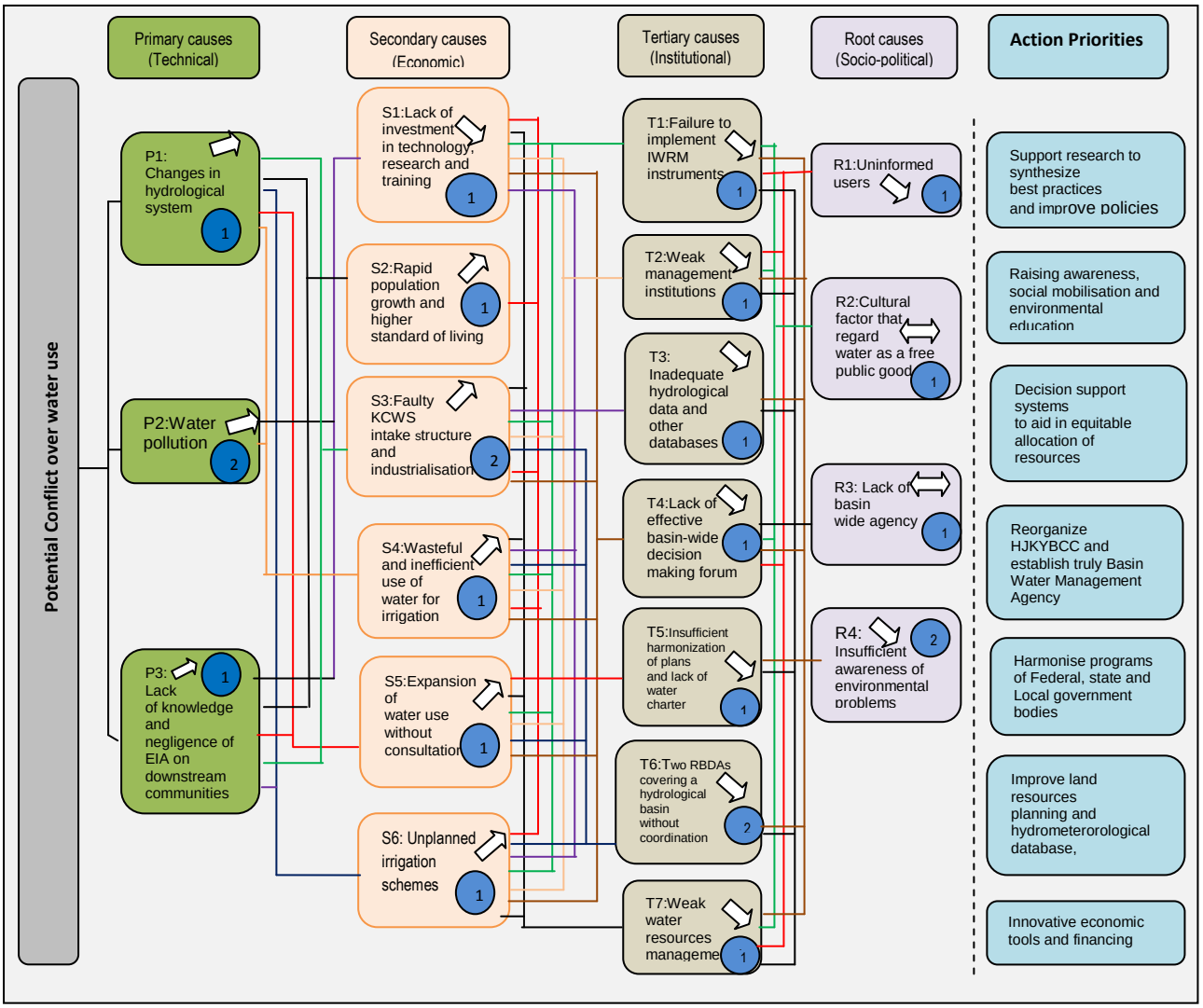
8.2.1 Issues associated with the hydrological system

8.2.1.1 Emerging Potential Conflicts over Water Use

Freshwater shortage has been considered by GIWA assessment study and indeed all knowledge based studies to be the most critical concern in the conventional Lake Chad Basin. The Lake Chad Basin in Nigeria is indeed a hotspot. The basin has witnessed considerable decline in potential water resources in the recent time. This situation can be attributed to both natural and anthropogenic factors. For instance, emerging potential for conflicts over water use in the basin can be ascribed to the absence of integrated water resources management in the basin. The lack of IWRM policies,

institutions and management instruments to lay the foundation for articulate and proactive management of the scarce water resources, has been compounded by insufficient quality information. Furthermore, absence of a forum for all stakeholders to participate actively in decision making have all combined to create potential for conflicts among users, the great majority of whom would need to be made aware of the conflict resolution and participative instruments foreseen in the establishment of NIWRMC.

Figure 8.2: Causal Chain – A1 Emerging Potentials for Conflicts over Water Use



There has been a substantial increase in population and high water consumptive economic activities in the basin. In particular, there has been significant increase in irrigated agriculture, livestock rearing, mining and tourism. As a consequence, the demands for water for irrigation, watering livestock, domestic and industrial water supply have increased significantly. At the same time, the equally significant deterioration in water quality arises from ineffective quality control and as direct consequences of increased demand from industries and none point pollution from

agricultural chemicals arising from run-off from the farmlands, animal and human wastes and poor disposal of waste water.

The field interview revealed that few stakeholders and water users in the basin perceive water as being a public good, with economic value. This is a reflection of lack of awareness and insufficient sensitization of the local population as has been confirmed by the socio-economic and environmental study. Likewise, institutional weaknesses of the organizations responsible for environmental and water resources management as reflected by limited capacities among the stakeholders, planners and managers as well as the inertia in implementing proven IWRM instruments remain a source of concern. Poor hydro-meteorological and cartographic databases are also contributing to exacerbate potentials for conflicts between water users by making logical decision tenuous.

8.2.1.2 Economic and Social Losses including those associated to Emergency Events (Droughts and Floods)

The aspects of economic and social losses was included in the analysis principally in recognition of the problems of uncontrolled flooding consequent upon the massive infestation of aquatic weeds that have led to siltation and blockage of the river channels. To address the problems associated with flooding, and to mitigate the scope of flood damage, basic measures are required that include mapping and risk assessments of areas most vulnerable to flooding, clearing of blocked channel, improved reservoir operations among others. Furthermore, the gentle gradients of the river channel in the floodplain, the low carrying capacities of the riverbeds and the flatness of the landscape have contributed to seasonal phenomenon of flooding, the situation which was often worsened by poor reservoir operations. While, the nature of the floods would not warrant structural measures as a flood defence mechanism, it is nevertheless appropriate to implement non-structural measures, such as flood mapping, zoning of areas, real-time early-warning systems based on adequate hydrological monitoring of rainfall and river gauging.

Table 8.1 Economic values of the Hadejia-Nguru Wetlands, valued using market pricing

Wetland goods or services	Economic value per annum converted to 2002 (million USD)
Agriculture	10.7
Fishing	3.5
Fuel wood	1.6
Doum palm	0.1
Potash	<0.1
Total economic value 15.9	**15.9**

(Source: Schuijt, 2002)

The floodplains, but most especially the Hadejia-Nguru wetlands, support a significant proportion of the basin's population, providing them with source of income and

nutrition in the form of agriculture, grazing lands, fishing, non-timber products, fuel wood, drought fall back security and tourism potential. Ramsar estimated between 34 to 51 USD per ha as the economic value of the wetlands (Barbier *et al*., 1997) following which Schujit (2002) estimated the total economic value of the Hadejia-Nguru wetlands to be 15.9 million USD (see Table 8.1).

The problems of unplanned urban and rural growth, coupled with migration towards the upper reaches of the basin in pursuit of better opportunities are another set of socio-economic issues. The rural to urban migration as well as the rapid demographic growth are stretching the basic infrastructure in the urban centers. Meanwhile, those migrating to urban centers are predominantly the able bodied young men, thus depriving agriculture of their services and putting additional stress on food production system.

The floodplains and wetlands have been intensively cultivated and grazed by domestic animals, especially during the dry season, when the nomadic pastoral groups migrate southwards in search of pasture. In particular, the Hadejia-Nguru wetlands host approximately 120,000 cattle in the wet season which increases to about 320,000 cattle in the dry season, 370,000 goats and 375,000 sheep (using aerial reconnaissance). The North East Arid Zone Development Programme (NEAZDP) estimated that there could be twice as many in the dry season and that is beside intensified agricultural production, areas claimed for human settlements and as bases for fishing. These anthropogenic activities have had significant impacts on the wetlands.

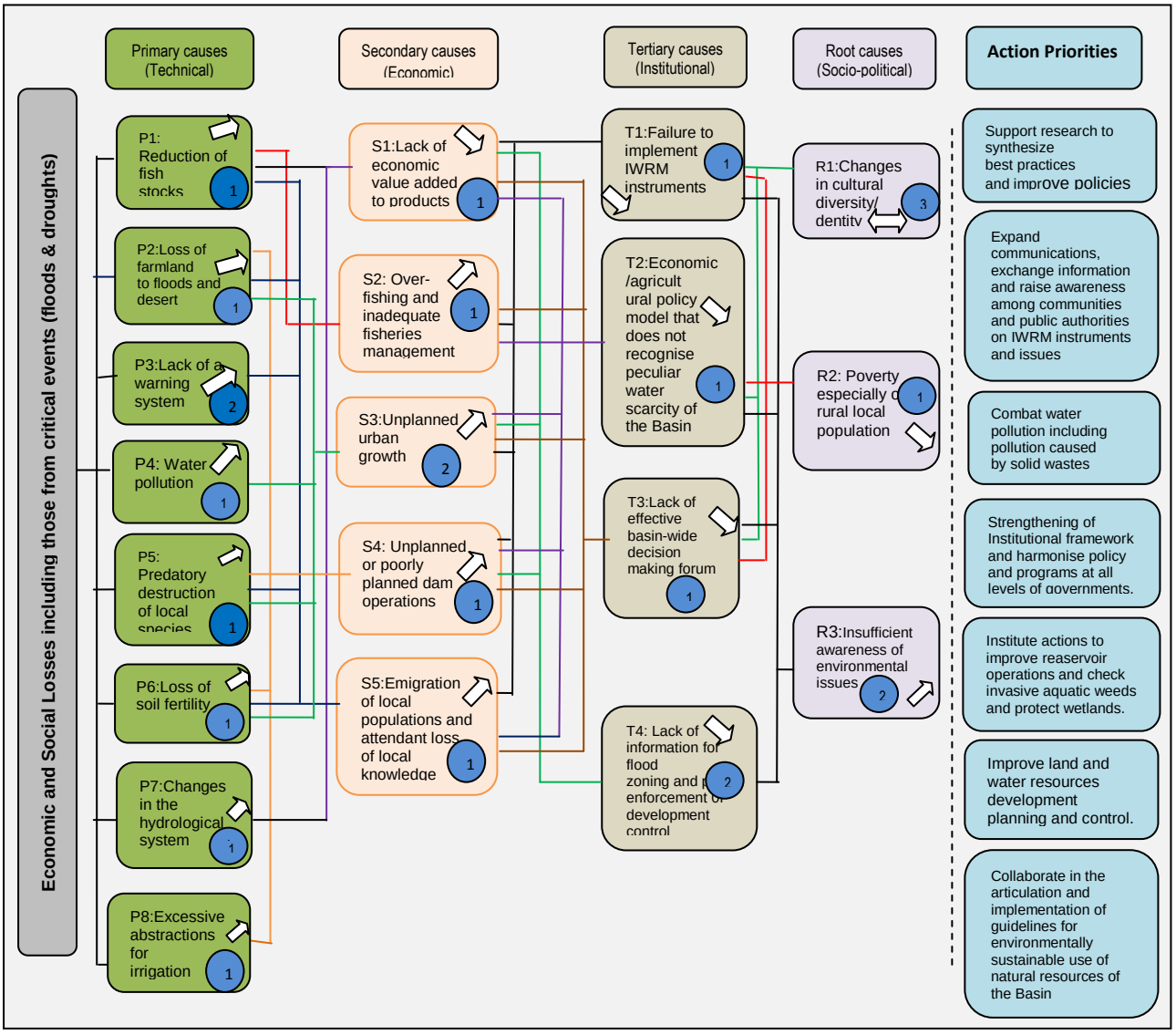
The fisheries are largely dictated by the intra-annual flood regime. The largest fish market in the Lake Chad Basin is Baga-Kawa on the lake shore in Borno State of Nigeria. The majority of fish caught in the Lake Chad Basin regardless of country of origin is traded in Nigeria. Like the communities on the shore of Lake Chad, fishing is also a critical activity of the floodplains and is practiced strictly within a seasonal matrix of various activities. Over-fishing has resulted in the decline in fishstocks, especially of the most commercially attractive species, and has caused a consequent sharp decline in income among riverine communities. Among the commercially attractive fish species before the 1972-1974 Sahelian drought were *Lates*, *Hydrocunus*, *Labeo*, *Citharinus* and *Distichodus* (Neiland and Béné, 2003). There are six key livelihoods associated with the fisheries, namely: fishermen, fish processors, fish wholesalers, fish retailers, fish gear dealers and boat builders.

Lack of coordination among the agencies, responsible for executing public programs and more specifically poverty alleviation program, has exacerbated these problems. Furthermore, unplanned agricultural activities based on high water consuming crop in complete disregard to the water scarcity situation in the basin not only deplete the resource but makes it difficult to attract investments in adequate infrastructure. It also makes it difficult to produce the kind of harvest that produce good returns on investment while exacerbating flashpoint for conflicts. Besides all of the foregoing,

further economic losses stemming from loss of soil fertility, water pollution, and decline in biodiversity have been recorded. What is even more disturbing is the fact that the effects of these environmental changes are generally very expensive to reverse. Meanwhile, due to the ineffectiveness of the environmental agencies, such effects have simply been ignored, thus compounding the problems even the more.

Figure 8.3: Causal Chain – A2 Economic and Social Losses including those associated to critical events (droughts and floods)

Figure 9.3: Causal Chain – A2 Economic and Social Losses including those associated to critical events (droughts and floods)



To avoid further deterioration of the basin's environmental quality, while attending to the developmental needs of current and future generations, public policies are needed that would stimulate local enterprises that conserve water, strengthen the earning capacity of local communities and promote agricultural policies that would optimize the use of scarce water resources and at the same time ensure better control and enforcement of environmental standards.

8.2.2 Issues associated with socio-political organization

8.2.2.1 Political and Institutional Weaknesses and Poor Utilization of IWRM Best Practices and Instruments

The critical theme of political and institutional weakness and poor utilization of IWRM best practices and instruments raises special concerns, because it is at the heart of sustainable Lake Chad Basin management. Its strategic importance in addressing other critical issues affecting the basin is not in doubt, as it holds the key to unlocking the interventions to address the other problems. The constraints arising from institutional weaknesses have for long been recognized by both the decision-makers and other stakeholders. The consensus has been that they require strong political will and motivation to produce the institutional reforms and actions needed to ensure environmental protection and foster basin-wide prosperity. The major constraints arising from institutional weaknesses can be classified in terms of their socio-political or root causes, namely:

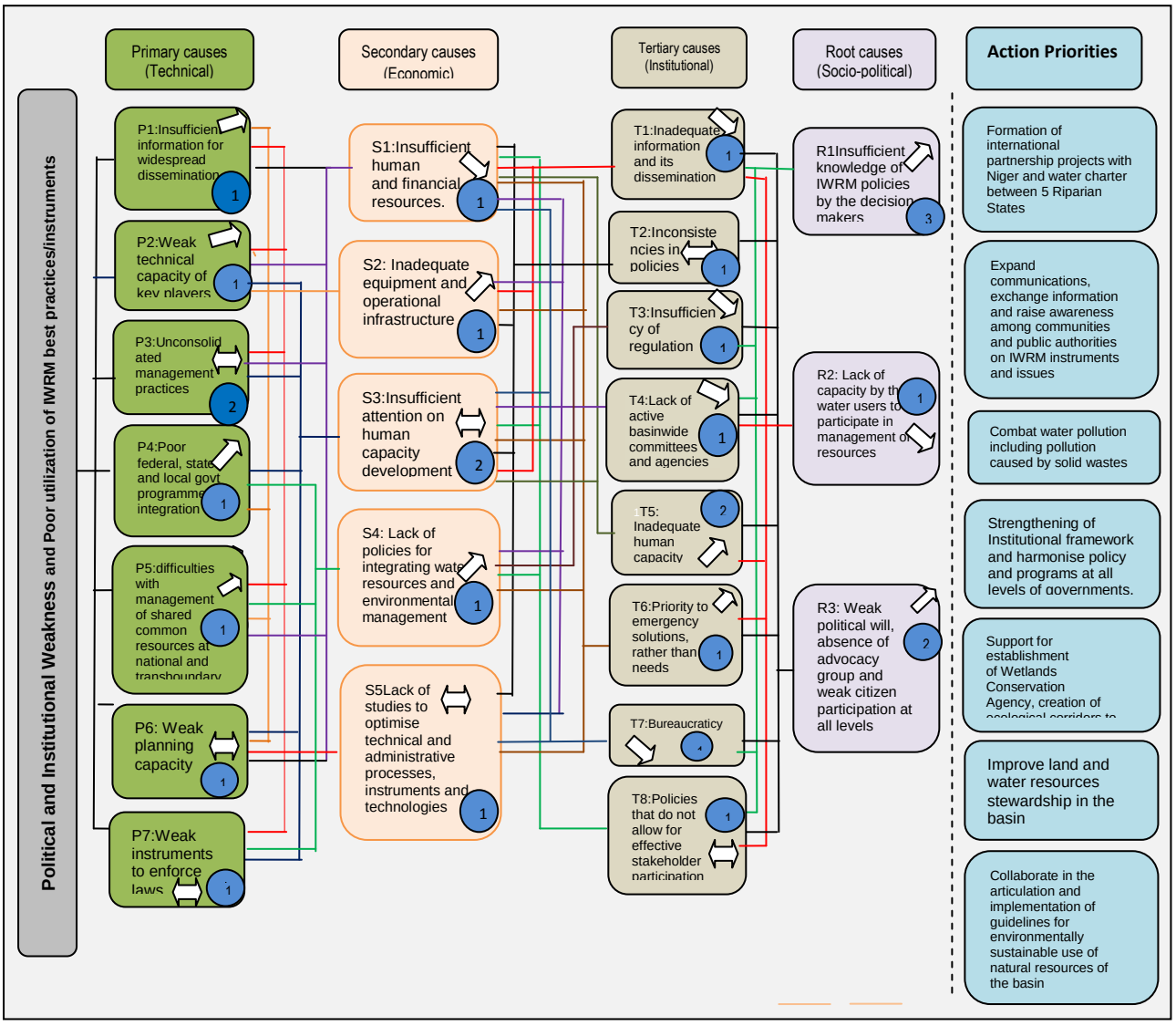
- Insufficient knowledge and appreciation on the part of decision-makers with regard to environmental problems, IWRM policies, best natural resources management practices and instruments;
- The communities are ill prepared to participate effectively in common resources management, and have not been sustainably assisted to acquire the required capacity to do so;
- Insufficient political will, absence grassroot advocacy group and low levels of citizen participation at all levels.

Insufficient knowledge and appreciation on the part of decision-makers with respect to the desired water resources policies for IWRM has been the most critical factor in the emergence and exacerbation of numerous governance problems in the basin. Such problems tend to generate others that all culminate in hampering actions required to institute IWRM for the basin. To a great extent, the problems of political and institutional weaknesses and the failure to deploy IWRM instruments derive from structural flaws in the current decision-making process.

There are currently three RBDAs supervising the basin, with no coordination except through HJKYBCC, which has not met in the past eight years. Although a statutory body – Nigeria Integrated Water Resources Management Commission was established in 2007 to coordinate and regulate water resources activities, its enabling law is yet to be promulgated and current has little or no direct influence on the activities of the RBDAs. Meanwhile, fragmentation of ill-defined and often conflicting responsibilities among many players engaged in water resources and environmental management in the basin, still persist. Water legislation is still use-oriented dealing with navigation, domestic use, irrigation etc. Decentralization is the defining feature of water resources management in Nigeria, with different ministries and agencies at different levels administering laws and policies without adequate coordination of their programmes. Furthermore, these problems, in turn reflect upon the lack of capacity on the part of the communities to participate effectively in basin management. Such unpreparedness

has tended to accentuate existing problems, with members of local communities being reluctant to assume the role of agents for change, by shunning responsibilities and adopting a narrow mind-set that makes them opposed to all attempts at instituting sustainable management practices in the basin.

Figure 8.4: Causal Chain – B1 Political and Institutional Weakness and Poor Utilization of IWRM Best Practices/Instruments



In 2006, the KYBP commissioned preparation of a Water Audit and a Catchment Management Plan for Komadugu-Yobe Basin. These knowledge base and policy documents were subjected to public consultation and unanimously adopted. The Plan attracted unprecedented political support at the summit of President of the Federal Republic of Nigeria with governors and leaders of the riparian states. The summit not only approved the CMP, but it also established a Trust Fund (HJKYBTF) to catalyse its implementation. Although, the CMP did not cover the entire Lake Chad sub-Basin in Nigeria, yet it was a significant document. Five years after, the CMP remains

unimplemented. The political will and momentum was frittered away by the absence of appropriate institutional framework and capacity to implement the plan.

Among the many institutional weaknesses are:

- The failure to pass the enabling law that would give statutory powers on NIWRMC to provide basin-wide water management coordination and regulation;
- Inability of RBDAs to constitute their advisory committee as provided in their enabling legislation;
- Insufficient trained personnel and dwindling financial resources, as well as operational equipment and infrastructure made available to NIWRMC to conserve and regulate water allocation and utilization;
- Limited understanding of and compliance with EIA laws, even on the parts of those responsible for deploying IWRM instruments, along with a lack of systematic process for mobilizing the society, applying water-use charges, and in enforcing environmental and water resources regulations; and
- Reluctance in exchanging information on water resources management issues.

There is need to build upon the recent display of political will and motivation, exemplified by Summit of Governors of the Riparian State governments led the President, to reverse public apathy at all levels. This momentum should be used to facilitate measures necessary for strengthening environmental and water resources management institutions in the basin; especially to promote information sharing, capacity building of the key agencies and stakeholders and sustained public participation.

8.2.3 Issues associated with human activities

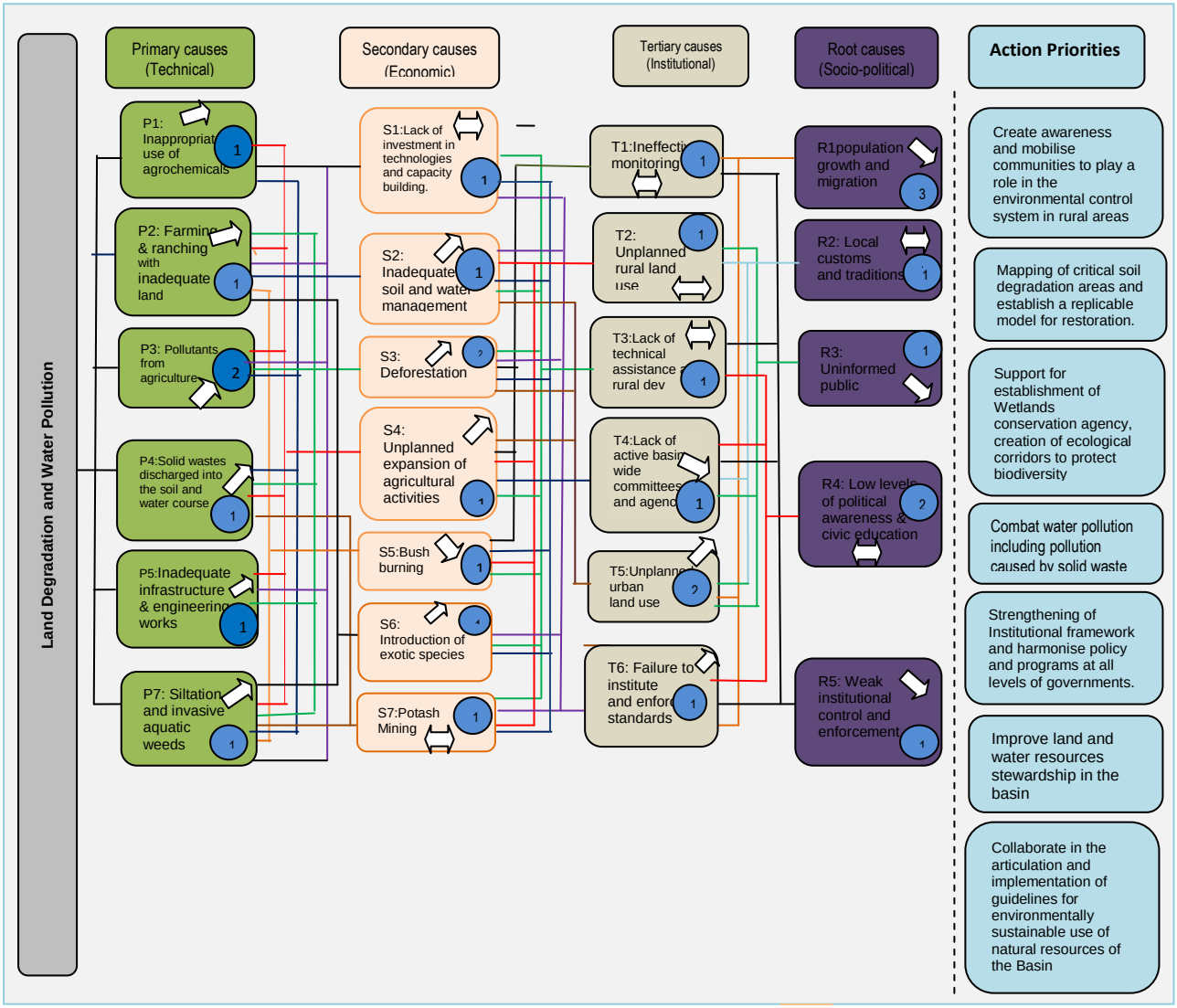
8.2.3.1 Land Degradation and Water Pollution

The principal causes of land degradation in the basin are associated with endemic poverty faced by the population. Increased population has further led to greater pressure on the natural resources of the basin. These in turn are exacerbating overexploitation of natural resources, poor agricultural practices and overgrazing. The concentration of population of the basin, which was estimated to be between 20-25 million (GIWA, 2004) has led to extreme pressure on the fertile floodplain. These changes have been accompanied by flooding and erosion that has resulted in considerable loss of soil nutrient. The legislation though not adequate in respect of land degradation and loss of biodiversity, yet even the inadequate provision is seldom implemented owing to weak enforcement and low level of environmental awareness. Erosion and related problems, especially from the headwater areas of the fast flowing streams that run down to the floodplain of Chad formation has aggravated problems of siltation, transport of agrochemical and interference in migratory patterns of fish in the basin.

There are other various causes of land degradation that stem from other human activities especially in the floodplain and Nguru-Hadejia Wetlands. Recent studies have shown that considerable deforestation, overgrazing and other land impacting activities are taking place in the floodplains and the wetlands, which have resulted in

modification of vegetation cover. The spread of *Typha* weeds and the constant trampling of the floodplains by cattle have affected the structure of the soil.

Figure 8.5: Causal Chain – C1 Land Degradation and Water Pollution



Overgrazing and over-cultivation are considered to be the most significant causes of desertification in the basin, as grazing removes the little vegetation cover and expose the soil to processes of wind and soil erosion while over-cultivation leads to unsustainable consumption of soil nutrients. The lands are now being replanted without sufficient fallow time. Large areas have thus been rendered useless for future regenerations because substantial quantities of soils and nutrients were removed by these processes thus limiting its future productivity. It is estimated that Nigeria losses up to 5.1 billion USD annually from environmental degradation, out of which desertification (and soil erosion) accounts for close to 73% (FGN, 2002). It has been estimated that between 50% and 75% of Adamawa, Bauchi, Borno, Jigawa, Kano and Yobe States are affected by desertification. Overall, the country is estimated to be losing close to 350,000 ha of its landmass annually to desert-like conditions, thus it is

projected that desertification has been advancing southwards at a rate of about 0.6 km per year (FGN, 2002). Land degradation and water pollution are being exacerbated by increase in human populations, with the result that in many areas in the basin the sustainable yield threshold of the vegetation and soils has been breached. Furthermore, increasing population pressure on the limited and fragile natural resources has been aggravating continuous overexploitation of the marginal lands resulting in further degradation even during years of normal rainfall. The steady environmental deterioration in the Northern States of Nigeria has continued largely ineffectively challenged for several years (FGN, 2002).

Presently there is insufficient information on water quality in nature. There are relatively little industrial and mining activities in the basin, except around Kano and the potash mining around Gashua. Effluents that are discharged directly into the river particularly in Kano City from tanneries and textile production have led to localized fish kills. Untreated domestic wastes are also being discharged into the rivers of the basin with negative effects on quality. Agro chemicals washed away from the farmlands as well as reduced stream flows have caused the proliferation of weeds, mainly *Kachalla* grass (*Typha sp.*) that have encroached into reservoirs and clogged channels near Madachi, Kirikisama and Nguru and hampered freshwater use. It has also been reported that water quality in the Hadejia River has been declining, with increased salinity (World Bank, 2002a).

8.2.3.2 Loss of Biodiversity

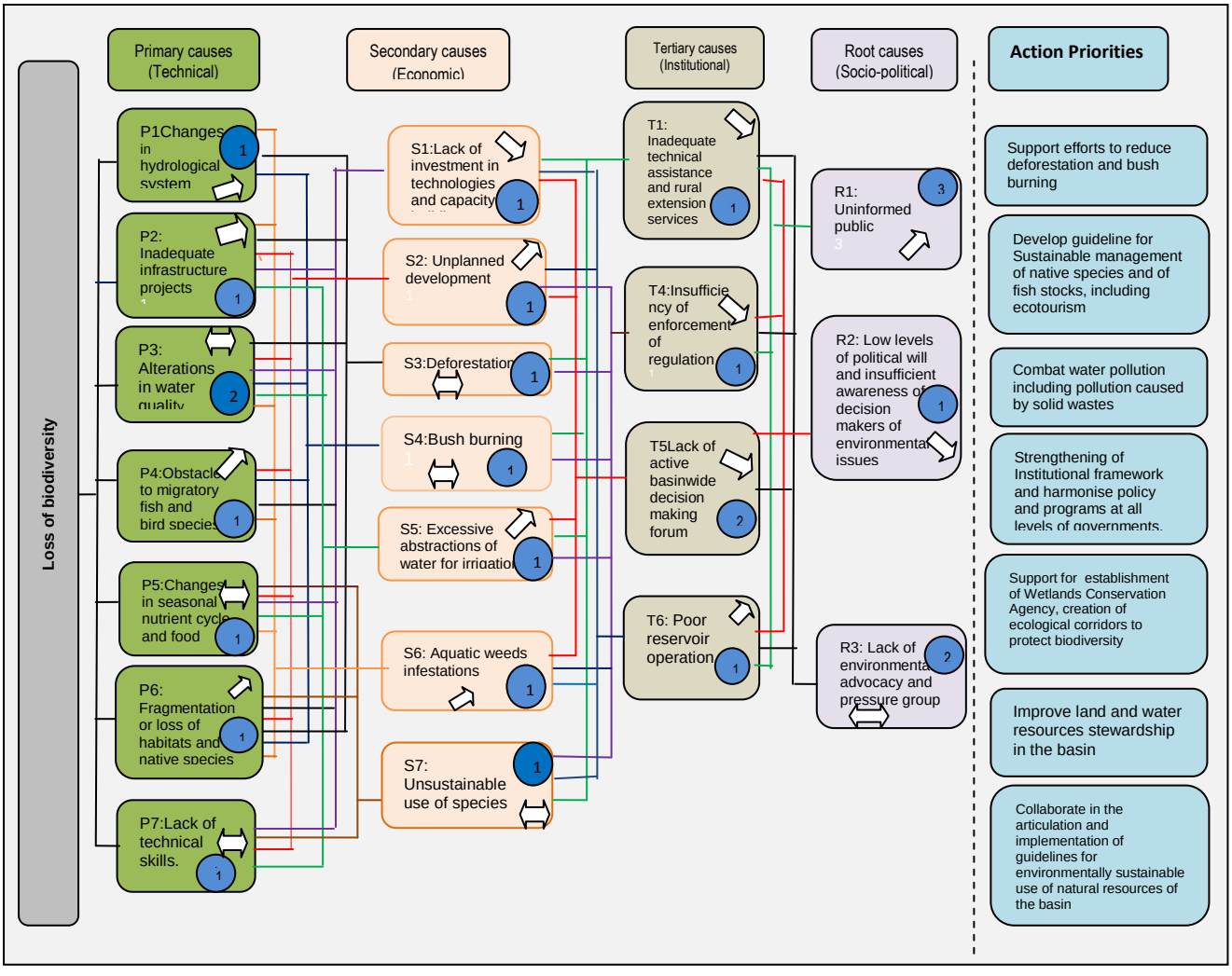
The long-term natural yield of the basin has been significantly changed in part by human stream diversion and in part by impact of drought arising from climate change. The proportion of the influence and the role of these factors remain to be fully studied and ascertained. The drought of the 1970s and 1980s severely affected the basin most especially the eastern half of the basin. This drought prompted massive construction of dams on the Hadejia River system that have negatively affected the hydrology of the Yobe River.

The largest irrigation scheme in the basin – Kano River Irrigation Project (KRIP), is located upstream of the Komadugu-Yobe Basin. It is fed by Tiga Dam that was completed in 1974 and has an active reservoir capacity of 1,400 million m^3. In 1992, the spillway level was lowered to preserve the structural stability of the dam, which resulted in a 31% reduction in its storage capacity. The dam also provides water to Kano City. It is reported that before the construction of Tiga Dam, Hadejia River system use to have relatively strong stream flow during the months of June to October and accounted for 98-99% of annual flow of Yobe (UNEP, 2004). This study however revealed otherwise, as the contribution of Jama'are River system was certainly always more that 2% of the Komadugu Yobe system.

The Challawa Gorge Dam on Challawa River - a tributary of Hadejia River - has a reservoir capacity of 972 million m^3. It was commissioned in 1992 and provides water

to supplement releases from Tiga Dam to Kano City and into Hadejia River for subsequent storage in the Hadejia barrage to supply the Hadejia Valley Irrigation Project. If all the 20 dams on the Hadejia River system were to operate at their design capacity the total reduction of flow at Gashua would be in the order of 76million m^3. Meanwhile, since the 1974, dry-season water releases from the dams upstream have modified the dry-season flow from hitherto zero flows to almost a perennial regime. These are in part responsible for the invasive aquatic weeds infestation and other negative impacts on the ecological systems downstream of Gashua (Oyebande, 2001). The absence of an articulate integrated river basin management strategy has allowed the uncoordinated operations of the dams to persist which have aggravated growth of invasive weeds and silt blockages along the old Hadejia River channel that have prevented its contribution to the Komadugu Yobe. This in turn has impacted drastically on the ecology of the basin, such as decline in wetlands extent which has proportionately decreased the fish abundance in the wetlands and taken out more than five species in the foodplain among other losses (Oyebande, 2001).

Figure 8.6: Causal Chain – C2 Loss of Biodiversity



The predominant vegetation of the basin is woodland with an understory of long grasses, shrubs and herbs. The north-eastern portion hosts mainly grasslands that are dominated by numerous short grasses. Shrubland that is scattered in patches can be witnessed throughout the basin. Riparian forests occur along many of the waterways and small areas of adaphic vegetation such as grassy floodplains or *fadamas* are found in the basin (UNEP, 2004). There are significant differences between the vegetation found on the higher reaches of the basin towards the Jos plateau and that found in the wetlands where seasonal flooding is a dominant factor, as well as the fringes of Lake Chad that is characterized by drought.

The gentle slope of the floodplain from south-west to north-east, the effects of seasonal flooding and the gradual ebb of its water create a complex of luxuriant natural habitat that shelter a relatively rich fauna, including a number of endemic species. Common large animals are vervet monkey (*Chrolocebus aethiops*), baboon (*Papio hamadryas papio and Papio hamadryas anubis*), bushbuck *(Tragelaphus scriptus),* warthog (*Phacochoerus africanus*), and savannah monitor lizard (*Varanus exathematicus*). Most large mammals have been heavily poached with most surviving species found sparsely in the National Park. World Bank study (2002a) estimated that irrigation developments and decreased precipitation have caused a significant shrinkage of Hadejia-Nguru Wetlands from between 250,000 and 300,000 ha in the 1960s and 1970s to the more recent 70,000 to 100,000 ha. The pronounced dry season which corresponds with winter in the higher latitudes signals migration of fauna within and without the region; including the annual passage of migrant birds on the afrotropica-palaeartic flyway (UNEP, 2004). The number of birds in the Hadejia-Nguru Wetlans is correlated with the extent of the wetlands. Consequently, abundance of birdlife has reduced considerably.

Table 8.2: Wood supply and demand in the Lake Chad Basin in Nigeria for 1989

Total area of Lake Chad Basin in Nigeria (km^2)	**136,000**
Human population	22 million
Annual domestic wood demand (tonnes)	7.5 million
Annual sustainable wood extraction (savannah) (tonnes/km^2)	50
Area required to meet present demand (km^2)	150,000

Source: Neiland and Verinumbe 1990 Note: Figures based on best reliable estimates of wood supply and demand

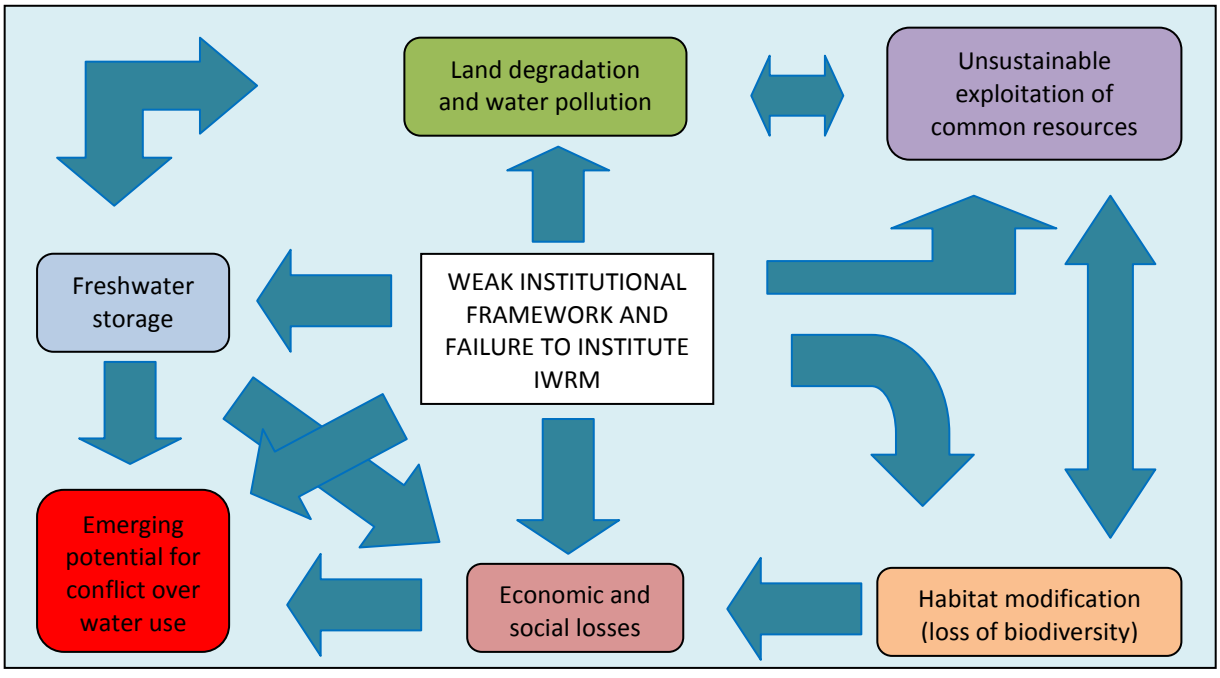
Firewood is the predominant source of fuel for basin's population. Furthermore, there has been expansion of agricultural land to meet the rapidly increasing population demand of the basin. Unsustainable forestry and agricultural practices to meet increased demand for firewood and food has resulted in the over-harvesting of the basin's woodland resources, habitat modification and acceleration of destruction of wildlife habitat on the remaining non-cultivated areas. Although, a number of forest reserves were developed in the basin, especially areas that are being heavily exploited by commercial firewood harvesters for large urban centers, not much has been done to protect or expand these forest reserves in the recent. Neiland and Vernumbre (1990) estimated that the demand for wood in Lake Chad Basin in Nigeria probably exceeds

the available supply as shown in the Table 8.2. However, the relationship between supply and demand for wood can be complicated by several factors.

8.3 Policy Options and Recommendations

The study confirms that freshwater scarcity is severe and remains the priority concern of the basin and that governance issues are the critical weakness responsible for the situation. Although other concerns have been expressed such as significant modification of habitats, losses of fish production, invasive aquatic weed infestation and even pollution, yet a close look as revealed above shows that all these are a function of and closely linked with fresh water shortage and inability to effectively manage the available resources that is at the heart of the problems. The wetlands and sensitive ecosystems have decreased primarily due to changes in the seasonal timing and extent of flooding (Oyebande, 2001). Freshwater scarcity arising from anthropogenic activities such as unsustainable flow modification, weed infestation, irrational use of water, uncoordinated reservoir operations can be substantially addressed through greater political will for robust institutional reforms, improved capacity building and utilization as well as effective use of integrated water resources management instrument.

Figure 8.7: A model showing centrality of governance issues and of inter-linkages and synergies of the five assessed concerns of the LCB and freshwater shortage



From the foregoing the obvious policy options are two:

- Implementation of Integrated Basin Management System and Instruments; and
- Sustainable Use of Water Resources and Environmental Restoration.

These policy options would be examined further in the process of preparing the CMP. Meanwhile, some broad recommendations are proffered herein.

8.3.1 Summary of Main Recommendations

The following concerns should be further assessed in the process leading to catchment management plan to identify activities that would promote a wider range of options/interventions and, in particular, options/interventions aimed at:

- ***Recommendation 1****:* Priority should be accorded to ensuring water security for all by guaranteeing access to sufficient water supplies as a productive input and protection against water risk and vulnerability.

- ***Recommendation 2:*** Water governance activities targeted at and complementary to interventions to the specific physical, social and institutional settings.

- ***Recommendation 3:*** State-level water related participatory planning should take place within a wider *economic planning framework.*

- ***Recommendation 4:*** There should be a much greater emphasis on water resources management and a shift of emphasis from supply to demand management of water resources.

- ***Recommendation 5:*** A major effort is needed to update and improve the quality of the water-related information that is being used to underpin decision making at all levels. Effort should be directed towards making information more accessible to potential users, particularly at the community level.

- ***Recommendation 6:*** The CMP should be vigorously implemented, regularly monitored and evaluated (at least biannually) and the water audit should be updated and improved upon at interval of not more than five years so that information and DSS that is being used to underpin decision making are correct and reflect current situation on the ground.

The recommendations listed above should be viewed within the overall recommendation that the CMP should adopt. These are aimed primarily at building capacity at all levels in adaptive and integrated water resources management principles and methodologies.

8.4 Conclusions

From all of the foregoing, the water problems of Lake Chad Basin in Nigeria are many and solutions are urgently required that would take into consideration the underlying social, economic and political forces involved to proffer the required changes; some of which would not be easy to implement. In particular the assessment of the water management situation has revealed acute paucity of and/or poor knowledge base in the basin but most especially the Borno Drainage sub-basin. This clearly is an indication of poor water resource management in the basin. Data are collected by

several organisations and their system have not been harmonised to make them compatible. On the other hand, the first step to finding solution to a problem is to correctly identify the issues and the problem. To that extent this document has attempted to solve that. Water resource management assessment and auditing should not be ad-hoc and once-off affair. It needs to carried-out in several steps with increasing complexity as more data is gained and to reflect modern advances in the disciplines associated with water resources management. Water management solutions, as has been demonstrated also, often emerge alongside the problems and issues.

Catchment Management Planning to introduce an IWRM approach may take several forms. The most powerful being that which seeks to address priority water problems affecting society as it may result in focused action and step-wise progression towards IWRM. More commonly, is the identification of water as a key factor in poverty reduction and sustainable development that drives national socio-economic planning in relation to water. It is also critically important to note that prioritisation of data needs be based on recognised key water problems and assessment of risks associated with water. These can help to develop and deepen the political support for more robust water governance. Failure of water management systems require long term plan with the primary agenda for more sustainable use of water resources.

Finally implementation of IWRM Concept in the Lake Chad Basin should not mean throwing away all current practices and adopting new. In the basin as in most Nigeria, some of the most basic elements are in place. For example:

- the elements of River Basin Organisations (NIWRMC and its 8 Catchment Management Offices) are being put in place, but would need strengthening and capacity building;
- the draft National Water Resources Policy that broadly defines specific elements of IWRM (though they are not described as such) has been in place since 2005 and all that is required now is for it to be approved by the NCWR and National Council of State and be implemented;
- the National Water Resources Policy should form the bedrock upon which the catchment management plan should be built on, for consistency;
- the water charter for KYB that has not been approved by the Summit of Leaders because no meeting was convened in the last four years, should also be updated to cover the entire Lake Chad Basin in Nigeria;
- there is a growing understanding in civil society, most especially in the Basin, that the water resources of the nation can be managed better, but this understanding needs to be better organised and mobilised with the signing and implementation of CMP and water charter for the basin.

The adoption of IWRM in Nigeria is fast gaining acceptance at all levels of government. This augurs well for improving the institutional framework for managing water resources especially in a basin like Lake Chad basin which is now to being managed as a single Lake Chad Catchment Office, on a unit of basin basis. The momentum created at the signing of Hadejia-Jama'are-Komadugu-Yobe Basin Memorandum of Understanding (MOU) between the 5 riparian states' governments led by Federal

Government in Damaturu in 2007 should be rekindled and sustained. The MOU approved the Komadugu-Yobe Basin Catchment Management Plan and established the Hadejia-Jama'are-Komadugu-Yobe Basin Trust Fund to catalyse its implementation. However, the implementation of the CMP was frustrated by lack of statutory body to coordinate the activities and implementations of the recommended interventions. Now that NIWRMC has been established, it needs to initiate the process of reconvening the Summit of Leaders of Lake Chad Basin in Nigeria to endorse the expanded knowledge base and CMP for the Lake Chad basin as well as update and secure the approval of the Water Charter.

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Appendix 1: Reliability analysis for Tiga flow series

Yr	Mth	S	infow	dd rel	optm rel	ecol dd	ecol rel	kcws	evap	spill	r. c
1964	1/1/1964	1200.00	0.00	65.61	52.49	8.04	8.04	7.31	34.67	0.00	1
1964	2/1/1964	1095.73	0.00	58.95	47.16	7.26	7.26	7.50	34.98	0.00	1
1964	3/1/1964	996.91	0.00	7.33	5.87	8.04	8.04	9.74	40.09	0.00	1
1964	4/1/1964	930.27	0.00	0.83	0.66	7.78	7.78	10.74	34.22	0.00	1
1964	5/1/1964	876.13	6.30	0.86	0.69	8.04	8.04	9.74	30.43	0.00	1
1964	6/1/1964	832.98	21.84	0.83	0.66	7.78	7.78	8.09	24.52	0.00	1
1964	7/1/1964	813.54	175.84	0.86	0.69	8.04	8.04	5.85	21.92	0.00	1
1964	8/1/1964	954.18	649.37	0.86	0.69	8.04	8.04	4.98	12.03	226.23	1
1964	9/1/1964	1345.00	549.84	0.83	0.66	7.78	7.78	5.59	16.18	511.20	1
1964	10/1/1964	1345.00	60.37	0.86	0.69	8.04	8.04	7.31	32.08	12.27	1
1964	11/1/1964	1345.00	8.07	38.84	31.07	7.78	7.78	7.47	32.73	0.00	1
1964	12/1/1964	1272.79	2.03	55.91	44.73	8.04	8.04	6.84	27.82	0.00	1
1965	1/1/1965	1186.20	0.51	65.61	52.49	8.04	8.04	7.31	34.39	0.00	1
1965	2/1/1965	1082.71	1.29	58.95	47.16	7.26	7.26	7.50	34.69	0.00	1
1965	3/1/1965	985.47	0.10	7.33	5.87	8.04	8.04	9.74	39.73	0.00	1
1965	4/1/1965	919.28	0.10	0.83	0.66	7.78	7.78	10.74	33.92	0.00	1
1965	5/1/1965	865.54	0.91	0.86	0.69	8.04	8.04	9.74	30.08	0.00	1
1965	6/1/1965	817.27	183.44	0.83	0.66	7.78	7.78	8.09	25.95	0.00	1
1965	7/1/1965	959.79	153.37	0.86	0.69	8.04	8.04	5.85	24.24	0.00	1
1965	8/1/1965	1075.32	343.85	0.86	0.69	8.04	8.04	4.98	21.85	40.23	1
1965	9/1/1965	1345.00	509.90	0.83	0.66	7.78	7.78	5.59	16.18	471.26	1
1965	10/1/1965	1345.00	25.71	0.86	0.69	8.04	8.04	7.31	31.92	0.00	1
1965	11/1/1965	1322.61	3.74	38.84	31.07	7.78	7.78	7.47	32.34	0.00	1
1965	12/1/1965	1246.40	0.91	55.91	44.73	8.04	8.04	6.84	27.41	0.00	1
1966	1/1/1966	1159.06	0.20	65.61	52.49	8.04	8.04	7.31	33.82	0.00	1
1966	2/1/1966	1055.80	0.00	58.95	47.16	7.26	7.26	7.50	34.02	0.00	1
1966	3/1/1966	957.89	0.00	7.33	5.87	8.04	8.04	9.74	38.84	0.00	1
1966	4/1/1966	892.44	0.00	0.83	0.66	7.78	7.78	10.74	33.18	0.00	1
1966	5/1/1966	839.34	57.22	0.86	0.69	8.04	8.04	9.74	30.14	0.00	1
1966	6/1/1966	848.07	58.23	0.83	0.66	7.78	7.78	8.09	25.25	0.00	1
1966	7/1/1966	864.70	30.90	0.86	0.69	8.04	8.04	5.85	21.53	0.00	1
1966	8/1/1966	859.44	533.50	0.86	0.69	8.04	8.04	4.98	20.57	16.98	1
1966	9/1/1966	1345.00	711.44	0.83	0.66	7.78	7.78	5.59	16.18	672.80	1
1966	10/1/1966	1345.00	106.31	0.86	0.69	8.04	8.04	7.31	32.08	58.21	1
1966	11/1/1966	1345.00	11.31	38.84	31.07	7.78	7.78	7.47	32.75	0.00	1
1966	12/1/1966	1276.04	2.74	55.91	44.73	8.04	8.04	6.84	27.87	0.00	1
1967	1/1/1967	1190.12	0.81	65.61	52.49	8.04	8.04	7.31	34.48	0.00	1
1967	2/1/1967	1086.85	0.18	58.95	47.16	7.26	7.26	7.50	34.78	0.00	1
1967	3/1/1967	988.41	0.00	7.33	5.87	8.04	8.04	9.74	39.82	0.00	1
1967	4/1/1967	922.03	0.00	0.83	0.66	7.78	7.78	10.74	34.00	0.00	1
1967	5/1/1967	868.12	2.85	0.86	0.69	8.04	8.04	9.74	30.18	0.00	1
1967	6/1/1967	821.71	20.26	0.83	0.66	7.78	7.78	8.09	24.26	0.00	1

1967	7/1/1967	800.95	116.78	0.86	0.69	8.04	8.04	5.85	21.15	0.00	1
1967	8/1/1967	882.78	363.46	0.86	0.69	8.04	8.04	4.98	19.90	0.00	1
1967	9/1/1967	1214.93	314.46	0.83	0.66	7.78	7.78	5.59	15.05	147.22	1
1967	10/1/1967	1345.00	56.92	0.86	0.69	8.04	8.04	7.31	32.08	8.81	1
1967	11/1/1967	1345.00	7.87	38.84	31.07	7.78	7.78	7.47	32.72	0.00	1
1967	12/1/1967	1272.59	2.13	55.91	44.73	8.04	8.04	6.84	27.81	0.00	1
1968	1/1/1968	1186.11	0.41	65.61	52.49	8.04	8.04	7.31	34.39	0.00	1
1968	2/1/1968	1082.51	0.00	58.95	47.16	7.26	7.26	7.50	34.67	0.00	1
1968	3/1/1968	983.99	0.00	7.33	5.87	8.04	8.04	9.74	39.68	0.00	1
1968	4/1/1968	917.75	28.52	0.83	0.66	7.78	7.78	10.74	34.27	0.00	1
1968	5/1/1968	892.47	54.48	0.86	0.69	8.04	8.04	9.74	31.48	0.00	1
1968	6/1/1968	897.07	75.44	0.83	0.66	7.78	7.78	8.09	26.47	0.00	1
1968	7/1/1968	929.85	313.56	0.86	0.69	8.04	8.04	5.85	25.05	0.00	1
1968	8/1/1968	1206.09	348.62	0.86	0.69	8.04	8.04	4.98	14.21	174.20	1
1968	9/1/1968	1345.00	135.64	0.83	0.66	7.78	7.78	5.59	24.61	97.00	1
1968	10/1/1968	1345.00	19.01	0.86	0.69	8.04	8.04	7.31	31.87	0.00	1
1968	11/1/1968	1315.90	2.07	38.84	31.07	7.78	7.78	7.47	32.22	0.00	1
1968	12/1/1968	1238.12	0.10	55.91	44.73	8.04	8.04	6.84	27.28	0.00	1
1969	1/1/1969	1150.09	0.00	65.61	52.49	8.04	8.04	7.31	33.63	0.00	1
1969	2/1/1969	1046.80	0.00	58.95	47.16	7.26	7.26	7.50	33.80	0.00	1
1969	3/1/1969	949.10	0.00	7.33	5.87	8.04	8.04	9.74	38.55	0.00	1
1969	4/1/1969	883.92	0.30	0.83	0.66	7.78	7.78	10.74	32.95	0.00	1
1969	5/1/1969	831.35	6.71	0.86	0.69	8.04	8.04	9.74	29.25	0.00	1
1969	6/1/1969	789.78	91.18	0.83	0.66	7.78	7.78	8.09	24.34	0.00	1
1969	7/1/1969	840.66	261.92	0.86	0.69	8.04	8.04	5.85	23.16	0.00	1
1969	8/1/1969	1066.88	381.66	0.86	0.69	8.04	8.04	4.98	21.81	69.71	1
1969	9/1/1969	1345.00	362.75	0.83	0.66	7.78	7.78	5.59	16.18	324.11	1
1969	10/1/1969	1345.00	84.06	0.86	0.69	8.04	8.04	7.31	32.08	35.95	1
1969	11/1/1969	1345.00	15.64	38.84	31.07	7.78	7.78	7.47	32.79	0.00	1
1969	12/1/1969	1280.36	2.95	55.91	44.73	8.04	8.04	6.84	27.93	0.00	1
1970	1/1/1970	1194.59	0.51	65.61	52.49	8.04	8.04	7.31	34.56	0.00	1
1970	2/1/1970	1090.93	0.09	58.95	47.16	7.26	7.26	7.50	34.87	0.00	1
1970	3/1/1970	992.31	0.00	7.33	5.87	8.04	8.04	9.74	39.95	0.00	1
1970	4/1/1970	925.81	0.00	0.83	0.66	7.78	7.78	10.74	34.10	0.00	1
1970	5/1/1970	871.79	17.69	0.86	0.69	8.04	8.04	9.74	30.47	0.00	1
1970	6/1/1970	840.13	22.72	0.83	0.66	7.78	7.78	8.09	24.69	0.00	1
1970	7/1/1970	821.42	127.05	0.86	0.69	8.04	8.04	5.85	21.62	0.00	1
1970	8/1/1970	913.13	661.67	0.86	0.69	8.04	8.04	4.98	11.65	198.05	1
1970	9/1/1970	1345.00	532.82	0.83	0.66	7.78	7.78	5.59	16.18	494.18	1
1970	10/1/1970	1345.00	30.80	0.86	0.69	8.04	8.04	7.31	31.95	0.00	1
1970	11/1/1970	1327.69	4.52	38.84	31.07	7.78	7.78	7.47	32.42	0.00	1
1970	12/1/1970	1252.19	1.83	55.91	44.73	8.04	8.04	6.84	27.51	0.00	1
1971	1/1/1971	1165.69	0.30	65.61	52.49	8.04	8.04	7.31	33.96	0.00	1
1971	2/1/1971	1062.39	0.55	58.95	47.16	7.26	7.26	7.50	34.19	0.00	1
1971	3/1/1971	964.88	1.32	7.33	5.87	8.04	8.04	9.74	39.09	0.00	1

1971	4/1/1971	900.54	1.08	0.83	0.66	7.78	7.78	10.74	33.42	0.00	1
1971	5/1/1971	848.30	13.72	0.86	0.69	8.04	8.04	9.74	29.80	0.00	1
1971	6/1/1971	813.29	17.80	0.83	0.66	7.78	7.78	8.09	24.04	0.00	1
1971	7/1/1971	790.26	102.96	0.86	0.69	8.04	8.04	5.85	20.82	0.00	1
1971	8/1/1971	858.47	513.58	0.86	0.69	8.04	8.04	4.98	20.54	0.00	1
1971	9/1/1971	1341.10	366.00	0.83	0.66	7.78	7.78	5.59	16.15	323.50	1
1971	10/1/1971	1345.00	22.67	0.86	0.69	8.04	8.04	7.31	31.90	0.00	1
1971	11/1/1971	1319.56	2.75	38.84	31.07	7.78	7.78	7.47	32.28	0.00	1
1971	12/1/1971	1242.41	0.61	55.91	44.73	8.04	8.04	6.84	27.35	0.00	1
1972	1/1/1972	1154.83	0.71	65.61	52.49	8.04	8.04	7.31	33.74	0.00	1
1972	2/1/1972	1052.15	0.55	58.95	47.16	7.26	7.26	7.50	33.94	0.00	1
1972	3/1/1972	954.88	0.61	7.33	5.87	8.04	8.04	9.74	38.75	0.00	1
1972	4/1/1972	890.14	0.00	0.83	0.66	7.78	7.78	10.74	33.12	0.00	1
1972	5/1/1972	837.10	19.82	0.86	0.69	8.04	8.04	9.74	29.58	0.00	1
1972	6/1/1972	808.49	31.18	0.83	0.66	7.78	7.78	8.09	24.08	0.00	1
1972	7/1/1972	798.94	61.09	0.86	0.69	8.04	8.04	5.85	20.59	0.00	1
1972	8/1/1972	825.11	405.54	0.86	0.69	8.04	8.04	4.98	19.42	0.00	1
1972	9/1/1972	1200.20	110.36	0.83	0.66	7.78	7.78	5.59	23.41	0.00	1
1972	10/1/1972	1273.56	19.62	0.86	0.69	8.04	8.04	7.31	30.85	0.00	1
1972	11/1/1972	1246.09	1.77	38.84	31.07	7.78	7.78	7.47	31.06	0.00	1
1972	12/1/1972	1169.10	1.02	55.91	44.73	8.04	8.04	6.84	26.21	0.00	1
1973	1/1/1973	1082.99	0.81	65.61	52.49	8.04	8.04	7.31	32.17	0.00	1
1973	2/1/1973	981.89	1.01	58.95	47.16	7.26	7.26	7.50	32.19	0.00	1
1973	3/1/1973	886.76	1.73	7.33	5.87	8.04	8.04	9.74	36.50	0.00	1
1973	4/1/1973	825.30	31.97	0.83	0.66	7.78	7.78	10.74	31.74	0.00	1
1973	5/1/1973	806.07	1.93	0.86	0.69	8.04	8.04	9.74	28.51	0.00	1
1973	6/1/1973	760.40	17.02	0.83	0.66	7.78	7.78	8.09	22.83	0.00	1
1973	7/1/1973	737.79	73.69	0.86	0.69	8.04	8.04	5.85	19.54	0.00	1
1973	8/1/1973	777.76	202.06	0.86	0.69	8.04	8.04	4.98	17.33	0.00	1
1973	9/1/1973	950.10	67.38	0.83	0.66	7.78	7.78	5.59	19.86	0.00	1
1973	10/1/1973	983.83	8.54	0.86	0.69	8.04	8.04	7.31	25.89	0.00	1
1973	11/1/1973	950.13	2.66	38.84	31.07	7.78	7.78	7.47	26.27	0.00	1
1973	12/1/1973	879.39	3.25	55.91	44.73	8.04	8.04	6.84	21.15	0.00	1
1974	1/1/1974	800.44	3.15	65.61	52.49	8.04	8.04	7.31	25.25	0.00	1
1974	2/1/1974	708.32	2.66	58.95	47.16	7.26	7.26	7.50	24.55	0.00	1
1974	3/1/1974	622.22	4.98	7.33	5.87	8.04	8.04	9.74	29.18	0.00	1
1974	4/1/1974	573.40	7.38	0.83	0.66	7.78	7.78	10.74	23.50	0.00	1
1974	5/1/1974	537.49	8.54	0.86	0.69	8.04	8.04	9.74	20.69	0.00	1
1974	6/1/1974	506.37	15.54	0.83	0.66	7.78	7.78	8.09	16.49	0.00	1
1974	7/1/1974	488.65	13.42	0.86	0.69	8.04	8.04	5.85	13.61	0.00	1
1974	8/1/1974	473.70	101.44	0.86	0.69	8.04	8.04	4.98	11.52	0.00	1
1974	9/1/1974	550.63	15.74	0.83	0.66	7.78	7.78	5.59	12.79	0.00	1
1974	10/1/1974	539.44	12.50	0.86	0.69	8.04	8.04	7.31	16.28	0.00	1
1974	11/1/1974	519.38	3.84	38.84	1.04	7.78	7.78	7.47	16.59	0.00	0
1974	12/1/1974	489.95	2.95	55.91	1.07	8.04	8.04	6.84	13.97	0.00	0

1975	1/1/1975	462.66	3.35	65.61	2.26	8.04	8.04	7.31	17.26	0.00	0
1975	2/1/1975	430.65	2.75	58.95	0.97	7.26	7.26	7.50	17.46	0.00	0
1975	3/1/1975	399.69	4.07	7.33	5.87	8.04	8.04	9.74	20.13	0.00	1
1975	4/1/1975	359.07	4.03	0.83	0.66	7.78	7.78	10.74	15.83	0.00	1
1975	5/1/1975	327.49	6.40	0.86	0.69	8.04	8.04	9.74	13.63	0.00	1
1975	6/1/1975	301.34	6.30	0.83	0.00	7.78	0.00	8.09	10.86	0.00	0
1975	7/1/1975	294.32	16.67	0.86	0.00	8.04	0.00	5.85	9.22	0.00	0
1975	8/1/1975	298.03	17.89	0.86	0.00	8.04	3.56	4.98	7.41	0.00	0
1975	9/1/1975	300.00	18.20	0.83	0.00	7.78	4.78	5.59	7.83	0.00	0
1975	10/1/1975	300.00	6.20	0.86	0.00	8.04	0.00	7.31	10.20	0.00	0
1975	11/1/1975	294.34	6.79	38.84	0.00	7.78	0.00	7.47	10.81	0.00	0
1975	12/1/1975	291.51	7.93	55.91	0.00	8.04	0.00	6.84	9.54	0.00	0
1976	1/1/1976	291.64	10.37	65.61	0.00	8.04	0.00	7.31	12.42	0.00	0
1976	2/1/1976	291.28	7.16	58.95	0.00	7.26	0.00	7.50	13.34	0.00	0
1976	3/1/1976	288.96	11.79	7.33	0.00	8.04	0.00	9.74	16.60	0.00	0
1976	4/1/1976	287.46	9.54	0.83	0.00	7.78	0.00	10.74	14.16	0.00	0
1976	5/1/1976	286.30	9.66	0.86	0.00	8.04	0.00	9.74	13.12	0.00	0
1976	6/1/1976	286.80	12.98	0.83	0.00	7.78	0.00	8.09	10.86	0.00	0
1976	7/1/1976	290.61	10.27	0.86	0.00	8.04	0.00	5.85	9.22	0.00	0
1976	8/1/1976	293.02	18.60	0.86	0.00	8.04	0.00	4.98	7.41	0.00	0
1976	9/1/1976	299.68	10.43	0.83	0.00	7.78	0.00	5.59	7.83	0.00	0
1976	10/1/1976	298.35	13.21	0.86	0.00	8.04	0.00	7.31	10.20	0.00	0
1976	11/1/1976	297.05	17.11	38.84	0.00	7.78	0.00	7.47	10.81	0.00	0
1976	12/1/1976	297.99	16.97	55.91	0.00	8.04	0.00	6.84	9.54	0.00	0
1977	1/1/1977	299.32	14.03	65.61	0.00	8.04	0.00	7.31	12.42	0.00	0
1977	2/1/1977	296.82	12.58	58.95	0.00	7.26	0.00	7.50	13.34	0.00	0
1977	3/1/1977	294.34	19.01	7.33	0.00	8.04	0.00	9.74	16.60	0.00	0
1977	4/1/1977	293.63	16.23	0.83	0.00	7.78	0.00	10.74	14.16	0.00	0
1977	5/1/1977	292.60	18.90	0.86	0.00	8.04	0.00	9.74	13.12	0.00	0
1977	6/1/1977	294.46	20.07	0.83	0.00	7.78	0.00	8.09	10.86	0.00	0
1977	7/1/1977	297.87	21.24	0.86	0.00	8.04	4.09	5.85	9.22	0.00	0
1977	8/1/1977	300.00	115.36	0.86	0.69	8.04	8.04	4.98	8.36	0.00	1
1977	9/1/1977	394.25	282.20	0.83	0.66	7.78	7.78	5.59	12.38	0.00	1
1977	10/1/1977	652.61	64.64	0.86	0.69	8.04	8.04	7.31	19.59	0.00	1
1977	11/1/1977	681.96	31.18	38.84	31.07	7.78	7.78	7.47	20.57	0.00	1
1977	12/1/1977	645.72	3.93	55.91	44.73	8.04	8.04	6.84	16.92	0.00	1
1978	1/1/1978	572.20	3.21	65.61	52.49	8.04	8.04	7.31	19.62	0.00	1
1978	2/1/1978	486.47	3.60	58.95	47.16	7.26	7.26	7.50	18.36	0.00	1
1978	3/1/1978	408.27	5.01	7.33	5.87	8.04	8.04	9.74	20.51	0.00	1
1978	4/1/1978	368.22	49.57	0.83	0.66	7.78	7.78	10.74	17.03	0.00	1
1978	5/1/1978	381.84	63.02	0.86	0.69	8.04	8.04	9.74	16.50	0.00	1
1978	6/1/1978	410.39	60.89	0.83	0.66	7.78	7.78	8.09	14.50	0.00	1
1978	7/1/1978	440.66	78.06	0.86	0.69	8.04	8.04	5.85	13.26	0.00	1
1978	8/1/1978	491.48	85.68	0.86	0.69	8.04	8.04	4.98	11.69	0.00	1
1978	9/1/1978	552.32	65.70	0.83	0.66	7.78	7.78	5.59	13.29	0.00	1

1978	10/1/1978	591.07	28.76	0.86	0.69	8.04	8.04	7.31	17.73	0.00	1
1978	11/1/1978	586.01	22.52	38.84	31.07	7.78	7.78	7.47	18.07	0.00	1
1978	12/1/1978	543.50	23.68	55.91	44.73	8.04	8.04	6.84	14.82	0.00	1
1979	1/1/1979	492.02	3.12	65.61	30.49	8.04	8.04	7.31	17.72	0.00	0
1979	2/1/1979	430.63	22.03	58.95	26.61	7.26	7.26	7.50	17.34	0.00	0
1979	3/1/1979	393.30	26.73	7.33	5.87	8.04	8.04	9.74	20.35	0.00	1
1979	4/1/1979	375.63	18.98	0.83	0.66	7.78	7.78	10.74	16.73	0.00	1
1979	5/1/1979	358.38	29.37	0.86	0.69	8.04	8.04	9.74	15.11	0.00	1
1979	6/1/1979	354.10	50.07	0.83	0.66	7.78	7.78	8.09	12.76	0.00	1
1979	7/1/1979	375.17	57.43	0.86	0.69	8.04	8.04	5.85	11.48	0.00	1
1979	8/1/1979	406.93	47.26	0.86	0.69	8.04	8.04	4.98	9.77	0.00	1
1979	9/1/1979	430.95	162.20	0.83	0.66	7.78	7.78	5.59	11.92	0.00	1
1979	10/1/1979	568.56	101.13	0.86	0.69	8.04	8.04	7.31	18.07	0.00	1
1979	11/1/1979	636.41	25.97	38.84	31.07	7.78	7.78	7.47	19.39	0.00	1
1979	12/1/1979	596.07	24.19	55.91	44.73	8.04	8.04	6.84	16.04	0.00	1
1980	1/1/1980	543.91	3.40	65.61	52.49	8.04	8.04	7.31	18.77	0.00	1
1980	2/1/1980	459.22	3.64	58.95	35.82	7.26	7.26	7.50	17.84	0.00	0
1980	3/1/1980	393.31	4.37	7.33	5.87	8.04	8.04	9.74	19.86	0.00	1
1980	4/1/1980	353.27	44.75	0.83	0.66	7.78	7.78	10.74	16.38	0.00	1
1980	5/1/1980	362.64	55.50	0.86	0.69	8.04	8.04	9.74	15.72	0.00	1
1980	6/1/1980	384.33	46.43	0.83	0.66	7.78	7.78	8.09	13.57	0.00	1
1980	7/1/1980	400.89	52.45	0.86	0.69	8.04	8.04	5.85	12.03	0.00	1
1980	8/1/1980	427.04	139.86	0.86	0.69	8.04	8.04	4.98	11.02	0.00	1
1980	9/1/1980	543.27	125.51	0.83	0.66	7.78	7.78	5.59	13.68	0.00	1
1980	10/1/1980	641.99	7.86	0.86	0.69	8.04	8.04	7.31	18.69	0.00	1
1980	11/1/1980	614.81	3.69	38.84	31.07	7.78	7.78	7.47	18.56	0.00	1
1980	12/1/1980	552.74	5.33	55.91	44.73	8.04	8.04	6.84	14.82	0.00	1
1981	1/1/1981	482.69	5.19	65.61	23.52	8.04	8.04	7.31	17.57	0.00	0
1981	2/1/1981	430.63	4.20	58.95	8.77	7.26	7.26	7.50	17.34	0.00	0
1981	3/1/1981	393.30	5.57	7.33	5.87	8.04	8.04	9.74	19.88	0.00	1
1981	4/1/1981	354.47	65.21	0.83	0.66	7.78	7.78	10.74	16.82	0.00	1
1981	5/1/1981	384.25	64.13	0.86	0.69	8.04	8.04	9.74	16.60	0.00	1
1981	6/1/1981	413.82	60.79	0.83	0.66	7.78	7.78	8.09	14.59	0.00	1
1981	7/1/1981	443.91	62.20	0.86	0.69	8.04	8.04	5.85	13.15	0.00	1
1981	8/1/1981	478.79	113.02	0.86	0.69	8.04	8.04	4.98	11.71	0.00	1
1981	9/1/1981	567.21	65.21	0.83	0.66	7.78	7.78	5.59	13.56	0.00	1
1981	10/1/1981	605.19	37.00	0.86	0.69	8.04	8.04	7.31	18.17	0.00	1
1981	11/1/1981	608.01	25.67	38.84	31.07	7.78	7.78	7.47	18.67	0.00	1
1981	12/1/1981	568.09	4.16	55.91	44.73	8.04	8.04	6.84	15.17	0.00	1
1982	1/1/1982	496.53	5.15	65.61	36.89	8.04	8.04	7.31	17.79	0.00	0
1982	2/1/1982	430.63	4.11	58.95	8.67	7.26	7.26	7.50	17.35	0.00	0
1982	3/1/1982	393.32	6.97	7.33	5.87	8.04	8.04	9.74	19.92	0.00	1
1982	4/1/1982	355.89	84.79	0.83	0.66	7.78	7.78	10.74	17.24	0.00	1
1982	5/1/1982	405.18	43.10	0.86	0.69	8.04	8.04	9.74	16.95	0.00	1
1982	6/1/1982	413.00	72.49	0.83	0.66	7.78	7.78	8.09	14.74	0.00	1

1982	7/1/1982	454.81	52.65	0.86	0.69	8.04	8.04	5.85	13.29	0.00	1
1982	8/1/1982	479.88	44.92	0.86	0.69	8.04	8.04	4.98	11.11	0.00	1
1982	9/1/1982	500.19	22.03	0.83	0.66	7.78	7.78	5.59	11.89	0.00	1
1982	10/1/1982	496.26	50.41	0.86	0.69	8.04	8.04	7.31	15.69	0.00	1
1982	11/1/1982	515.19	16.43	38.84	1.04	7.78	7.78	7.47	16.65	0.00	0
1982	12/1/1982	498.47	15.14	55.91	16.29	8.04	8.04	6.84	14.14	0.00	0
1983	1/1/1983	467.95	10.57	65.61	14.62	8.04	8.04	7.31	17.34	0.00	0
1983	2/1/1983	430.63	13.04	58.95	17.61	7.26	7.26	7.50	17.34	0.00	0
1983	3/1/1983	393.30	16.87	7.33	5.87	8.04	8.04	9.74	20.13	0.00	1
1983	4/1/1983	365.77	18.39	0.83	0.66	7.78	7.78	10.74	16.35	0.00	1
1983	5/1/1983	348.30	22.06	0.86	0.69	8.04	8.04	9.74	14.64	0.00	1
1983	6/1/1983	337.06	22.72	0.83	0.66	7.78	7.78	8.09	11.87	0.00	1
1983	7/1/1983	331.29	27.44	0.86	0.69	8.04	8.04	5.85	10.04	0.00	1
1983	8/1/1983	334.14	40.45	0.86	0.69	8.04	8.04	4.98	8.29	0.00	1
1983	9/1/1983	352.79	21.74	0.83	0.66	7.78	7.78	5.59	8.93	0.00	1
1983	10/1/1983	351.55	13.21	0.86	0.69	8.04	8.04	7.31	11.43	0.00	1
1983	11/1/1983	337.10	15.54	38.84	25.50	7.78	7.78	7.47	11.36	0.00	0
1983	12/1/1983	300.00	19.72	55.91	0.00	8.04	3.34	6.84	9.54	0.00	0
1984	1/1/1984	300.00	19.82	65.61	0.00	8.04	0.09	7.31	12.42	0.00	0
1984	2/1/1984	300.00	16.07	58.95	0.00	7.26	0.00	7.50	13.34	0.00	0
1984	3/1/1984	297.61	20.23	7.33	0.00	8.04	0.00	9.74	16.60	0.00	0
1984	4/1/1984	295.80	22.72	0.83	0.00	7.78	0.00	10.74	14.16	0.00	0
1984	5/1/1984	296.89	20.43	0.86	0.00	8.04	0.00	9.74	13.12	0.00	0
1984	6/1/1984	297.29	15.15	0.83	0.00	7.78	0.00	8.09	10.86	0.00	0
1984	7/1/1984	296.78	20.33	0.86	0.00	8.04	2.12	5.85	9.22	0.00	0
1984	8/1/1984	300.00	22.87	0.86	0.69	8.04	8.04	4.98	7.43	0.00	1
1984	9/1/1984	301.75	11.70	0.83	0.00	7.78	0.01	5.59	7.85	0.00	0
1984	10/1/1984	300.00	8.84	0.86	0.00	8.04	0.00	7.31	10.20	0.00	0
1984	11/1/1984	295.67	14.07	38.84	0.00	7.78	0.00	7.47	10.81	0.00	0
1984	12/1/1984	295.79	11.28	55.91	0.00	8.04	0.00	6.84	9.54	0.00	0
1985	1/1/1985	295.40	25.41	65.61	0.00	8.04	1.24	7.31	12.42	0.00	0
1985	2/1/1985	300.00	12.67	58.95	0.00	7.26	0.00	7.50	13.34	0.00	0
1985	3/1/1985	295.91	17.28	7.33	0.00	8.04	0.00	9.74	16.60	0.00	0
1985	4/1/1985	293.52	15.25	0.83	0.00	7.78	0.00	10.74	14.16	0.00	0
1985	5/1/1985	292.06	17.08	0.86	0.00	8.04	0.00	9.74	13.12	0.00	0
1985	6/1/1985	293.28	34.82	0.83	0.66	7.78	7.78	8.09	10.86	0.00	1
1985	7/1/1985	300.91	51.23	0.86	0.69	8.04	8.04	5.85	9.59	0.00	1
1985	8/1/1985	328.32	60.78	0.86	0.69	8.04	8.04	4.98	8.38	0.00	1
1985	9/1/1985	367.41	12.20	0.83	0.66	7.78	7.78	5.59	9.14	0.00	1
1985	10/1/1985	356.33	10.88	0.86	0.69	8.04	8.04	7.31	11.53	0.00	1
1985	11/1/1985	339.41	14.85	38.84	27.05	7.78	7.78	7.47	11.39	0.00	0
1985	12/1/1985	300.00	2.93	55.91	0.00	8.04	0.00	6.84	9.54	0.00	0
1986	1/1/1986	293.27	3.51	65.61	0.00	8.04	0.00	7.31	12.42	0.00	0
1986	2/1/1986	288.64	0.00	58.95	0.00	7.26	0.00	7.50	13.34	0.00	0
1986	3/1/1986	284.11	0.00	7.33	0.00	8.04	0.00	9.74	16.60	0.00	0

1986	4/1/1986	279.25	27.15	0.83	0.00	7.78	0.00	10.74	14.16	0.00	0
1986	5/1/1986	291.16	23.28	0.86	0.00	8.04	0.00	9.74	13.12	0.00	0
1986	6/1/1986	295.95	40.52	0.83	0.66	7.78	7.78	8.09	10.94	0.00	1
1986	7/1/1986	309.20	72.67	0.86	0.69	8.04	8.04	5.85	10.06	0.00	1
1986	8/1/1986	357.84	141.69	0.86	0.69	8.04	8.04	4.98	9.74	0.00	1
1986	9/1/1986	477.25	92.07	0.83	0.66	7.78	7.78	5.59	12.13	0.00	1
1986	10/1/1986	543.81	5.35	0.86	0.69	8.04	8.04	7.31	16.30	0.00	1
1986	11/1/1986	516.48	4.42	38.84	1.04	7.78	7.78	7.47	16.52	0.00	0
1986	12/1/1986	487.71	5.17	55.91	1.07	8.04	8.04	6.84	13.95	0.00	0
1987	1/1/1987	462.69	5.74	65.61	4.71	8.04	8.04	7.31	17.26	0.00	0
1987	2/1/1987	430.63	4.50	58.95	9.07	7.26	7.26	7.50	17.34	0.00	0
1987	3/1/1987	393.30	5.19	7.33	5.87	8.04	8.04	9.74	19.88	0.00	1
1987	4/1/1987	354.09	51.34	0.83	0.66	7.78	7.78	10.74	16.54	0.00	1
1987	5/1/1987	370.01	58.44	0.86	0.69	8.04	8.04	9.74	16.02	0.00	1
1987	6/1/1987	394.40	75.05	0.83	0.66	7.78	7.78	8.09	14.26	0.00	1
1987	7/1/1987	439.29	133.25	0.86	0.69	8.04	8.04	5.85	13.87	0.00	1
1987	8/1/1987	545.33	190.37	0.86	0.69	8.04	8.04	4.98	13.56	0.00	1
1987	9/1/1987	709.88	88.33	0.83	0.66	7.78	7.78	5.59	16.27	0.00	1
1987	10/1/1987	768.40	8.24	0.86	0.69	8.04	8.04	7.31	21.53	0.00	1
1987	11/1/1987	738.76	7.64	38.84	31.07	7.78	7.78	7.47	21.65	0.00	1
1987	12/1/1987	677.63	7.65	55.91	44.73	8.04	8.04	6.84	17.66	0.00	1
1988	1/1/1988	607.14	7.68	65.61	52.49	8.04	8.04	7.31	20.73	0.00	1
1988	2/1/1988	524.85	3.33	58.95	47.16	7.26	7.26	7.50	19.59	0.00	1
1988	3/1/1988	445.12	4.85	7.33	5.87	8.04	8.04	9.74	22.07	0.00	1
1988	4/1/1988	403.33	46.03	0.83	0.66	7.78	7.78	10.74	18.25	0.00	1
1988	5/1/1988	412.10	50.01	0.86	0.69	8.04	8.04	9.74	17.30	0.00	1
1988	6/1/1988	426.59	47.61	0.83	0.66	7.78	7.78	8.09	14.76	0.00	1
1988	7/1/1988	443.13	47.87	0.86	0.69	8.04	8.04	5.85	12.97	0.00	1
1988	8/1/1988	463.70	265.08	0.86	0.69	8.04	8.04	4.98	12.81	0.00	1
1988	9/1/1988	704.46	444.20	0.83	0.66	7.78	7.78	5.59	19.04	0.00	1
1988	10/1/1988	1118.94	40.16	0.86	0.69	8.04	8.04	7.31	28.57	0.00	1
1988	11/1/1988	1114.46	12.60	38.84	31.07	7.78	7.78	7.47	28.79	0.00	1
1988	12/1/1988	1050.53	19.31	55.91	44.73	8.04	8.04	6.84	24.38	0.00	1
1989	1/1/1989	984.60	0.00	65.61	52.49	8.04	8.04	7.31	29.89	0.00	1
1989	2/1/1989	884.85	4.33	58.95	47.16	7.26	7.26	7.50	29.66	0.00	1
1989	3/1/1989	795.50	6.00	7.33	5.87	8.04	8.04	9.74	33.99	0.00	1
1989	4/1/1989	741.37	86.36	0.83	0.66	7.78	7.78	10.74	30.09	0.00	1
1989	5/1/1989	779.04	208.26	0.86	0.69	8.04	8.04	9.74	30.57	0.00	1
1989	6/1/1989	940.44	191.02	0.83	0.66	7.78	7.78	8.09	28.51	0.00	1
1989	7/1/1989	1087.89	148.19	0.86	0.69	8.04	8.04	5.85	26.19	0.00	1
1989	8/1/1989	1196.14	166.59	0.86	0.69	8.04	8.04	4.98	22.42	0.00	1
1989	9/1/1989	1327.33	560.85	0.83	0.66	7.78	7.78	5.59	16.03	504.73	1
1989	10/1/1989	1345.00	23.46	0.86	0.69	8.04	8.04	7.31	31.90	0.00	1
1989	11/1/1989	1320.35	8.49	38.84	31.07	7.78	7.78	7.47	32.34	0.00	1
1989	12/1/1989	1248.93	7.87	55.91	44.73	8.04	8.04	6.84	27.50	0.00	1

1990	1/1/1990	1168.51	8.21	65.61	52.49	8.04	8.04	7.31	34.10	0.00	1
1990	2/1/1990	1073.06	7.51	58.95	47.16	7.26	7.26	7.50	34.53	0.00	1
1990	3/1/1990	982.27	12.04	7.33	5.87	8.04	8.04	9.74	39.82	0.00	1
1990	4/1/1990	928.12	100.13	0.83	0.66	7.78	7.78	10.74	35.52	0.00	1
1990	5/1/1990	974.17	94.22	0.86	0.69	8.04	8.04	9.74	33.96	0.00	1
1990	6/1/1990	1016.47	79.77	0.83	0.66	7.78	7.78	8.09	28.89	0.00	1
1990	7/1/1990	1051.15	69.32	0.86	0.69	8.04	8.04	5.85	25.02	0.00	1
1990	8/1/1990	1081.10	96.05	0.86	0.69	8.04	8.04	4.98	20.69	0.00	1
1990	9/1/1990	1143.14	106.43	0.83	0.66	7.78	7.78	5.59	22.70	0.00	1
1990	10/1/1990	1213.28	12.16	0.86	0.69	8.04	8.04	7.31	29.87	0.00	1
1990	11/1/1990	1179.26	9.74	38.84	31.07	7.78	7.78	7.47	29.95	0.00	1
1990	12/1/1990	1111.34	9.08	55.91	44.73	8.04	8.04	6.84	25.33	0.00	1
1991	1/1/1991	1034.19	9.14	65.61	52.49	8.04	8.04	7.31	31.16	0.00	1
1991	2/1/1991	942.46	7.48	58.95	47.16	7.26	7.26	7.50	31.25	0.00	1
1991	3/1/1991	854.78	9.11	7.33	5.87	8.04	8.04	9.74	35.54	0.00	1
1991	4/1/1991	801.75	66.69	0.83	0.66	7.78	7.78	10.74	31.57	0.00	1
1991	5/1/1991	817.93	71.76	0.86	0.69	8.04	8.04	9.74	29.77	0.00	1
1991	6/1/1991	841.77	16.13	0.83	0.66	7.78	7.78	8.09	24.65	0.00	1
1991	7/1/1991	816.44	0.00	0.86	0.69	8.04	8.04	5.85	20.34	0.00	1
1991	8/1/1991	781.19	63.02	0.86	0.69	8.04	8.04	4.98	16.33	0.00	1
1991	9/1/1991	814.42	271.08	0.83	0.66	7.78	7.78	5.59	19.38	0.00	1
1991	10/1/1991	1053.96	0.00	0.86	0.69	8.04	8.04	7.31	27.10	0.00	1
1991	11/1/1991	1010.44	0.00	38.84	31.07	7.78	7.78	7.47	26.96	0.00	1
1991	12/1/1991	935.85	0.00	55.91	44.73	8.04	8.04	6.84	22.11	0.00	1
1992	1/1/1992	852.60	0.00	65.61	52.49	8.04	8.04	7.31	26.59	0.00	1
1992	2/1/1992	756.00	0.00	58.95	47.16	7.26	7.26	7.50	25.94	0.00	1
1992	3/1/1992	665.86	0.00	7.33	5.87	8.04	8.04	9.74	30.74	0.00	1
1992	4/1/1992	610.40	75.15	0.83	0.66	7.78	7.78	10.74	25.85	0.00	1
1992	5/1/1992	641.02	90.46	0.86	0.69	8.04	8.04	9.74	25.11	0.00	1
1992	6/1/1992	688.61	74.75	0.83	0.66	7.78	7.78	8.09	21.83	0.00	1
1992	7/1/1992	725.45	136.81	0.86	0.69	8.04	8.04	5.85	19.92	0.00	1
1992	8/1/1992	828.78	144.73	0.86	0.69	8.04	8.04	4.98	17.65	0.00	1
1992	9/1/1992	943.01	241.57	0.83	0.66	7.78	7.78	5.59	20.99	0.00	1
1992	10/1/1992	1151.04	19.34	0.86	0.69	8.04	8.04	7.31	28.93	0.00	1
1992	11/1/1992	1125.21	14.05	38.84	31.07	7.78	7.78	7.47	29.00	0.00	1
1992	12/1/1992	1062.53	18.71	55.91	44.73	8.04	8.04	6.84	24.58	0.00	1
		mean	704.69	232.56	134.24	94.61	81.96	91.14	255.60	151.26	0.80