Final Report

UNDP/ WORLD BANK/ GEF PROJECT
REVERSAL OF LAND AND WATER DEGRADATION TRENDS IN THE LAKE CHAD BASIN ECOSYSTEM

ENVIRONMENTAL AND SOCIAL RISK ASSESSMENT (ESRA)

(EVALUATION DES RISQUES ENVIRONNEMENTAUX ET SOCIAUX (ERES) DANS LE BASSIN DU LAC TCHAD)

Submitted to:

LAKE CHAD BASIN COMMISSION
COMMISSION DU BASSIN DU LAC TCHAD

Submitted by:

IMPACT ASSESSMENT, INC.
2166 Avenida de la Playa, Suite F
La Jolla, California 92037

July 17, 2006

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In Collaboration with:

Endangered Wildlife Trust

July 17, 2006

IMPACT ASSESSMENT, INC.

2166 AVENIDA DE LA PLAYA, SUITE F • LA JOLLA, CA 92037

TELEPHONE (858) 459-0142 • FACSIMILE (858) 459-9461 • E-MAIL IAI@SAN.RR.COM

July 17, 2006

Mr. Anada Tiega
Project Manager
LCBC/GEF Project
United Nations Office for Project Services (UNOPS)
CBLT / Siège
B.P.5019 N'Djamena, Chad

Re: Contract 00030954 (RAF/00/G31)

In accordance with the terms of the above contract with the United Nations Office for Project Services, we are submitting the enclosed Final Report entitled "Environmental and Social Risk Assessment in the Lake Chad Basin."

This report is intended to augment a broad range of studies undertaken in support of the GEF-sponsored program "Reversal of Negative Trends of Land and Water Degradation in the Lake Chad Basin Ecosytem: Establishment of Mechanisms for Land and Water Management."

The report argues that the Lake Chad Basin Commission must urgently adjust its perspective to the much larger, and more important, basin-level risks associated with global climate change. Relying on advanced GIS-based tools, we quantify the relative role and significance of locally versus globally-induced environmental changes, and provide a framework for measuring, understanding and integrating these social risks into the LCBC basin-wide planning process.

The report was originally scheduled for delivery on 31 May 2006. However, as a result of delays in entering the field, extended field work on additional tasks (e.g., inter-basin water transfer in Bangui, CAR and oil development in southern Chad), as well as a concerted effort to develop the underlying foundation for a long-term GIS-based risk monitoring program, the report is just now coming to conclusion. We hope you feel the additional time and effort has been warranted.

We wish to again acknowledge, and express our appreciation for, the guidance provided by you and your staff in the design and content of this research as well as the direct field and technical assistance provided during the course of our field work in Nigeria, Chad, Cameroon, and Central African Republic.

Many thanks for your past and continuing support on this important project.

Sincerely,

John S. Petterson, Ph.D.
President


10°E
15°E
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Libya
Algeria
Niger
Chad
Sudan
Lake Chad Hydologic Basin
Lake Chad
Lake Chad Conventional Basin
Nigeria
Cameroon
Central African Republic
Zaire
Impact Assessment, Inc.
Applied Social Science Research

Conclusion

While Africa has played only a minor historical role in the degradation of the planet's atmospheric shield, because of the delicate nature of human adaptations to the African environment, particularly its rainfall regime, it has nevertheless borne much of the brunt of the adverse consequences of global climate change and, as the process advances, can be expected to bear a disproportionate share of future impacts. Global climate change, taken in its entirety, dwarfs all other environmental issues combined, as the most profound environmental factor affecting the sustainable management of water and other natural resources of the Lake Chad conventional basin.

Acknowledgments

The members of the project team wish to express their appreciation for the opportunity to contribute toward the reversal of land and water degradation trends in the Lake Chad Basin ecosystem, and for the assistance of Lake Chad Basin Commission and UNOPS staff in performing this work.

The project, of necessity, was carried out under urgent and difficult conditions in Nigeria, Chad, Cameroon, and the Central African Republic. In addition to the two principal investigators, John Petterson and Charlie Wolf, who conducted the field interviews, and our collaborator Lars Soeftestad, and the kind assistance of the Endangered Wildlife Trust, we must commend the exceptional effort and long hours of analysis undertaken by Rusty Scalf, the project GIS and data management expert responsible for the analytic graphics, measurements, and population growth and distribution projections, on which our conclusions are based. Finally, our special thanks to Cody Petterson, whose relentless attention to content, narrative arc, and editorial detail, gave the report its coherence, readability, and broader utility.

Over 80 in-depth interviews were carried out over the field period, drawing on the unique expertise and experience of government representatives, faculty and issue experts, engineers, water managers, community leaders, farmers, herdsmen, fishermen (and fisherwomen), in addition to our guides and security detail, who were constant sources of insights large and small. Each is owed special thanks for their assistance in furthering the purposes of our research.

We are likewise indebted to the many authors who preceded us in this work and on whose works we have freely drawn.

ABBREVIATIONS AND ACRONYMS

AMCEN	African Ministerial Conference on the Environment
CAR	Central African Republic
CAZS	Centre for Arid Zone Studies, University of Maiduguri
CILSS	Permanent Interstate Committee for Drought Control in the Sahel
DRC	Democratic Republic of Congo
DSS	Decision Support System
EA/SA	Environmental Assessment and Social Assessment
EIA	Environmental Impact Assessment
ESRA	Environmental and Social Risk Assessment
EU	European Union
EWS	Early warning system
FAO	Nations Food and Agriculture Organization (UN)
FRN	Federal Republic of Nigeria
GEF	Global Environment Facility
GIS	Geographical Information System
IAM	Impact Assessment Model
IFAD	International Fund for Agricultural Development (FAO)
IUCN	The World Conservation Union
IWRM	Integrated Water Resources Management
KYB	Komadugu-Yobe Basin
LADA	Land Degradation Assessment in Drylands (FAO)
LCB	Lake Chad Basin
LCBC	Lake Chad Basin Commission
LCBD	Lake Chad Basin Database
LCBM	Lake Chad Basin Model
MAB	Man and the Biosphere (UNESCO)
MDGs	Millennium Development Goals
NAP	National Action Program (GEF)
NGO	Non-Governmental Organization
OECD	Organization for Economic Cooperation and Development

SAP	Strategic Action Plan
	Strategic Action Programme
SEA	Strategic Environmental Assessment
SafMA	Southern African Millennium Assessment
SIA	Social Impact Assessment
TDA	Transboundary Diagnostic Analysis (GEF)
ToR	Terms of Reference
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNOPS	United Nations Office of Project Services
UNSO	United Nations Sudano-Sahelian Office
USAID	United States Agency for International Development

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EXECUTIVE SUMMARY

STUDY GOALS AND OBJECTIVES

The mission of the Lake Chad Basin Commission (LCBC), and its member states, is the concerted integrated sustainable management of water and other natural resources of the Lake Chad basin. The goal of the ENVIRONMENTAL AND SOCIAL RISK ASSESSMENT OF THE LAKE CHAD CONVENTIONAL BASIN is to assist the LCBC in meeting this mandate. The objectives of the report are to: (1) identify potential environmental and human-induced risks to the agricultural, pastoral, and fisheries resources of the basin; (2) identify environmental risks, and the nature of those risks, to long-term water supply at the level of the basin and its sub-basins; and (3) offer recommendations and guidance on long-term resource management policies and priorities at the basin level.

In order to achieve these objectives, this report provides the LCBC with an operational framework for understanding and evaluating the relative importance of environmental and human contributions to the present and future water resources regime of the conventional basin.[1] The resulting framework, in turn, is designed to facilitate integrated analysis of information, at varying levels of detail from local to regional, and across a broad range of social and environmental variables.

The present report builds upon and expands in key areas, the analysis, findings, and conclusions of previous research undertaken by or on behalf of the LCBC. Foremost in importance, from the perspective of the present study and Terms of Reference, is the work entitled "Lake Chad Conventional Basin: Diagnostic Report." This report was well conceived, thorough, and most importantly, highly defensible on the basis of the scientific understanding of the late 1980s. It carefully details what continue to be the issues of principal concern to the LCBC and residents of the Lake Chad sub-basins. While many of these issues are being addressed in some fashion, at local, national, and regional levels very few have been entirely resolved. The authors conclude, correctly we believe, that:

> There is nothing that can be done about the rain. Thus a major concern is more efficient use of rainfall by reducing windspeed across farms, increasing infiltration, reducing ground temperature with shade plants increasing ground humidity, and reducing evaporative losses on reservoir surfaces and irrigated fields. The major

[1] The Lake Chad water basin is a terminal depression consisting of portions of eight countries (Chad, Niger, Nigeria, Cameroon, Central African Republic, Sudan, Libya and Algeria), with a total of 2,381,635 km^2 of shared drainage. This area represents approximately 8% of the total land mass of Africa. The Lake Chad Basin Commission, formed in 1964, was mandated to promote the "most rational use of water, land and other natural resources" with responsibility for helping to coordinate member activities within the so-called "conventional basin." The initial conventional basin consisted of approximately 20% (427,500 km^2) of the total area of the Lake Chad basin (i.e., it excluded the majority of the terminal depression consisting of desert that provides little or no effective hydrological contribution to the conventional basin). The conventional basin was subsequently expanded to include additional watersheds in northern Nigeria, southern Chad, and northern Central African Republic, with a current total area 967,000 km^2 (see Frontispiece). Lands within the Chad portion of the conventional basin represent approximately 36 percent (361,980 km^2), Cameroon 6 percent (56,800 km^2), Niger 17 percent (162,375 km^2), Nigeria 19 percent (188,000 km^2), and Central African Republic 22 percent (197,800 km^2) of this total land area

> channel flow concerns are insured instream flows for fisheries and the lake; adequate flooding to supply "natural" irrigation to floodplain pastures, fish breeding sites, agriculture and forest regeneration; and adequate flows to insure the recharge of groundwater. Major groundwater concerns are overexploitation of groundwater and possible land subsidence from overexploitation; conjunctive use rules that reserve groundwater for the drier type-years; sustained yields from rechargeable urban water supply and urban water conservation are increasing crucial.

These solutions, at the level of sub-basins, communities, and individual farmers and herders continue to offer the best short-term options for addressing pressing immediate local concerns. In light of important changes in scientific understanding since publication of the Diagnostic Report, however, we believe the Lake Chad Basin Commission must now adjust its perspective to the much larger, and more important, basin-level risks associated with global climate change. While it is true that "nothing" can be done about the rain, it is also true that something must be done at national and international levels in anticipation of long-term declines in the region's water resource regime.

The Diagnostic Study recognized the complexity of problems affecting the Lake Chad conventional basin:

> The diversity of ecological and water resource conditions within the basin prevents easy, conclusive generalities about the impacts of drought, human activities, and environmental degradation. Economic production, drought, land tenure policies, diseases and pests, allocation of national and donor funds, ethnic traditions, governmental organization, family planning, urban/rural migrations, and civil unrest all intertwine to create a complex picture of locally diverse situations.

We have the advantage today, however, of tools designed with the specific function of analyzing such complexity across different geographies, across a broad range of environmental and social variables, across a lengthy period of time, and into the future. We have utilized these tools in the present effort to quantify the relative role and significance of locally versus globally-induced environmental changes, and to provide a framework for understanding and integrating these social risks into the LCBC basin-wide planning process.

Finally, in addition to the task identified in the Terms of Reference, we were requested to carry out a preliminary review and evaluation of two additional issues: (1) the actual or potential social effects of the Chad pipeline and future oil development scenarios; and (2) the general perspectives of, and potential prospects for, the proposed Inter-basin Water Transfer Project now under consideration between the Oubangui river and the Lake Chad basin involving the construction of a hydroelectric dam and water pipeline system connecting the two basins.

CONCLUSIONS

We begin with the conclusions of our analysis. First, the dominant source of past and future social risks to populations of the Lake Chad conventional basin results from the intersection of accelerating global climate change and accelerating population growth. These global environmental changes, we now know, derive primarily from the human extraction, processing, and partial consumption of naturally occurring hydrocarbons (e.g., primarily in the form of oil, gas and coal). While Africa has played only a minor historical role in the degradation of the planet's atmospheric shield, because of the delicate nature of human adaptations to the African environment, particularly its rainfall regime, it has nevertheless borne much of the brunt of the adverse consequences of global climate change and, as the process advances, can be expected to bear a disproportionate share of future impacts. Global climate change, taken in its entirety, dwarfs all other environmental issues combined, as the most profound environmental factor affecting the sustainable management of water and other natural resources of the Lake Chad conventional basin.

The principal local and regional contribution to land degradation, habitat destruction, pollution, and so on, derives from accelerated local and regional population growth. The increasingly adverse influence of human activities on local environments differs according to the specific components of the different local ecosystems (or sub-basins) that make up the conventional basin. Coe and Foley (2004), in a study prepared for NASA, determined that Lake Chad's volume had declined between 1966 and 1975 by approximately 30 percent (see also Exhibit 0-1). They calculated that irrigation and river water diversions accounted for only 5 percent of the decline, with declining rainfall accounting for the remaining 95 percent. As population expanded, and as increasingly marginal lands were brought into production, irrigation demands would increase four-fold between 1983 and 1994, accounting for 50 percent of the subsequent decrease in lake volume. Population of the conventional basin has subsequently increased by nearly 10,000,000 inhabitants (a 30 percent increase) between 1994 and 2004. These two intersecting trends, rapid population growth and declining rainfall, represent the principal problem facing the future of the Lake Chad conventional basin.

While it may remain open to question whether the pace of climate change or population growth will represent the greater of the two threats to human adaptation to the changing water regime of the Lake Chad conventional basin, it is our conclusion that population growth will eventually outpace environmental change as the leading risk factor for the future of the basin. Vulnerability, as measured in relation to both chronic and acute events, continues to increase throughout the Sahel – if for no other reason than the dramatic increases in population at the environmentally precarious margin between sufficient and insufficient rainfall to support rain-fed agriculture (as opposed to irrigated). In this environmental and social risk assessment we examine how changes at the margin of human adaptation represent the best early warning system for future environmental and social change in the Lake Chad conventional basin.

A social/geographic vulnerability analysis was carried out to identify the range and relative significance of the environmental and social variables affecting the ability of population groups within the conventional basin to respond to an abrupt environmental disruption (e.g., a major drought). The assessment considered the contribution of a various environmental factors to social vulnerability. Among the environmental variables considered in this analysis was the contribution of globally-induced changes in rainfall quantity, duration, distribution, and variability, wind and sand storms, and both intentional and natural fires, to social vulnerability.

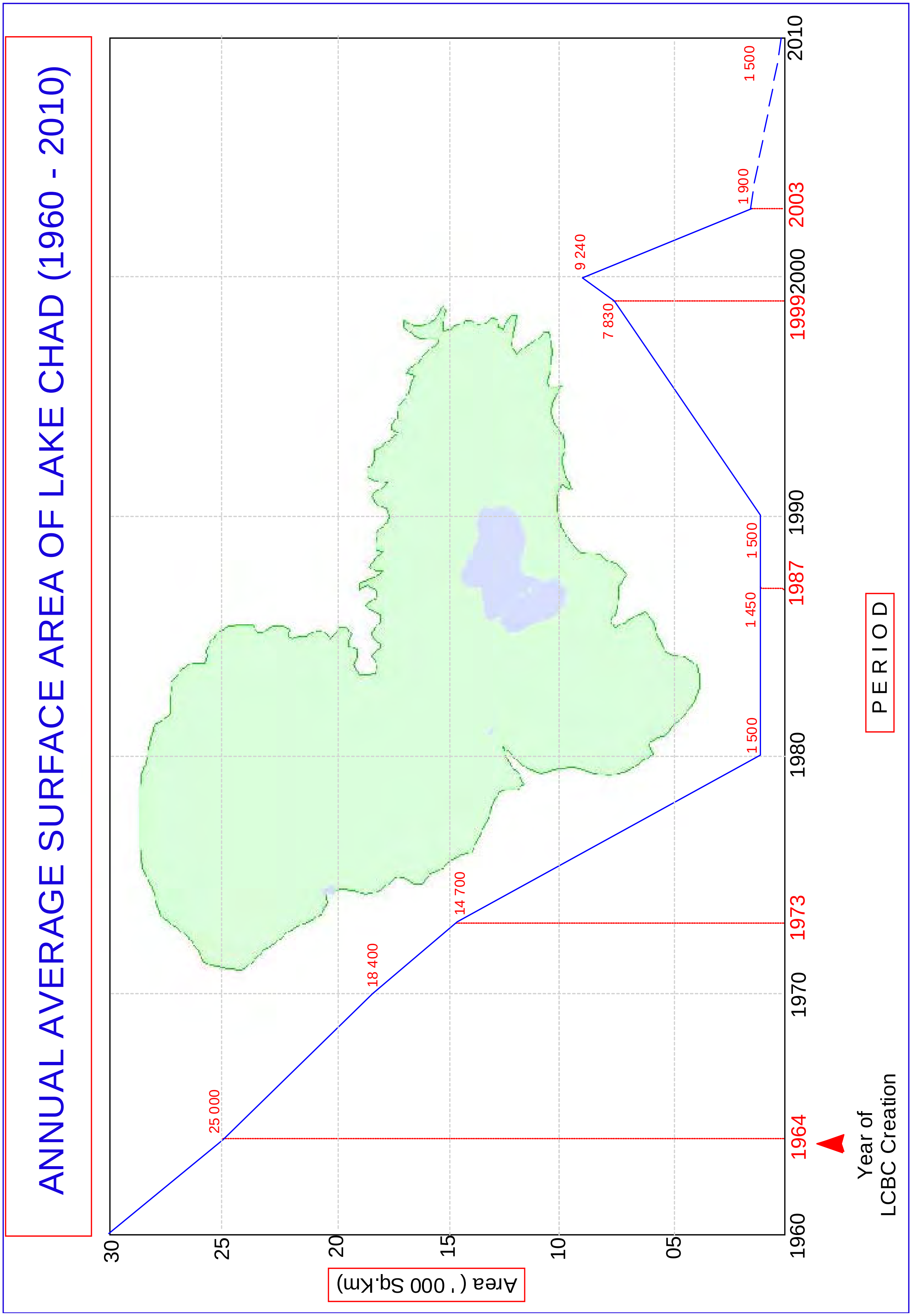

ANNUAL AVERAGE SURFACE AREA OF LAKE CHAD (1960 - 2010)
Area (' 000 Sq.Km)
30
25
20
15
10
05
1960
1964
1970
1973
1980
1987
1990
1999
2000
2003
2010
25 000
18 400
14 700
1 500
1 450
1 500
7 830
9 240
1 900
1 500
P E R I O D
Year of
LCBC Creation

Exhibit 0-1

The assessment also considered the role of a broad range of social variables affecting the sensitivity of different populations to environmental risk. Among the social variables considered were the following: (1) continued accelerated population growth; (2) economic disparities (poverty); (3) indicators of wellbeing/security; (4) agricultural dependency ratios; (5) male-female ratios; (6) male-female agricultural involvement; (7) language boundaries; (8) national boundaries; (9) cultural boundaries; and (10) persistent low-level and sometimes outright conflict within and among the member nations of the LCBC.

It is also important to note that the environmental and social vulnerabilities described in this analysis will not be recognized, or appreciated for their severity, under a sequence of gradual, incremental, changes – i.e., changes that occur slowly over a period of decades. In fact, if gradual change could be assured, there would be little need to conduct a social vulnerability analysis except to show the disproportionate burden assumed by particularly sensitive populations, minorities, children, women, the disabled, and so on. Gradual, measured, predictable, environmental changes are of relatively minor concern to this analysis. The principal purpose of this analysis of environmental and social risks is to highlight the source and likely consequence of a broad range of environmental and social vulnerabilities in the event of continued acceleration of risk components, and, more particularly, in anticipation of future acute events (such as floods, droughts, channel flow and mid-season rainfall disruptions, and famines).

This report, while it identifies and characterizes individually the environmental and social risks affecting the conventional basin, is intended to sound a particular alert with respect to the impeding, and almost certain to occur, environmental catastrophe in the Lake Chad conventional basin. The history of the Sahel is one of frequent and extended droughts, intensive flooding, and widespread famines. While many of the factors that have contributed to the scale and scope of these past droughts have been mitigated – more wells have been drilled, more roads constructed, more efficient national and non-governmental food distribution systems established – many risk factors continue to accelerate.

Recommendations for environmental and social management can be summarized to the following interventions:

- Address system holistically, encompassing ecological components and key social stressors as an integrated system using an SEA approach;

- Reduce full integrated system to functioning sub-systems for ease of management interventions, but not to individual component levels, which leads to unforeseen additional problems;

- Do cumulative impact assessments on interventions to determine indirect consequences;

- Set realistic targets for the desired state of ‘optimal’ system functioning (e.g. fisheries output/productivity) to be achieved incrementally in both time and geographic space;

- Establish ‘base-line’ or ‘ecological reserve’ limits beyond which the system cannot function and make provision for automatic management interventions to be invoked where such limits are approached;

- Address interventions at both local site-level scale and catchment scale e.g. for land restoration and re-vegetation, starting in the headwaters on a hectare by hectare basis but incentivized by changes in macro-policies;

- Simultaneously address political and governance structures at the highest levels (e.g. the harmonization of regional regulations and enforcement measures such as institutional capacity to enforce minimum net mesh size in all LCCB countries) as well as local level incentives such as PES;

- Establish a monitoring and evaluation system based on an information system for which data can be readily collected and analysed at two levels—ecological integrity and management processes, impacts and outcomes.

0. CONCEPTUAL FRAMEWORK

The assessment process begins with the construction of an environmental framework for analysis – at the global and regional level. What are the paramount past, present, and future influences of global scale climatic change on North Africa and the Lake Chad Basin? What is the relative pace of these global changes, and their long-term implications for managing water resources in the Basin? We look first at the influence of changes in rainfall regime, temperature increases, processes of desertification, wind velocity increases and wind-borne carrying capacity, water content declines, soil erosion, and so on. These environmental influences are expected to persist into the distant future, and are not subject to significant influence at the community, national, or even basin level. They represent the background or foundation against which human contributions and human consequences are to be considered. In order to begin our assessment, we must therefore have a clear understanding of the predominant historical trends, primarily rainfall trends, as well as a firmly-based projection of future change.

As noted by Coe and Foley, local human irrigation and other water uses accounted for approximately 5 percent of the lake level decrease experienced between 1966 and 1975, and approximately 50 percent for the period 1983 and 1994. By all measures, human water use patterns, primarily irrigation and consumption, currently represent the dominant source of human-induced environmental degradation in the basin. Equally importantly, the role of humans in this equation is certain to increase in parallel with increases in population. Thus, the principal question that must be addressed in constructing the social framework of this assessment is "How will recent and anticipated patterns of population growth, in the form of water consumption demands (urban vs. rural, agricultural versus livestock, etc.), intersect with natural decline in water resource availability and the errors and successes of past man-made water management interventions?" In order to understand and to accurately predict the form and consequence of this intersection, we must build an accurate historical record and understanding of population growth and distribution, current population characteristics, and future population projections. To ensure consistency, a careful characterization of past population growth was reconstructed for the currently recognized "conventional basin" (the geographic frame of reference utilized throughout the report) in order to consider the interaction of environmental and social trends. In order to understand the effects of future global climate change, we assembled the history of past climate events and constructed a trajectory of future environmental change in the basin.

0.1 Introduction

The LCBC goal is to determine how best to ***reverse land and water degradation trends in the Lake Chad Basin extending over the past forty years***. As the authors of the *Diagnostic Study* (Kinder and others 1989: 2) point out, however, “The diversity of ecological and water resource conditions within the basin prevents easy, conclusive generalities about the impacts of drought, human activities, and environmental degradation.”

Let us state at the outset that the terms and conditions of the present project are such as to preclude reaching definitive answers to this leading question and its ramifications contained in the terms of reference (ToR). A synthesis of such tentative answers as can be offered is presented in sections of this main report. It is amplified and annotated in a lengthy series of annexes representing some directions for the further improvement of knowledge relevant to the present project and overall LCBC/GEF ecosystem program.

Ideally, the results of this project would be theory- and evidence-based. As it happens, that cannot be achieved in the present state of knowledge, and there is good reason to believe that such attempts represent a fallacy of misplaced precision. According to Holling and his associates (1978), the true aim should rather be to develop a process of adaptive management that can promote system resilience in adapting to inherently uncertain and unpredictable futures.

In fact, the essence of risk assessment is decision making under conditions of uncertainty stemming from imperfect knowledge and imprecise application. Moreover, the social learning approach adopted here would regard such answers as misguided and mischievous. Rather, it prescribes a "co-evolutionary" process of cooperative and collaborative learning involving all potentially affected and interested parties throughout the project, the program, and beyond.

By design, the ESRA project represents only an initial step in this ongoing process. Unlike the forthcoming stakeholder analysis and pilot projects, ESRA is primarily a desk study, for which abundant information resources exist despite critical lacks and gaps in available data. In the process of surveying these materials, some key issues and options have emerged that may prove useful in framing the Transboundary Diagnostic Analysis (TDA) and Strategic Action Programme (SAP) and in facilitating their implementation in future projects.

The Terms of Reference (ToR) provide the natural point of departure for the study. The structure of this report parallels the order of topics presented there, followed by a summary of findings and recommendations.

0.2 Section Synopsis

Following are brief summaries of the section contents.

1. Background

   The background section provides some basic information on the environmental and institutional histories relevant to the present project, and on the project itself.

2. Objective of the Study

   Statements of the objective are reviewed, together with their expression in the project's ToR. The substantive focus of the project embodies this objective and provides guidance for parameters for operationalizing the ESRA project.

3. Methodology

   Three complementary methodological approaches for the ESRA project are introduced: ecosystems, social learning, and integrated impact assessment. The latter can be characterized by two pairs of terms: "comprehensive and integrated" and "proactive and creative." An operational methodology for integrated impact assessment is outlined in the Impact Assessment Model and Main Pattern schema, applied to risk assessment methodology.

4. Application to ESRA

This section applies the methodology described in Section 3 to the substantive focus of the project. A more systematic treatment is outlined and initiated in the annex volume that accompanies this report.

The ToR directs attention to seven sectors:

- Climatic & Atmospheric Change
- Land Transformation
- Sustainability of Freshwater Systems & Resources
- Social Environment and Health
- Economic Environment
- Political Environment
- Natural Resources Sustainability, Biodiversity, Integrity, Productivity

For present purposes these will be clustered in two main categories, environmental and social, and will be interpreted as components of environmental and social systems and conditions.

Naturally there are numerous intersections and interactions between the two sets; a major concern of the project is to trace and map these linkages.

The ToR further calls for consideration of three cross-sectoral topics:

- Monitoring and Evaluation
- Decision Support Framework
- Adaptive Management

These converge in the context of Lake Chad Basin (LCB) in the concluding subsection, on regional assessment.

5. Results

This section offers a summation of the project's findings, implications, and recommendations and how they can be exploited in further advancing the LCBC/GEF ecosystem program.

0.3 Annex Volume

Although this report has been drafted as a stand-alone document, a lengthy series of annexes has been added to provide greater detail and depth:

- The first three annexes parallel the corresponding main report sections (Background, Objectives, Methodology);
- Annex 4 is an ESRA scoping report;
- Annexes 5-8 explore and apply the Impact Assessment Model introduced in Section 3;
- Annex 9 outlines a process for integrating this content in a basin-wide framework;
- Annex 10 draws some further implications from the ESRA exercise; and
- Annex 11 illustrates a resource inventory for possible systematic development.

The annexes serve as a first approximation of a comprehensive and integrated knowledge base to inform and guide regional assessment and management of the Lake Chad Basin.

Archives of supporting documentation have also been compiled, including the field trip report, a clipping file, a bibliographic database, a register of completed, ongoing, and proposed projects, and Internet downloads.

1.0 BACKGROUND

The section provides some basic information on the environmental and institutional histories relevant to the present project, and on the project itself.

1.1 Environmental History

1.1.1 ENVIRONMENTAL AND SOCIAL SYSTEMS

A distinction is often made between environmental and social systems, or between "nature" and "culture." Indeed, social systems have been residually defined as those whose existence cannot be explained by reference to human heredity and the non-human environment (Levy, Jr. 1966).

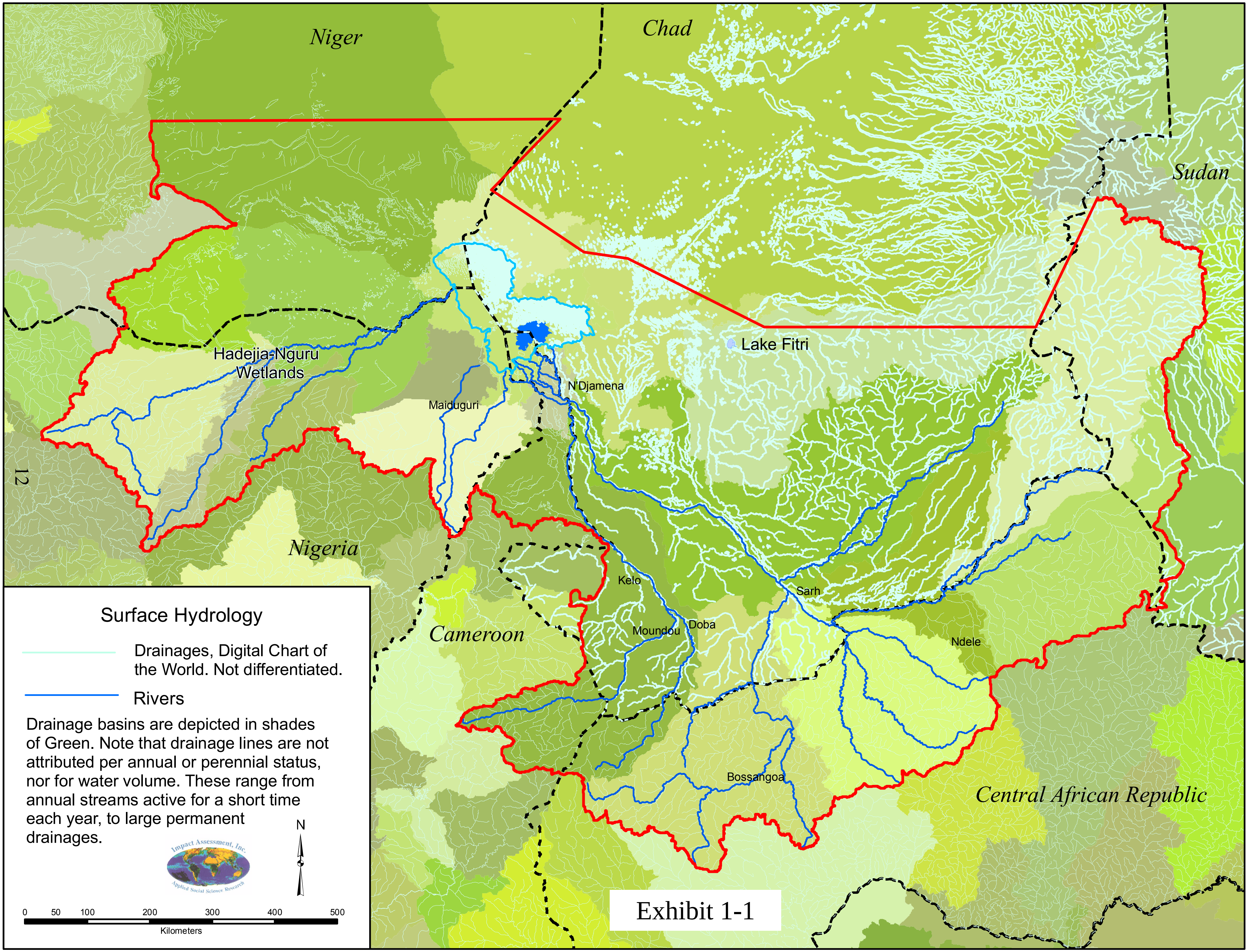
Nevertheless, it is obvious that human survival depends fundamentally on continuous and consistent access to environmental resources and services. Equally, it is evident that human activity may impact those very resources and services in ways that are clearly unsustainable.

Understanding these relations and responding to their demands is an abiding concern everywhere in the world. In fragile and marginal areas such as Lake Chad Basin, that concern has become urgent. For this reason, tracing and mapping systemic linkages between environmental and social systems is a central focus of this project.

1.1.2 THE NATURAL ENVIRONMENT

The natural setting of the LCBC/GEF project centers on the lake and its surrounding wetlands (see Exhibit 1-1):

> Lake Chad is Africa's fourth largest lake, the largest in Western and Central Africa. Its basin constitutes an important freshwater source shared by Cameroon, the Central African Republic (CAR), Chad, Niger, Nigeria, and Sudan. The lake is fed by the Chari River, which flows northward from the highlands of CAR through to southern Chad, supplies approximately 95% of the lake's surface water input. Likewise, the Komadougou-Yobe surface water system which flows from northern Nigeria into Chad, is considered to be of minor significance to the whole of the basin, yet locally significant to the northern reaches of the Lake Chad wetlands. The lake is shallow, with an average depth of 1.5 meters, and is of relatively small volume. The lake is subject to considerable evaporation and yet is not saline. (Africa Region 2002: 1)


Niger
Chad
Sudan
Lake Fitri
Hadejia-Nguru Wetlands
N'Djamena
Maiduguri
Nigeria
Kelo
Sarh
Moundou
Doba
Ndele
Cameroon
Bossangoa
Central African Republic
Surface Hydrology
Drainages, Digital Chart of the World. Not differentiated.
Rivers
Drainage basins are depicted in shades of Green. Note that drainage lines are not attributed per annual or perennial status, nor for water volume. These range from annual streams active for a short time each year, to large permanent drainages.
Impact Assessment, Inc.
Applied Social Science Research
N
0 50 100 200 300 400 500
Kilometers
Exhibit 1-1

The total inflow (which includes tributaries from Cameroon, Chad, and Nigeria), however, is extremely variable, ranging from a high of 54 km3/year (1955/56) to low of 7 km3/year (1984/85). The flow from the Chari River originates in a tropical water regime (i.e., single annual flood events), primarily from northern Central African Republic, and extend from the end of the rainy season in August through November. The flow from the Logone River, formed by the Mbéré River and its tributary the Vina, originating in northeastern Cameroon and southern Chad, and the Pendé of northwestern Central African Republic, join the Chari just above N'Djamena, passing the remaining 400 km to the remaining southern surface waters of Lake Chad.

It was near conjunction the confluence of the Mayos, Tsanaga and Boula rivers, in 1979, that Maga dam was constructed, forming Lake Maga. The waters, when released, then continue to flow north, passing into the Waza-Logone (Yaéré) flood plain (estimated at 8,000 km^2) where efforts are underway to remedy problems created by the construction and operation of Maga dam in 1979. Operation of the dam resulted in a substantial reduction of the flood plain flooding and an abrupt decline of available surface water during the dry season. The impact was profound on the area's inhabitants (estimated at 100,000 today), particularly in the area of the Waza National Park and UNESCO Biosphere Reserve, where it led to partial evacuation of the flood plain, reduction in biodiversity, removal of large tracts of agricultural and pasture lands, and decline of the local fishery. The area continues to supply approximately 2,000 tons of fish, and remains the seasonal destination for herders with an estimated 100,000 head of cattle residing in the area during the dry season.

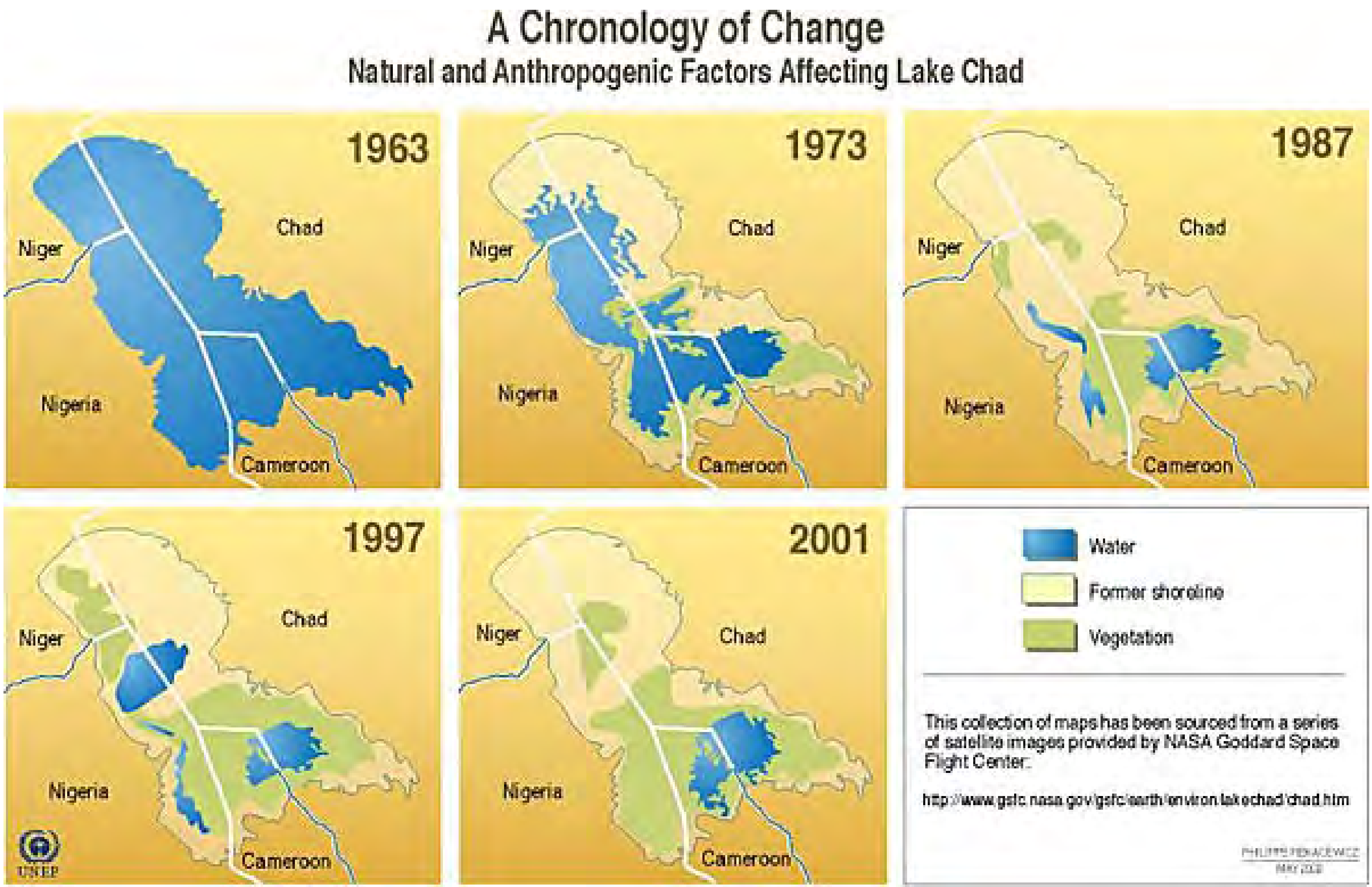
Although the most pronounced feature of the Lake Chad Basin is the presence of "wetlands in drylands" (see Woodhouse, Bernstein, Hulme, and others 2001) by far the largest area is comprised of drylands in varying degrees of aridity, from desert to savanna. Hence drylands should be very much within the scope of study. On the other hand, both human and wildlife populations and communities are concentrated in wetland areas. Again, however, those areas contain a wide variety of environmental conditions, from upstream irrigated agriculture to seasonally flooded riverine wetlands to open lake aquatic.

Not only is there great diversity in environmental conditions, there is also an unusually wide range of natural variation. The implication is that an environmentally sensitive—and socially acceptable—basin-wide development plan must accommodate and adapt to a wide diversity of ecosystems and conditions.

The natural history of the region will be considered in regard to its geology, climatology, hydrology, and ecology, including human ecology. Climate history is of particular interest in light of recent and recurrent droughts and resulting famines, although there are strong opinions held that those are properly ascribed to political rather than climatic conditions. Some environmental issues here are not only what is "natural" but also what is "normal"—whether there is an identifiable "normal" rainfall pattern.

According to the Terms of Reference (ToR, p. l), "The shift in rainfall regimes in the southern Sahel since the late 1960s has resulted in generally lower rainfall with the corresponding reduction in the open water area of the lake." A chronology of recent changes in Lake Chad's surface area is shown in Exhibit 1-2.

Exhibit 1-2



A Chronology of Change
Natural and Anthropogenic Factors Affecting Lake Chad
1963
1973
1987
1997
2001
Niger
Chad
Nigeria
Cameroon
UNEP
Water
Former shoreline
Vegetation
This collection of maps has been sourced from a series of satellite images provided by NASA Goddard Space Flight Center:
http://www.gsfc.nasa.gov/gsfc/earth/environ/lakechad/chad.htm

The ToR continues,

> The problems of land and water degradation in the basin are now widely recognized and the Lake Chad Basin Commission (LCBC) has already identified a number of transboundary issues. The five member states (Cameroon, the Central African Republic, Chad, Niger and Nigeria) have agreed on an initial Strategic Plan for the sustainable development of the Lake Chad basin. (ToR, p. 1)

The transboundary issues ("threats"; LCBC 1998: 3) are identified as follows:

1. mistakes in allocating water resources and their consequences on the ecosystems downstream.
2. the formation of spirals of degradation, with the consequences of harmful action aggravating the production of causes.
3. the accentuation of conflicts linked with more acute competition for limited resources.
4. upsetting the balance of aquatic ecosystems and the appearance of new types of environmental degradation.
5. a possible extension of pollution from the intensive exploitation of mining and oil resources.
6. discouragement of the population if all players are not informed now and do not participate from the outset in implementing sustainable solutions.

The 1992 Master Plan contains a similar list (Exhibit 1-3). All of these refer to systemic linkages between natural and social environments, and behind them all are social histories.

Exhibit 1-3. Main Causes of Environmental Problems in the Lake Chad Basin

MAIN CAUSES	CHARACTERISTICS
Climatic Causes	
1. Change in rainfall conditions in the Sahel over the past 24 years (decrease in annual mean rainfall)	A tendency to underestimate the question and its effects. Insufficient multidisciplinary forecasting studies concerning rainfall/human activities/water resources/desertification. Ignorance of equilibrium thresholds of ecosystems, and limits of human ability to adapt to change. Poor collective memory and abandonment of measuring networks.
Human Causes	
Ill-adapted development policies focused on the short term	
2. Unsustainable development decisions	Failure of development strategies (including health) in rural areas. Absence of long-term views of regional development: absence of integrated development strategies for international basins. Several large projects started without producing the expected benefits but seriously disturbing downstream conditions on the rivers, ecosystems and floodplains (Yaêrês). Agricultural and industrial policies geared towards production quantities and likely to become unsustainable.
Unsuitable or non-existent water and environmental management policies	
3. Bad water management practices and unsuitable production methods.	Too little value accorded to water and the environment (considered as non-productive) in economic policies. Very poor knowledge of water resources and ecosystems. Poor measurement of water demand (unsuitable tariffs, etc.). Absence of economic instruments and incentive measures. Absence of financial resources adapted to local initiatives. Poorly adapted production and consumption methods. Absence of control, warning and protection facilities. Absence of preparation to adapt to an emergency situation.
Means of coordination with limited impact	
4. Low level of player participation. Institutions unsuitable	Failure to take participation into account. Regional cooperation in line with central policy. Absence of regional policy for managing sub-basins. Lack of coordinated international laws for the region (mines, oil, agricultural pollution, wetlands, etc.). Poor inter-sector coordination in each country. Lack of public information concerning water and ecosystems. Weakness of local institutions, public, private and associations.
Persistent poverty of rural populations	
5. Poverty, which results in damage to the environment	Insufficient productive activities and jobs in rural areas. Deep poverty of people who exploit natural resources (water, soil, wood, fauna, etc.) for their short-term survival. Deterioration of ratio between resources and population, insecurity, desertification, towards towns; poverty and pollution both increase.

Source: LCBC 1998: 4

1.1.3 THE HUMAN ENVIRONMENT

The *Strategic Action Plan* (p. 4) also identifies the main causes and characteristics of environmental problems within Lake Chad Basin, displayed in Exhibit 1-3, in which "human causes" predominate. According to the ToR (p. l),

> In parallel with the change in rainfall patterns, human populations continue to increase rapidly, putting additional pressure on natural resource systems. By the year 2020, the population that depends on the lake and its associated resources is projected to reach 35 million. Throughout the basin there are now indications of unsustainable land use, uncontrolled cutting of trees for fuel wood or construction purposes, and little or no sound management fisheries. The reduction in surface water sources in Lake Chad basin has intensified groundwater abstraction for domestic and industrial supplies and there are already indications that extraction rates may be exceeding recharge. Large irrigation schemes established in the 1970s and '80s in the four countries bordering the lake are now largely non-functional.

The human environment is comprised of a population distributed across the area in various settlement patterns and livelihood pursuits using natural resources for their sustenance. These inhabitants are organized according to various cultural patterns and practices and mobilized to collective action, clustered in institutional patterns, to meet functional needs for survival and solidarity.

1.2 Institutional History

Social institutions exist and evolve in all functional areas required for human welfare, notably economy and polity, community and culture. Formal institutional organizations emerge to direct and coordinate the activity of their members. Of particular interest to this project is the Lake Chad Basin Commission (LCBC).

1.2.1 LAKE CHAD BASIN COMMISSION

The year before it's founding, 1963, was the modern peak year for the lake's water level, in marked contrast to the conditions now prevailing. At that time, shortly after gaining independence, ambitious schemes were in preparation to divert the lake's waters for extensive irrigation agriculture. In that time of relative abundance, potential conflicts over division of the lake's waters seemed imminent.

With the encouragement and assistance of international development agencies such as the United Nations Development Programme (UNDP), the bordering states (later joined by the Central African Republic because of its upstream watersheds) (see Exhibit 1-4) entered into a Convention "to exploit the waters of the Lake Chad basin for the well-being of the people concerned." The Convention follows closely the customary law of international waters (Hirsch and Housen-Couriel 1996: 130-31) in its recognition of:

- The principle of limited territorial sovereignty, which prescribes that no member state is permitted to utilize Lake Chad waters in a way that will cause significant harm to their utilization by other riparians;

- Each member state is entitled to an equitable and reasonable share of the water resources according to the standards of international customary law;

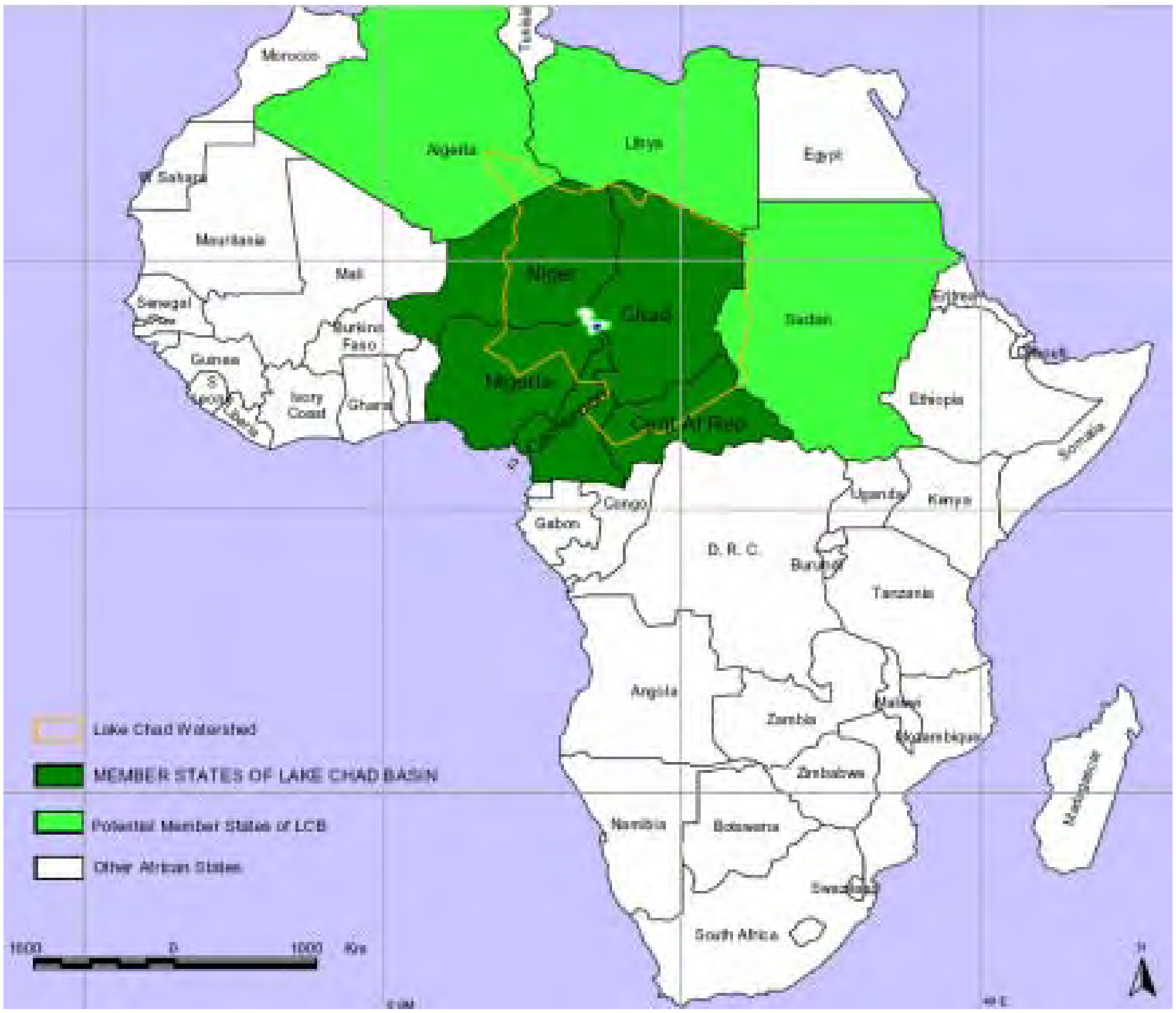
- A member state planning a utilization project must notify other riparians and negotiate with them in good faith in order to ensure their equitable share in the waters;

- The most efficient and equitable division of the benefits accruing from utilization of the lake's waters can be achieved only by an international treaty between all parties; and

- Such a future agreement should address issues such as apportionment, water quality, monitoring, technical and scientific cooperation, and settlement of disputes.

The Convention established the framework for policy formulation and implementation that has guided planning efforts down to the present.

Exhibit 1-4. Lake Chad Basin Member States



1.2.2 POLICY HISTORY

In implementing these commitments over the years since 1964, LCBC have engaged in a series of planning efforts, of which the ESRA project is the latest manifestation. Together they reflect the policy history of the organization, and provide the institutional and policy context for the present project.

Current history begins in December 1985, following the Sahelian droughts and famines of the 1970s and early 1980s, with a decision of the first African Ministerial Conference on the Environment (AMCEN) to support LCBC "for the integrated development of the Lake Chad Basin, in order to halt the drying up of Lake Chad and use its waters and ecosystems rationally" (LCBC 1992: 121). A UNEP Reconnaissance Study was reported to AMCEN in December 1988, and a further decision was made to commission the *Diagnostic Study of Environmental Degradation in the Lake Chad Conventional Basin,* completed the next year (Kindler 1989).

At its November 1989 meeting AMCEN authorized LCBC to prepare a Master Plan for the development and environmentally sound management of the resources of the basin, published in 1992. Its principal objectives (pp/ 4-5) were:

1. To increase the availability of water resources and promote their rational utilization, including environmental an socio-economic assessment of water projects;

2. Prevent soil erosion and improve soil fertility;

3. Maintain and improve vegetative cover and nutritive value of pasture land through sound management of livestock; restore denuded landscapes; balance regeneration of wood biomass with offtake, establish sustained yield management of hardwoods; and

4. Work towards food security preparedness scheme, combining irrigated agriculture, food processing, preservation and storage.

After unsuccessful efforts to implement its provisions, and "Given the exceptional importance of protecting the lake environment, the threats facing it and the need for concrete action, a Strategic Action Plan (SAP) was initiated in May 1996 following a request for assistance from the Lake Chad Basin Commission (LCBC) to the GEF" (LCBC 1998: 1).

> The objective of the SAP is to prepare a regional framework for protecting the environment and for the sustainable development of the various resources throughout the Lake Chad basin. This framework must provide for preventive and remedial measures. The SAP both constitutes and organises a permanent process of achieving a regional agreement on environmental changes, on real threats and on the priorities to be considered at regional level.

Implementation of the SAP seems to have fared no better than the 1992 Master Plan, but since 1996 GEF has been actively involved in program development for Lake Chad Basin (1.3), leading to formulation and implementation of another SAP, this one a Strategic Action Programme.

1.2.3 THE INTERNATIONAL COMMUNITY

In all these efforts LCBC have been strongly supported by the international community and their executing agencies, multilateral and bilateral, and by regional associations such as AMCEN and the Permanent Interstate Committee for Drought Control in the Sahel (CILSS). In addition to humanitarian relief organizations, NGOs such as the World Conservation Union (IUCN) and the Ramsar Convention Secretariat have been influential and instrumental in environmental planning and management programs.

The current institutional environment of the region has been largely shaped by the international community's response to recurrent droughts in the region. Following the drought of the 1970s, the United Nations Convention to Combat Desertification (UNCCD) was ratified, and the United Nations Sudano-Sahelian Office (UNSO) was established. Several other UN specialized agencies have mounted special programs, such as the International Fund for Agricultural Development (IFAD) Special Programme for Sub-Saharan African Countries Affected by Drought and Desertification (SPA).

1.3 Project History

Ancestry of the ESRA project can be traced back to the 1989 *Diagnostic Study* then forward through the World Banks' "Integrated Environmental and Social Assessment" (2002) to the LCBC/GEF ecosystem program and its present project.

1.3.1 THE DIAGNOSTIC STUDY

The *Diagnostic Study*

> … summarizes the "symptoms" of environmental "ill health" such as erosion of formerly productive lands, overused groundwater, loss of wildlife species, and forced migrations of humans during periods of famine and drought. The report attempts to pinpoint the causes of degradation of the soils, water, air, plant and animal life within the conventional basin, and to suggest and set priorities for strategies for healing the basin's environmental wounds. (Kindler 1989: 1)

Its findings and recommendations extend beyond the environmental to the institutional; the executive summary concludes by recommending that LCBC place " … a new emphasis on communications and networking between the nations of the conventional basin and a new or expanded role in environmental planning, monitoring, and assessment."

> The LCBC has not fulfilled its role as arbiter of water and land use conflicts within the basin because it lacks the power. It is not well-suited to perform projects that are strictly national in character, but is uniquely organized to coordinate regional pest control, communications, early warning systems, health quarantines, water disputes, climate and channel flow monitoring, and training workshops.
>
> As exploitation of water and land resources becomes ore intense within the basin, and as citizens migrate and trade more extensively, the need for an overall administrative and legal framework will increase. The Heads of State should

consider a legally binding framework for regional water resource concerns as suggested in their 1970s meetings.

1.3.2 THE ENVIRONMENTAL AND SOCIAL ASSESSMENT

In compliance with environmental and social safeguard requirements, the World Bank conducted an Environmental Assessment and Social Assessment (EA/SA) of the LCBC/GEF ecosystem program, focusing on the six proposed pilot projects as the project components expected to have direct positive and/or negative environmental and social impacts. Objectives of the EA/SA were to:

- Identify, qualify, and to the extent possible, quantify the likely negative and positive environmental and social impacts of the project as presently designed;
- Propose mitigating measures to be implemented to avoid negative impacts;
- Ensure that the project is in compliance with the World Bank's Safeguard Policies and Quality At Entry requirements;
- To enhance the quality and sustainability of the project.

The results of this project risk assessment are shown in Exhibit 1-5.

Exhibit 1-5. Critical Risks (reflecting the failure of critical assumptions)

RISK	RISK RATING	RISK MITIGATION MEASURE
From Outputs to Objective		
Government commitment to decentralized decision-making and resource transfer to rural communities and their grouping (future rural municipalities) is not sustained	M	Ownership of the Program by the Government is high (preparation by National team; high level Steering Committee with representatives of all major ministries involved)
Natural resources degradation proves not to be a high-priority concern for the communities and therefore buy-in for the sub-watershed approach and engagement in IEM activities is compromised	N	Years of experience on NRM in Burkina Faso show that communities are very aware of the constraints imposed on their production systems and usually respond well to land planning and new technologies. The project intends to emphasize communication and discussion to ensure that the proposals and plans that emerge are well owned by the communities.

From Components to Outputs Government does not maintain its support to decentralized rural development	S	The Government policy for decentralized rural development was reaffirmed in its recently approved rural development strategy. Decentralization is an irreversible trend in Burkina. Implementation of the baseline CBRD program shows that while the Government is slow in the reform process, this has never resulted in withdrawing a right already secured by local communities and has never prevented successful implementation of community-based local development.
Funds availability for sub-projects are delayed thereby preventing their timeliness or implementation	N	Funds will be mobilized with similar mechanisms as the baseline Project. … A monitoring system is in place to measure the time between each steps of the process.
Non-availability of quality service providers and enterprises in sufficient number	M	A training program for service providers is included in community-based land management/local development approach. A roster of competent service providers was compiled as part of the preparation to assess availability of skills required.
Regional and provincial services do not share the project vision and approach and do not demonstrate a sufficient level of commitment to its results	S	IEM requires land planning and then multiple interventions from many sectors. Not all regional or provincial services fully share the national vision of their Government not do their all have the skills, or commitment, to engage in agreed plans and new technologies. The project, through its communication strategy, its participatory process and training will attempt to engage these partners to the extent possible. The CPAT will also serve as mediator when difficulties in implementation of new plans or

Phase 2 of the baseline CBRD program either does not materialize or follows Phase 1 with a time gap which prevents SILEM from the benefit of the administrative support of the baseline program	N	rules are raised by a sector. The baseline Project is progressing well toward its triggers and is now a well established "institution" with multiple donors. It is also flexible enough to accommodate changes in the direction and pace of reforms. Should Phase 2 of the baseline CBRD program not proceed, SILEM will recruit a Financial administrator who will supplement and complement the SILEM team already comprising a Coordinator, an accountant and four field officers.
Overall Risk Rating	S	The approach proposed under the Program has been tested successfully in Africa in general and in Burkina in particular, and presents relatively low risks. Notwithstanding, the scale of implementation envisaged will be a challenge.

Risk Rating - H (High Risk), S (Substantial Risk), M (Modest Risk), N (Negligible or Low Risk)

It should be noted that unlike the ESRA project, the EA/SA was directed only to program impacts, not to the actual conditions of resource degradation the program is seeking to reverse. In connection with this study, the Africa Safeguards Policy Enhancement Team (2002) also prepared a "process framework for the mitigation of social impacts of the Lake Chad Basin Commission (LCBC) Project.

1.3.3 The LCBC/GEF Ecosystem Program

For the past decade GEF have supported and promoted a program under LCBC auspices to reverse land and water degradation in the Lake Chad Basin.

> In order to address these issues and create a suitable framework for the reversal of land and water degradation trends in the Lake Chad Basin, GEF is funding a project with UNDP and the World Bank as Implementing Agencies and UNOPS as executing Agency/Service Provider. The Lake Chad GEF Project will enhance collaboration and will develop capacity among riparian countries and relevant stakeholders through the completion of a Trans-boundary Diagnostic Analysis (TDA) and the formulation of a Strategic Action Program (SAP). The project will also support the creation of regional programs and the execution of demonstration projects to test and validate methodologies, secure stakeholder involvement and develop implementation modalities. (ToR, p. 1)

Trans-boundary Diagnostic Analysis (TDA)

In support of their mission to protect and improve the global environment, GEF place special emphasis on trans-boundary issues and their solutions through the use of Trans-boundary Diagnostic Analysis (TDA), described as a "systematic method of obtaining and analyzing scientific, technical and socioeconomic information and data necessary to facilitate sustainable use of [a] water system and its resources."

> A TDA is a scientific and technical fact-finding analysis used to scale the relative importance of sources, causes and impacts of trans-boundary waters problems. It should be an objective assessment and not a negotiated document. The analysis is carried out in a cross sectoral manner, focusing on trans-boundary problems without ignoring national concerns and priorities. In order to make the analysis more effective and sustainable it should include a detailed 'governance analysis' which considers the local institutional, legal and policy environment. Further, the TDA should be preceded by a full consultation with all stakeholders, and the stakeholders are involved throughout the subsequent process. The TDA approach is not only a proven way of achieving progress, it also acts as a diagnostic tool for measuring the effectiveness of SAP implementation. (GEF 2006 1)

Its use is recommended for:

- identifying relevant items, issues & policy failures hindering sustainable use of a given water system (lake, river, groundwater aquifer);
- identifying root causes of problems; and
- providing initial guidance on programs & activities necessary to address them (with context of Internationally-agreed Strategic Action Programme (SAP)).

In the Benguela Current TDA, two operational levels were designated, "synthesis" and "specifics," the former involving "issues and perceived main transboundary problems, root causes and areas where action is proposed" and the latter "comprehensive information on the issues, sub-issues, problems, causes, impacts, uncertainties, socio-economic consequences, the perceived solutions, priorities, outputs and costs" (UNDO 1999: 9-10).

Both levels have been explored and combined on previous occasions. In the 1998 Master Plan's logical framework, for example, "synthesis" took the form of trans-boundary problem identification and issues analysis, followed by designation of priority tasks and operational targets, along with resource requirements for reaching them.

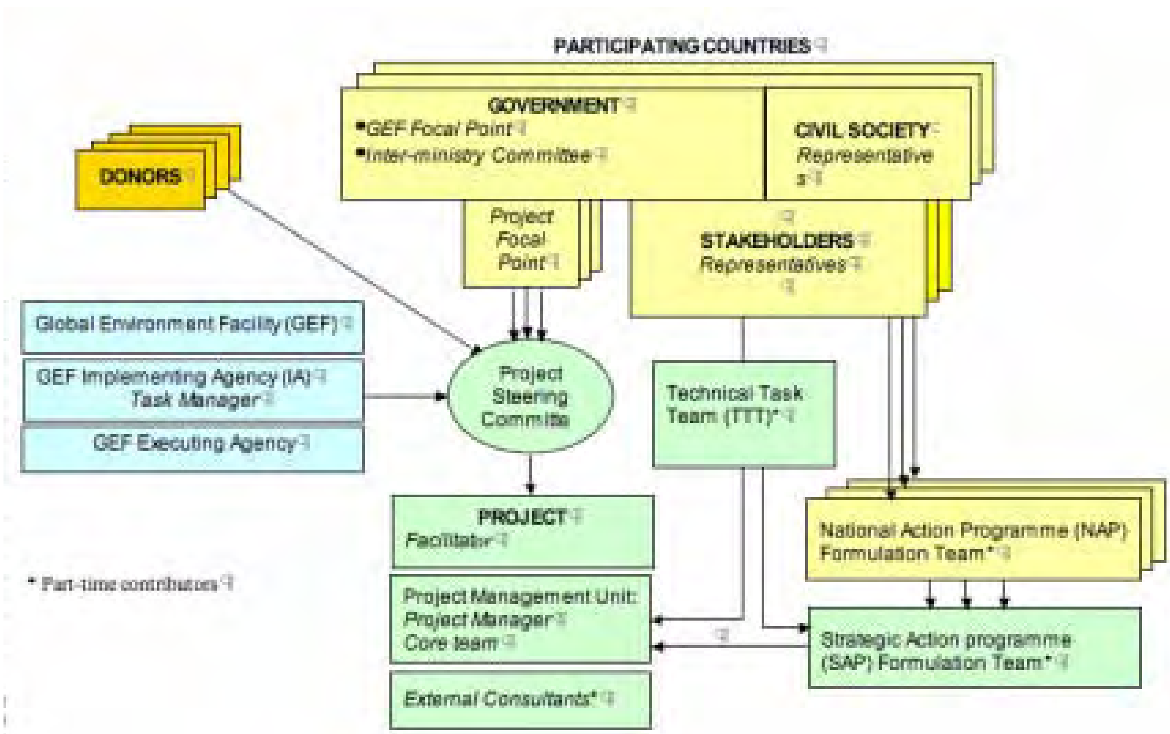
Strategic Action Program (SAP)

For its part, a Strategic Action Programme is

> … a negotiated policy document which should identify policy, legal and institutional reforms and investments needed to address the priority transboundary problems. Endorsed at the highest level, it establishes clear priorities for action to resolve the priority transboundary problems / which were identified in the TDA. The preparation of a SAP is a cooperative process among the participating countries. The TDA identifies the priority problems, the underlying sectoral causes, and the root causes of the problems. The SAP outlines the actions needed to resolve the priority problems and must be agreed before technical assistance, capacity-building, or investment projects can be developed. The SAP sets out specific actions for each country that can be adopted nationally (through National Action Programmes, or NAPS) but harmonised with the other concerned countries. (GEF 2006 1)

The interrelations of TDA, SAP, and NAPS are shown in Exhibit 1-6.

Exhibit 1-6. Notational Organizational Diagram for a Full Project TDA/SAP



The ESRA project is intended to contribute to the formulation and implementation of both the TDA and the SAP, which in turn will be used to implement and monitor the five pilot projects proposed under the LCBC/GEF ecosystem program.

2.0 OBJECTIVE OF THE STUDY

2.1 Statements of the Objective

According to UNOPS (n.d.: 1), the executing agency for the LCBC/GEF ecosystem program, the long-term objective is to

> … achieve global environmental benefits through concerted management of the naturally integrated land and water resources of the Lake Chad Basin. The specific purpose is to overcome barriers to the concerted management of the basin through well-orchestrated and enhanced collaboration and capacity building among riparians and stakeholders. This requires orchestration of both national and regional activities through a working system of basin governance.

The objective of the ESRA project is announced in its title: "Reversal of Land and Water Degradation Trends In the Lake Chad Basin Ecosystem: Establishment of Mechanisms for Land and Water Management":

> … the study aims at using an environmental and social risk assessment to identify and analyze actual and potential risks to human health, land, water, biodiversity and other wetland values due to water and land-use activities in the basin**.** The results of the study will be used to design and implement a monitoring and evaluation system for adaptive management. The implementation of the monitoring and evaluation system will help to make early warning and mitigate any adverse effects of human activities and natural disasters within the basin." (ToR, p. 2)

2.1.1 THE GOAL OF SUSTAINABLE DEVELOPMENT

The LCBC's 1998 *Strategic Action Plan* is explicitly "For Sustainable Development of the Lake Chad Basin"; its main objective is stated (p. 5) as follows: "*Lake Chad is sustainably projected by concerted, integrated management of the basin's resources, guaranteed by all players within the basin taking responsibility and cooperating.*" Long-term objectives include (pp. 5-6):

- Concerted management of international waters, based on regional cooperation and national policies harmonized and applied to each sub-basin.

- Integrated management of the use of finite and vulnerable water resources in the ecosystem, based on better knowledge of these resources.

- Players in the basin take responsibility for protecting common heritage

In pursuing this aim, it further states that integrated management of the basin will follow "sustainable development principles," implying (pp. 15-17)

- re-situating people's socio-economic development within the wider context of the use and management of water resources (including rainfall), which are fragile, limited, variable, and uncertain, while emphasizing the respective abilities of local populations and natural systems to adapt to changes (and their limits);

- comparing the various uses of water with the use of soils, forests, and the management of wildlife; and

- aiming at a forward-looking management that is capable of identifying long-term consequences and impacts (i.e. over the next 20-30 ears) of the various development options for which choices have to be made in the short term. These impacts depend on the needs of present and future generations in the basin, in terms of natural resources, basic food resources and human safety in the face of unpredictable and uncertain weather conditions.

At this point the question naturally arises, “sustain what?” Certainly not the existing conditions and trends, which point toward resource degradation, and perhaps not traditional ways of life that now appear unsustainable. Recognizing “the respective abilities of local populations and natural systems to adapt to changes (and their limits),” perhaps the goal should be not “sustainable livelihoods” in stable environments but “adaptive livelihoods” in resilient ones.

Following the 1970s drought, USAID joined in a multilateral initiative for rural development aimed at promoting “long-term self-sufficiency” in the region (Shear n.d.: 5). It may be that “long-term self-sufficiency” aims at the wrong target, and that a relation of “mature dependency,” propelled by globalization trends and recognizing regional interdependence, is considered more appropriate.

Denève (1995: 55) is of the view that “the overall result of development aid is disastrous … The ultimate goal of triggering a sustained self-development process (without structural subsidies) seems completely out of reach.” The moral hazard of artificially maintaining marginal peoples in marginal conditions is likewise worrying. However resourceful and adaptable people may be, surely there are limits to prudence and endurance. As the OECD Futures Study (1988) suggests, answering to the question of “sustain what?” may lie not in restoration but rather in transformation.

Raising this development policy option further implies priorities for short- and long-term regional planning and management decisions, and for building institutional capacity “that is capable of identifying long-term consequences and impacts“ of this and other development alternatives.

Although the goal of “sustainable development” is not mentioned explicitly, the ToR does call for sectoral assessments of the sustainability of freshwater systems and natural resources generally.

2.2 Terms of Reference

The structure of this report follows the ToR outline of topics, except that Section 4 is now entitled ”Application to ESRA.” The content of coverage for that section remains unchanged, including sectoral analysis of environmental and social systems and cross-sectoral discussions of Monitoring and Evaluation, the Decision Support Framework, and Adaptive Management. An overview of the ToR is shown in Exhibit 2-1.

Exhibit 2-1. ESRA Terms of Reference

… how the resource is affected by multiple stressors at multiple scales and how it responds to the change(s) caused by the management action.

…identify and analyze actual and potential risks to human health, land, water, biodiversity and other wetland values due to water and land-use activities in the basin.

… design and implement a monitoring and evaluation system for adaptive management to make early warning and mitigate any adverse effects of human activities and natural disasters within the basin.

… characterize the numerous stressors, interconnected pathways, and multiple endpoints.

… identification and assessment of activities with significant environmental and social impact within and adjacent to wetlands.

… provide an approach for:

- Identifying potential risks to the agricultural resource base and farmer livelihoods by actual or perceived contamination;
- Identifying risks in the watersheds, especially water supply areas and characterizing them in terms of impact on underlying ecosystem processes;
- Making decisions that guide both short term and long-term, and both site-level and landscape-level resource management activities;
- Implementing management activities in an adaptive manner to continually improve understanding and practice.

…provide guidance regarding how to mitigate risks through an improved decision support framework.

- The collection, with the assistance of the LCBC/PMU and the National, of existing documentation and information;
- The analysis of relevant data in conjunction with the work of the Technical Task Team on the TDA/SAP process;
- The review of policies as well as legal and institutional frameworks, and other back-up material in LCBC member countries;
- The discussions with the high-ranking officials of the member countries as well as with relevant NGOs and user groups, including communities and private sector;
- Verification visits regarding distinctive areas

… principal issues to be addressed:

- What are the major risks due to human activities?
- What are the major stressors?

- What is the collective impact of stressors on the health or condition of the aquatic biota?
- What is the relative contribution of each stressor (chemical, physical, and biological) to the condition of the resource?
- What is the relative contribution of each source (atmospheric, terrestrial, and aquatic in origin) for each stressor affecting the condition?
- Given these contributions, what alternative management options are available to achieve the local, regional, or national expectations for the system in question?
- Identify credible assessment endpoints that accurately reflect management goals and societal values;
- Develop and apply measures of effects and ecosystem characteristics to adequately represent assessment endpoints;
- Understand ecological processes, mechanisms, and relationships that support development of stressor-response analyses and cause-and-effect relationships;

… the ESRA will be used primarily as a tool for monitoring and evaluation and a decision support framework.

As noted in the Exhibit above, the terms of reference (ToR) outline a report structure containing four topics:

- Sectoral Analysis
- Monitoring and Evaluation
- Decision Support Framework
- Adaptive Management

These topics are addressed and analyzed following the stages and steps of the Impact Assessment Model (IAM) and Main Pattern schemas described below in Section 3 and applied in Section 4.

2.2.1 SECTORAL ANALYSIS

Sectoral analysis is stipulated in the following areas:

- Climatic & Atmospheric Change
- Land Transformation
- Sustainability of Freshwater Systems & Resources
- Social Environment and Health
- Economic Environment
- Political Environment
- Natural Resources Sustainability, Biodiversity, Integrity, Productivity

"Sectors" in the context of ESRA are spheres of activity whose patterns may contribute to land and water degradation trends and their reversal. For present purposes these will be clustered in two main categories, environmental and social, and will be interpreted as attributes, components, or functional subsystems of environmental and social systems and conditions in the Lake Chad Basin.

The issue of sustainability involves trend impact analysis of existing sources and stocks and rates of their depletion and replenishment, e.g., lake water balance and groundwater abstraction and recharge.

2.2.2 Topical Analysis

Three items are included under this heading, "Monitoring and Evaluation," "Decision Support," and "Adaptive Management."

"Monitoring and Evaluation" are inverted in the Main Pattern schema (infra); evaluation logically precedes, in the selection of a preferred alternative for implementation, whose subsequent impacts are then the proper focus of monitoring. Of course, those results are themselves subject to evaluation in regard to their effectiveness in achieving policy objectives.

"Decision Support" is provided throughout the decision process at each stage and step by application of Impact assessment methodology; the assessment process itself constitutes a framework for decision support.

"Adaptive Management" completes the assessment cycle, as in Holling and associates (1978) recognize in their title, "Adaptive Environmental Assessment and Management." As anticipatory research, it lends further support to strategic management.

2.2.3 Mitigation

The ToR stipulates a requirement for mitigation in the following contexts:

- … how the resource is affected by multiple stressors at multiple scales and how it responds to the change(s) caused by the management action …

- … design and implement a monitoring and evaluation system for adaptive management … to make early warning and mitigate any adverse effects of human activities and natural disasters within the basin.

- … provide guidance regarding how to mitigate these risks through an improved decision support framework

Mitigation is thus closely related to the three topics discussed above, to monitoring and evaluation in judging the need and extent of mitigation measures and the effectiveness of their application, and providing guidance to the decision process in reaching these determinations—all of which can be included in the category of "adaptive management."

The point of early warning systems, of course, is preventive—to anticipate and obviate the need for mitigation measures, rather than providing compensation for actual loss.

2.3 Substantive Focus

These statements of program and project objectives and their embodiment in the ToR frame the substantive focus of the project and set the parameters for its execution.

A broad construction of the project's substantive focus might be stated as "solving" (or, more modestly, addressing or engaging) the problem of sustainable African development in the Lake Chad conventional basin (LCCB). Such an "endpoint" would entail operationalizing and implementing a comprehensive and integrated plan for sustainable drylands development in the LCCB and the Sahel generally, as well as the region's extensive wetlands.

2.3.1 Environmental and Social Risk Assessment

A more tenable and tractable focus for this project is stated its title: "Environmental and Social Risk Assessment of the Lake Chad Basin Ecosystem." With that redefinition, our focus shifts from the question of "sustain what?" to that of "assess what?" The answer can be given in terms of existing and future systems and conditions in the region, and of policies and plans whose implementation might shape their contours and characters (e.g., further exploration and production of petroleum resources, inter-basin water transfers) (Gratzfeld 2003).

Specifying and characterizing those systems and conditions is discussed in Sections 5 and 6; the potential impacts of their intersections and interactions, in Section 7. Whether those are to be categorized as "risks" or "benefits" (or as differential distributions and balances of both) is a matter for impact evaluation. The critical issue here is who decides, and by what decision making process are such decisions reached. Certainly, the former should include the full range of interested and affected parties, and not simply the formally designated authorities. Their inclusion in the present project appears problematic, although the sequel stakeholder analysis project addresses this directly.

Before proceeding, the meaning of "risk" itself requires some clarification. For present purposes, risk is understood to mean the antecedent probability of negative impacts occurring from the operation of existing and future systems and conditions and the implementation of proposed actions potentially affecting them.

Unlike the probabilistic risk assessment of more determinant systems, such as physicochemical reactions, by application of quantitative analyses, judgments concerning environmental and social systems are more likely to be qualitative and subjective. Methodological approaches and issues relating to such matters are discussed in the next section.

One other definition of "risk" should be entertained as well, namely: "Risk is a situation or an event where something of human value (including humans themselves) is at stake and where the outcome is uncertain" (Rosa 2003: 54). This further implies that some decision or action may be expected of participants in such situations – decision makers and other interested and affected parties – to anticipate and mitigate their potential adverse consequences. Following this logic, the essence of risk management is uncertainty reduction. It must be recognized however that residual uncertainty is inherent in the systems and conditions of interest.

2.3.2 Lake Chad Conventional Basin Ecosystem(s)

LCBC/GEF program documents speak of the Lake Chad "Ecosystem" in the singular, but in fact the region is characterized by a great diversity of ecosystem types. Perhaps most distinctive feature is the wide distribution of "wetlands in drylands" (see Woodhouse, Bernstein, Hulme, and others 2001).

The Lake and the Basin

One's attention is naturally drawn to the basin's namesake and unique feature, and the dramatic shrinkage in size experienced since the 1963 peak year. Absent the lake, there would be no Lake Chad Basin.

Nevertheless, there is a great deal more to the basin than the lake, and the extent to which people in the region actually depend on its health for their welfare (e.g., whose livelihood and sustenance depend on lake fisheries, is open to question).

An alternative view is that water that previously replenished the lake but is now diverted for agriculture in densely populated areas such as the Komadugu-Yobe Basin is more valuable for that use. Moreover, recession of the lakeshore has afforded benefits to some in opening large tracts of fertile land for cultivation.

These views raise a further and fundamental question of the desirable proportions for the "natural" lake. More broadly, what is the state to which the natural environment should be restored? Reversing land and water degradation trends is one thing, but to what desirable condition? The question is complicated by the region's extreme ecological diversity and natural variation.

Moreover, its "natural" carrying capacity is by no means sufficient to sustain recent and rapid population growth in the region, itself hardly a "natural" feature of traditional society and culture. Clearly the environment in question is not solely a "natural" one; it is also, and predominantly, a human environment, on the sides of both cause and effect.

On the side of cause, while drought is certainly a natural condition, its incidence and severity may be significantly altered locally by human interventions in agricultural practices and settlement patterns, and globally by anthropogenic climate change.

Conversely, "severity" is a social judgment on how that condition affects human activities and human welfare. Following the Sahelian drought of the 1970s, it became clear that the resulting famine was not an environmental but an institutional disaster (Glantz 1976). As in the ongoing "food crisis" in Niger and elsewhere, the problem is not that there is insufficient food, but that people in need cannot afford to buy it. The shortfall is not in rainfall but in social equality and justice. To get the water right, you have to get the politics right.

2.3.3 SCOPE OF WORK

"Scoping" is a process of establishing boundaries of inquiry for the assessment process in a particular impact situation and focusing the central issues of concern. It is a way of engaging these concerns and of limiting study efforts to manageable proportions.

According to the Main Pattern schema (infra), scoping is the initial step in the assessment cycle, although normally preceded by a screening process to determine whether the scale and severity of a proposed action warrant a formal assessment. Four analytic operations are prescribed for this purpose:

1. Formulate terms of reference
2. Identify and dimension impact categories
3. Develop study design
4. Perform mini-assessment

Terms of Reference for the ESRA project were stipulated in the RFP and interpreted above (Section 2). "Identify and dimension impact categories" refers to the distinction between impact categories and properties. Besides what potential impacts, existing conditions and/or proposed actions might induce and what about them, included in this analysis are also questions of impacts on *whom*—characteristics of potentially affected groups and persons.

"Develop study design" involves, among many other things, an inventory of institutional and informational requirements and resources, as outlined in Annex 1. The clippings database is one element of this; a bibliographic database (annotated and analyzed) is another; archives of remote sensing, population census, meteorological and hydrologic data series and sets yet others.

An important aspect of the literature search and synthesis is a review of analogue and cognate studies, such as those on Aral Sea recession and the Bengula Current Large Marine System. The extent of this universe is suggested by the keywords listed in Exhibit 2-2. These refer to substantive and methodological topics bearing directly or indirectly on the project, such as similar environmental and social conditions, proposed actions, and assessed impacts throughout the region, the continent, and the world. Their relevance to the project' raises questions about the validity and utility of comparative methodology, e.g., comparing ecosystems (Cole, Lovett, and Findlay 1991).

Adaptation Adaptive Management Agricultural Development Anthropomorphic Impacts Arid Lands Biodiversity Capacity Development Causal Analysis Climate Change Community Based Natural Resource Mgt. Conflict Assessment Decision Analysis Desertification Drought Drylands Ecological Modeling Ecological Risk Assessment Ecological Resilience Ecosystems Evaluation Environmental Impact Assessment Environmental Management Evaporation Suppression Exposure Assessment Famine Food Security Forecasting GIS Global Warming Governance Groundwater Indicators Institutional Development Integrated Impact Assessment Integrated Water Resources Management Interbasin Transfer International Waters Irrigation	Lake Management Land Degradation Land Management Mitigation Modeling Monitoring Natural Hazards and Disasters Nomadism Organizational Development Participatory Development Pastoralism Poverty Assessment Rangelands Regime Analysis Regional Development Remote Sensing Resource Management Restoration Ecology Risk Assessment Rural Development Sahel Savannas Scenario Analysis Sedantarism Social Impact Assessment Stakeholder Analysis Strategic Action Program/Plan Strategic Assessment Strategic Environmental Assessment Stressors Sustainable Development Sustainable Livelihoods Transboundary Transhumance Vulnerability Assessment Water Quality Water Resources

Exhibit 2-2. ESRA Keywords

Of undoubted importance are project reports drawn from GEF's own portfolio, such as "Building Scientific and Technical Capacity for Effective Management and Sustainable Use of Dryland Biodiversity in West African Biosphere Reserves," whose geographical scope includes Niger. The project summary reads:

> The development goal of the project is to conserve and sustainably use biodiversity in six biosphere reserves in West Africa that are predominantly composed of savanna ecosystems. The project purpose is to systematically strengthen scientific and technical capacity for effective management of the biosphere reserves. This targeted intervention strategy has been designed to complement existing investments and projects within the biosphere reserves. The project will improve the understanding of interactions between local communities and savanna ecosystems, identify and promote sustainable use of biodiversity in pilot demonstrations, strengthen stakeholder capacity at all levels, and more effectively integrate stakeholders into the management of each biosphere reserve. The project will make extensive use of the African Network of Biosphere Reserves, AfriMAB, and, in particular, the sub-regional AfriMAB network for West Africa for regional technical and scientific information exchange, capacity building, and sharing of lessons learned.

"Perform mini-assessment," the last of these scoping activities, is a procedure which cycles through the full series of assessment steps, previewing each one to identify priorities and evaluate appropriate means for addressing them. Ideally, it would be performed in the course of a proper scoping workshop, in which representatives of all interested and affected parties would participate. That was not possible under the terms and conditions of the project, so surrogate figures and proxy measures must suffice at present.

3.0 METHODOLOGY

Three complementary methodological approaches for the ESRA project are ecosystems, social learning, and integrated impact assessment. The latter can be characterized by two pairs of terms: "comprehensive and integrated" and "proactive and creative." An operational methodology for integrated impact assessment is outlined in the Impact Assessment Model and Main Pattern schema, applied to risk assessment methodology.

3.1 Methodological Approaches

As indicated above, this analysis proceeds from the intersection of three methodological approaches: ecosystems: social learning, and integrated impact assessment.

3.1.1 THE ECOSYSTEMS APPROACH

The ecosystems approach is a special case of systems approaches generally. A system can be any identifiable entity with definable connections between its parts (Jordan 1973: 72). Ashby (1960: 25) points out however that the systems of interest are mainly those, which display a "naturalness of association" among their parts. In the case of living systems, he further identifies as "essential variables" those closely related to survival and dynamically linked, so that marked changes in one leads to marked changes in the others (p. 42). Their values ("states") at any point in time and ranges of variation over time are the defining characteristics of the system. Their systemic relations determine its structure. Degree of "systemness" in any particular case is of course an empirical question.

A system's "environment" is by definition external to the system, as in the distinction between a species and its habitat. Yet a close association exists between some relevant aspects of the two—the "effective" environment—and while they are clearly different, it is inconceivable to think of them as existing apart from one another. A species may experience habitat loss, but total loss spells extinction, in which case we cease to speak of "habitat" at all.

Ashby (p. 36) defines "environment" as "those variables whose changes affect the organism, and those variables which are changed by the organism's behavior" (p. 36). An example is a prey-predator system. Because of this close association, a distinction is sometimes made between "internal" and "external environment" (or systems). Clearly then, "system" and "environment" are relative terms, and the boundary between them will vary according to the purpose being pursued. Because of this relativity, the distinction made here is between "systems" and "conditions"—although the relation is the same, as in "necessary" conditions ("conditions of existence").

The systems of interest here are environmental and social, and the concern is to trace their linkages to the "root causes" of degradation trends in land and water quality, and subsequently to interventions that might effect the reversal of those trends in the LCB. As in the case of habitats and species, there is close association between the two—so close that Bennett (1993: 14-21) speaks of "socionatural systems": "The term 'socionatural system' is an empirical generalization that attempts to combine both Nature and Culture" (p. 16). This closeness is underscored in the debate over the causes of the Sahelian famines, whether "natural" or "social" (or "political," e.g., Glantz 1976). Similarly, the onset of climate change, previously considered a purely natural phenomenon, is now thought to be entirely "anthropogenic" in origin and effect.

Despite their interpenetration—Bennett (pp. 4-11) calls it the "ecological transition," referring to the cultural control of natural systems though adaptive human behavior, but also the incorporation of nature into culture—the two can be separated for purposes of analysis. We propose to construct and calibrate environmental and social system models to establish their interconnections and identify points of strategic intervention. Initially conceptual, model development will become increasingly evidence-based by associating indicator data with the empirical referents of structural and processual components.

According to one source (UNESCO 2000: 4), the ecosystem approach is said to embody twelve principles:

0. The objectives of management of land, water and living resources are a matter of social choice.

1. Management should be decentralized to the lowest appropriate level.

2. Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.

3. Recognizing potential gins from management, there is a need to understand the ecosystem in an economic context.

4. Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach.

5. Ecosystems must be managed within the limits of their functioning.

6. The ecosystem should be undertaken at the appropriate spatial and temporal scales.

7. Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term.

8. Management must recognize that change is inevitable.

9. The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.

10. The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.

11. The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

Five operational guidelines are proposed in applying these principles (p. 4-5):

- Focus on the functional relationships and processes within ecosystems.

- Promote the fair and equitable access to the benefits derived from the functions of biological diversity in ecosystems and from the use of its components.

- Use adaptive management practices.

- Carry out management actions at the scale appropriate for the issue being addressed, with decentralization to [the] lowest level, as appropriate.

- Ensure intersectoral cooperation.

3.1.2 Social Learning

The "social learning" approach emerged in the 1960s as a reflection on early development experience (Dunn, Jr. 1971; Korten 1980; Schön 1994), and has recently been advanced in the context of environmental management (Keen, Brown, and Dybill 2005: 3). Those authors recognize as distinctive of the approach three agendas—creating learning partnerships, learning platforms, and learning ethics that support collective action towards a sustainable future—and five “strands” of activity integral to environmental management—reflection, systems orientation, integration, negotiation, and participation. The concepts of monitoring and “adaptive management” fit comfortably within this approach.

“Social learning” may also stand as a critique and corrective to the comprehensive rationality implied in much (wishful) development thinking, anticipated in an early (1962) statement by Albert O. Hirschman, who may be considered the originator of the approach, and Charles E. Lindblom (“The Science of ‘Muddling Through’”) on “the basic justification for rejecting traditional precepts of rationality, planning, and balance”:

> For Lindblom, it is complexity, i.e. man’s inability to *comprehend* the present interrelatedness and future repercussions of certain social processes and decisions, as well as imperfect knowledge and *value conflicts*. For Klein and Meckling it is … *future uncertainty*, i.e. man’s inability to *foresee*, the shape of technological breakthroughs, or the desirability of letting oneself be guided by these breakthroughs if and when they occur, instead of following a predetermined sequence. For Hirschman it is the difficulty of mobilizing potentially available resources and decision-making activity itself; the *inadequacy of incentives* to problem solving, or, conversely, the need for *inducements* to decision making. (Hirschman and Lindblom 1969: 365; original emphasis)

While this litany of human frailty does not justify relinquishing the ideal of comprehensive rationality, it does caution against its uncritical acceptance.

3.1.3. Integrated Impact Assessment

The systems approach is further exemplified in the methodology of integrated impact assessment.

“Adaptive capability and anticipatory planning, to be fully effective, must …” So begins the UNOPS rationale for seeking a “Regional Consultant (Originating from the Lake Chad Basin Region).” The field of knowledge and application best fitting this description is impact assessment. “Impact” means “change”; “effects” and “consequences” are synonyms. Its omission, as in the case of “Global Water Assessment,” connotes a focus on inventorying a source or supply. “Assessment” is the coupling of analysis with evaluation.

3.2 The Field of Impact Assessment

The purpose of impact assessment can be stated as: “developing international and local capacity to anticipate, plan, and manage the consequences of change so as to enhance the quality of life for all.” As in other fields, estimating and improving the state of the art/science/craft of impact assessment can be analyzed in four linked areas: theoretical, methodological, institutional, and professional.

The field of impact assessment can be fairly characterized in two phrases” “comprehensive and integrated” and “proactive and creative”— comprehensive in its coverage of assessment levels, scales, schedules, and sectors and integrated across perspectives, paradigms, disciplines, and methods.

3.2.1 "COMPREHENSIVE AND INTEGRATED"

"Comprehensive and Integrated" means consideration of all assessment levels, scales, schedules, and sectors (Exhibit 3-1).

Exhibit 3-1. Assessment Levels, Scales, Schedules, and Sectors

LEVELS	SCALES	SCHEDULES	SECTORS
Policy	Global	Far-Future	Multisectoral
Program	National	Near-Future	Environmental
Project	Regional	Baseline	Social
Product/Process	Local	History	Economic

For example, "becoming comprehensive" may mean raising the assessment level to the consideration of policy alternatives, as in strategic environmental assessment (SEA), or broadening the scope of assessment to global dimensions. A full assessment would include consideration of such factors as:

- The full range of alternatives
- The full program or project development cycle
- The full range of impact categories and dimensions
- The full range of interested and affected parties

3.2.2 "PROACTIVE AND CREATIVE"

"Proactive and Creative" means that impact assessors should participate from the inception of a study or project through the full cycle to mitigation, monitoring and management, and that they must be concerned with the formulation and implementation of alternatives that are economically viable, socially acceptable, and environmentally sustainable. These precepts are embodied and expressed in the operational methodology of impact assessment.

3.3 Application of the Methodology

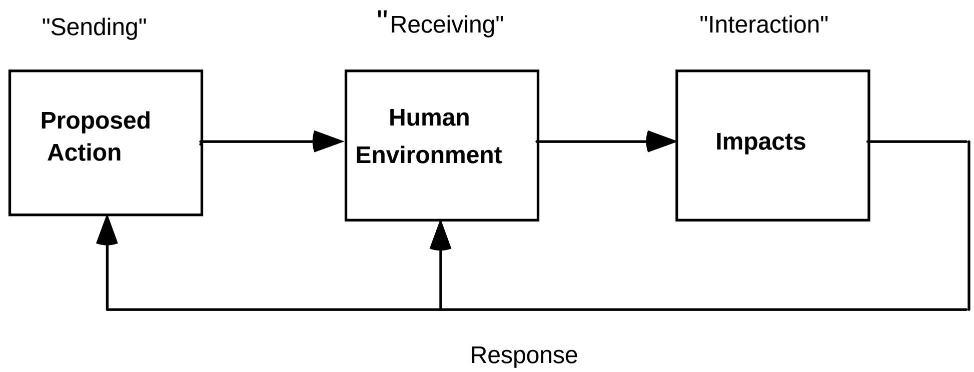
In principle, the methodology of impact assessment can be applied to the full range of regional, topical, and sectoral interest. A sampling of those relevant to the ESRA project is arrayed in Exhibit 3-2).

Exhibit 3-2. Impact Assessment Applications

Adaptation Assessment Aquatic Ecological Risk Assessment Beneficiary Assessment Biodiversity Assessment Biological Assessment Capacity Assessment Climate Impact Assessment Community Impact Assessment Comparative Country Assessment Conflict Assessment Consequence Assessment Cultural Assessment Cumulative Impact Assessment Demographic Impact Assessment Development Impact Assessment Disaster Assessment Economic Impact Assessment Ecological Risk Assessment Ecosystem Assessment Effects Assessment Environmental Impact Assessment Exposure Assessment Fiscal Impact Assessment Habitat Assessment Hazard Assessment Health Impact Assessment	Human Impact Assessment Institutional Assessment Integrated Impact Assessment Issues Assessment Life Cycle Assessment Needs Assessment Participatory Poverty Assessment Political Risk Assessment Policy Impact Assessment Project Appraisal Rapid Rural Appraisal Regional Assessment Regulatory Impact Assessment Resource Assessment Risk Assessment Social Impact Assessment Strategic Environmental Assessment Sustainability Assessment Technology Assessment Urban Impact Assessment Vulnerability Assessment Watershed Risk Assessment

The methodology of impact assessment bears a close resemblance to that of TDA and SAP. It can be visualized in a simple Impact Assessment Model (IAM; Exhibit 3-3).

Exhibit 3-3. Impact Assessment Model (IAM)



"Sending": Impacts "of" (on the side of cause)—what is (potentially) causing the impact? (problem identification, formulation of alternatives)

- Proposed action
  - Activity systems and cycles
  - Change agents and instruments
  - Technical systems description and characterization
- Alternative actions
  - "Reasonable" alternatives
  - "Do nothing"

"Receiving": Impacts "on" (on the side of effects)—what is being impacted; "impacts on whom?" (profiling)

- "Human environment"
  - Environmental and social conditions (existing, future) ("with and without" the proposed action
  - Environmental and social l systems "with and without" the proposed action
    - Existing: population segments, institutions, and organizations
    - Impacted: potentially affected publics and concerns

"Interaction": Consequences arising from the interaction of causative factors and affected conditions and systems in terms of impact categories and dimensions (projection, analysis of alternatives)

- Impact categories: *What impacts?* (economic, demographic, cultural, political, etc.).
  - System types and parts
- Impact dimensions: *What about* what impacts? (incidence, distribution, significance)
  - System properties and relations

"Response": Anticipation and adaptation—impacted systems do not simply react; their response ("feedback") can modify both causative factors and their own structures

- Impact evaluation
  - Risk perception, attribution, and acceptance
- Impact mitigation: strategies and measures
  - Policy adjustment, program alteration, and project modification
- Impact monitoring
- Impact management

3.3.1 The Impact Assessment Model (IAM)

In IAM, activities that can produce impacts represent the “sending” side of the impact equation. The “human environment” is the “receiving” side, and consists of social conditions and social systems “with and without” the proposed action. It is the interaction of the proposed action with the human environment that produces impacts, cross-classified under substantive categories and analytic dimensions. “Categories” refers to what *type* of impacts, e.g., economic, demographic, cultural, and psychological. “Dimensions” refers to *properties of* those impacts, e.g., their incidence, distribution, and significance. Human systems are adaptive and respond not only to impacts that have already occurred from proposed actions but also to the *anticipation* of their possible occurrence. This adaptive and anticipatory response may take the form of adjusting to changes in social conditions and systems or to the alteration of proposed actions that may cause these changes, or to both. Following is a brief description these model components and their relations, elaborated in depth and detail in later sections.

<u>The Proposed Action</u>: The proposed action consists of instrumental activities and operational phases intended to achieve some policy goal or program objective. They may involve physical alterations of the natural environment by technological applications, or the instituting of “non-structural” measures to promote a social policy. Usually both are involved, though in unequal proportions. For example, the provision of primary health care entails transportation of staff and patients, construction of community health centers, and stocking them with medical equipment and drugs, as well as training health care providers and educating the public. Alternatives to the proposed action are also included in this component, their range varying with the level of assessment (policy, program, or project).

<u>The Human Environment</u>: The human environment is comprised by environmental and social conditions and systems. The distinction between them is analogous to that between habitats and species; while habitats are essential for the survival of species, they are not identical with those species. Existing conditions are the present states of social conditions and social systems. Future conditions are projected future states of those social conditions and social systems “with and without” the proposed action. The difference between the two is the estimate of impact from the proposed action.

<u>Impacts</u>: Impacts are changes in the states and structures of social conditions and social systems. The interaction of the proposed action with the human environment can be analyzed in terms of impact categories and impact dimensions. Impact categories refer to *types* of social conditions and systems, e.g., psychosocial, socioeconomic, and sociocultural, and their attributes. Impact dimensions indicate what properties of those impacts should be assessed, e.g., their incidence, distribution, and significance.

<u>Response</u>: Impacted systems do not simply react; responses can appear quite disproportionate to precipitating events (“social amplification”). Such responses can modify both causative factors and existing conditions and systems. The response of adaptive systems includes impact evaluation (risk perception, attribution, and acceptance), impact mitigation strategies and measures (policy adjustment, program alteration, project modification), impact monitoring and management.

3.3.2 THE MAIN PATTERN

This model can be further analyzed in a series of assessment steps referred to here as the "Main Pattern" because they appear to represent a professional consensus. (Exhibit 3-4). They are further explicated in Exhibit 3-5 and interpreted below in the context of the ESRA project. Associated with each step are specific analytic techniques and empirical data sets. Although the series of assessment steps is presented in a logical sequence, in practice there is frequent interaction and iteration among them.

Exhibit 3-4. The Main Pattern Schema

Assessment Steps	Analytic Operations
1. **Scoping**	1. Formulate terms of reference 2. Identify and dimension impact categories 3. Develop study design 4. Perform mini-assessment
2. **Problem Identification**	1. Explicate policy goals, planning objectives 2. Identify publics and concerns 3. Perform needs assessment 4. Determine evaluative criteria
3. **Formulation of Alternatives**	1. Define set of "reasonable" alternatives 2. Characterize and describe technical system(s) 3. Analyze for social components and correlates 4. Profile change agents, instruments
4. **Profiling**	1. Characterize potentially impacted system(s) 2. Assign impact indicators 3. Perform indicator measurements 4. Compile baseline system(s) profile
5. **Projection**	1. Explicate "state of society" assumptions 2. Perform trend impact analysis 3. Construct dynamic system models 4. Estimate impact indicator values for alternatives
6. **Analysis of Alternatives**	1. Perform sensitivity analysis for alternative outcomes of alternative plans 2. Perform cross-impact analysis 3. Perform cumulative impact analysis 4. Describe and display "significant" impacts
7. **Evaluation**	1. Rank and weight preferences for alternatives 2. Perform tradeoff analysis 3. Identify preferred alternative
8. **Mitigation**	1. Identify possible mitigation measures 2. Perform sensitivity analysis of possible measures 3. Specify terms & conditions for applying measures
9. **Monitoring**	1. Devise monitoring plan 2. Measure actual vs. predicted impacts 3. Feed back results to policy makers and publics
10. **Management**	1. Devise management plan 2. Adjust objectives, procedures, and specifications

Exhibit 3-5. The Main Pattern Explained

1. **Scoping**: This is a preliminary problem analysis and intensive research planning stage in which the entire series of assessment steps is previewed in relation to the application at hand. The inputs are an analysis of the background of the problem, the proposed action which is the subject of the assessment, and of the study itself; the identification and dimensioning of impact categories (what impacts—and what about them—where, when, and on whom); and the development of detailed work plans for meeting the analytic and data requirements that "solve" the assessment problem. The output is the plan of study, which provides guidelines and directives for performing the impact assessment.
2. **Problem Identification**: At this step the assessment task is to understand better the nature of the problem in relation to which the proposed action is offered as a solution. This involves the identification of parties at interest in the impact situation (such as proponents, opponents, and regulators), the nature of their interests and concerns, and the evaluative criteria by which they will determine the adequacy of alternative solutions. The output of this step is a matrix of identified publics by associated interests and evaluative criteria.
3. **Formulation of Alternatives:** Here the assessment task is to analyze the proposed action in greater detail and to develop a range of alternative plans of action that should be considered and compared in arriving at a preferred alternative. The social (institutional/behavioral/attitudinal) components of such plans and their implementation (were they to be carried out) are part of this analysis, as well as technical systems characterization and description. The output is a "project profile" for each alternative.
4. **Profiling**: The proposed action represents the "sending" side of the impact situation; now attention is directed to the "receiving" side—the context into which the various alternatives must fit in order to yield a solution. The output at this step is a baseline (without project) profile of potentially impacted systems; the profile features and dimensions are the attributes of those systems, formulated earlier as impact categories.
5. **Projection**: The next step is to project the existing state of the system with and without implementation of the proposed action or alternative actions. Assessed impacts are then variations in profile features (i.e., in the values of impact indicators) under these assumed future conditions. The output of this step is a set of profile projections that display the alternative outcomes of alternative plans.
6. **Analysis of Alternatives**: The further analysis of alternatives is carried out by varying the degree (configuration, treatment) of plan implementation for each alternative. Besides sensitivity analysis, cross impact and cumulative impact assessment are performed at this step. The output is a detailed set of alternative plans and their associated impacts under varying future conditions.
7. **Evaluation**: The preceding steps were calculated to reveal possible differences among alternatives. The task now is to assign values to the desirability of these potential outcomes. Evaluative criteria of various publics are applied and compared (ranked and weighted) to arrive at a "preferred alternative."

8. **Mitigation**: Adjustments in a proposed action can now be made to avert or mitigate impacts evaluated as adverse. Mitigation measures will themselves have impacts and they too must be assessed following the same pattern. The output is an impact agreement to be implemented under stated and agreed terms and conditions.
9. **Monitoring**: Once implementation of a preferred alternative begins, it is possible to measure actual against predicted impacts and to institute the mitigation measures, including project modifications, contained in the mitigation plan. The measurement system for detecting and comparing differences between actual and potential impacts is formulated in a monitoring plan, and is the output of this step.
10. **Management**: Implementing the mitigation and monitoring plans is the responsibility of impact management. The output is the activation of various measures and procedures contained in those plans, as prescribed in a management plan.

The Main Pattern is essentially a "rational problem-solving" schema closely resembling many others in impact assessment and related fields (e.g., decision analysis). Although it aims at methodological completeness, the art of impact assessment lies in selecting the methods and techniques most relevant to the particular application at hand.

3.3.3 RISK ASSESSMENT METHODOLOGY

The methodology of risk assessment follows this general pattern, with some minor variations. Regarding environmental risk assessment, for example, Carpenter (1998: 195-202) compresses the ten steps into five:

- Hazard Identification
- Hazard Accounting
- Scenarios of Exposure
- Risk Characterization
- Risk Management

Risk forces and factors can be identified and analyzed at each step in this series. "Hazard Accounting" corresponds roughly to profiling; "Scenarios of Exposure," to projection. "Risk Characterization" (p. 201) "facilitates the judgment of the acceptability of the risk" by means of risk comparison, corresponding to analysis of alternatives and impact evaluation.

4.0 APPLICATION TO ESRA

This section applies the assessment methodology described previously to the substantive focus of the project:

- The scoping and problem identification steps were addressed in Sections 1 and 2.
- The formulation, analysis, and evaluation of alternatives are discussed in Section 5.2.
- Sectoral analysis (4.1) parallels the steps of profiling and projection in consideration of existing and future systems and conditions.
- In topical analysis (4.2), monitoring and evaluation, decision support framework, and adaptive management correspond to the Main Pattern steps of evaluation, mitigation, monitoring, and management.

A more systematic application of the assessment process is outlined and illustrated in the annex volume accompanying this report.

The Terms of Reference (ToR) directs attention to seven sectors:

- Climatic & Atmospheric Change
- Land Transformation
- Sustainability of Freshwater Systems & Resources
- Social Environment and Health
- Economic Environment
- Political Environment
- Natural Resources Sustainability, Biodiversity, Integrity, Productivity

Following the ecosystems approach, these will be clustered in two main categories, environmental and social, and will be interpreted as components of their respective systems and conditions. Naturally there are numerous intersections and interactions between the two sets; a major concern of the project is to trace and map these linkages.

For example, “land transformation” may occur by either natural forces such as wind erosion or by human intervention, say by agricultural development, or by both combined. Similarly, “natural resources” are naturally occurring features that enter the category of resources by their exploitation for human purposes. From the social sides, health is directly and indirectly affected by environmental factors such as disease vectors.

These relations are systematized below in the discussion of natural and social capital.

The ToR further calls for consideration of three cross-sectoral topics:

- Monitoring and Evaluation
- Decision Support Framework
- Adaptive Management

These converge in the context of Lake Chad Basin (LCB) in the concluding subsection on regional assessment.

4.1 Sectoral

4.1.1 Sectoral Analysis

In the present context, sectoral analysis focuses on existing and future environmental and social systems and conditions. For the environmental sector that implies characterizing the various Lake Chad Basin ecosystems and measuring their present states, for example by means of degradation indicators such as those employed in the United Nations Food and Agriculture Organization's Land Degradation Assessment in Drylands (LADA) project, and estimating their future states given present trends and proposed and future actions.

If that description seems to resemble the usual "baseline inventory," a distinction should be drawn between "baseline" and "existing" systems and conditions, the former being "initial" conditions and system states at t_o, say 1960, and the latter "present" levels and states at t_1, 2006. For future conditions and states present values can be projected to near-, medium-, and far-futures of various time intervals, say 2015, 2030, and 2100. The resulting levels represent actual impacts in the present compared to baseline levels, and potential future impacts compared to present levels.

Two additional factors that should be taken into account are the units of analysis and the "direction of the sign." For most purposes, the unit of analysis may be the "conventional" basin, but the ToR also refers to the "effective" basin, meaning the actual drainage area. The former was delineated for purposes of framing the 1964 convention and later modified with the accession of the Central African Republic. The ToR also refers to "multiple scales," meaning that major sub-basins within those boundaries also be given consideration.

As regards "the direction of the sign," "risks" are considered a special (negative) case of "impacts" in general, initially considered value-neutral. Impact evaluation is a process of drawing up a balance sheet of "significant" positive, neutral, and negative impacts in the assessment situation. Assignment of those values to specific impacts and where their net balance may fall lies beyond the assessor's capacity, however. That determination must be rendered by interested and affected parties to the assessment, foremost in the present case the Lake Chad Basin Commission, representing the member states.

4.1.2 THE ENVIRONMENTAL SECTOR

The environmental sector is analyzed from the standpoint of an ecological risk assessment (ERA). The following discussion of the LCCB environmental risk components was prepared by Dr. Nick King, of the Endangered Wildlife Trust, and is intended to identify the principal ecological problems, their root causes and possible solutions, and what risks may attend policy decisions and management actions. In terms of overall reversal of land and water degradation in the Lake Chad Basin, priority ecological considerations to be assessed are indicated below, but need not be limited to these. As a complement to the social risk assessment (4.1.3), "social" components are introduced in their direct and indirect relations to ecological impacts and influences.

Ecological risks in the LCCB are not easy to characterize in terms of single issues, because natural systems are by definition composed of multiple interconnected components. It is not only these components which are at risk but, usually and more importantly, the linkages among them which are affected by changes, leading to further changes in the components. As well as effects, the causes of the changes evident in the LBC are also not clear-cut; opinions differ as to their sources and relative significance.

Moreover, questions exist as to whether such changes are "beyond the norm" in an evolutionary sense in terms of natural fluctuations or whether they are occurring at an unnatural rate. Authors such as Coe and Foley (2001) are convinced that these changes are largely if not entirely anthropocentric in origin; some others attribute them to natural causes. In any event, no magic formula exists for management interventions to reverse degradation trends and restore "normal" functionality in the LCB.

As summarized by the Millennium Ecosystem Assessment (UNEP 2005), if natural systems were well understood and behaved in predictable ways, it might be possible to calculate what would be a "safe" amount of pressure to inflict on them without compromising the basic services they provide to humans. Unfortunately they have a tendency to move from gradual to catastrophic change with little warning. Such is the complexity of the relationships between plants, animals and micro-organisms that these "tipping points" cannot be forecast by existing science. Once such "tip-overs" occur, it can be extremely difficult, if not impossible for natural systems to be restored.

For Lake Chad Basin, just how close critical ecosystems are to the tipping point, or whether that may have already been reached and exceeded, is unknown. It can safely be assumed however that the changes witnessed over the last few decades have moved them substantially closer to the edge.

Problem Identification: Straddling the borders of Chad, Niger, Nigeria and Cameroon, Lake Chad has been a traditional source of freshwater for domestic consumption and agricultural production throughout the centuries. Over the past forty years, the lake has shown a dramatic decrease in size, however. Since 1963 the lake has shrunk to a twentieth of its former size, apparently due to both climatic changes and high demands for agricultural water. About 50% of the decrease in the lake's size since the 1960s is attributed to water abstractions for human use, with the remainder attributed to shifting climate patterns.

Between 1953 and 1979, irrigation appeared to have only a modest impact on the Lake Chad ecosystem. Between 1983 and 1994, however, irrigation water use increased four-fold. Invasive plant species currently cover about 50% of the remaining surface of Lake Chad, seriously impairing its functionality. Research carried out over the past 40 years indicates that major factors in the shrinking of the lake have been:

- Heavy overgrazing in the region, resulting in the loss of vegetation and serious deforestation, thereby contributing to dessication;

- Large and unsustainable irrigation projects built by Niger, Nigeria, Cameroon, and Chad, which have diverted water from both the lake and the major contributing watershed, the Chari and Logone system.

- The resulting changes in river-flows and the lake levels have contributed to a continuing decline in local access to water, crop failures, livestock deaths, collapsed fisheries, rising soil salinity, and increasing poverty throughout the region.

- Unless remedied, these trends may accelerate, placing the entire lake system and all attendant livelihoods at risk from devastating ecological, social, economic, and political consequences.

Global Climate Change: It is today universally acknowledged that human activities are the primary cause of accelerated global climate change. The American Geophysical Union (2003) concluded, that "human activities are increasingly altering the Earth's climate" and that "natural influences cannot explain the rapid increase in global near-surface temperatures observed during the second half of the 20th century." The Intergovernmental Panel on Climate Change (IPCC) concluded, in 2001, that, "human activities have increased the atmospheric concentrations of greenhouse gases and aerosols since the pre-industrial era." The U.S. Climate Action Report, of the United States Global Change Research Program (2002), stated that, "greenhouse gases are accumulating in Earth's atmosphere as a result of human activities, causing surface air temperatures and sub-surface ocean temperatures to rise." The American Meteorological Society (2003) concluded that, "during the industrial period, the atmospheric abundance of carbon dioxide, methane, nitrous oxide, halocarbons (e.g., chlorofluorocarbons), and tropospheric ozone have increased as a direct result of human activity."

The dominant role of anthropogenic sources of global climate change, in combination with the precipitous nature of the changes underway, lead to the conclusion that "natural," "systemic," or "dynamic" changes in planetary weather patterns are not the primary source of recent accelerated climatic change. This realization must extinguish the common, but largely unstated, belief that we can simply "wait for the weather to return to normal."

The difference in attribution (i.e., anthropogenic or "natural") for these large scale climatic changes is of profound importance in terms of the range of potential human responses available and the vigor by which they are pursued. That is, if global climate changes are imagined to be of "natural" or "divine" origin (i.e., of "non-anthropogenic" origin), then the arguments "nothing can affect the weather" or that weather changes are not amenable to human intervention will continue to carry weight. Those that hold such a view can continue to argue that since changes in the weather are of supernatural providence, little can or should be done to avert inevitable crises. In fact, much can be done, and must be done soon, to avert predicable environmental catastrophes.

The problem is, despite the unprecedented pace of global climate change, at the level of a human lifetime, local expressions of these changes are difficult to recognize from year to year, or even from one decade to the next. But as the changes accumulate, and accumulate in a certain direction, they are eventually recognized as substantial, reaching a level that threatens human lives. For example, fluctuations in the size of Lake Chad are not unusual in the geologic record, but the pace of changes which are presently affecting it represent a vastly larger problem in terms of human vulnerability than during any previous geologic or historic epoch.

According to the Third Assessment Report of the IPCC, "recent regional changes in climate, particularly increases in temperature, have already affected hydrological systems and terrestrial and marine ecosystems in many parts of the world." It is these changes in the regional hydrological system that pose the greatest risk to the Sahel region of Africa, and, more narrowly, to the Lake Chad conventional basin. Levels of rainfall over the Sahel have declined precipitously since the mid-1960s (see Exhibit 4-1). The difference between average annual rainfall levels before and after this date have been dramatic – in the range of 30 percent. The Sahel experienced the most accelerated decline in rainfall in the world during the 20th Century.

It is safe to say that the decreasing rainfall and devastating droughts in the Sahel region during the last three decades of the 20th century are among the most undisputed and largest recent climate changes recognized by the climate research community. Indeed, substantial field based research has been conducted into the impacts and coping strategies deployed by Sahelian pastoralist communities in response to their deteriorating natural resource base (e.g. Mortimore and Adams, 2001; Tarhule and Lamb, 2003). (Aiguo Dai, et al., National Center for Atmospheric Research, Int. J. Climatol. 24: 1323–1331, 2004)

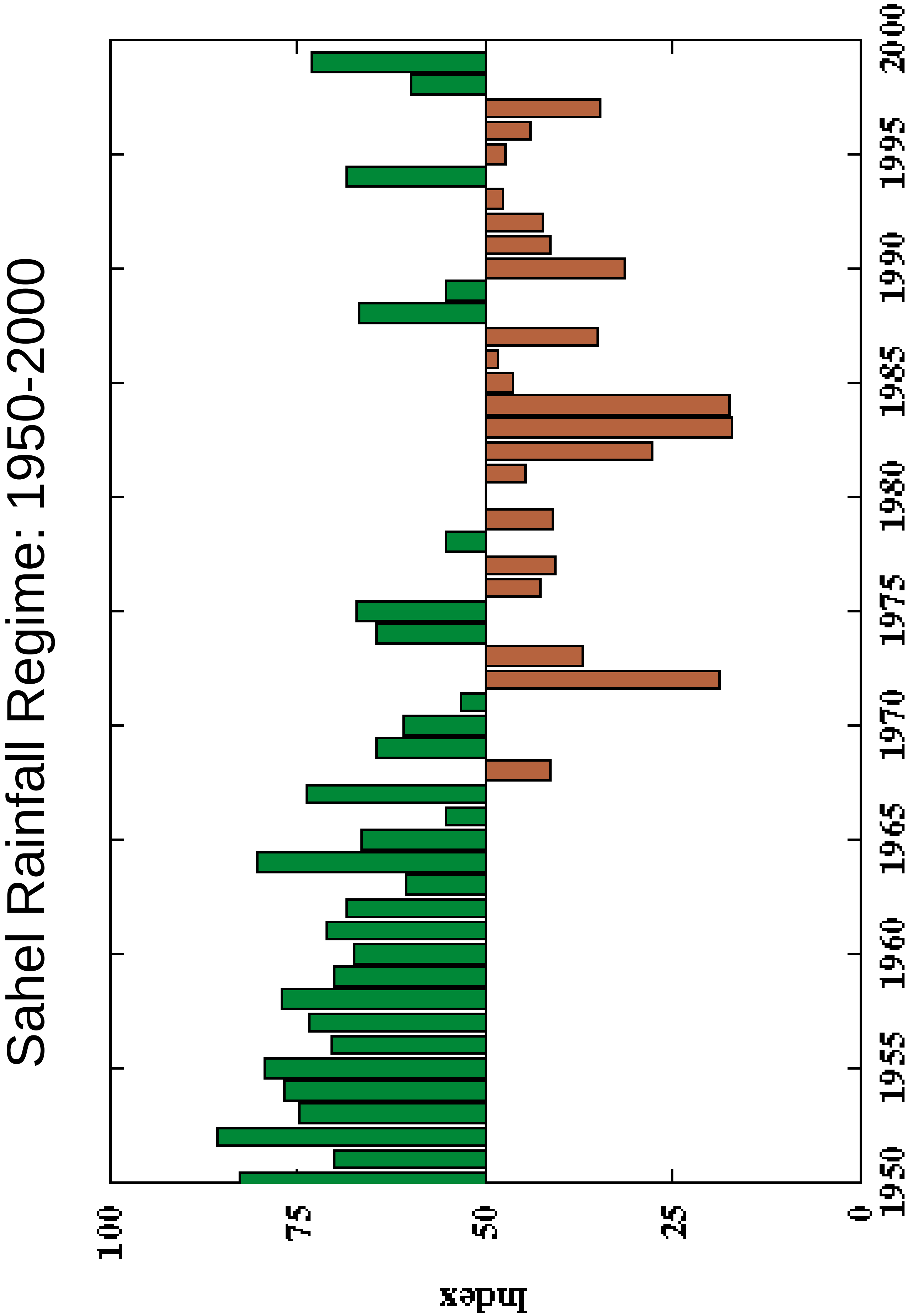

Sahel Rainfall Regime: 1950-2000
Index
100
75
50
25
0
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000

Exhibit 4-1

Changes in rainfall patterns, reflected in shifting isohyets, actually determine where rain-fed agriculture can take place, determine the range and success of livestock, determine the specific range and success of specific agricultural products (e.g., millet, sorghum, etc.), and, therefore, what areas humans can feasibly inhabit. The following Exhibits (4-2, 4-3, 4-4, 4-5, and 4-6) utilize the 300 mm isohyets line to depict the distribution of rainfall for each of the years from 1950-1996. Small-scale yearly changes can and will be accommodated, and responsible water usage can stretch available water resources to extend their utility, but as these changes accumulate over time, large areas will simply be unable to sustain human life without the commitment of increasingly massive external social, political, and economic resources – resources that are, in fact, generally in decline.

An important point of our analysis is that the most at-risk populations depicted in our analysis will always be extended to the very margins of survivability, and will therefore always be precariously positioned in the event of single-year drought or relative water scarcity. The number of people at risk and the nature of their exposure, however, increases very rapidly as the severity and duration of the drought continues. The present assessment of social risks associated with environmental and human-induced vulnerability is organized to identify which populations, organized by what geography, are presently poised to sustain the concentrated burden of future acute and chronic environmental events within the Lake Chad conventional basin.

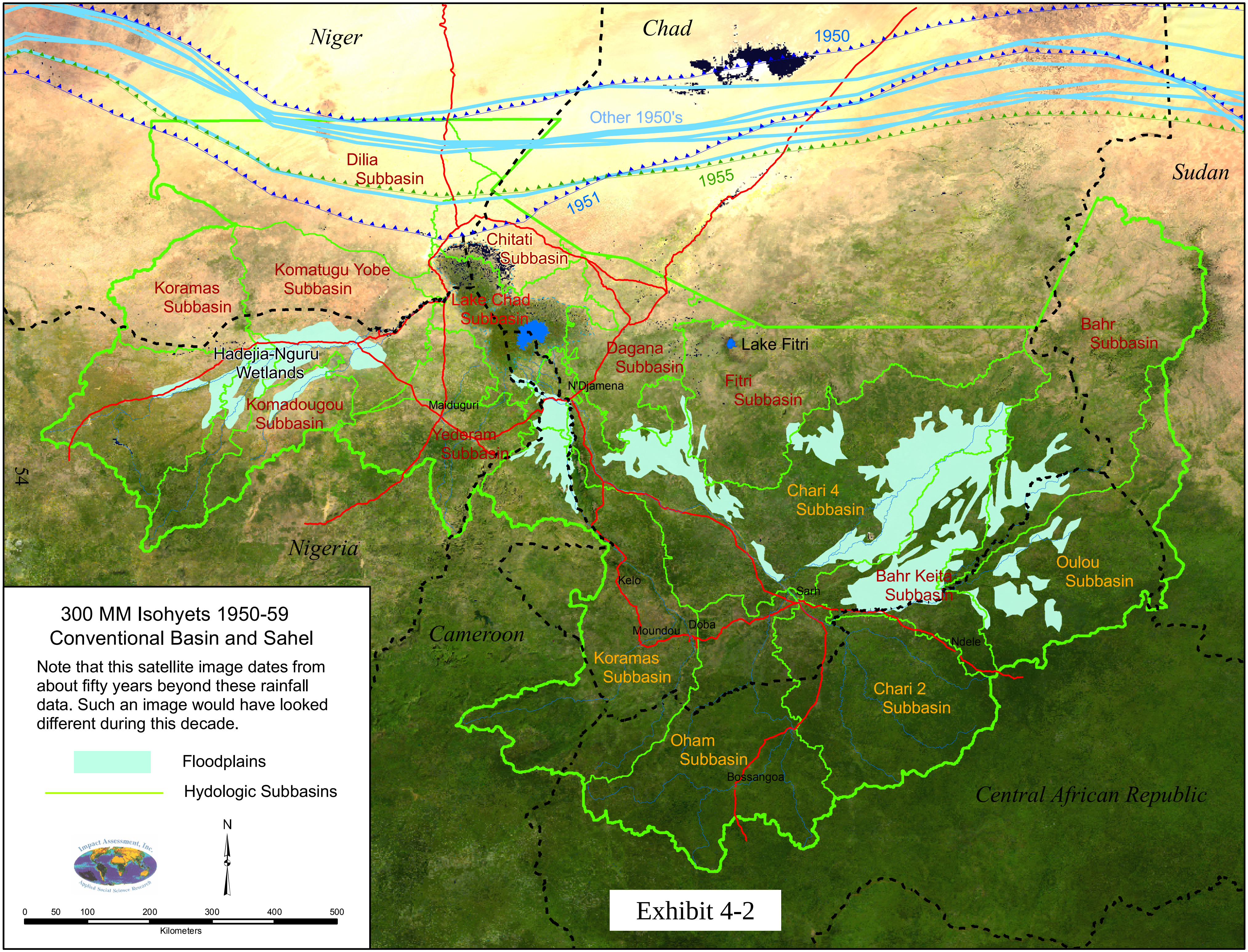

300 MM Isohyets 1950-59
Conventional Basin and Sahel
Note that this satellite image dates from about fifty years beyond these rainfall data. Such an image would have looked different during this decade.
Floodplains
Hydrologic Subbasins
N
0 50 100 200 300 400 500
Kilometers
Niger
Chad
Sudan
Nigeria
Cameroon
Central African Republic
1950
Other 1950's
1955
1951
Dilia Subbasin
Chitati Subbasin
Komatugu Yobe Subbasin
Koramas Subbasin
Lake Chad Subbasin
Hadejia-Nguru Wetlands
Komadougou Subbasin
Maiduguri
Yederam Subbasin
N'Djamena
Dagana Subbasin
Lake Fitri
Fitri Subbasin
Bahr Subbasin
Chari 4 Subbasin
Oulou Subbasin
Bahr Keita Subbasin
Sarh
Kelo
Moundou
Doba
Ndele
Koramas Subbasin
Chari 2 Subbasin
Oham Subbasin
Bossangoa

Exhibit 4-2

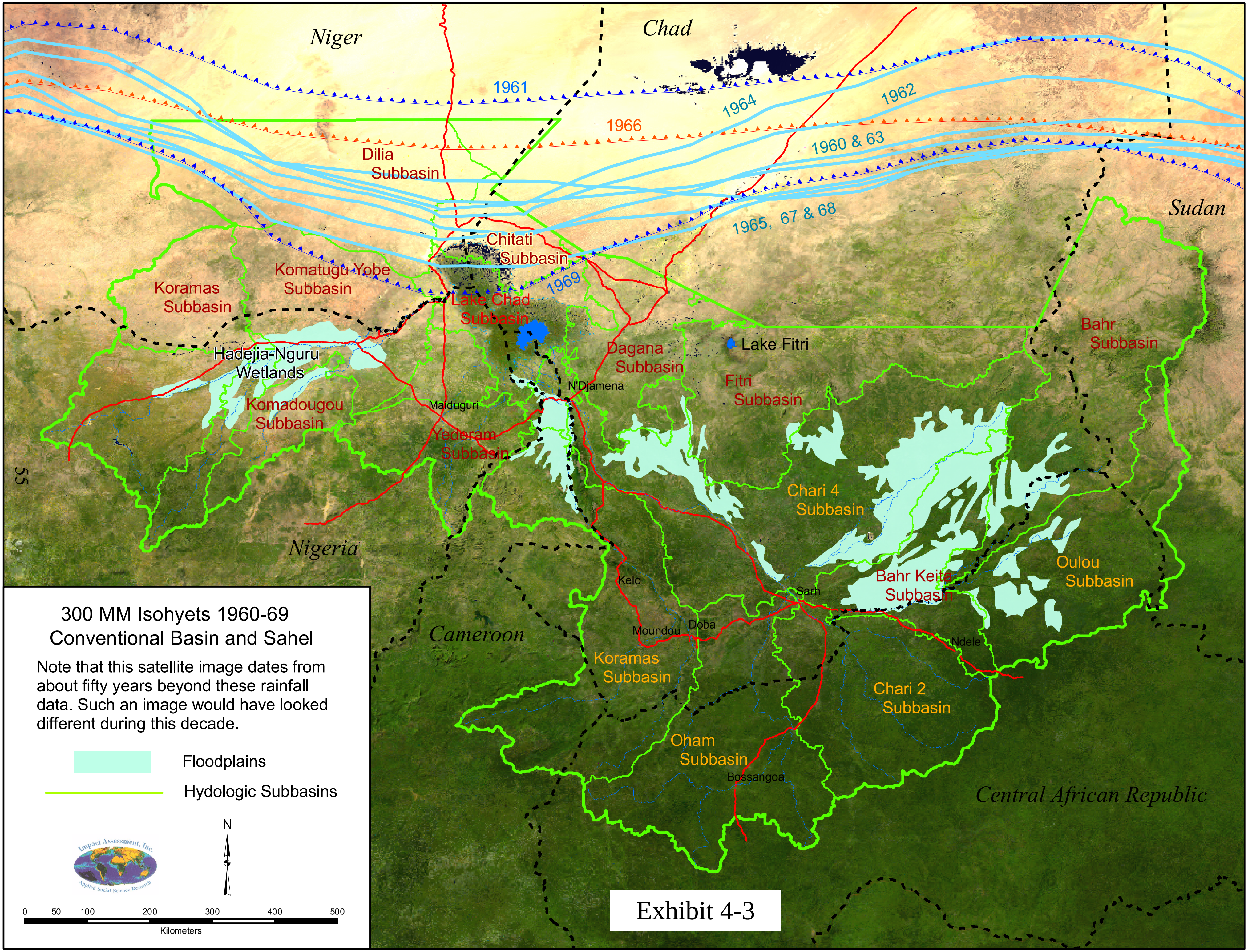

300 MM Isohyets 1960-69
Conventional Basin and Sahel
Note that this satellite image dates from about fifty years beyond these rainfall data. Such an image would have looked different during this decade.
Floodplains
Hydrologic Subbasins
N
0 50 100 200 300 400 500
Kilometers
Niger
Chad
Sudan
Nigeria
Cameroon
Central African Republic
1961
1962
1964
1966
1960 & 63
1965, 67 & 68
1969
Dilia Subbasin
Chitati Subbasin
Koramas Subbasin
Komatugu Yobe Subbasin
Lake Chad Subbasin
Hadejia-Nguru Wetlands
Komadougou Subbasin
Yederam Subbasin
Dagana Subbasin
Fitri Subbasin
Lake Fitri
Bahr Subbasin
Chari 4 Subbasin
Bahr Keita Subbasin
Oulou Subbasin
Koramas Subbasin
Chari 2 Subbasin
Oham Subbasin
Maiduguri
N'Djamena
Kelo
Moundou
Doba
Sarh
Ndele
Bossangoa

Exhibit 4-3

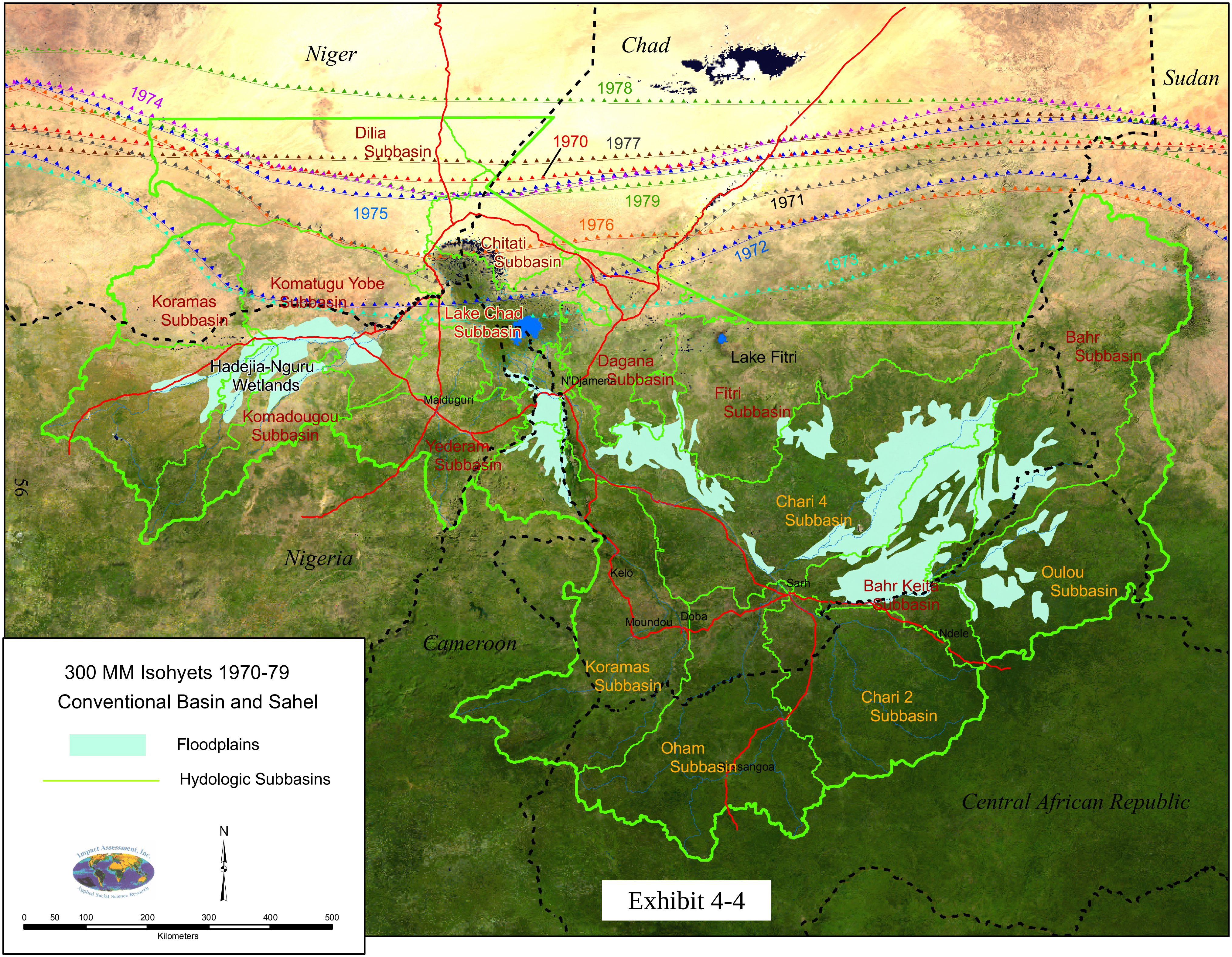

Niger
Chad
Sudan
Nigeria
Cameroon
Central African Republic
1974
1978
1970
1977
1975
1979
1971
1976
1972
1973
Dilia Subbasin
Chitati Subbasin
Komatugu Yobe Subbasin
Koramas Subbasin
Lake Chad Subbasin
Hadejia-Nguru Wetlands
Komadougou Subbasin
Maiduguri
Yederam Subbasin
N'Djamena
Dagana Subbasin
Lake Fitri
Fitri Subbasin
Bahr Subbasin
Chari 4 Subbasin
Sarh
Bahr Keita Subbasin
Oulou Subbasin
Ndele
Kelo
Moundou
Doba
Koramas Subbasin
Chari 2 Subbasin
Oham Subbasin
Bossangoa
300 MM Isohyets 1970-79
Conventional Basin and Sahel
Floodplains
Hydologic Subbasins
Impact Assessment, Inc.
Applied Social Science Research
N
0 50 100 200 300 400 500
Kilometers

Exhibit 4-4

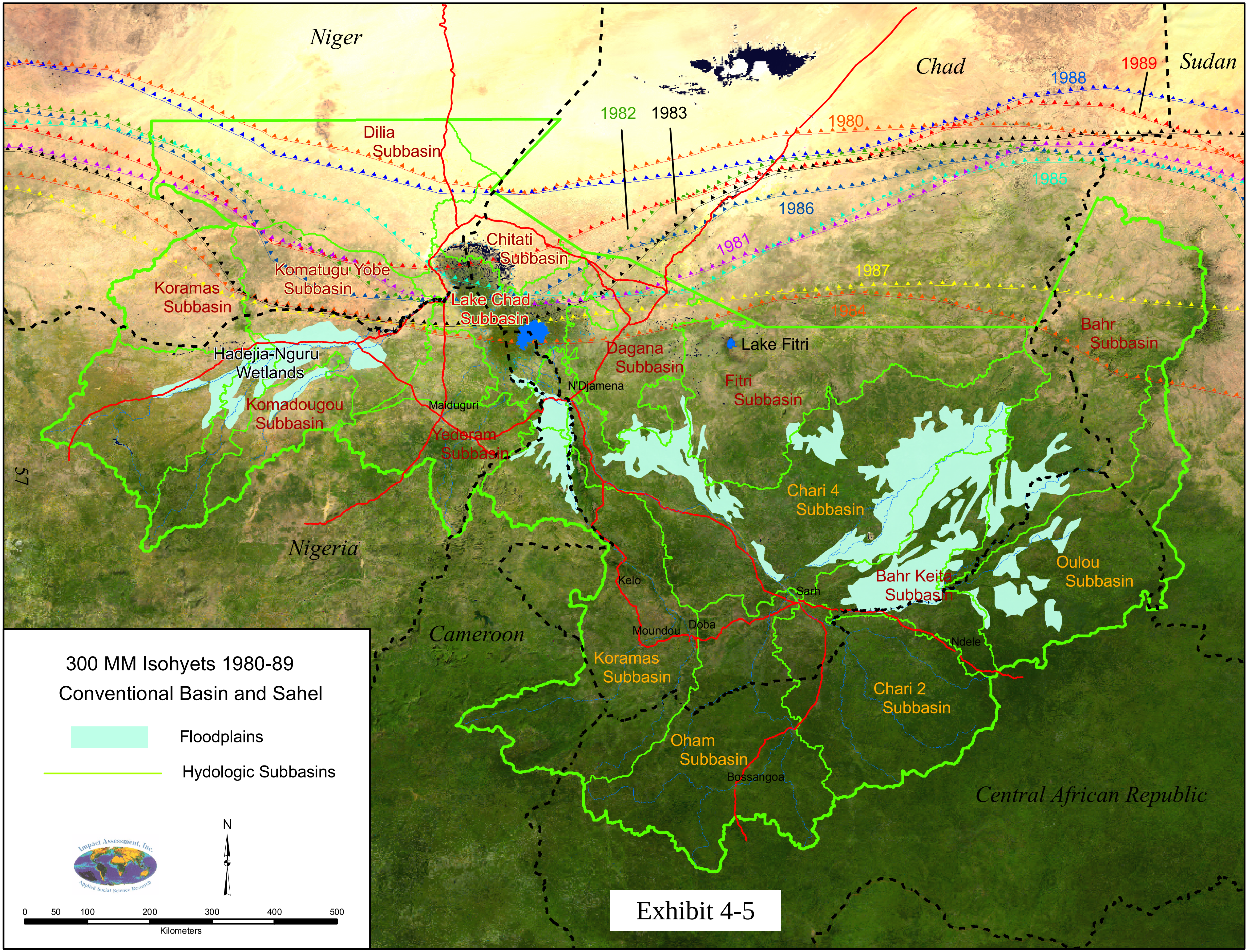

Niger
Chad
Sudan
Nigeria
Cameroon
Central African Republic
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
Dilia Subbasin
Chitati Subbasin
Komatugu Yobe Subbasin
Koramas Subbasin
Lake Chad Subbasin
Hadejia-Nguru Wetlands
Komadougou Subbasin
Yederam Subbasin
Dagana Subbasin
Lake Fitri
Fitri Subbasin
Bahr Subbasin
Chari 4 Subbasin
Bahr Keita Subbasin
Oulou Subbasin
Chari 2 Subbasin
Oham Subbasin
Koramas Subbasin
N'Djamena
Maiduguri
Kelo
Moundou
Doba
Sarh
Ndele
Bossangoa
300 MM Isohyets 1980-89
Conventional Basin and Sahel
Floodplains
Hydologic Subbasins
N
0 50 100 200 300 400 500
Kilometers

Exhibit 4-5

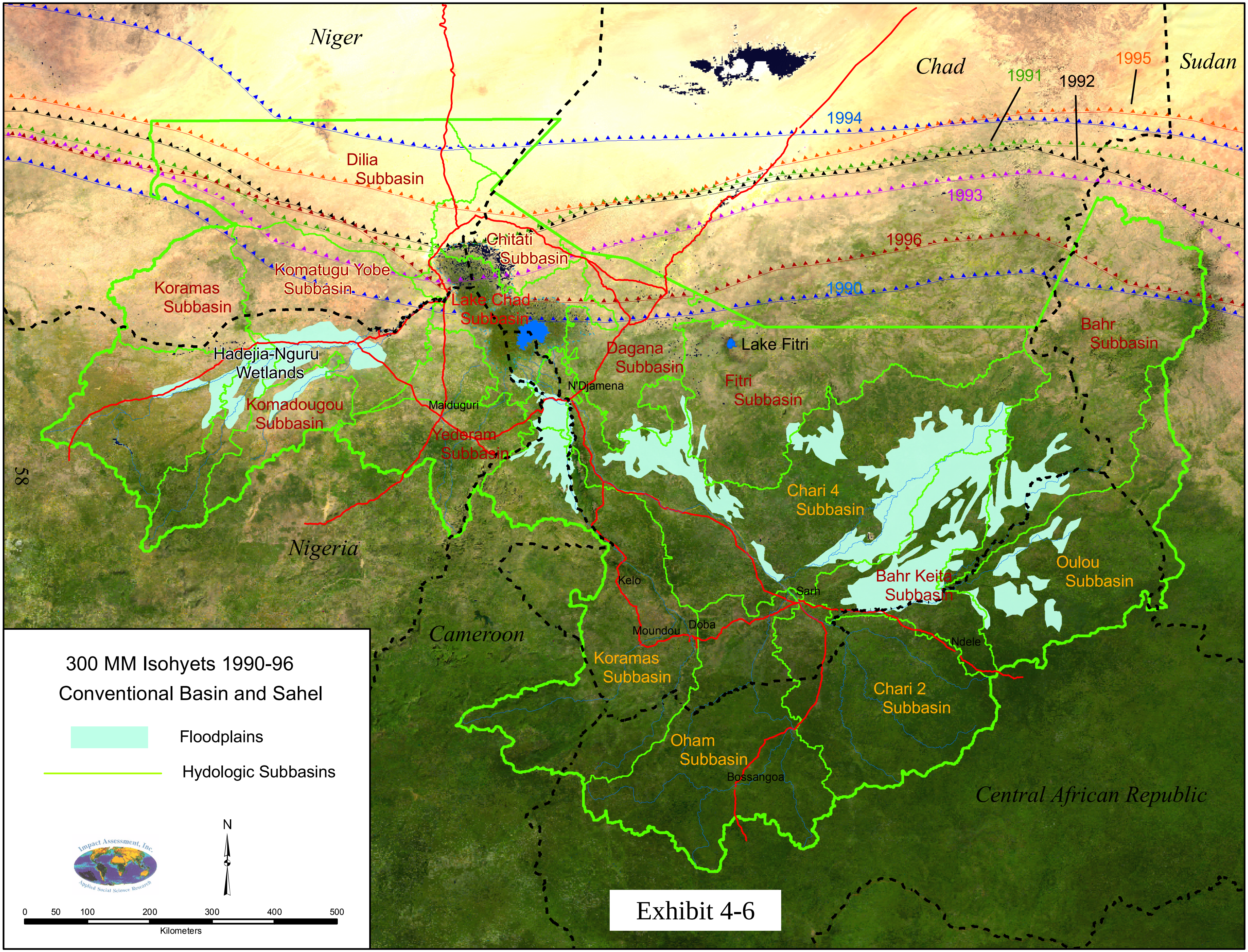

Niger
Chad
Sudan
1995
1991
1992
1994
1993
1996
1990
Dilia Subbasin
Chitati Subbasin
Komatugu Yobe Subbasin
Koramas Subbasin
Lake Chad Subbasin
Hadejia-Nguru Wetlands
Komadougou Subbasin
Maiduguri
Yederam Subbasin
N'Djamena
Dagana Subbasin
Lake Fitri
Fitri Subbasin
Bahr Subbasin
Chari 4 Subbasin
Bahr Keita Subbasin
Oulou Subbasin
Sarh
Kelo
Moundou
Doba
Ndele
Koramas Subbasin
Chari 2 Subbasin
Oham Subbasin
Bossangoa
Nigeria
Cameroon
Central African Republic
300 MM Isohyets 1990-96
Conventional Basin and Sahel
Floodplains
Hydologic Subbasins
N
Impact Assessment, Inc.
Applied Social Science Research
0 50 100 200 300 400 500
Kilometers

Exhibit 4-6

A comparison of isohyets of the 1950s (the wettest recent decade), with the driest decade (the 1980s) showed considerable shift in rainfall patterns toward the south. In particular, the 300 mm isohyets line moved 200-250 km toward the south in the west of Lake Chad, 100 km toward the south in the east but only a few tens of kilometers in Ouaddai, Chad. The 800 mm isohyets line, by contrast, shifted by 300 km to the south at the longitude of Guera in northern Cameroon and by 200 km southwest of Guera into northeast Nigeria.

Climate

The climate in this ecoregion is considered hyper-arid, with an annual average of 320 mm of rain falling on the lake. However, this “average” is declining. Rainfall occurs from June through October with the northward movement of a volatile maritime air mass. Conditions are hot and dry from March through June, and dry and cooler from November through February.

The basin’s rivers exhibit a tropical regime with a single flood occurring at the end of the rainy season lasting from August to November. Evaporation is extremely high, reaching of 2,300 mm per year. Despite the high rates of evaporation, Lake Chad has low levels of salinity because the more saline waters sink and exit the lake through subterranean conduits in the north. These underground passageways account for 8 percent of the lake’s total water outflow.

The shifts were due to orographic effects, but effects on the vegetation did not exactly parallel the shift of the isohyets as soil types also had major influences in maintaining the status quo or in accelerating the rate of degradation (as do the effects of humans and animals). The reduction in rainfall was about 100 mm for each 100 km of distance (apart from the annual and spatial variations). The shift showed that areas that had experienced a mean rainfall of 320 mm (e.g. over the Lake itself) currently receive less than 210 mm.

Finally, the GIWA Lake Chad regional assessment notes that natural variability has characterized the basin’s climate history and continues today as the main determinant of stream flow and lake level fluctuations.

Simply stated, it is the geographic scope of the global climate changes underway at the level of the Lake Chad conventional basin, in combination with the growing social vulnerability of the at-risk population (e.g., poverty, conflict, high population density, linguistic constraints, culture), in relation to the pace of those two intersecting changes that represent the most profound threat to the long-term sustainability of the Lake Chad water resource regime and the survival of it’s dependent human populations. Finally, it will be the duration of future acute events that will determine the ultimate human toll. Past droughts of 4 and 5 years’ duration have had devastating human consequences, despite massive external intervention. Longer periods of drought are possible, with predictably greater social consequence.

The two important observations to be noted from these figures are: (1) the progressive, albeit erratic, movement of the 300 mm isohyets line southward; and (2) the routine, and sometimes dramatic, variation from one year to the next in rainfall over a particular area.

Strong correlation between sea surface temperature (SST) anomalies on a global scale with wet and dry periods in the Sahel have been demonstrated. After the mid-1960s, a marked cooling of the oceans of the northern hemisphere and simultaneous warming in the southern hemisphere was observed.

A reversal occurred around 1970; since then temperatures in both hemispheres have increased. Experiments with prescribed sea temperatures were able to replicate rainfall reductions in the Sahel for recent drought years: 30% reductions over western Sahel, 20% over eastern Sahel and up to 50% over the mountains of southern Sudan and northeast Ethiopia.

The observed trends are the subject of much debate: for the LCCB, it appears that the Sahelian drought may persist and even be exacerbated by continuing reductions in the radiational and CO_2 sinks, giving rise to significant positive feedbacks leading to an increase in regional warming.

The GIWA regional assessment considers anthropogenic stream flow modification as inflicting severe impacts on freshwater availability. An unsustainable level of water use has caused diminished flows over the past 40 years, stream diversion being a key factor in the extent of the freshwater shortage downstream of large dam constructions.

This is of even greater concern regarding the use of limited water supplies during periods of low rainfall. While the future variability of the climate is critical to freshwater availability, presently no accurate models are available for predicting rainfall over the region. The role of regional anthropogenic climate change in the recent episode of freshwater shortage is likewise undetermined. Several studies have demonstrated reduced frequency of rainfall events and subsequent drought, but further studies are needed to gauge the influence of habitat modification on regional climate change.

<u>Factors Affecting Regional Expression of Climatic Change</u>: Unlike other continents, Africa south of the Atlas Mountains has no major continuous mountain barriers, either longitudinally or latitudinally orientated, to interrupt circulation. As depicted in the following graphics (Exhibits 4-7 [unmodified] and 4-8 [vertical 8X exaggerationl]), the topography of the Lake Chad basin and conventional basin are is exceptionally flat and undifferentiated (see also Exhibit 4-9, exaggerated relief draped on Modis satellite imagery).

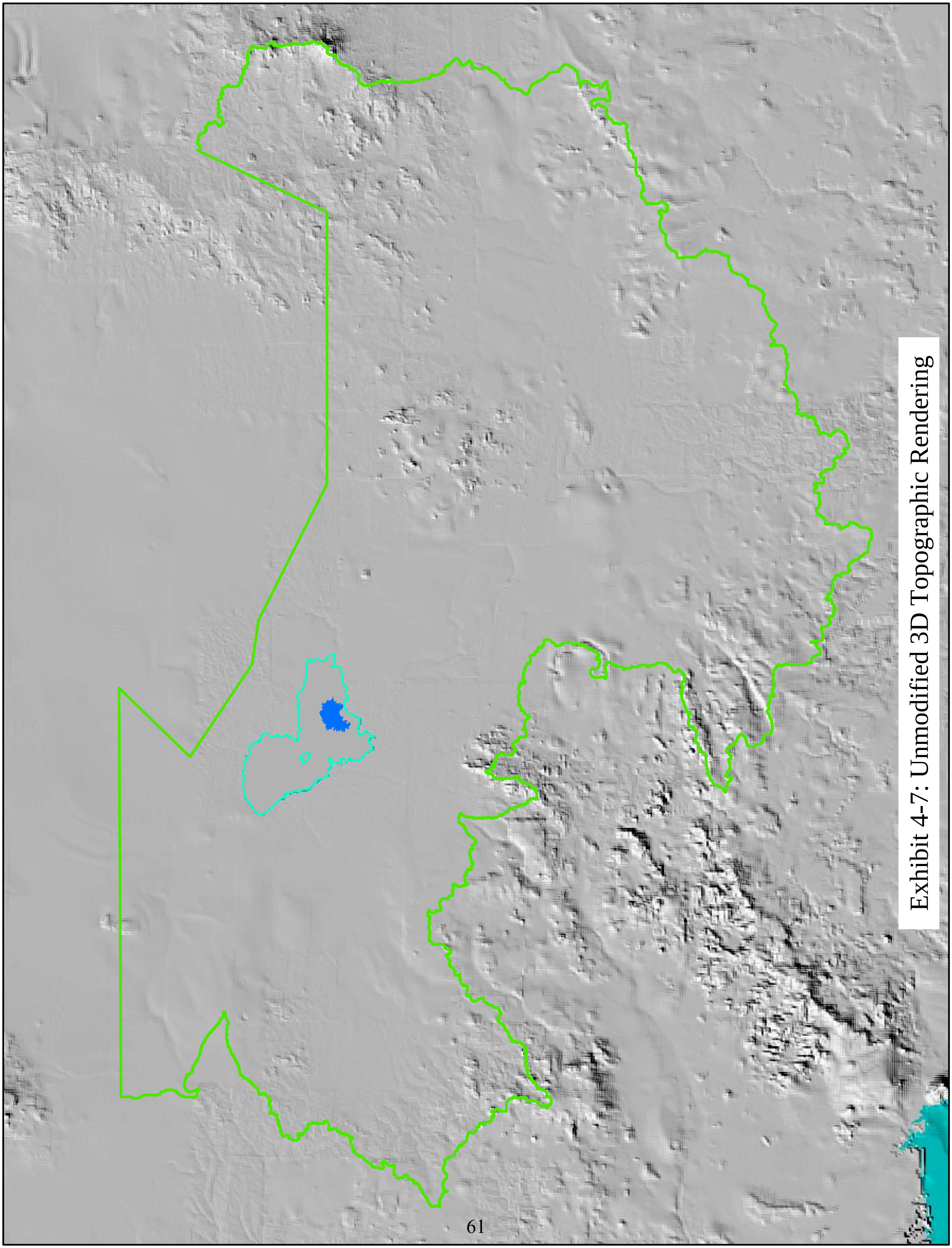


Exhibit 4-7: Unmodified 3D Topographic Rendering

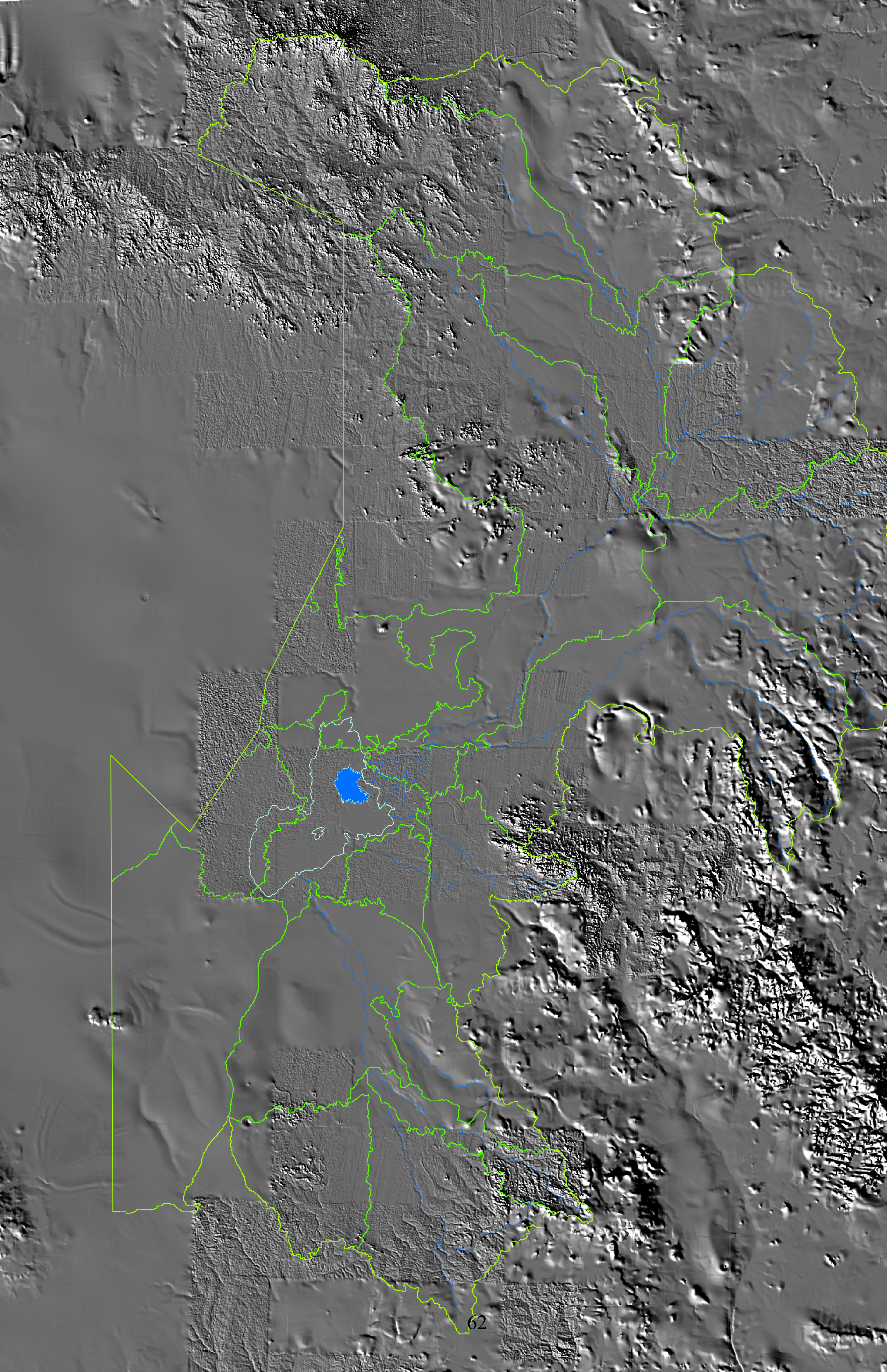


Exhibit 4-8: Exaggerated 3D Topographic Rendering

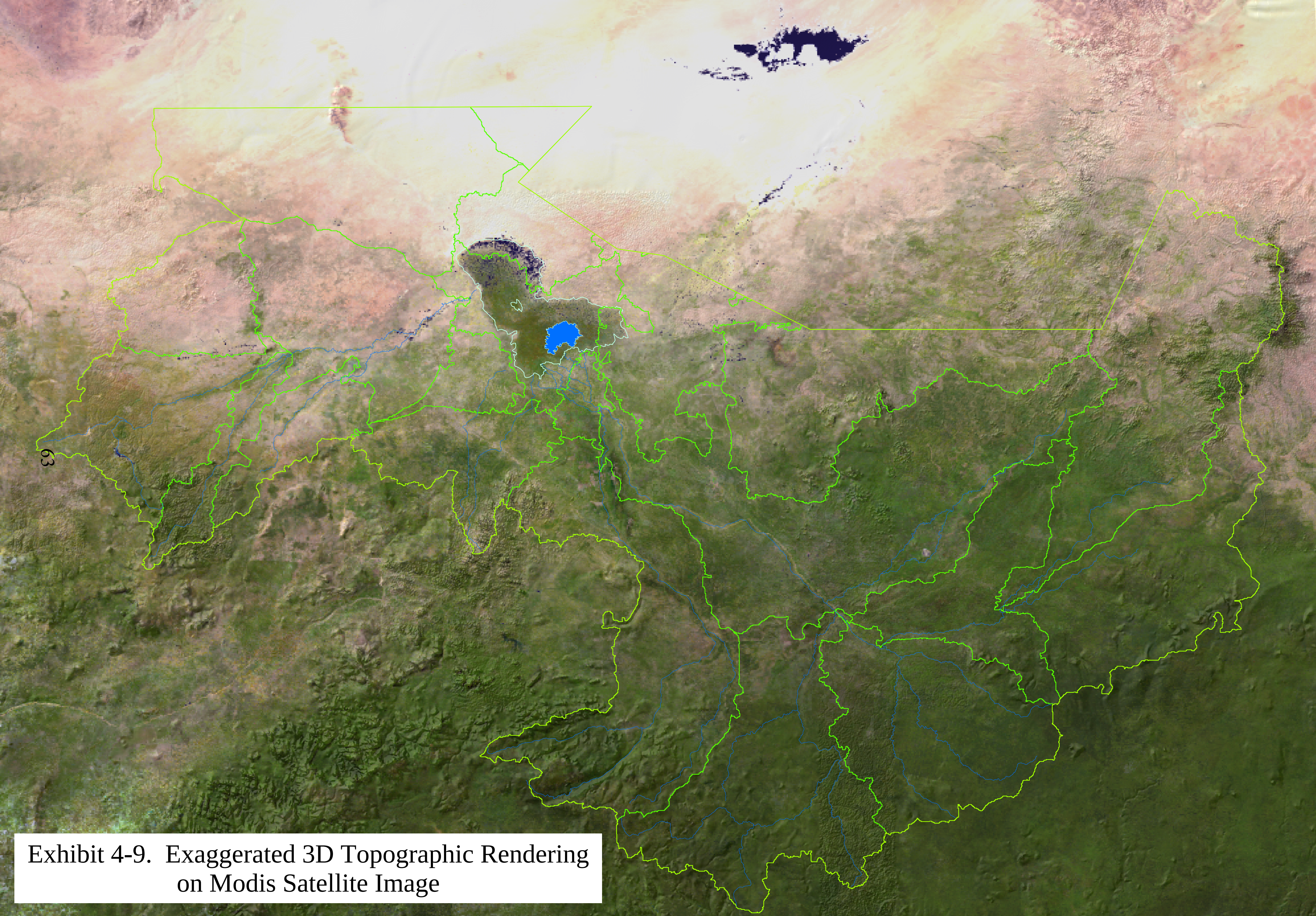


Exhibit 4-9. Exaggerated 3D Topographic Rendering on Modis Satellite Image

Consequently, climatic and seasonal variations are less complex, being governed to a large extent by the oscillating Inter-Tropical Convergence Zone, which follows the sun on its annual passage between the two hemispheres. The extreme drought years of 1972 and 1984 that devastated the Sahel region from the Atlantic coast to Ethiopia are clearly reflected in the flows of the Nile, Chari, Zaire, Niger, Zambezi, and Orange rivers in these years.

Although a high degree of homogeneity does exist between climatic fluctuations in the north and south of the continent, the influences of such large-scale systems as the Southern Oscillation and the Atlantic Oscillation, both in part driven by sea temperature variations and the monsoons of Asia, do produce spatial anomalies of climatic extremes in various areas of Africa. An example is the tendency for precipitation in the equatorial band to react in an opposite direction from the rest of Africa. Interestingly, it seems that for extreme wet and dry years the whole continent is affected with only minor deviations.

Four broad climatic patterns over the continent are postulated:

- northern and southern subtropical areas dry; equatorial regions wet;
- northern and southern subtropical areas wet; equatorial regions dry;
- whole continent dry;
- whole continent wet.

Dry continent and dry subtropical area modes have dominated the continent since 1970.

For water resources management the major concern is whether the dry period, which started in the late 1960s in the Sahel, and became dominant in southern Africa throughout the 1980s, will continue. One favored viewpoint is the existence of cyclic behaviour whereby one dry year seems to be followed by another and one wet year by another wet year.

This is explained by biogeophysical short-term feedback processes, the so called “Joseph” and “Noah” effects: reduced vegetation leads to increased albedos and increased radiation losses, surface cooling and greater atmospheric stability which reduces rainfall and encourages persistence. Similar persistences are produced by lower soil moisture levels indicating the importance of rainfall itself in initiating a significant feedback process. Such feedback processes explain much of the natural persistence of sequences of wet years and dry years found in the Sahel region, although fluctuations in sea surface temperature also play a role.

Water resource engineers tend to rely on statistical data, stochastically and historic, for estimates of reliability of yield. Long-term trends are generally ignored unless physical explanations can be presented to justify their inclusion. In this respect the Sahelian drought has persisted for almost 40 years, suggesting that it is maintained by causal factors other than normal feedback processes, in contrast to the GIWA position. Global warming is an obvious explanation, as are continuing trends in catchment degradation.

Key Environmental Risks: A combination of factors including vegetation cover, soil moisture, monsoon dynamics and SST is thought to best explain the reduction in rainfall in the Lake Chad conventional basin. Predicted patterns of climate change include rising temperature and declining precipitation which will threaten water supplies. Temperature increases will reduce the availability of water, and enlarge the area prone to vector-borne diseases such as malaria.

Crop production could be affected by temperature either way—if sufficient water is available, output could increase. Higher CO_2 levels could reduce productivity of grasslands in livestock producing areas, particularly in drier parts of the basin, and fisheries will be negatively affected by changes in water temperature, jeopardizing sustainable livelihoods in dependent communities. Increasingly, the impact of climate change is emerging as possibly the greatest risk to biodiversity loss in the long-term as habitats shift but species can no longer expand their ranges. This of course assumes that representative populations of species can survive the current pressures.

Freshwater Systems Sustainability:

Lake Water Balance

The lake experiences a close interaction between rainfall, evaporation, the generation of lateral inflow, groundwater leakage under the body of the lake and human abstraction. Thus the water balance of the lake is highly variable, resulting in fluctuating open surface waters that have exhibited dramatic expansion and contraction over geologic and recent history. Climate data show a great decrease in rainfall since the early 1960s, largely due to a decrease in the number of large rainfall events.

Lake Chad appears to have always undergone seasonal and annual fluctuations because its shallow depth, averaging less than 23 feet (7 m), is highly dependent on seasonal inflows. Today average depths vary between 1.5 and 5 m and any increase in lake volume means a substantial increase in lake area and shoreline. The surface of the lake is covered with a mixture of island archipelagoes (23 percent), reed beds (39 percent), and open water (38 percent).

Lake Chad divided into northern and southern pools in 1973, which have remained separated ever since. The northern pool has not contained permanent open waters for the past several years although recently there has been some flooding associated with wet years in 1994 and 1999. A swamp belt now divides the lake into north and south basins. Areas of open water persist in the southern basin, mostly near the Chari River inflow. Swamps are found to the west of this open water and archipelago zones are located along the northeast coast of the lake.

There is also some speculation that the drought is ending in the Sahel. There have been only three wet years (1975, 1994 and 1999) in the last 30, but they were always separated from each other by at least four dry years. The 1990s were indeed less dry than the 1970s and 1980s, and in the wet year of 1999 increases in precipitation led to the flooding of the northern pool once again. The 1990s was still the third driest decade of the 20th century and wet years were isolated events. It is therefore premature to state whether recent increases in precipitation are part of a larger climatic trend.

Catchments and Rivers

Lake Chad's primary source of water comes from monsoon rains that typically fall in June, July, and August. By virtue of its location and climate, the Lake Chad drainage area has limited surface and groundwater resources. Its water supply is primarily from the Chari-Logone River, which provides approximately 95% of the total input and empties into the southern pool, and the Komadugu-Yobe River, which contributes less than 2.5% and is the only river flowing into the northern pool.

The total annual mean river inflow decreased from the pre-1984 drought value of 39.8 km^3 to the present value of 21.8 km^3, reflecting a decrease of 47%. During the same time period, the total lake input (including direct rainfall on the lake) decreased by 50%. These decreases in inflows reflect largely the current dry conditions that affect all the river systems in the basin.

The LCCB comprises a number of transboundary waters that include three main aquifers and a network of catchment sub-basins (see Exhibit 4-10). The Chari-Logone River Basin is located in CAR, Cameroon, and Chad and contains various rivers that flow from the Mongos Hills (CAR), as well as the Adamawa Plateau and Mandara Mountains (Cameroon). The major tributaries are the Pende, which become the Logone-oriental on entering Chad, and the Chari.

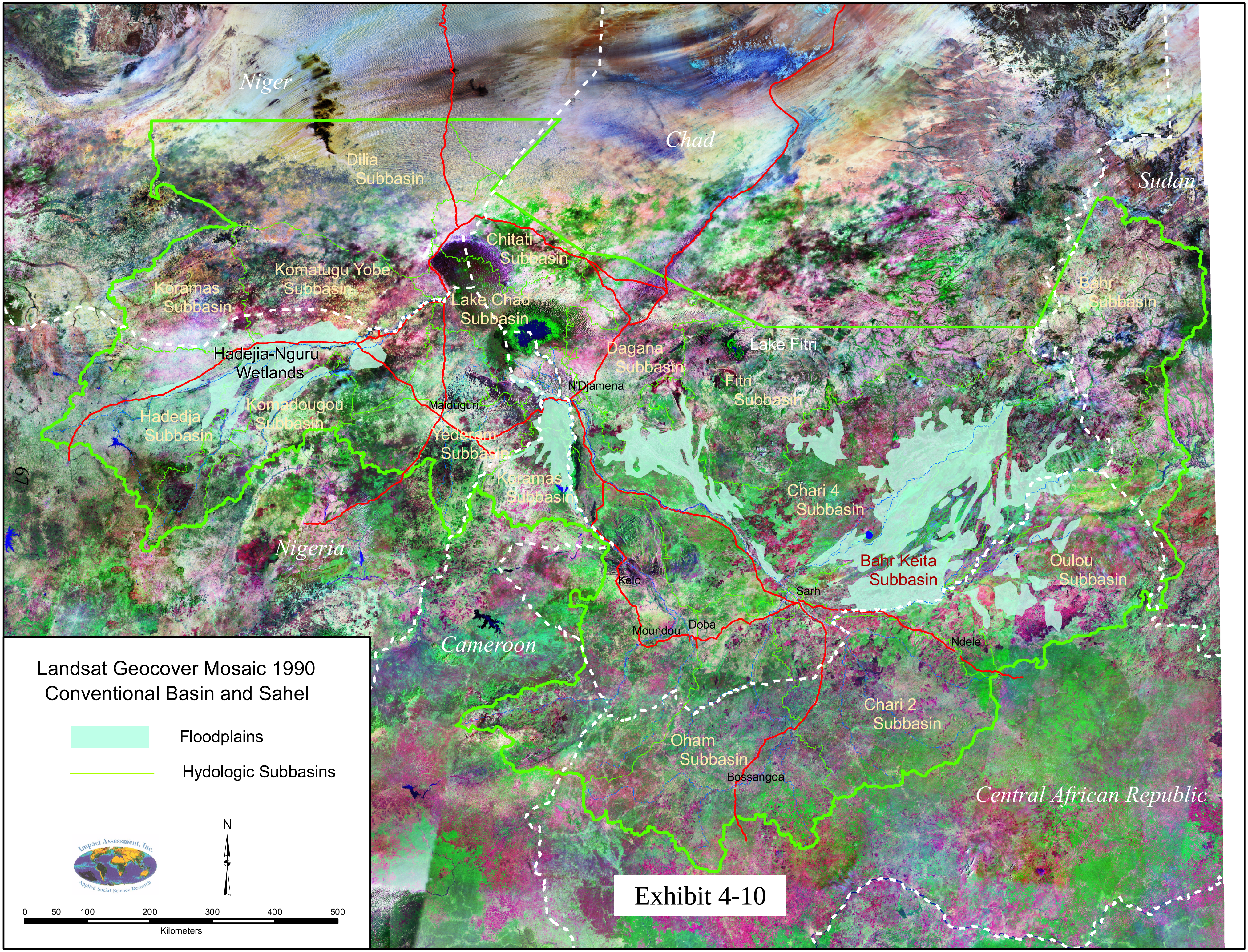

Landsat Geocover Mosaic 1990
Conventional Basin and Sahel
Floodplains
Hydrologic Subbasins
N
0 50 100 200 300 400 500
Kilometers
Impact Assessment, Inc.
Applied Social Science Research
Niger
Chad
Sudan
Nigeria
Cameroon
Central African Republic
Dilia Subbasin
Chitati Subbasin
Komatugu Yobe Subbasin
Koramas Subbasin
Lake Chad Subbasin
Hadejia-Nguru Wetlands
Hadedja Subbasin
Komadougou Subbasin
Yedeseram Subbasin
Karamas Subbasin
Dagana Subbasin
Lake Fitri
Fitri Subbasin
Bahr Subbasin
Chari 4 Subbasin
Bahr Keita Subbasin
Oulou Subbasin
Chari 2 Subbasin
Oham Subbasin
N'Djamena
Maiduguri
Kelo
Moundou
Doba
Sarh
Ndele
Bossangoa

Exhibit 4-10

The only other system of any significance is the Komadugu-Yobe River Basin located in Nigeria and Niger and formed by various tributaries, in particular the Hadejia, Jama'are, and Misau rivers that flow from the Jos Plateau (northern Nigeria).

There is seasonal flooding in both the Chari-Logone and Komadugu-Yobe basins, which feeds the extensive Waza-Logone floodplains and Hadejia-Nguru wetlands, respectively. These are used extensively for pasture, fishing, flooded rice production and flood recession cropping.

The Yedseram and Ngadda sub-system and its tributaries rise in the Mandara Hills and "lose" most of their water while flowing northwards through a floodplain. From Sudan in the east flow seasonal wadis (Wadi Kaya and Wadi Azum), whereas from the north there is virtually no surface flow.

Water Use

The bulk of water resources are used in agriculture, followed by domestic use. Traditional agriculture in the LCCB is generally rain-fed, although farmers in the downstream regions rely on flood farming and recessional farming. In the last 40 years there have been several large irrigation projects initiated, mostly in the Komadugu-Yobe Basin. A scattering of other projects, located around the lake, are not functioning, except for some farming of the polders.

A 30 percent decrease in in-flow took place in the lake between 1966 and 1975. Irrigation only accounted for 5 percent of that decrease, with drier conditions accounting for the remainder. Irrigation demands increased four-fold between 1983 and 1994, accounting for 50 percent of the additional decrease in the size of the lake.

Groundwater Resources

There is a general lack of information on groundwater reserves and the impacts of abstraction are not known, but potential groundwater resources are minimal. The impact of changes in the water table due to the reduction in the flows, wetlands, and lake, and therefore their aquifer recharge function, and due to the indiscriminate sinking of boreholes that are often uncapped and free flowing, is unknown.

Causes of Decline

Between the increase in agricultural water use and the drier climate, Lake Chad has experienced a massive decline water volume. Over the last 40 years, the discharge from the Chari/Logone river system at the city of N'Djamena in Chad has decreased by almost 75 percent, drastically reducing the input into the lake. While vegetation undoubtedly has a major influence, especially in semi-arid regions, in determining weather patterns, disagreements persist on actual causes of the decline in precipitation and hence in river-flows.

Coe and Foley (2001) maintain that changes are human-induced, with loss of vegetation contributing to a drier climate. They contend that while global climate change in the form of declining rainfall was the principal cause of decline prior to the 1980s, subsequent declines have been the product of local human initiatives. The situation is the result of a "domino effect" – overgrazing reduces vegetation which, in turn, reduces the ecosystem's ability to recycle moisture back into the atmosphere. That contributes to the retreat of the monsoons. The consequent drought conditions have triggered a huge increase in the use of lake water and ground water for irrigation, while the Sahara continued its gradual advancement southward.

Information Needs

Key aspects of hydrology which need to be monitored include surface water-ground water flows and interaction, siltation and sedimentation, salinization, contributing chemical and geological processes, meteorological aspects, hydrological modeling (including historic and future high and low flow scenarios), water quality (especially related to nutrients), contamination and assimilative capacity. A major effort is needed to determine whether root causes are local, human-induced or part of global climate change.

Key Risks

Water resources have been used at an unsustainable level for the climatic scenario of the past 40 years. All scenarios predict the worsening of these trends in the coming years as population and irrigation demands continue to increase. Stream diversion, associated with the construction of water infrastructure, has been the immediate cause of anthropogenic stream flow modification. The numerous dams have disrupted the timing and extent of the flooding of the LCCB wetlands. The low water-use efficiency (about 11%) that characterizes the region's irrigation projects needs to be improved. All of these aspects risk not being addressed.

Freshwater shortage has impacted heavily on the Basin's economic activities including the fisheries, agriculture, animal husbandry, fuel wood provision, and wetland economic services. There has been consequential food insecurity in the region, and combined with a lack of potable water, this has had implications on the health status of the LCB's population.

Social impacts of freshwater shortage have included upstream/downstream conflict over who has the right to use the diminishing water resources. Social tensions have been further provoked by the increased pressure on resources from the migration of people from the drought stricken northern regions of the LCCB into areas surrounding the lake and associated river basins. Continuing social disruptions hold the key risk of diverting the majority of resources into seeking to mitigate for these 'symptoms' rather than addressing root causes of system decline.

For example, it has been suggested to replenish the lake with water from the Congo/Zaire basin, possibly through the construction of a 1350 km-long canal and including a hydro-electric scheme (see extended discussion in Section 5.1.3), and that this would be an opportunity to rebuild the ecosystem, rehabilitate the lake, reconstitute its biodiversity and safeguard it because people will no longer need to cut wood for energy. For the time being this has been shelved on technical, economic, and political grounds. However, the ecological considerations are probably more critical than any of the former.

Such lofty aspirations are laudable, but grandiose engineering schemes have historically resulted in grandiose problems, often compounding rather than addressing those they are designed to solve. Highly complex, cross-sectoral, and long-term large problems like rehabilitating the ecosystem functioning of the LCCB are more likely to be solved through numerous small-scale and local-level interventions, rather than large, single “heroic engineering solutions”. Such schemes carry huge risks, and if pursued, need to be subjected to rigorous strategic environmental assessment (SEA) processes.

Land Transformation

Geology

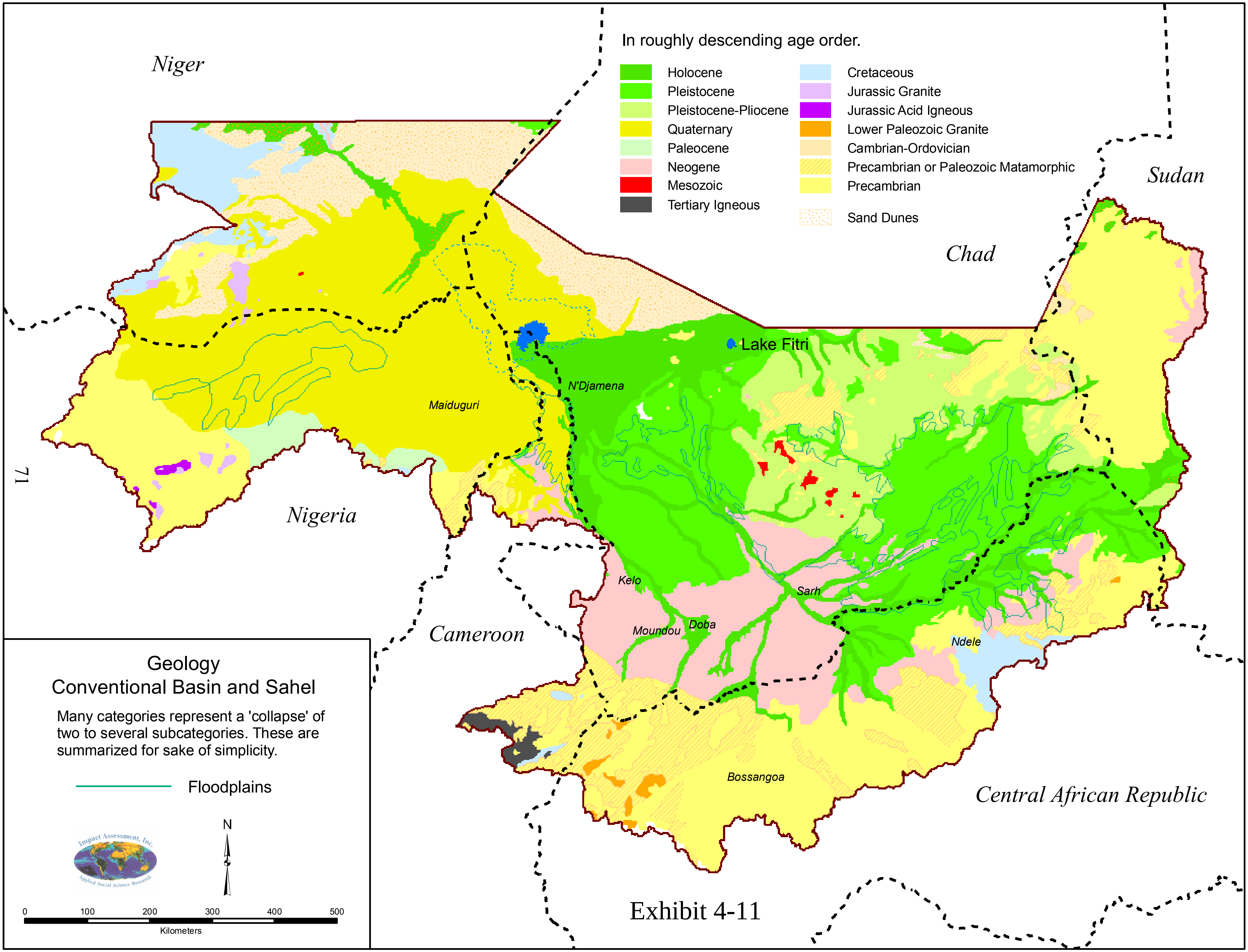
The Chad basin evolved on part of what is known as the Precambrian African Shield. Shields are "large areas of relatively low elevation that form parts of continental masses" (6th Sixth Edition, the Columbia Encyclopedia). This shield has been identified by the presence of crystalline rock. Exposed Precambrian rocks are found in the areas surrounding Lake Chad, such as portions of northern Nigeria. The underlying geology of the basin is depicted in Exhibit 4-11.

In earlier geologic epochs, approximately 7,000 years ago, the lake itself, referred to as “Mega Chad,” extended to a surface area of over 414,000 km^2 (130,000 square miles), reaching 335 meters (1,100 feet) above mean sea level, and a depth of 167 meters (550 feet). There have also been periods in the geologic record during which the lake had been entirely extinguished. The lake has experienced a persistent long-term decline in size over the last seven millennia. Of particular concern to this analysis, however, is the precipitous decline in surface area over the last fifty years, dropping from 25,000 km^2 in 1963 to less than 1,350 km^2 today. The floor of the Chad basin intersects with the ancient Mega-Chad basin in the northeastern portion of Lake Chad at the lowest point of the lake called the Djourab Depression (ThinkQuest, 2006).

The size of both Lake Chad and Lake Mega-Chad have been subject to very long-term changes in climate over time, and these fluctuations have had a large impact on what kinds of sediments made their way to the basin. According to Dieleman and de Ridder (1963):

> These transgressions are supposed to be contemporary with the European glaciations. During a glacial period the climate in Africa would have been humid, resulting in a transgression of the lake. During an interglacial period the climate would have been more arid, giving rise to a regression of the lake and to the formation of wind-blown deposits.

This means that the basin, over time, encountered not only water-borne sediment, but also wind-borne sediment derived from the surrounding areas, such as granite, metamorphic rocks, and sandstone, creating a unique combination of topsoil. There were many processes which contributed to these sediments, from the weathering of the nearby mountains to volcanic activity during the Quaternary. In a closer look, Isiorho and Nkereuwem observed that:



In roughly descending age order.
Holocene
Pleistocene
Pleistocene-Pliocene
Quaternary
Paleocene
Neogene
Mesozoic
Tertiary Igneous
Cretaceous
Jurassic Granite
Jurassic Acid Igneous
Lower Paleozoic Granite
Cambrian-Ordovician
Precambrian or Paleozoic Matamorphic
Precambrian
Sand Dunes
Niger
Sudan
Chad
Nigeria
Cameroon
Central African Republic
Lake Fitri
N'Djamena
Maiduguri
Kelo
Moundou
Doba
Sarh
Ndele
Bossangoa
Geology
Conventional Basin and Sahel
Many categories represent a 'collapse' of two to several subcategories. These are summarized for sake of simplicity.
Floodplains
N
0
100
200
300
400
500
Kilometers

Exhibit 4-11

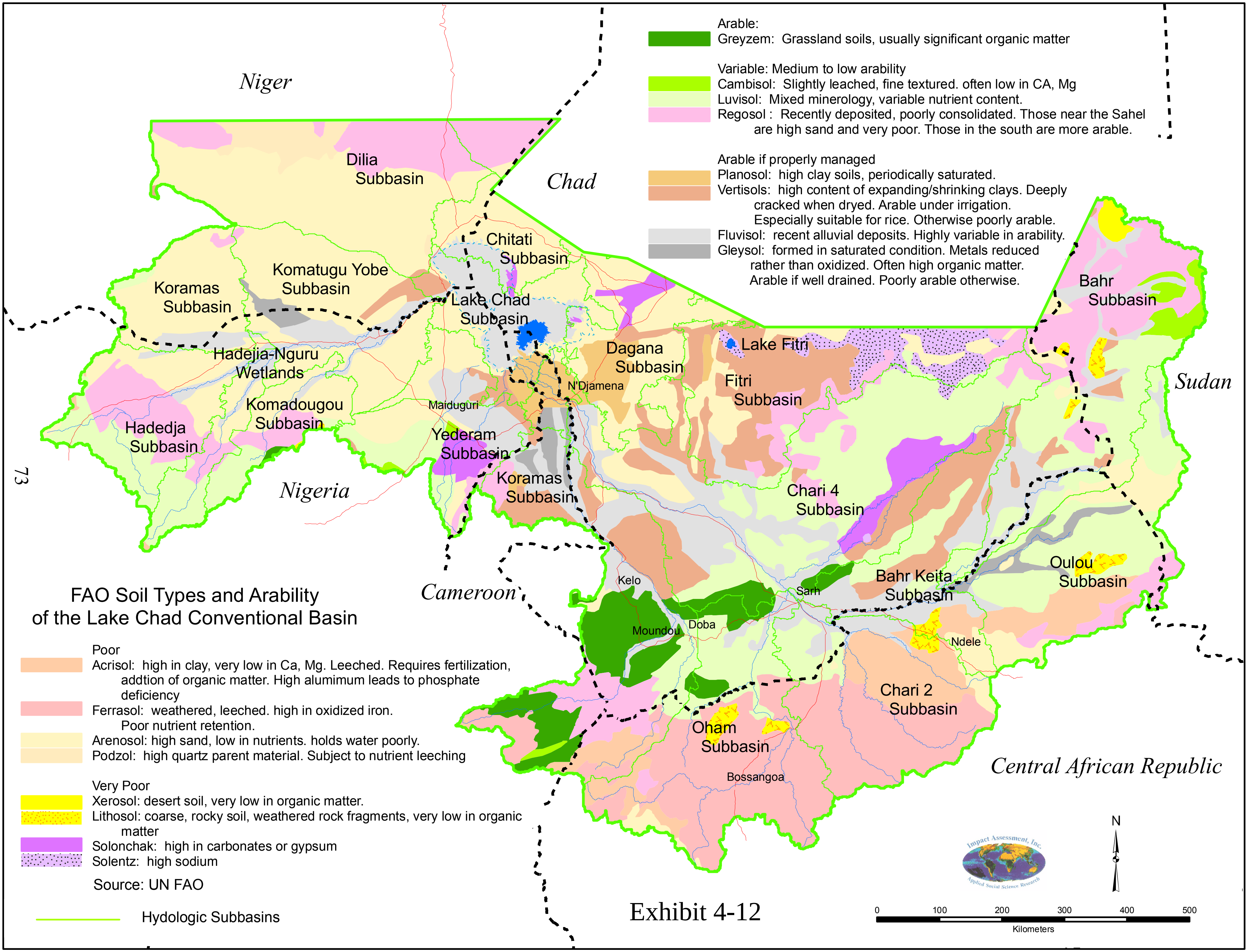
The Chad Formation is overlain by aeolian sands, fluvial, deltaic and lacustrine deposits approximately 1 to 6 m thick. Most of the fluvial deposits occur along stream valleys which are made up of two units: the old alluvium and the young alluvium (Hammand and Abdou, 1982). The old alluvium consists of deposits of old rivers, while the young alluvium contains recent river beds and flood plains. Field observations indicate the presence of silt and clay-sized sediments approximately 0.6 m thick in some places. Along the New Marte-Kirenowa road, the silt-clay sediment overlying the Chad Formation may be at least 1-1.5 m thick.

Sand and Soil

Given soil stability, plantlife is the ultimate source of yearly weatth within the Lake Chad Basin. Phytoplantkton support the fisheries; wood supplies the energy for preparing food; grass and browse support beef, mutton and goat production; specific wild species are drought fallback foods; and genetic diversity of cultivars decreases the risk of drought becoming famine. There is no map existing CB vegetation which shows actuals (vs. theoretical) plant communities and their state of health.

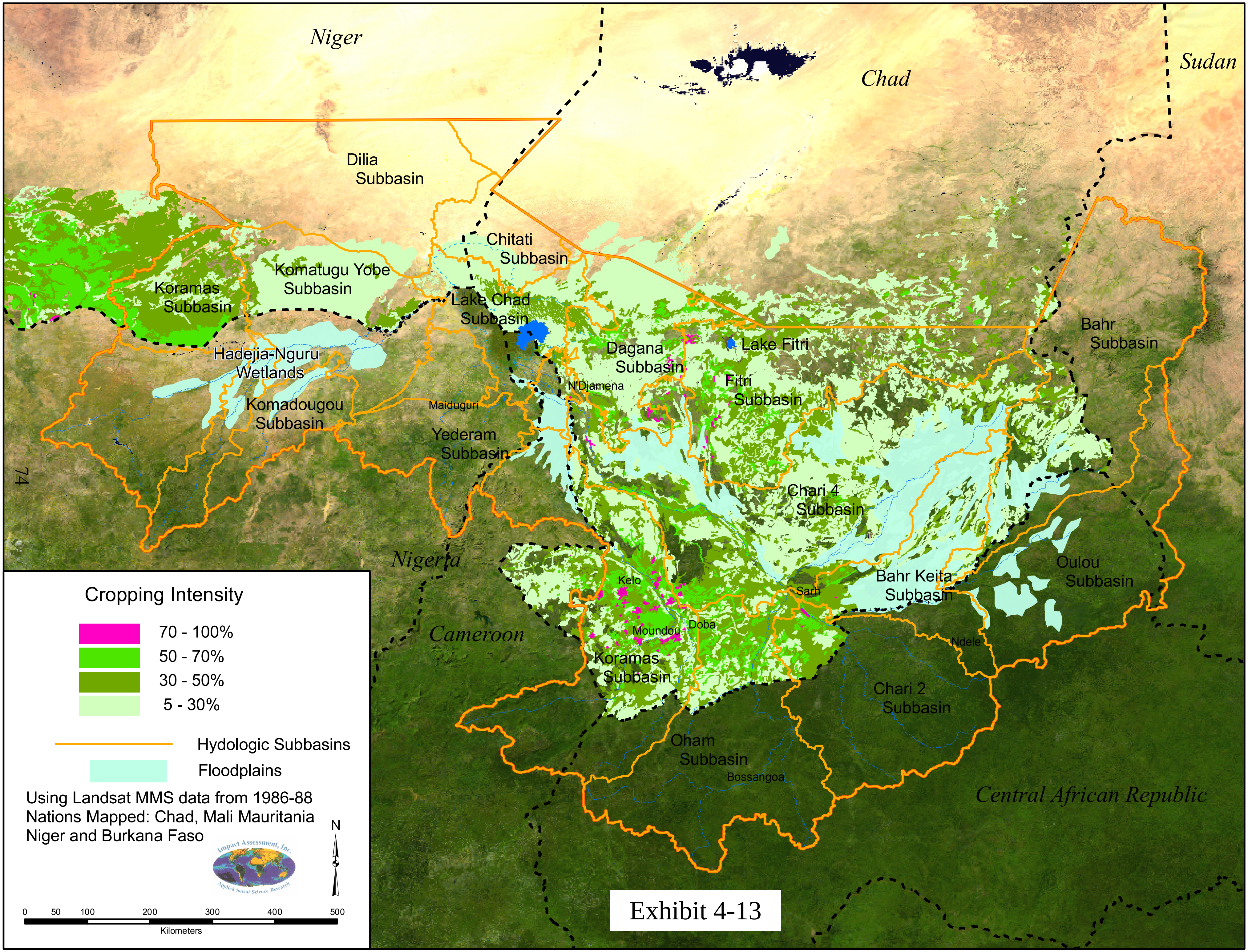
The major kinds of floristic degradation include: (1) reduction of canopy coverage that provides the best plant microclimates and prevents erosion; (2) change of grasses from perennial species to annuals and dicots; (3) reduced biomass of forest products; (4) loss of root volume and soil-holding capacity; (5) reduced cycling of soil minerals by deep rooted trees; (6) loss of legumes that restore nitrogen to the soil; and (7) loss of species diversity. Human (vs. drought) influences include: (1) over-cutting trees for fuelwood, especially near cites; (2) over-cutting construction wood, especially borassus and doum palm; (3) overbrowsing, overgrazing and trampling by livestock; (4) clearing for irrigation agriculture and waterworks; and (5) clearing for human settlements.

Exhibit 4-12 depicts the distribution of basic soils types in the basin.



FAO Soil Types and Arability of the Lake Chad Conventional Basin

Exhibit 4-12


Niger
Chad
Sudan
Dilia Subbasin
Chitati Subbasin
Komatugu Yobe Subbasin
Koramas Subbasin
Lake Chad Subbasin
Hadejia-Nguru Wetlands
Komadougou Subbasin
Maiduguri
Yederam Subbasin
N'Djamena
Dagana Subbasin
Lake Fitri
Fitri Subbasin
Bahr Subbasin
Chari 4 Subbasin
Nigeria
Cameroon
Kelo
Moundou
Doba
Sarh
Koramas Subbasin
Bahr Keita Subbasin
Oulou Subbasin
Ndele
Chari 2 Subbasin
Oham Subbasin
Bossangoa
Central African Republic
Cropping Intensity
70 - 100%
50 - 70%
30 - 50%
5 - 30%
Hydologic Subbasins
Floodplains
Using Landsat MMS data from 1986-88
Nations Mapped: Chad, Mali Mauritania
Niger and Burkana Faso
N
0 50 100 200 300 400 500
Kilometers
Exhibit 4-13

The vulnerability of these soils to degradation, coupled with a tendency to over-exploit the limited carrying capacity to meet food requirements by using inappropriate our unsustainable farming methods (see Exhibit 4-13), has resulted in far-reaching soil degradation, with large portions of the conventional basin classified as highly degraded (see Exhibit 4-14). Together with the recorded rainfall reductions and ongoing destruction of vegetative cover, the LCCB is experiencing high rates of desertification, which are likely to be increasing.

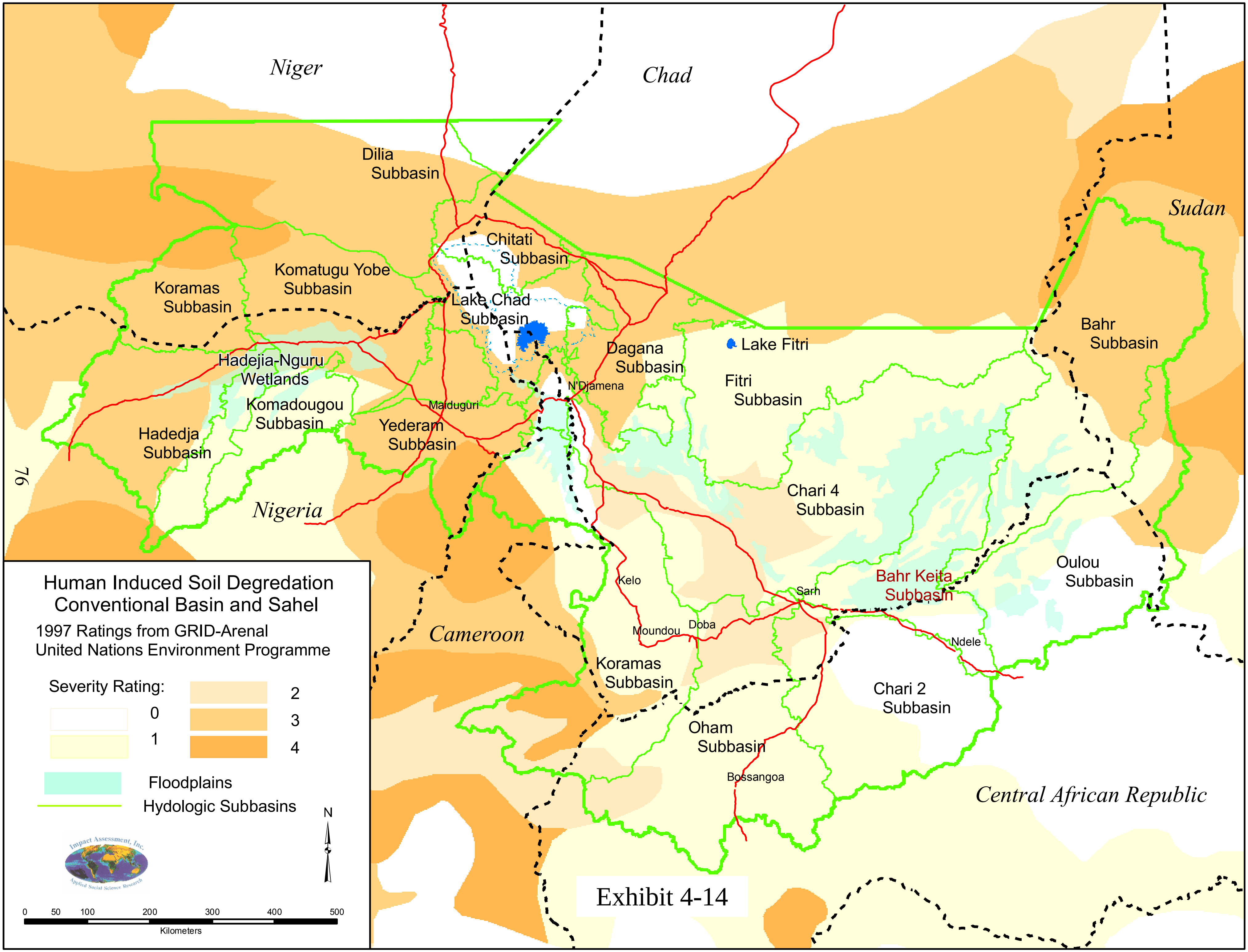

Human Induced Soil Degredation
Conventional Basin and Sahel
1997 Ratings from GRID-Arenal
United Nations Environment Programme
Severity Rating:
0
1
2
3
4
Floodplains
Hydologic Subbasins
N
0 50 100 200 300 400 500
Kilometers
Niger
Chad
Sudan
Nigeria
Cameroon
Central African Republic
Dilia Subbasin
Chitati Subbasin
Komatugu Yobe Subbasin
Koramas Subbasin
Lake Chad Subbasin
Hadejia-Nguru Wetlands
Komadougou Subbasin
Hadedja Subbasin
Yederam Subbasin
Maiduguri
N'Djamena
Dagana Subbasin
Lake Fitri
Fitri Subbasin
Bahr Subbasin
Chari 4 Subbasin
Oulou Subbasin
Bahr Keita Subbasin
Sarh
Ndele
Kelo
Moundou
Doba
Koramas Subbasin
Chari 2 Subbasin
Oham Subbasin
Bossangoa

Exhibit 4-14

Desertification

Land degradation is the deterioration in the quality and productive capacity of land and has been identified as one of the major environmental challenges facing Central Africa. For example, Nigeria's 2002 Interim Strategy Update cites land degradation as the most serious environmental problem facing Nigeria. A large proportion of the Lake Chad Basin is classified as being highly vulnerable to desertification, defined as land degradation in arid, semi-arid, and dry sub-humid areas resulting from different factors, including climatic variations and human activities.

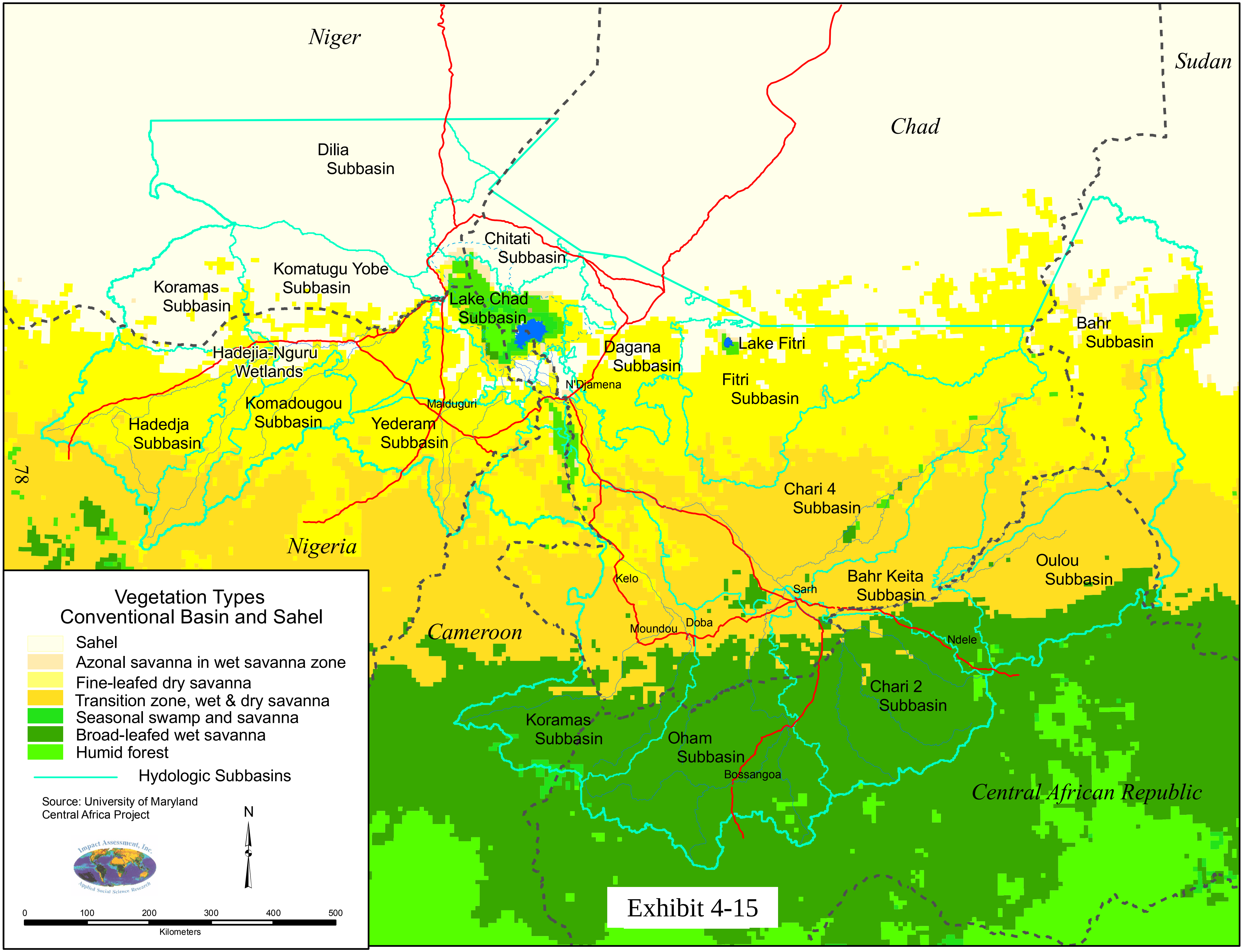
Human induced desertification has occurred as a result of unsustainable land use practices arising from rapidly increasing population and intensive economic activities. Desertification has been indicated by the gradual shift in vegetation from grasses, bushes, and occasional trees, to grass and bushes to, in the final stages, expansive areas of desert-like sand (see Exhibit 4-15). The desert is said to be moving at an annual rate of 5 km southwards in these semi-arid areas. Nigeria and the Central African Republic have the largest percentage area of land vulnerable to desertification, but Chad, Niger, and Sudan have the largest percentage of areas at very high risk. Consequently Chad is currently experiencing the greatest vulnerability to desertification, with 58% of the area already classified as desert, and 30% classified as highly or extremely vulnerable.

Overgrazing is considered a major cause of desertification in the Lake Chad Basin, as grazing animals remove vegetation cover and expose the soil to processes of wind and soil erosion (see Exhibit 4-16). Large quantities of soil can be moved by these processes and future productivity of the land rendered limited or useless.

Traditional animal husbandry is not very important economically but its impact on the environment constitutes a significant threat of desertification, especially in times of drought. Nomadic pastoralists have been encouraged by the sinking of boreholes to settle in locations that they previously only grazed for relatively short periods of time. This has been detrimental to soils, vegetation, and wildlife that were previously allowed to regenerate.

Over-cultivation can lead to desertification due to the unsustainable consumption of nutrients from soil resources. Nutrients are not replaced as agricultural products are removed and the soil is replanted without sufficient fallow time. This increasingly degrades the soil resulting in lower crop yields, which consequently forces farmers to plant on larger areas of land and in marginal lands to receive the same return on their agricultural investment. Land degradation eventually becomes so severe that the land turns to desert-like conditions (desertification).

Agriculture in the LCCB has been forced to expand due to the climate constraints, intense population pressures, and reduced soil fertility, increasingly shifting into marginal lands. Extensive removal of vegetation by humans combined with a considerable fall in water level in Lake Chad and the associated aquifers has resulted in a decline in perennial vegetation. This has resulted in soil erosion and soil compacting leading to severe land degradation. The main reasons for vegetation removal are commercial logging and tree cutting to provide domestic fuel, clearance of forests for commercial, or subsistence cultivation, as well as livestock browse and bush burning.


Niger
Sudan
Chad
Dilia Subbasin
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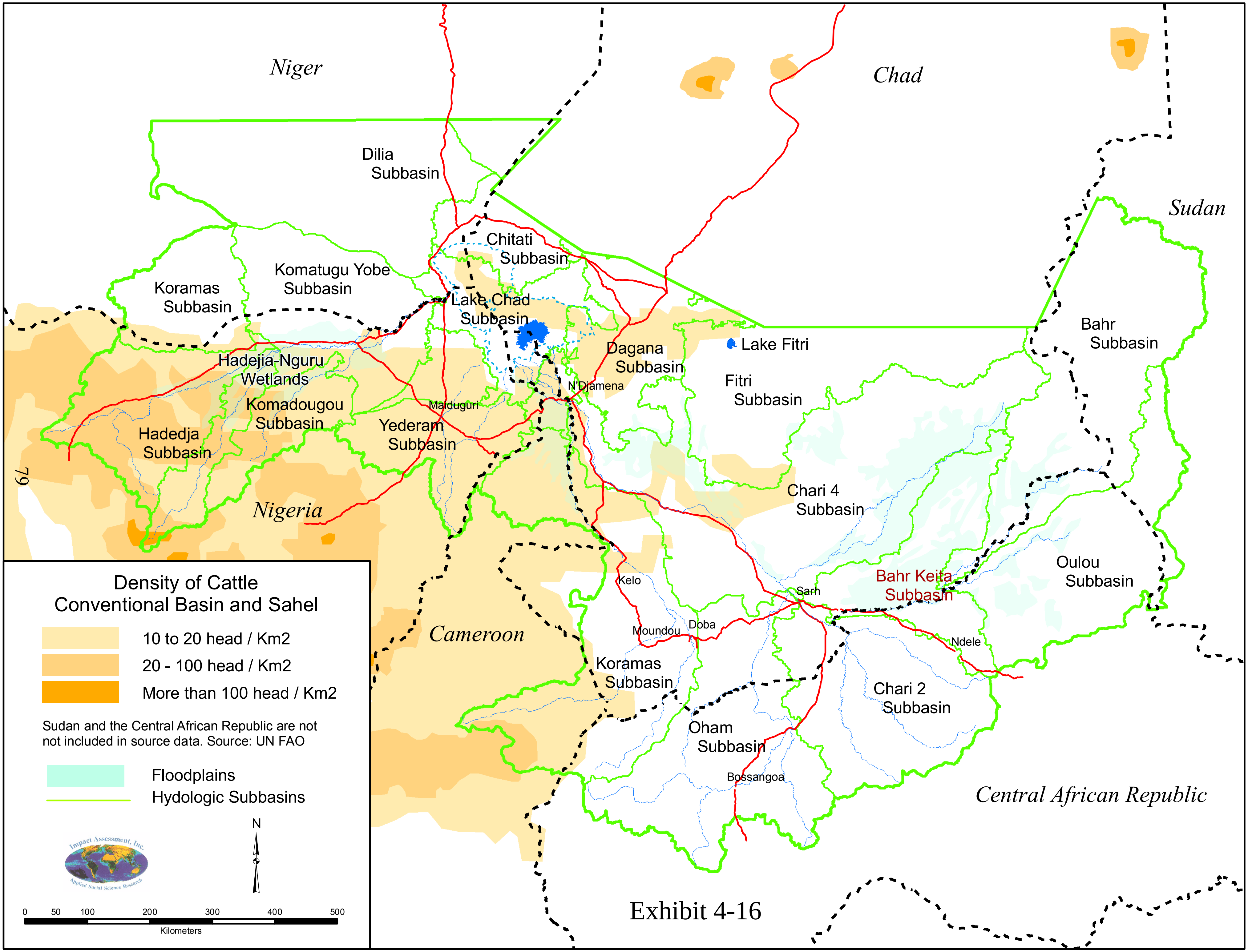
Koramas Subbasin
Komatugu Yobe Subbasin
Lake Chad Subbasin
Bahr Subbasin
Lake Fitri
Dagana Subbasin
Hadejia-Nguru Wetlands
N'Djamena
Fitri Subbasin
Komadougou Subbasin
Maiduguri
Hadedja Subbasin
Yederam Subbasin
Chari 4 Subbasin
Nigeria
Oulou Subbasin
Kelo
Bahr Keita Subbasin
Sarh
Moundou
Doba
Cameroon
Ndele
Chari 2 Subbasin
Koramas Subbasin
Oham Subbasin
Bossangoa
Central African Republic
Vegetation Types
Conventional Basin and Sahel
Sahel
Azonal savanna in wet savanna zone
Fine-leafed dry savanna
Transition zone, wet & dry savanna
Seasonal swamp and savanna
Broad-leafed wet savanna
Humid forest
Hydologic Subbasins
Source: University of Maryland
Central Africa Project
Impact Assessment, Inc.
Applied Social Science Research
N
0 100 200 300 400 500
Kilometers

Exhibit 4-15


Niger
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Dilia Subbasin
Chitati Subbasin
Koramas Subbasin
Komatugu Yobe Subbasin
Lake Chad Subbasin
Lake Fitri
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Hadejia-Nguru Wetlands
Komadougou Subbasin
Hadedja Subbasin
Yederam Subbasin
Maiduguri
N'Djamena
Chari 4 Subbasin
Oulou Subbasin
Bahr Keita Subbasin
Sarh
Kelo
Moundou
Doba
Ndele
Koramas Subbasin
Chari 2 Subbasin
Oham Subbasin
Bossangoa
Density of Cattle
Conventional Basin and Sahel
10 to 20 head / Km2
20 - 100 head / Km2
More than 100 head / Km2
Sudan and the Central African Republic are not
not included in source data. Source: UN FAO
Floodplains
Hydrologic Subbasins
N
0
50
100
200
300
400
500
Kilometers

Exhibit 4-16

Unsustainable forestry practices to meet increased demand for firewood and lumber for local use, has resulted in the over-harvesting of the LCCB's woodland resources. The removal of vegetation also alters drainage patterns and rates, increasing surface run-off, which again results in further soil erosion. The rate of forest loss in the LCCB is a cause for huge concern in terms of its impacts on biodiversity, atmospheric change, and hydrological cycles, in addition to the concerns regarding soil erosion. Firewood is the predominant source of fuel for the population. This high demand and scanty supplies has resulted in fuel wood becoming an increasing source of land degradation and conflict.

The increasing pressure on the limited natural resources of the desertification-prone zone is exacerbated by the southward migration of people and livestock, resulting in overgrazing and continuous overexploitation of marginal lands. This action leads to an intensive use of fragile lands and marginal ecosystems resulting in further degradation even during years of normal rainfall.

Several techniques have been developed to fight against desertification or to minimise the impacts of factors that exacerbate the processes of desertification which can be adapted to the LCB. These techniques include the reduction of stocking rates, plantation of shelter belts, replication of sustainable agricultural practices, and agro-forestry. These techniques if widely applied in the LCCB are capable of reversing some of the presently observed degradation trends in future.

Key risks

Current trends of continued land cover and soil degradation and desertification threatening land productivity will continue and increase, threatening local food security and causing mass migrations. Continued loss of the very limited high-value arable soils is likely as the cities and towns expand through population growth and migration.

Large irrigation schemes are increasing salinization of the soil, which may halt or reduce potential for further large-scale agricultural expansion. Projects designed to protect soils and water supplies as well as the long-term productivity of the land surface in general have to date received little support at the macro-policy level. The key risk in land transformation is that political attention will not focus on the root causes but on mitigating for local social disruptions.

The key intervention needed is to develop and institute a large-scale land rejuvenation program for the LCCB that prioritizes and supports organic and conservation farming methods. Management plans must carefully tailor their technical and social interventions to the specific diverse landscapes. A key risk is that only general guidelines will be developed which will be inappropriate for most landscapes to which they are applied.

Mitigation opportunities include the incentivizing of major organic farming initiatives (e.g. the model in Cuba), declaring soil revitalization as a basin-wide multi-national priority; including in all integrated development plans a total ban on the conversion of high value agricultural land for purposes of urban development, and the promotion of urban agriculture. A basin-wide soils restoration policy will be required to reverse a rapidly deteriorating situation. A re-definition of infrastructure investment may be required so that funds can be directed into major initiatives to restore and rejuvenate soils using approaches and techniques generated by cutting edge agricultural science that works with rather than against ecosystems. Without this, increased production in agriculture will be unlikely, and land reform projects could instead result in mass bankruptcies and rural instability. Exhibit 4-17 summarizes the cumulative effects of land degradation in rural areas.

Exhibit 4-17. Cumulative Effects of Land Degradation in Rural Areas

IMPACT	CUMULATIVE EFFECTS
Loss of land cover	Loss of biodiversity, loss of ecosystems function, increasing flood run-off and decreased water retention, increasing soil erosion, decline in system productivity
Loss of soil	Reduced land productivity; decline in agricultural potential, loss of income, increasing poverty
Reduced water retention capacity	Increased high/low flows, increasing flood damage, increased siltation of lakes, dams and estuaries, increasing cost of water treatment, declining fisheries production, loss of income
Increased costs of maintaining soil productivi – remediation, fertilizers inputs, etc.	Increased costs, increased chemical pollution in water, declining water quality, increasing cost of treatment, increasing incidence of crop, stock and human disease, loss of income
Overall decreased land, crop/stock productivity	Rising 'unit costs' of living, decline in livelihoods, increasing urban migration, increasing social problems (crime, poor nutrition, health, etc), increasing human conflict over reduced resources, loss of national food security

Wind and Dust

Higher global temperatures expressed over the Sahara have increased convection, and thereby wind speed, resulting in higher lifting capacity, an accelerated lower level wind jet, and typically longer distances over which Saharan dust travels (in this case, well into the Amazon Basin) (Goudie, et al., 2003). As depicted in the following graphic (see Exhibit 4-18), the conventional basin is subject each year to weeks of disruption in local economic activities, agriculture, fisheries, product transportation, and to associated social disruptions as a result of wind and dust storms that originate primarily out of the Bodélé depression (in the Djourab just northeast of Lake Chad) – regarded as the largest source of dust on earth. These very strong winds, consisting primarily of diatomites and clays from the now-dry ancient lake bed of "Mega-Chad," are believed to be the source of over half the dust that leaves West Africa each year (Todd, et al., 2003).

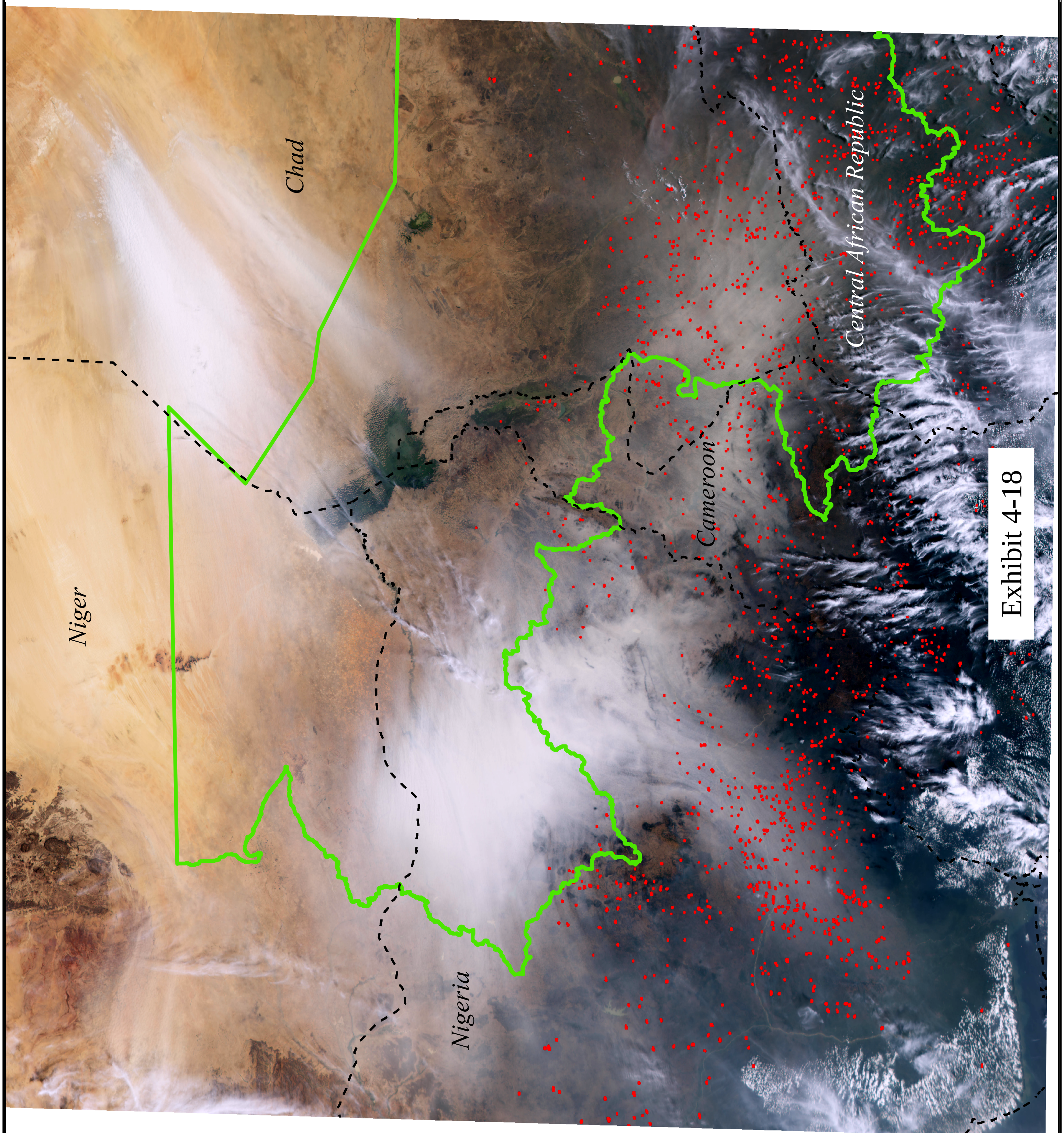


Exhibit 4-18

These wind and dust conditions can be extreme, can last for weeks, sometimes months, and occur always during the dry seasons (i.e., winds between July and September range below 1 m/s, while between October and April range they from 4 - 8 m/s). These persistent and powerful dust storms contribute in a significant manner to the social vulnerability of the most sensitive populations and at-risk populations (elderly, women, children, and the ill) in several ways. First, dust particles smaller than 2.5 micrometers are easily inhaled and retained in the lungs. Particularly hard hit are children and adults already contending with upper respiratory tract issues, as well as individuals with asthma, allergies, or other dust-based sensitivities. Second, aerosols containing transition metals, such as iron (dust particles from the Bodele contain 3 to 5 percent iron), are particularly efficient in generating an inflammatory response in the lungs.

The storms also directly affect the ability of at-risk populations to respond to an abrupt or extended environmental disruption – such as a major drought. The most obvious effect is on mobility. Both public and private transportation systems are brought to a near halt during a typical dust storm event. Herdsmen cannot move cattle from one pasture to another during these storms, and must find a safe and secure holding location to wait out the storm. This means remaining longer and longer periods of time at relatively protected animal watering locations, and associated social, logistical, and economic effects. The dust generated during the storms is ultimately deposited on farmlands, on gardens, and on watering holes throughout in the region and, depending on deposition patterns, can positively or negatively affect productive capacity of farmland, livestock, and fish. During a period of drought, these persistent dust storms would bring an immediate disruption of efforts to move herds from north to south, make commercial and subsistence fishing all but impossible, prevent harvests, prevent delivery of goods and services, reduce access to medical or welfare assistance locations, and temporarily shut down any human evacuation efforts. The wind and dust storms narrow the range of options available in response to drought or other acute environmental events, and thereby contribute to the social vulnerability of selected populations.

Dust in the conventional basin may be the largest source of atmospheric pollutants (aerosols) and represent the largest source of respiratory health risk. Dust from the evaporite pans or sediments of Bodélé depression is also a principal source of vital soil nutrients, including iron, potassium, phosphorus and calcium, in the western Sahel (Chappell, et al., 1998).

Dust has also been suggested as a direct contributor to changes in regional climate by suppressing rainfall (Rosenfeld and Lahav, 2000), and increasing aerosols that absorb and scatter radiation, thereby creating a positive feedback cycle. Note the very high concentration of aerosols in the area just north of Lake Chad in Exhibit 4-19.

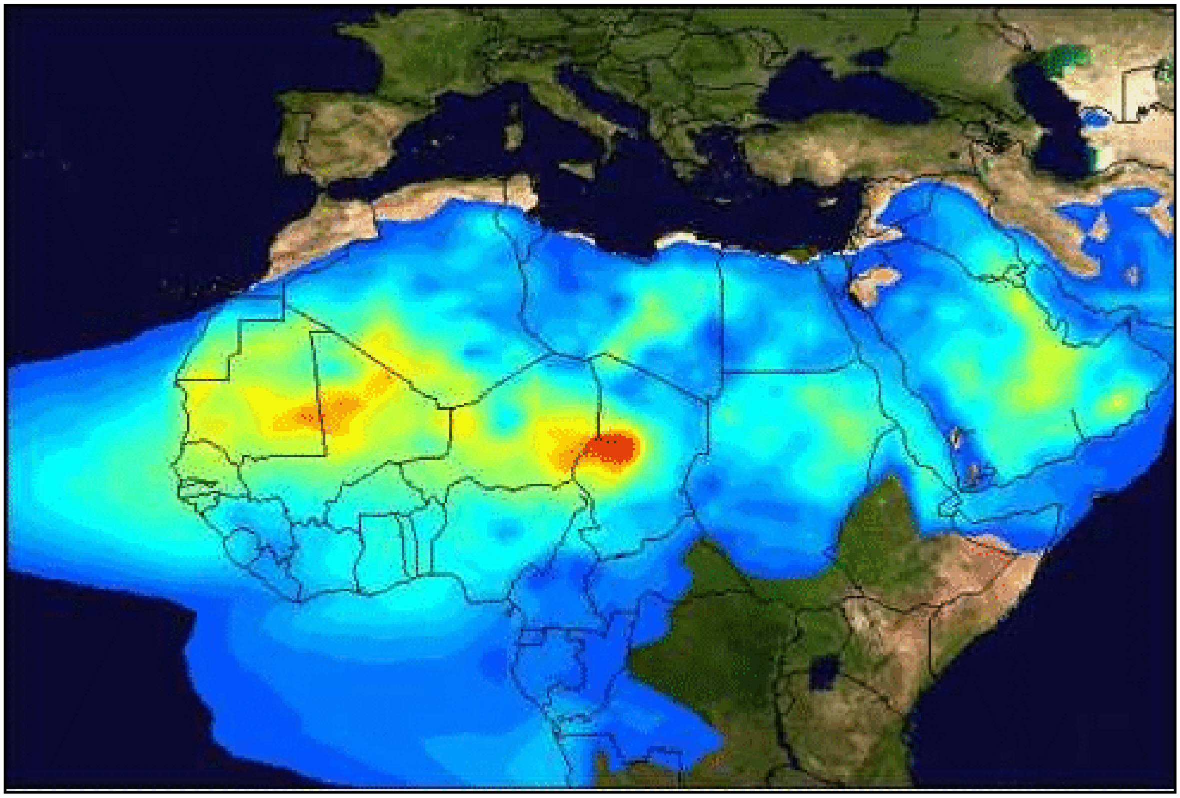


Exhibit 4-19. Aerosol Relative Index for North Africa (TOMS AI, NASA Goddard Space Flight Center)

Fire

Intentional fires are set in the conventional basin early in the dry season, usually in January and February, with the purpose of removing dead vegetation, controlling unwanted plants, preparing the ground for planting, releasing nutrients bound up in living vegetation, thus fertilizing new growth and, at the same time, preventing access to grazing animals. The red dots and smoke (see Exhibit 4-18) in the southern portions of the conventional basin represent intentional burns during first week of January. Some Sahelian plants have adapted to require fire during their growth cycle, sprouting on newly burnt soil in order to reproduce. Later in the season, when broad expanses of dry grass become available as fuel, dry lightning strikes ignite broad uncontrolled fires that sweep through the region. These fires, both intentional and unintentional have both positive and negative consequences.

The early January burns convert vast quantities of the biome to dust and smoke, which spread across the entire southern portion of the conventional basin. The burns, normally intended to be controlled at the margins of a particular agricultural parcel, often spread to other unintended forest, consuming fuel wood and living trees of great importance as wildlife habitat, many of significant financial value as lumber. These fires also create a shortage of fuel wood resources on which the majority of farmers and pastoralists continue to rely for cooking and heat. Fires are also believed to result in the loss of grasslands vital to cattle and other livestock, resulting in declining animal productivity in the basin. They have also reduced the diversity and availability of wild products such as fruits, nuts and mushrooms. Each of these effects, in turn, constrain human adaptability, available coping strategies, and increase social vulnerability to environmental disruption.

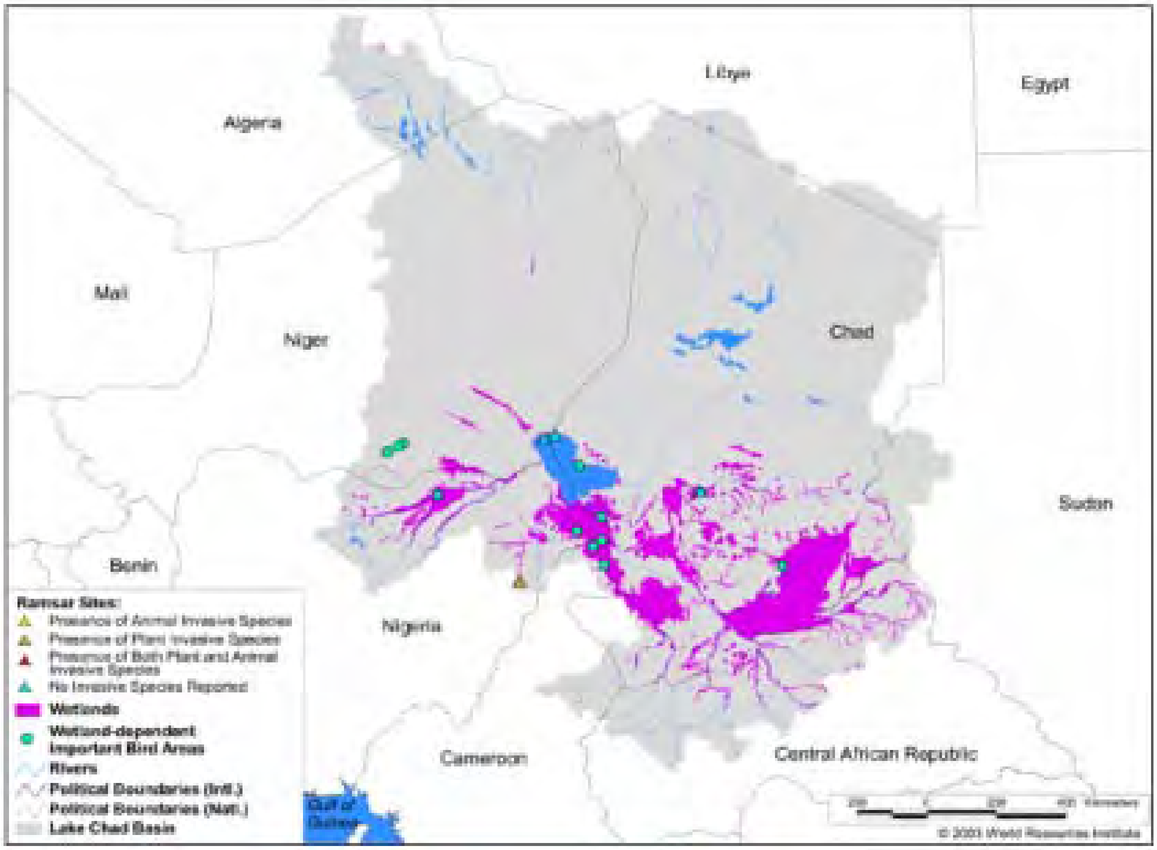
Fires in the Sahel represent the most important cause of the destruction of vegetation cover. These fires prevent the natural regeneration or restoration of indigenous vegetation, have a constraining effect on ecosystem production and structure, and facilitate accelerated runoff and erosion. Accelerated runoff, when the rains come, results in larger and more unpredicted flooding events, and less infiltration for recharge of groundwater tables.

The intentional biomass burning of the Sahel also represents a significant injection of "pollutants" into the atmosphere, perhaps Africa's largest contribution, affecting the region's radiation balance and resulting in acidification of precipitation. On a planetary scale, the biomass burning, in effect, offsets or undermines the historical role of the region as one of the major planetary carbon dioxide sinks.

Ecosystems and Biodiversity

The Lake Chad Basin contains a variety of habitats, including deserts, shrub steppes, savannahs, forests, lakes, wetlands, and mountains. The humid zones of the LCCB and the lake itself constitute a unique ecosystem in this area of the Sahel, and a refuge of biodiversity of global importance. These terrestrial and aquatic habitats form a unique sanctuary for the diverse fauna of the region that include ostriches, cheetahs, hyraxes, crocodiles, hippopotamus, and elephants (see Exhibit 4-20).

Exhibit 4-20. Lake Chad Basin Biodiversity



Biodiversity Information and Indicators

Number of Fish Species (Lake Chad only):	93
Number of Fish Endemics (Lake Chad only):	9
Number of Amphibian Species:	57
Number of Ramsar Sites:	4
Number of Wetland-Dependent IBAs:	12
Number of Endemic Bird Areas:	0
Percent Protected Area:	10.2

These habitats also have a good stock of water birds, migratory birds, and waders that thrive in the river valleys depending primarily on the waters of the numerous small lakes that are formed during periods of receding floods. For example, 140 species of fish and 372 species of birds, of which one third are migratory species, have been recorded. The integrity of the ecosystems and maintenance of biodiversity is an essential shield against desertification.

Extensive habitat and community modification of the aquatic ecosystems has been experienced in both the lake and river environments. Stream flow modification has also significantly affected the lake environment as the habitat has changed from predominantly open-water to a marshy environment as the lake has contracted. Intensive cultivation and large numbers of domestic animals have degraded the wetland ecosystems. The primary reason for the reduction in the extent of the wetlands has been attributed to the changes in the seasonal timing and extent of flooding. Consequently, since the 1960s wetland resources in the LCCB have been reduced by almost 50%.

Fisheries

The conventional Lake Chad Basin encloses one of the most productive regions of freshwater fish in Africa (see Exhibit 4-21). Some 140 species are found within the lake basin. The fish habitat in the lake has altered from being an open water environment to being a predominantly marshy environment. The fish species composition has changed to reflect this and significant biodiversity loss has been recorded during the past decade or so. Although there has been significant habitat modification, this has been largely a consequence of the freshwater shortage. The unsustainable exploitation of the fish and other living resources is not considered the primary reason for the fluctuations in fisheries production experienced over the past four decades.

It is difficult to talk of fisheries in terms of sustainability in such a naturally fluctuating environment—freshwater shortage and the consequential habitat modification are regarded as the main influencing factors. Prior to the drought years the fisheries had developed rapidly with fishing effort increasing by 50 times between 1967 and 1972. The contracting lake and wetlands caused fish to be concentrated and more vulnerable to fishing gears and eventually the fisheries collapsed in the northern pool, followed by the southern pool fisheries in 1982.

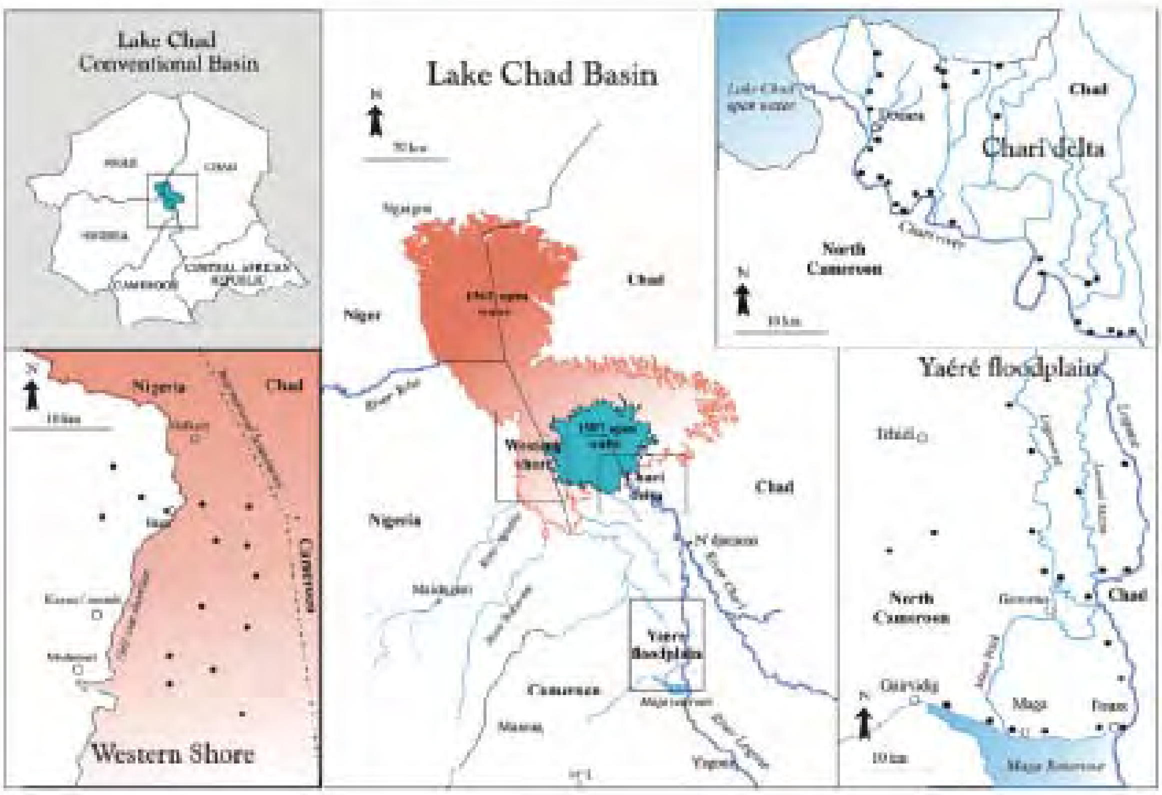
Some fish species such as *Alestes* and *Shilbe spp.* whose pattern of migration and spawning is triggered by the rising annual flood are more severely affected by the change in the flood cycle, than, say the *Claris* and *Tilapia.* A comparison of flooding extents and fish catches in 1992, 1993, 1994, and 1996 (the last two years being regarded as good years) together with the information obtained on the fishermen's perception of the flood impact suggests that the minimum annual flooding extent required to sustain the fish ecosystem and fishing industry in the Hadejia-Nguru Wetlands is 800 km^2.

As a result of climate variability and unsustainable water projects, five to eight species of fish have disappeared from different parts of the Lake Chad Basin in Nigeria. The experience in the Logone valley south of the Semry Irrigation Project is similar: fish yields collapsed by 90% for lack of inundations.

The fisheries market species composition has been a prominent indicator of these changes. Among the most important commercial fish species recorded in the Nigerian sector of Lake Chad before the 1972-1974 Sahelian drought (recorded 1963-1967) were *Lates, Hydrocunus, Labeo, Citharinus,* and *Distichodus*. Following the 1972–1974 drought these species generally disappeared and were replaced by species such as *Clarias*; for example, in 1972 *Clarias* made up 0% and *Lates* 52.7% of fish markets, whereas in 1976 they consisted 89.6% and 0%, respectively.

These changes were accelerated by intensive opportunistic fishing effort in the northern pool in which open-water species such as *Lates* were easily caught. The natural selection operating on the fish communities during the drying up period (1972-1978) favoured the development of these marsh-adapted species endowed with adoptions of diet, reproduction, and respiration that allowed them to survive in an unstable environment, but at the expense of open-water species that are generally migratory with strict preferences. Following the total drying of the northern pool in 1975, fishermen migrated south and began to target the southern pool more seriously.

Exhibit 4-21. Key Fisheries of the Lake Chad Conventional Basin (source Béné C. and Nieland, A.E., 2004)



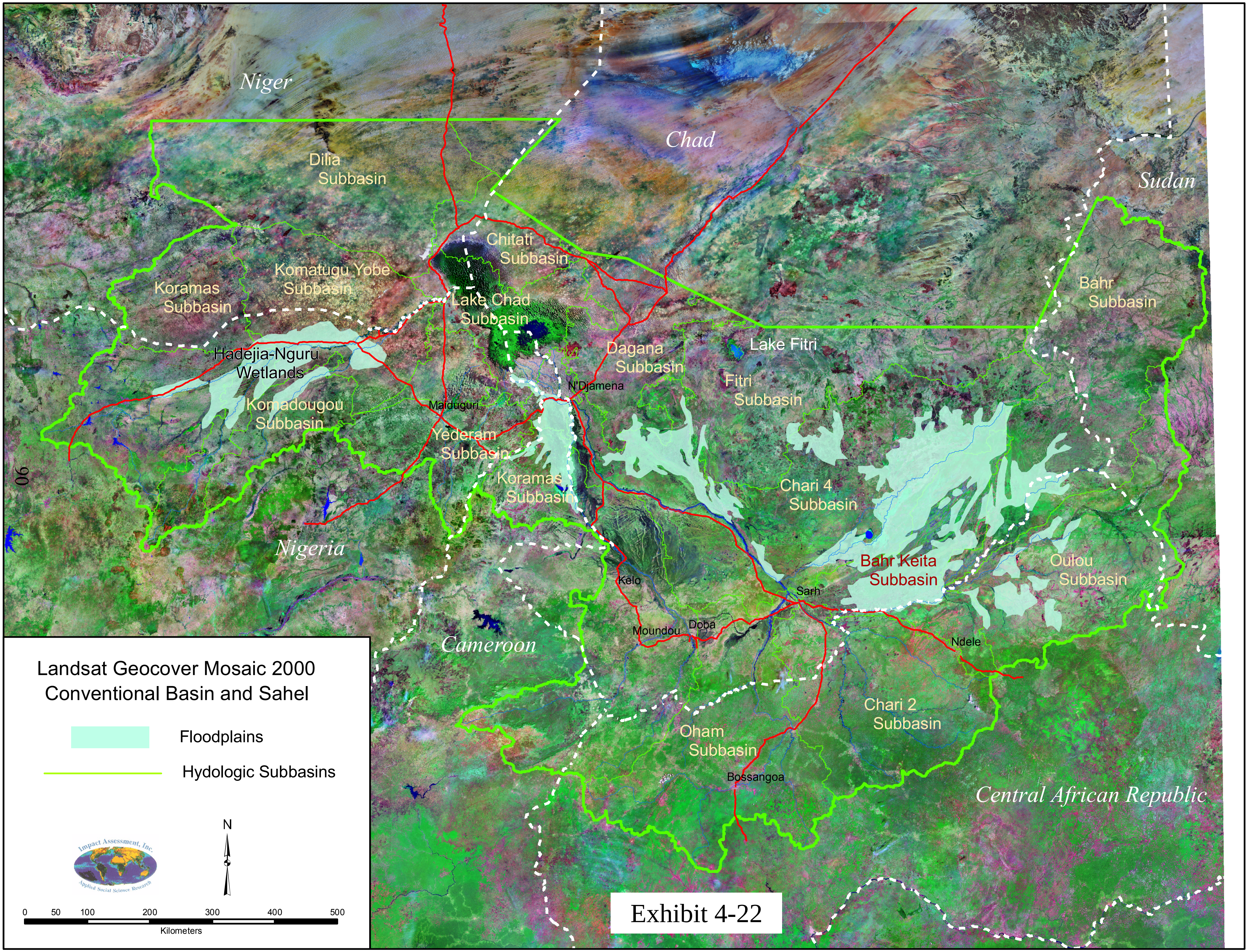
■ **Figure 1.** Top left map: general location within the whole Lake Chad Conventional Basin of the region concerned by the study. Central map: detailed location within the study region of the three specific areas included in the survey: the western shores of the Lake, the Chari Delta and the Yaéré floodplain. The black dots on the local maps (bottom left and right hand side maps) indicate the villages surveyed in each area = 64 in total.

This environment, containing both open water and marshes, may explain the incipient reappearance of some lacustrine species such as *Lates, Hydrocynus*, *Labeo,* and *Distichodus*, and a decline in mudfish from 1980 onwards. Species which disappeared from the northern sector of the Lake are still found within the lacustrine environment of the southern pool. Typical examples include *Hydrocynus* and *Lates,* but also swamp species such as *Clarias* (catfish), tilapiine cichlids, *Synodontis, Gymnarchus*, *Mormyrus* spp., and *Mormyrops*. One reason for survival of the purely open-water species is the connection between the southern open water and the Chari-Logone river system, which can provide the refuge of deeper and well-oxygenated water.

The change in dominance between open-water and marshy species is very rapid when there are changes in the lake environment, and as no species are restricted only to the Lake, the reconstruction of stocks is possible from river fish communities if a normal lake state reoccurs. Since 1982, the fisheries have shown something of a recovery, which demonstrates the lake's ability to regenerate the fish stocks during periods of greater freshwater availability.

Vegetation

The great majority of the larger Lake Chad Basin is desert and savanna drylands, as discussed earlier. However, the key ecosystems are those associated with the limited water supply. The major wetland plant communities present in the lake fall into three broad categories: floating "sudd" communities, permanent reed swamps, and seasonal herbaceous swamps (edaphic grasslands) (see Exhibit 4-22). A swamp belt—the great barrier—separates the lake into the north and south pools. Vegetation in the south basin consists of *Cyperus papyrus*, *Phragmites mauritianus*, *Vossia cuspidata*, and other wetland plants. *Phragmites australis* and *Typha australis* grow in the more saline north basin.



Landsat Geocover Mosaic 2000
Conventional Basin and Sahel
Floodplains
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N
Impact Assessment, Inc.
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0 50 100 200 300 400 500
Kilometers
Niger
Chad
Sudan
Nigeria
Cameroon
Central African Republic
Dilia Subbasin
Chitati Subbasin
Komatugu Yobe Subbasin
Koramas Subbasin
Lake Chad Subbasin
Hadejia-Nguru Wetlands
Komadougou Subbasin
Maiduguri
Yederam Subbasin
Koramas Subbasin
Dagana Subbasin
N'Djamena
Lake Fitri
Fitri Subbasin
Bahr Subbasin
Chari 4 Subbasin
Bahr Keita Subbasin
Oulou Subbasin
Sarh
Kelo
Moundou
Doba
Ndele
Chari 2 Subbasin
Oham Subbasin
Bossangoa

Exhibit 4-22

Occasionally, the floating plant Nile lettuce (*Pistia stratiotes*) covers large areas of open water. Vast expanses of dark, cracking Pleistocene clays line the southern shore of the lake. Grassland communities dominate where flooding is extensive because most tree species cannot tolerate prolonged flooding. Woody communities dominated by *Acacia* species grow interspersed with grasslands. These woody communities vary in density, ranging from scattered trees and bushy grasslands to woodlands and thickets. Xeric woodland species found around Lake Chad include baobabs, desert date palms, African myrrh, and Indian jujube.

'Yaére' grasslands grow on the southern lakeshore where flooding is prolonged and water depth reaches 1 m to 2 m. Vegetation consists of *Echinochloa pyramidalis*, *Vetiveria nigritana*, *Oryza longistaminata*, and *Hyparrhenia rufa*. Yaére dries up completely during the dry season. In areas with shallow and less prolonged flooding, 'karal' or 'firki' vegetation is present. *Acacia seyal* is the dominant species here, but is replaced by *A. nilotica nilotica* in depressions. Below the trees, a layer of tall herbs and coarse grasses grows to 2 to 3 m in height, including *Caperonia palustris*, *Echinochloa colona*, *Hibiscus asper*, *Hygrophila auriculata*, *Sorghum purpureosericeum*, and *Schoenfeldia gracilis*.

An outlier of the ecoregion is found at the Hadejia-Nguru floodplain in northern Nigeria. This floodplain forms where the Hadejia River joins the Jama'are River in a vast mix of criss-crossing water channels. Wet season rainfall falls from June through September and floods the headwaters in July and August. Peak inflow to the wetlands occurs in late August, resulting in extensive shallow flooding. These wetlands cover a total area of about 6,000 km^2, with a water surface area of 2,000 km^2. Referred to as an inland delta, the floodplain has a maximum width of 65 km at the confluence of the two rivers, but then diminishes to a 5 km span that continues for several hundred kilometers. Many patches of higher, unflooded ground are mixed within the floodplain.

Birds

The ecoregion has highest biological importance for the large numbers of migrant birds that use the area, especially ducks and waders that spend the Palearctic winter period in Africa. The lake provides a vital refuge for birds migrating between the Palearctic and Afrotropical realms. Over one million waterbirds congregate on the lake in the Palearctic winter period, making it the third most important area for migratory water birds in West Africa. Some 49 of the 83 major Palaeoarctic species attracted to the Sahel depend on wetlands, and for another 10 species wetlands are the preferred habitat.

Periodic counts of waterfowl and other species have been conducted in Chad and Hadejia-Nguru since 1955. Seventeen species of waterfowl and 49 other wetland bird species are recorded, and abundance varies in different years with the size of the lake and wetlands conditions elsewhere in West Africa. The most abundant bird is the wader ruff (*Philomachus pugnax*), with more than one million seen on the lake at one time. In the Hadejia-Nguru wetlands the most common waterbirds are white-faced whistling duck (*Dendrocygna viduata*), garganey (*Anas querquedula*), northern pintail (*Anas acuta*), and ruff (*P. pugnax*).

Lake Chad also supports two near-endemic bird species, the river prinia (*Prinia fluviatilis*) and the somewhat more widespread rusty lark (*Mirafra rufa*). Although little is known on the range, abundance or status of the listed rare species river prinia (*Prinia fluviatilis*), the contraction of the wetlands is likely to have been detrimental to their populations. One other bird of note is the marbled teal (*Marmaronetta angustirostris*), which is occasionally seen on Lake Chad and in northern Chad; it is thought to be declining worldwide.

Mammals

The semi-arid Sahel savanna supports relatively few mammal species, and their population numbers tend to be low. However, the wetlands of Lake Chad and the Hadejia-Nguru wetlands formerly supported a higher diversity and abundance of mammals. Sahelian large mammal species that used to be common in the Lake Chad ecoregion include redfronted gazelle, dama gazelle, and dorcas gazelle (*Gazella rufifrons, G. dama, G. dorcas*), patas monkey (*Erythrocebus patas*), striped hyena (*Hyaena hyaena*), cheetah (*Acinonyx jubatus*), caracal (*Felis caracal*), and the endangered wild dog (*Lycaon pictus*).

Other species found because of the mesic lake habitat include the African elephant (*Loxodonta Africana*), two species of otter (*Lutra maculicollis, Aonyx capensis*), hippopotamus (*Hippopotamus amphibious*), sitatunga (*Tragelaphus spekei*), and kob (*Kobus kob*). Populations of these mesic species were probably quite widespread when the lake was more extensive, but no reliable records exist.

Two near-endemic rodent species, *Mastomys verheyeni* and the Lake Chad gerbil *Taterillus lacustris*, are also found. The sitatunga is now considered extinct in Niger while only a few declining populations remain in the Lake Chad region of Nigeria and no recent information is available for Chad and Cameroon. A reduced hippo population is still present and otters remain common. Nile crocodiles are now uncommon in the lake. A few populations of elephant, kob, and red-fronted gazelle still survive. Although humans have generally hunted out other large mammals and crocodiles, viable populations of smaller mammals (such as the endemic Lake Chad gerbil), smaller reptiles, and amphibians remain.

The decreased inundated area of the Waza-Logone floodplain has been a major cause for the reduction in the number of kob, and the complete disappearance of buffalo, waterbuck, bushbuck and common duiker in the Waza National Park. The decrease in crocodile and hippopotamus populations may have adversely affected fish populations. Crocodile prey heavily upon catfish (*Clarias gariepensis*) which consume the eggs and fry of tilapia and other cichlids. Without crocodiles to control catfish populations, the catfish reduce tilapia stocks. Hippos also maintain fish stocks by stirring up rich water sediments, keeping deep-water channels open and increasing water fertility with their dung.

Protected Areas and Conservation Activities

The Lake Chad Game Reserve is currently the only formally protected area on Lake Chad. It occupies 7,044 km2 along 150 km of the western lakeshore in Nigeria, which is more than half the Nigerian shoreline of the lake. However, this reserve is a ‘paper park’ and local communities have claimed the land for settlements, farms, and cattle grazing and for use as bases for fishing. A similar situation exists in the Hadejia-Nguru wetlands where there are some forest reserves and small areas that are under National Park status, but local populations also heavily use these areas. It is necessary to formulate and enforce access rules for adherence locally, nationally and regionally.

Various conservation-oriented activities have occurred in an ad hoc way in the LCB, but with a total lack of coordination, synergy, and strategised overall objectives. For example, in July 2000, the Lake Chad Basin Commission (LCBC) met and declared all of Lake Chad a transboundary Ramsar site of international importance. A Global Environmental Facility (GEF) project has been approved for Ramsar designation, including a management plan for the lake and the basin.

World Wide Fund for Nature's Living Waters Campaign is in the process of awarding grants to each of the LCBC member countries to assist in the designation of related Ramsar sites in each country. The Hadejia-Nguru Wetlands Conservation Project was started in 1985, as a joint undertaking by IUCN, BirdLife International, and the Nigerian Conservation Foundation.

In 1990, the European Community started a major development project that included the eastern part of this area. The North East Arid Zone Development Project (NEAZDP) has a large budget to generate village-based initiatives, and it has partly focused on the potential resources of the wetlands.

Key Risks

While conditions differ for different ecosystems and parts of the LCB, in general the biodiversity and ecosystem health have declined dramatically and continue to do so. Freshwater shortage and the consequential habitat modification are regarded as the main influencing factors, with climate change predicted to have further severe further impacts on biodiversity.

River ecosystems are under pressure from over-abstraction of water and the main-stem freshwater ecosystems are threatened with an estimated 50% of wetlands already destroyed and 36% of fish species threatened. Terrestrial ecosystems are threatened mainly due to loss and degradation of natural habitat, desertification, and over-exploitation of terrestrial species, followed by invasion by alien species.

The bird life is threatened by decreasing water levels resulting in loss of wetland habitats in general and seasonal inundations in particular. Recent concerns include the availability of nesting sites for the endangered West African subspecies of black-crowned crane (*Balearica pavonina pavonina*) and adequate wintering grounds for numerous intercontinental migrants such as the ruff (*Philomachus pugnax*).

The fish populations in the lake have suffered declines recently from drought, overfishing, diversion or blockage of instream flows, and increased juvenile catch due to use of smaller mesh. The most important fish in Lake Chad are the characin (*Alestes baremoze*) and the Nile perch (*Lates niloticus*). Characin populations have decreased drastically while Nile perch catch-sizes have decreased substantially so that they seldom exceed 5 to 8 kg in weight. The average size of the fish shows that the resource is today being severely exploited.

Despite climatic and environmental fluctuations, a naturally high productivity of the lake system results from complex and diverse mechanisms bound by particular environmental characteristics. In comparison to other continental fluvio-lake systems, Lake Chad displays exceptional performance in terms of productive capacity and resources available to fishermen.

Recent production estimates have indicated a significant recovery of the fishery since the collapse of 1982, which demonstrates the Basin's natural ability to regenerate. The reconstruction of stocks is always possible from river fish communities if a "normal" lake state reoccurs.

The most significant risk regarding the overall biodiversity in general and fisheries in particular in the Lake Chad Basin is that of governance. Management cannot operate effectively because there is confusion over which agencies have jurisdictions over which areas, the formulation of regulations cannot keep up with dynamics of the lake system, and the organisations charged with enforcement are so poorly resourced that their staff are rarely in a position to enforce regulations In all of the riparian states, as well as in the Lake Chad Basin Commission (LCBC), there are weaknesses in institutional capacity for enforcement.

The key risks associated with LCCB ecosystems and biodiversity include:

- Loss of biodiversity is frequently irreplaceable; extinction is forever. Negative impacts on ecosystem services are also often irreplaceable, or replaceable only at great cost.

- Changes in biodiversity affect ecosystem functions and productivity. While some of these impacts can be predicted, others cannot. As biodiversity decreases, ecosystem productivity and services deteriorate.

- Climate change is altering the ecological profiles, and with it, many of the ecosystems and associated services on which people depend.

- Loss of biodiversity pattern and process undermines the resilience of ecosystems and their ability to evolve and adapt to changing conditions. The ability to adapt to such things as climate change is compromised through loss of biodiversity.

- Clearly, the penalties for making decisions that allow for loss of biodiversity and negative impacts on ecosystem services are substantial. In addition, they could be contrary to the goal of sustainable development, namely not to compromise the ability of future generations to meet their own needs in the LCB.

Major constraints to improved management include the absence of adequate quantitative information about historical or long-term trends in the state of the biodiversity. Failure to address this opens the risk of further loss of biodiversity. The conservation status of fish species is not monitored at all and there is no active alien control program in the LCB. All of this puts the continued ecosystem functioning at serious risk.

A final contributing risk is increasing oil exploitation within the basin which will give rise to increased urbanization, population, and resource consumption. Oil spills and related hazards could cause severe contamination of the water bodies and further deplete the flora and fauna.

Mitigation opportunities lie in making an effective case for the role and benefits of biodiversity to socio-economic well-being. To minimize further biodiversity loss, it will be necessary to foster working relations between the biodiversity protection agencies and production sectors such as major land users, including agriculture, infrastructure development, fisheries, and mining. A major imperative lies in building the capacity of local governments to incorporate biodiversity into their development planning. An initial requirement is to develop a system to value biodiversity and make it a mandatory component of the evaluation of project feasibility.

Far greater effort is needed on raising awareness and understanding of the centrality of biodiversity and healthy ecosystems for economic and social development. Only when policy makers at all levels and decision makers in all sectors understand that healthy ecosystems are prerequisites for sustainable economic growth, and not in opposition to it, will progress towards sustainability be possible. Once again, the key risk here is the lack of attention to root causes in macro-policy changes.

Environmental Pollution

A key distinction is required between pollution and contamination. Pollution per se is not necessarily harmful to the receiving environment depending on any number of local factors and if it is within assimilative capacities. When pollution loadings exceed such bounds the harm caused may result from the chemical and/or physical composition of the substances concerned, their volumes and concentrations, the assimilative capacities of the receiving environment (which may for example vary seasonally), and the cumulative effects of all these factors.

Due to the limited industrial activity and relatively limited and localised application of agricultural fertilisers in the LCB, contamination is currently of limited concern and current quantities are thought not to exceed the local environmental assimilative capacity. However, increasing commercial agriculture in, for example, the cotton and rice industries, which are known to use large quantities of agro-chemicals, is likely, and therefore inorganic chemical pollution is an increasingly likely risk.

The distribution and quantity of these chemicals in the environment is not known and there is currently a severe lack of monitoring and information networks regarding pollution. However, with the onset of oil and mining exploitation in Chad, pollution of water supplies either directly from such project activities or by the increased urbanisation in the region is an increasing risk. Pollution studies will be required to monitor levels and to assist in the formulation of regulations regarding contamination, which are lacking in the current legislative framework. Key information needs are concerned with the assimilative capacities of the local receiving environments in the LCB.

Key Risks

Insufficient attention is paid to the potential for contamination as it is currently not considered a risk. Inadequate monitoring systems will fail to pick-up contamination until significant harm has been done. Current inadequate regulations concerning contamination will not be revised.

Livelihoods and Demographics

An estimated 20 million people rely on Lake Chad for their economic activities, a figure that is projected to rise to 35 million by the year 2020. Large numbers of people and their livestock have migrated due to the changes in rainfall and have increased pressure on resources upstream (south). Desertification is rising rapidly. Unsustainable development decisions such as the construction of large dams and mining operations without sufficient planning have exacerbated environmental problems in the LCB. Deforestation is creating worsening erosion and desertification problems.

None of the environmental problems can be reversed unless the livelihoods and demographics of the people in the LCCB are incorporated fully as part of the problem and the solutions. Over and above the key issue of all political governance, all of the following 'social' components need to be included: rural development sociology; livestock and agricultural systems; pastoralism; rural water supply; cultural natural resource uses (including traditional and religious use); indigenous knowledge systems and management; community fuelwood use and use of non-wood products; local communities migration and population distribution; spatial demographics; livestock and crop value, use, and management; human, crop, and animal diseases; education, awareness, and attitudes.

Key Risks

Management interventions will be based on a separation of ecological and social components, leading to failure. It cannot be emphasized more strongly that today they are all part of a single system.

Governance

The cascade of dependencies in any restoration of the LCCB is similar to any other large-scale interventions which attempt to significantly change socio-economic systems that have developed over decades. Whilst management plans and activities need to be devolved to the lowest common denominator, as appropriate e.g. individual households for improved land management, local authorities for law enforcement, and national governments for policy intervention, all of these fall within the realm of the necessary underpinning "governance" (Exhibit 4-23).

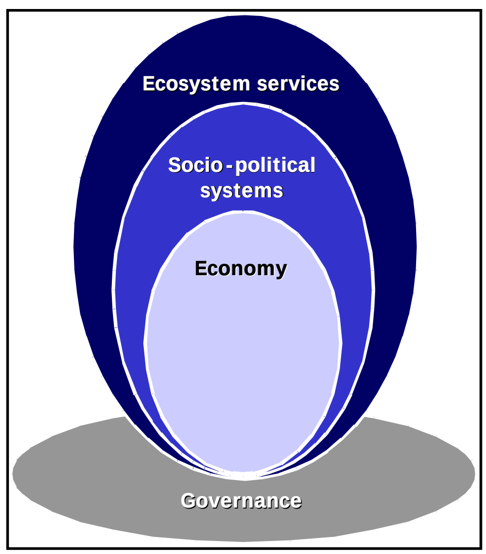


Exhibit 4-23. Governance Interdependencies

Restoring desired ecosystem functionality in the LCCB poses a number of additional challenges from a transboundary perspective, but the multinational agreements and actions required still fall under overall governance. For example, Lake Chad poses a significant challenge for fishing regulations because it lies within four different countries. Taking

Nigeria as an example, regulations are very complicated and haphazardly enforced, with confusion among different administrative agencies over regulation and taxation. Similarly, disagreements over water use can become volatile, sparking conflicts between neighboring provinces and countries.

Key Risks

None of the necessary interventions will be successful without sound governance at all levels. Such governance will require an assessment of all existing relevant policies and practices, such as government subsidies for harmful agricultural practices, which exacerbate land degradation. Analysis needs to include institutional frameworks, strength, and capacity, development and management approaches, international law and relevant conventions (e.g. Ramsar and CBD) ratified by member states and their national implementation, harmonization of national law and policy and their implementation and enforcement, and provision for setting aside and enforcing transboundary protected areas as key components of ecological integrity and political agreements.

The use of economic instruments to manage resource use and degradation has begun to be seriously considered in many areas of the globe. Examples include improving the pricing of natural resources, pollution taxes, and tradable permit schemes. The LCCB countries need to support the development and maintenance of natural resource accounts for energy, water, and land, and integrate all of the natural resource accounts into macroeconomic policy. The most critical risk to restoration of the LCCB is that inadequate effort will be taken to rigorously assess what the current governance constraints are to achieving success, and revise macro-policies accordingly. A key part of this is revising the current imbalance of massive support for ‘production’ regimes/agencies which exploit natural resources and low-levels of support for those agencies required to manage the resources.

Key Linkages and Synergies among Ecological Concerns for Lake Chad Basin Management

No management interventions will be successful in the long-term if they try and separate out ecological components. The primary inter-dependencies for consideration are outlined below.

Global Change Linkages to Freshwater Shortage

Climate variability is considered as a key determining factor in freshwater availability in the LCB. In the past four decades there has been a persistent reduction in rainfall. Stream flows have consequently decreased and available water supplies have been unable to meet the water requirements.

Freshwater Shortage Linkages with Habitat Modification

Freshwater shortage has significantly modified the habitats and community structure of the LCB’s ecosystems. Stream flow modification as a result of decreased rainfall events and upstream dam impoundments primarily in the Chari-Logone and Komadugu-Yobe river systems has impacted on the habitats downstream. Wetlands have been the most affected as a result of changes in the timing and extent of seasonal flooding. This has significantly altered the lake from being an open water environment to being a predominantly marshy environment. The fish species composition has correspondingly also been modified. A lowering of water tables has caused a reduction in perennial vegetation.

Freshwater Shortage Linkages with the Unsustainable Exploitation of Fish and Other Living Resources

The size and composition of fish stocks is integrally linked to the size, duration, and timing of the annual floods and the level of Lake Chad. Changes in stream flows changed the distribution of aquatic habitats of both the floodplains and Lake Chad environment and fisheries production fluctuated accordingly. Recent production estimates have indicated somewhat of a recovery of the fishery since the collapse of 1982, which demonstrates the LCB’s capacity to regenerate its fish stocks if water levels increase.

Habitat Modification Linkages with Fisheries

Aquatic habitats have been altered from being predominantly open water to a marshy ecosystem. Fish species have also modified accordingly from ‘open water’ species to ‘marshy’ species. ‘Open water’ species have therefore been more vulnerable to fishing gears. Wetland habitat modification has also contributed to considerable losses of both riverine and lake fisheries, as they provide habitats for fish in general and spawning in particular.

Habitat Modification Linkages with Global Climate Change

Climate change can partially be attributed to regional habitat modification. Vegetation in semi-arid regions such as the Lake Chad Basin has a significant influence in determining weather patterns. As the climate became drier over the past 40 years and overgrazing continued, vegetation declined. The ability of the ecosystem to recycle moisture back into the atmosphere was thus reduced, contributing to the retreat of the monsoons.

Summary

Environmental cause and effects is a hugely complex, little-developed science. We currently have insufficient knowledge of environmental linkages and interactions to develop comprehensive system management plans with any confidence. All environmental management plans must be designed on the principle of continuous adaptive management. Further, it must be understood and planned for that the rate of environmental impact and change is non-linear, i.e. usually starting slowly, growing incrementally, and finally rising exponentially until a break-point when the systems collapse into a different domain.

The GIWA report predicts that all of the major trends will increase in severity, at least in the short-term (to 2020). Overall, the reduction in freshwater is considered as being the most severe impact due to it driving almost all environmental concerns in the Lake Chad Basin.

The ecological impacts on the wetlands and lake environment have been most severe, but serious degradation of the drylands is also on the rise. Consequently, the changed rainfall patters, desertification, freshwater shortage, habitat and community modification, unsustainable exploitation of living resources, and global change are predicted to have increasingly severe impacts on the ecosystems and human population of the Lake Chad

Basin. The threat of contamination is predicted to become increasingly significant in the future. The major concerns and risks are:

- Population increases will place further pressure on wetland, river and lake ecosystem resources and thus lead to increased habitat loss and modification.

- Poverty in the region is widespread and for their short-term survival communities will increasingly employ practices which are harmful to the environment, leading to increasing poverty.

- Desertification in the arid northern regions of the LCCB will continue to cause a southward migration towards the lake and the southern river basins, and consequently increase the pressure placed on these habitats.

- Freshwater availability is dependent on the amount of human water abstraction and climatic variability. Freshwater shortages will be aggravated further by proposed developments that include the construction of more dams that will further alter the wetland, lake, and fisheries habitats accordingly. There are presently no accurate forecasts of future climate change, making interventions problematic.

- Greater aridity could lead to further desiccation of the drylands and wetlands and the persistence of a marshy lake environment or ultimately complete drying out of the lake.

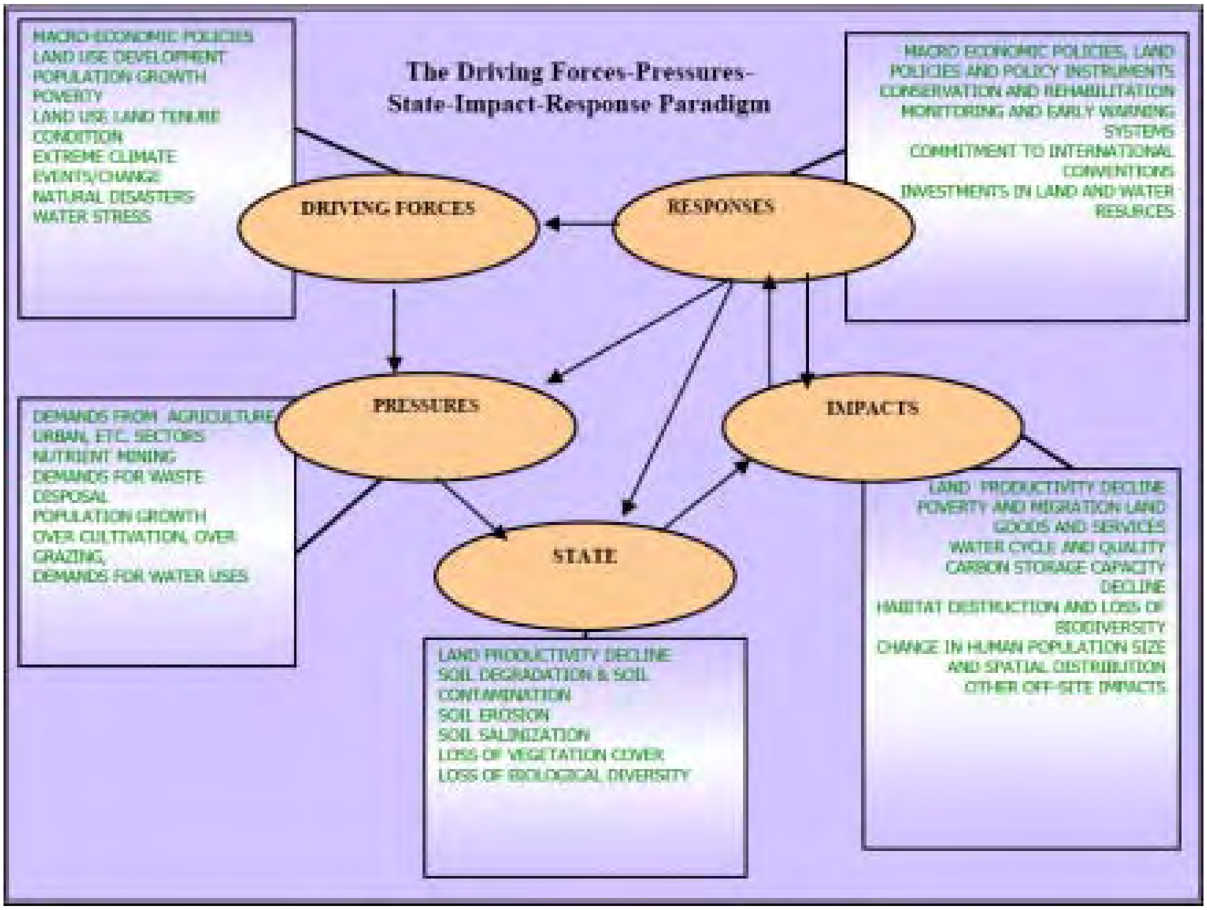
- Extreme deficiencies in information availability will hamper planning efforts.

- Lack of integrated legal agreements, political will, and multi-national cooperation and sharing of information will prevent regional approaches.

Outline of the Approach

Various approaches need to be adapted for various policy and management interventions. Overall, the LADA DPSIR Framework (Exhibit 4-24) is a useful device for formulating policy, program, and project alternatives.

Exhibit 4-24. LADA Framework: Drivers, Pressures, States, Impacts, Responses



State of Environment Reporting offers a useful template for establishing “baseline” systems and conditions. In this the current “state” (or at a selected point in time) all of the selected components are assessed as a “snapshot” in time. Then a ‘before’ picture is established identifying and quantifying the pressures which have created this current state, and finally the social, economic, political, and institutional “drivers” which have created these pressures. Key drivers include policies and legislation, governance capacity and political will, enforcement or lack thereof, market forces, culture and history of use, education, awareness and attitudes, and demographics.

Key ecological “state” components to be assessed include; overall ecosystem’s functioning and resilience to change; land, soil, water, and vegetation dynamics in the basin, and long-term indicators of ecosystem health. Major biodiversity components include the existence and status of rare and endangered species and habitats and migratory species and habitats, lake system biotic components, and the presence and impacts of invasive species of flora and fauna.

Human stressors of the natural ecology to be addressed include natural resources use and management (including human impact on the overall water resources, use and management of water and wetlands), economic and ecological validation of natural resources use value, wildlife management and conflict, and the existence, extent, ecological composition, and viability of protected areas.

In projecting forward, various scenarios can be developed around "responses" to the drivers, pressures, impacts, and state which will result in quantifiable changes to reach a "desired state." The responses can be any one of a "triage" of interventions—devising alternative drivers, doing nothing, or directing operative drivers to effect change—all of which will have attendant feedbacks and impacts.

The sequence of selected intervention requirements must be identified, followed by the resources required to affect such interventions. The desired state needs clear definition, with specific quantifiable indicators to allow measurement of the success of responses in moving the system towards the desired state, with intermediate time-dependent targets. Responses require a combination of "top-down" macro-policy changes together with local management interventions to create incentives and alternative livelihoods, such as the Payment for Ecosystems Services (PES) to landowners and rural communities, which will lead to "bottom-up" reduction and/or replacement of the current non-sustainable use patterns.

Finally a monitoring and evaluation system must be established based on the identified key indicators of ecosystem functioning and health. Within all of the above is the necessity to establish a matrix of scale and time of trends, impacts and responses, and intervention outcomes.

For Lake Chad, one such key indicator would be fisheries—the monitoring system would assess relative species populations both in spatial extent, and over various time scales, against set system rehabilitation targets e.g. getting species x (preferred food source) complement up to 5, 10, and 20 percent of overall fish stocks by year 2, 5, and 10, by increasing areas of preferred species by habitat by, for example, digging deeper channels and/or removing alien vegetation clogging channels.

In addition, part of optimizing system self-regulation, after initial management interventions to re-establish preferred species complements, would be to re-introduce the natural systems regulators such as crocodiles to maintain catfish (less preferred species) populations at lower levels, and hippopotamus to improve lake and channel functions—the role of strategic protected areas is key in re-establishing the presence of these macro-fauna and their important ecosystem functions.

What must not be attempted is adding a further "external" component as a "solution" to a human-induced problem, which in turn creates further (and greater!) problems—as for example, in the introduction of Nile perch to Lake Victoria, which created a whole set of new problems and exacerbated those it was supposed to solve.

The resilience of the components and the ecosystem functioning, especially concerning their vulnerability to change is critical to establish—what are the thresholds, both in terms of not pushing systems too far or too fast, as well as how great an intervention is needed where such breaching of thresholds is required in terms of management.

A key example of this for Lake Chad would be setting minimum limits on fishing-net mesh sizes so that immature stocks of preferred species are not depleted, whilst perhaps taking the opposite approach for species (such as catfish) of which populations have grown to undesirable levels.

Similarly, an aspect unique to Lake Chad is lack of salinization due to the colder saline waters draining through subterranean conduits in the north—however, will these areas be the last to dry out, or, should they be exposed sooner by declining water levels, then the lake may well experience sudden increasing salinity levels, together with increases in temperatures with decreasing depth, all of which will drive changes such as changes in fish species composition, affecting fisheries returns and thus fisheries management. A critical threshold which may need to be decided upon is that lake levels may not be allowed to drop to the point where this self-regulating desalination function is impaired.

The ultimate theoretical objective should be to restore the ecosystem functioning to optimal levels which no longer require ongoing management intervention or investment of resources. However, this is unrealistic in practical terms of human needs and influences, thus the objective needs to be adjusted to increasingly optimizing system functioning via self-regulation whilst reducing management interventions and costs over time.

Management interventions need to be targeted at a hierarchy of ecosystem levels, from the overall basin down to the smallest functioning 'sub-system' interventions, and must not be leveled at individual components in isolation, as this simply has 'domino' effects on other components, often in unforeseen ways.

A case in point is the Southern Chad Irrigation Project (SCIP) developed by Nigeria's government, where, as water levels in the lake fell in the late 1980s, no irrigation could take place. However, the SCIP had an unintended ecological consequence resulting in severe negative social impacts, requiring further costly interventions: its dried-up canals were invaded by the *Typha australis* macrophyte, which is a preferred breeding habitat of the *Quelea* bird, the avian world's equivalent to locusts. Resulting *Quelea* infestation and crop ravages put additional pressure on already unstable local livelihoods, with the regular loss of grain crops to large flocks of *Quelea*.

This led Nigeria's government to begin spraying the area with chemical control agents whose long-term effects on other life forms have not yet been determined but are sure to be detrimental (The primary negative effects arising from pesticide use include increasing pest resistance, the destruction of non-target and natural enemy species, the appearance of new pests to replace those eliminated by pesticides and harmful effects on soil processes, especially loss of soil micro-organisms, water bodies, livestock, and humans).

The more prudent solution would have been to pay local people to harvest the *Typha* reeds on an ongoing basis thus removing *Quelea* habitat and thus the bird problem. In addition, the local people could have been assisted to harvest the birds themselves as a protein and income source, as well as find uses for the typha plant material—thatching/building material, stock fodder, soil improvement/organic fertiliser, mulch, biofuels, etc.

Any number of positive "products"/outputs from such an "addressing causes/self-regulatory" approach could have been generated, rather than adding negative impacts of chemical inputs in an 'addressing symptoms' engineering approach which also provided no permanent solution as the reed-beds remain, and as long as they do, birds will seek to roost there.

For this reason it is essential to perform cumulative impact assessments on each and a combination of all interventions. Ideally, replicable demonstration projects should be at a lowest (subsystem) level. Finally, a Strategic Environmental Assessment (SEA) approach should be adopted which not only identifies what interventions are possible, but more importantly, which are not, e.g. those which will breach system resilience and create outcomes which are worse than those being addressed.

A summary of the key ecological concerns, risks, and possible solutions discussed in this subsection is shown in Exhibit 4-25.

Exhibit 4-25. Summary of Key Ecological Concerns, Risks, and Possible Solutions

KEY CONCERNS	**KEY RISKS**	**POSSIBLE SOLUTIONS**
Declining River/Lake Health	Decline in available water volume; loss of wetlands, loss of fisheries, loss of biodiversity	Regulate abstraction; simulate natural flow regimes through dam releases; incentivize alternative livelihoods not based on irrigation
Freshwater shortage	Climate change; Increased demand of water;	Develop management plans based on plausible future scenarios of change
Climate change	Further water development projects	Set maximum off-take targets and invest in alternative livelihoods strategies
Habitat and community modification	Overstocking and overgrazing; deforestation of woodlands; too frequent and uncontrolled fires; local farmers have insufficient control over management of rangeland	Sustainable management through community based approaches and devolution of rights (i.e. rights over resources); incentivizing alternative livelihoods e.g. Payment for Ecosystems Services (PES); local capacity building in soil and rangeland restoration including cultivation and propagation of trees; empowerment of traditional authorities, developing awareness and capacity with appropriate skills; enforce existing traditional and legal mechanisms; establish a network of protected areas and implement catchment restoration plans
Desertification, silting, erosion	Loss of productive land, urban migration, social disruption	Implement soil restoration and revegetation in upper catchments; incentivize improved farming and land management (PES); incentivise reduced stocking rates; implement riverbank stabilization and protection measures; avoid cultivation close to watercourses; seek alternative energy sources
Unsustainable exploitation of fish and other living resources	Increased demographic pressure; too many people fishing, using inappropriate fishing methods e.g. small net	Incentivize appropriate and traditional fishing methods; intense monitoring system and adaptive management; enforcement of fishing regulations; create use zones including ‘no-take’ protected areas for fish

	sizes; No local control over outsiders Local fishermen have insufficient management and control of the fish resources; breeding areas not protected; no protected areas	breeding; regulations for fishing and boat use and quotas, with local control; restore habitats and flow regimes through controlled releases and restoration programs
Overall decline of Species and Natural Resources	Loss of wildlife and other resources through poaching, habitat loss, etc.; conflict between different land uses; resources overutilized without permission (outsiders); migrant refugees exerting pressure on land, natural resources and social infrastructure; settlement encroachment; lack of information and awareness of sustainable practices; lack or protected areas and ‘no take’ zones; loss of habitat and associated species; negative impacts of invasive alien species (IAS)	Entrench community based approach to manage and control access to resources; incentivize community involvement in formation of laws and local strategies on harvesting of natural resources and management practices; develop guidelines for harvesting of natural resources; develop incentives and opportunities for new livelihoods through sustainable use and conservation, e.g. through PES; establish and enforce protected areas with representative populations of threatened species and sufficient habitat for, e.g. migratory species; ensure ecosystem functionality secured through protection measures; incentivize eradication and management programs for IAS
Pollution	Oil and solid mineral development	Draft adequate regulations and enforce before problems arise
	Increased use of agro-chemicals	Shift to organic fertilisers and Integrated Pest Management (IPM)
Governance	Lack of political commitment to change macro-policies; lack of multi-national agreements and cooperation; lack of incentives to change activities at local levels; continued support for ‘production/exploitation agencies and not for management agencies	Elevate discussions to highest possible political level, with explicit description of consequences of not changing; support the development of natural resource accounts for energy, water, and land, and integrate all of the natural resource accounts into macroeconomic policy; rigorously assess current governance constraints to achieving success, and revise macro-policies accordingly; revise current imbalance of massive support for ‘production’ regimes/agencies that exploit natural resources vs low-levels of support for those agencies required to manage the resources.

4.1.3 THE SOCIAL SECTOR

Traditionally, the "social sector" has been conceived as exclusively concerned with health, education, and welfare. While recognizing their social character, economic and political affairs were held apart from such concerns. In recent years however the social category has expanded to include such interests as population, gender, culture, and social integration. Perhaps the broadest conception of human existence and action is "that which is inexplicable in terms of human heredity and the nonhuman environment" (Levy, Jr. 1952: 8).

In this subsection, population, health, and the economic and political "environments" will be considered in the social sector context. Together they comprise a large part of any society. A generalized, "functional" model of society was developed half a century ago by sociologist Talcott Parsons and his colleagues, known as the "AGIL" schema, where:

A = Adaptation (economy)

G = Goal Attainment (polity)

I = Integration (community)

L = Latent Pattern Maintenance and Tension Management

"Adaptation" refers to the interface between natural and social systems; human ecology is another way to express this relation. "G" might well stand for "governance" or even "control." The functional problem of integration is the socialization of individuals to group living, and the harmonizing intergroup relations. The "L" term can be rendered intelligible by translating it as "culture," but also with cognizance of motivational commitment ob the psychosocial level. Together they define the four "functional problems" that any society must solve to ensure its survival.

How this is achieved naturally varies widely from society to society. Corresponding to each of the functional subsystems is a range of structural patterns (alternatives) for characteristic institutions: the business enterprise and market (A), government and its military branch (G), community and family (I), and education, language, religion, art, science, and other "cultural" pursuits (L).

Societal dynamics take place in terms of "boundary interchanges" between each of the functional systems, within which are replicated the full set of functional problems. Societal development takes place by the structural differentiation of functionally specialization units within these subsystems—the separation of church and state, for example—while at the same time retaining their functional interdependence as a whole.

While the AGIL schema was criticized for its "static" quality and an assumption of "functional unity," it is not difficult to imagine that tensions can and do arise at every juncture, hence the "L" term might as well stand for conflict management. Other schemas may be entertained, such as Rastogi's (1977), in which society as a "complex adaptive system" is analyzed in terms of variables such as:

MPM	politicomilitary pressure
IR	investable resources
AE	administrative effectiveness
ED	education
GS	government stability
EG	economic growth
UE	unemployment
PR	price rise
PG	population growth
PU	public unrest
TPG	institutional pressure on government
ES	citizens' evaluation of leadership response to pressing problems
LDF	leadership factor
ET	ethnic tension

Societal system dynamics—including Nigeria's—are then simulated by combining these variables, along with exogenous factors such as the weather, and projecting them over a five-year period.

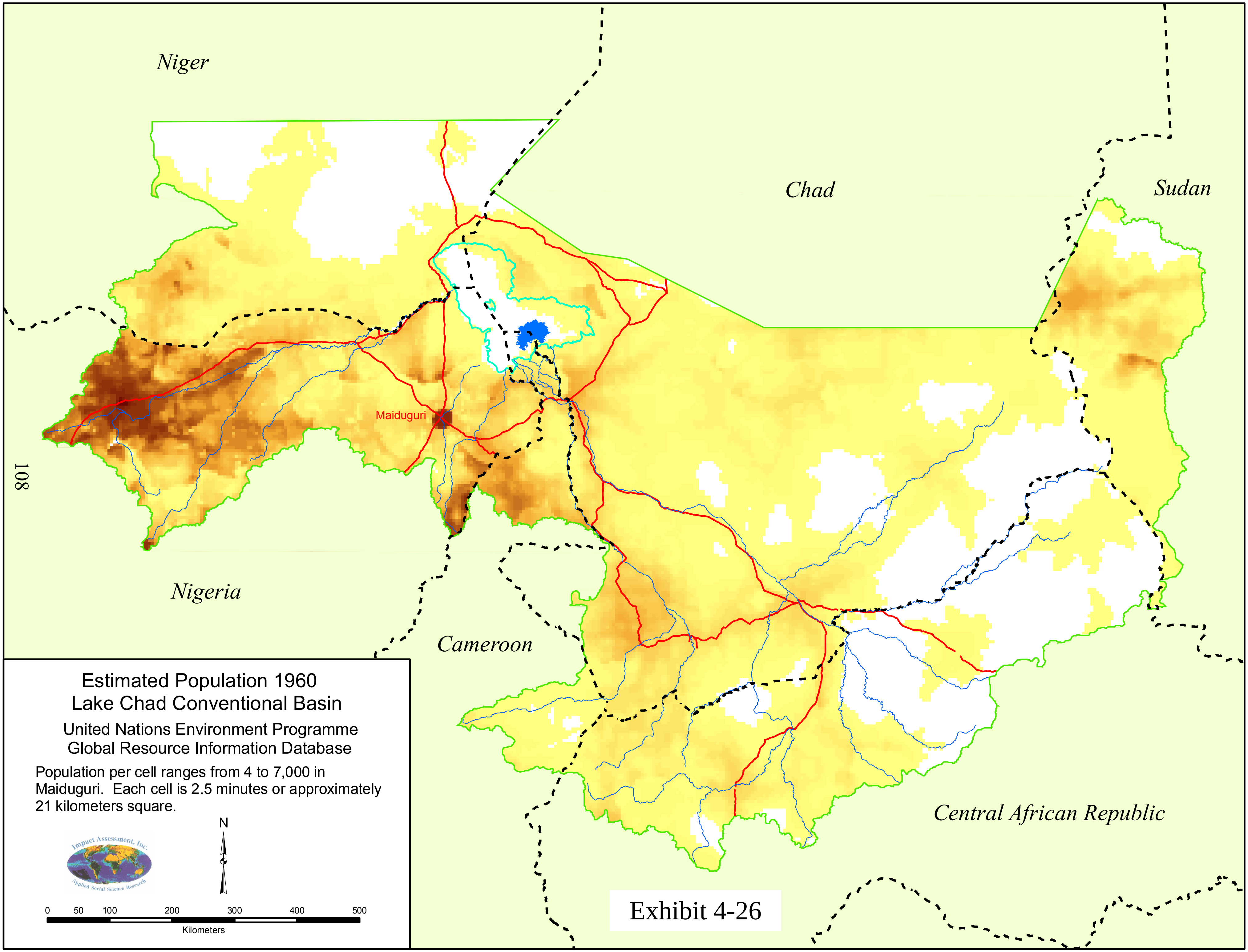
The point of all this is not to see how complicated societal analysis can be made, but how to identify essential system variables ("system problems") to monitor their performance and guide appropriate policy responses.

Historical Population Dynamics

In order to establish a firm and consistent population baseline, we obtained the most reliable UNDP estimates for the present conventional basin geography and recalculated the distribution of population at each decade. This analysis yielded the graphic results depicted in Exhibits 4-26, 4-27, 4-28, 4-29, and 4-30). The population of the present conventional basin has increased from approximately 11,091,000 in 1960, to 13,958,000 in 1970 (a 26 percent increase), to 18,097,000 in 1980 (a 30 percent increase), to 23,587,000 in 1990 (a 30 percent increase), and to an estimated 31,461,000 inhabitants in 2000 (a 33 percent increase).

This pattern of growth is unusual from two perspectives. The first is the effect of growth rates when applied to low numbers (e.g., the increase from 10 residents to 20 residents over a ten year period results in a 100% decennial growth rate). In general, growth rates typically decline as the size of the city or community increases over time. Second, the growth rate steadily increases every decade despite severe droughts, famine, water distribution problems, human and animal disease, and host of other negative contributions.

As characterized in the report, growth in the basin has concentrated in accordance with predictable geographic principles of distribution – radiating out from cities, and along principal transportation corridors. As indicated in the progression of population growth in the conventional basin, urban areas and their expanding peripheries account for the majority of growth over the last fifty years. This is of profound importance to planners and planning agencies in each of the LCBC member states, and for addressing LCBC water management responsibilities. Urban water demands, for a broad range of personal and industrial consumption purposes, are invariably met at the expense of agricultural, environmental, and habitat requirements. This principle is amply demonstrated by the case of Maiduguri, where the agricultural objectives of dam construction were ultimately subordinated to the needs of urban consumers. This will be the case at precisely the point where the total rural and urban water demands of a particular geography exceed available resources. Wherever surface waters are allocated preferentially to agricultural purposes, it will be at the expense of groundwater resources which, in virtually all urbanizing basin environments, are in steady decline. At the same time, it must be also be emphasized that per capita consumption of water is also increasing in urban environments.


Niger
Chad
Sudan
Maiduguri
Nigeria
Cameroon
Central African Republic
Estimated Population 1960
Lake Chad Conventional Basin
United Nations Environment Programme
Global Resource Information Database
Population per cell ranges from 4 to 7,000 in Maiduguri. Each cell is 2.5 minutes or approximately 21 kilometers square.
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Applied Social Science Research
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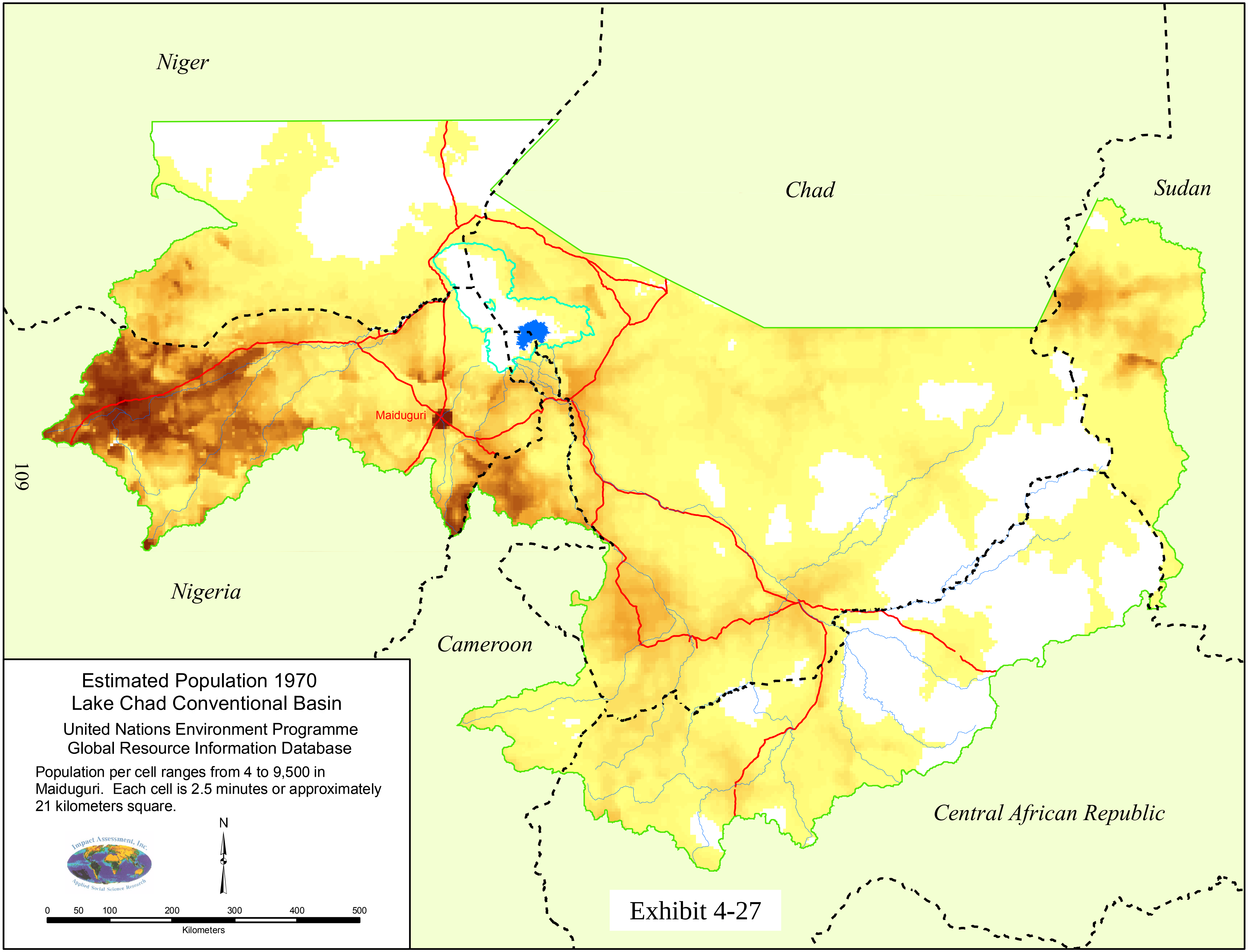
Kilometers

Exhibit 4-26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Lake Chad Conventional Basin
United Nations Environment Programme
Global Resource Information Database
Population per cell ranges from 4 to 9,500 in Maiduguri. Each cell is 2.5 minutes or approximately 21 kilometers square.
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Exhibit 4-27

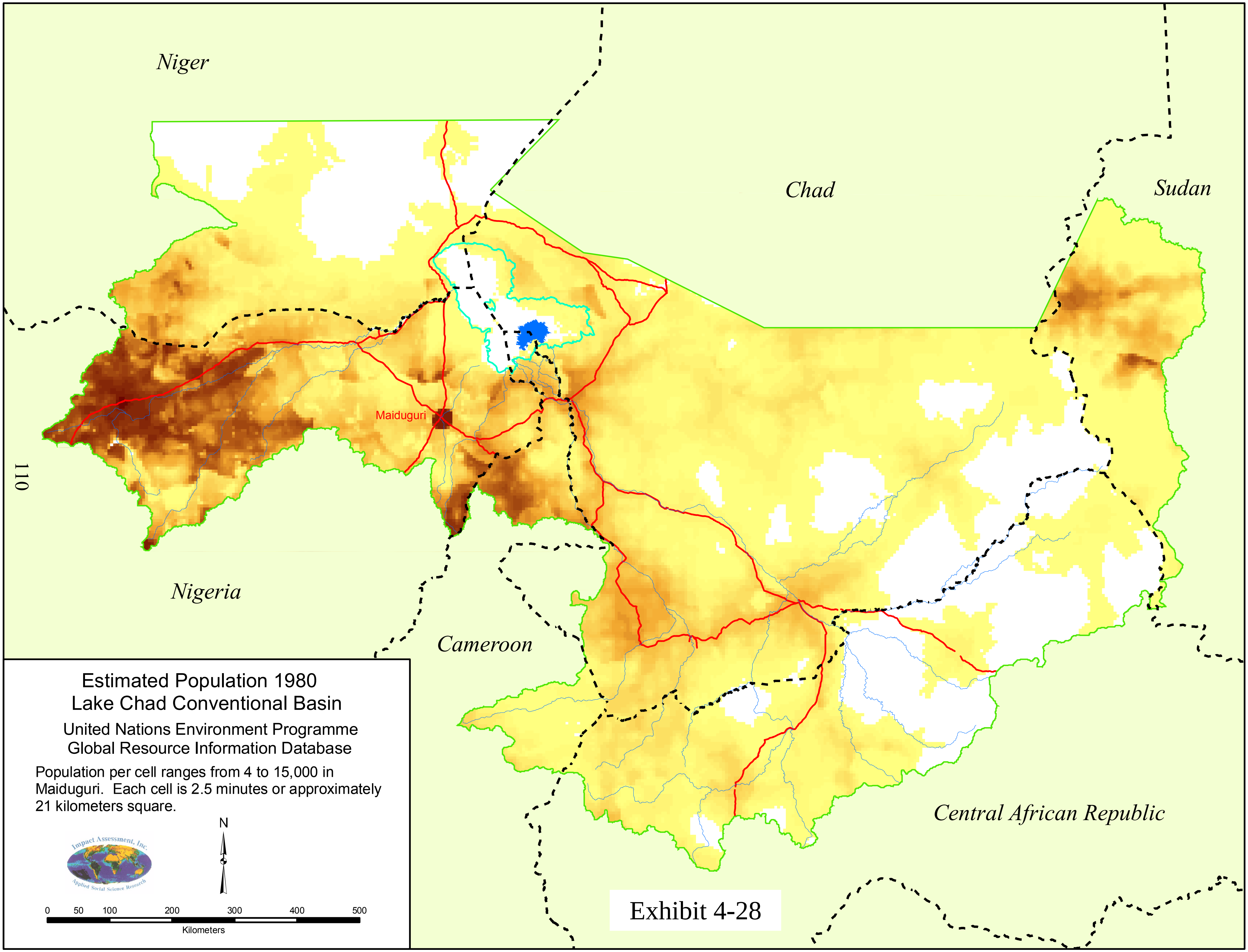
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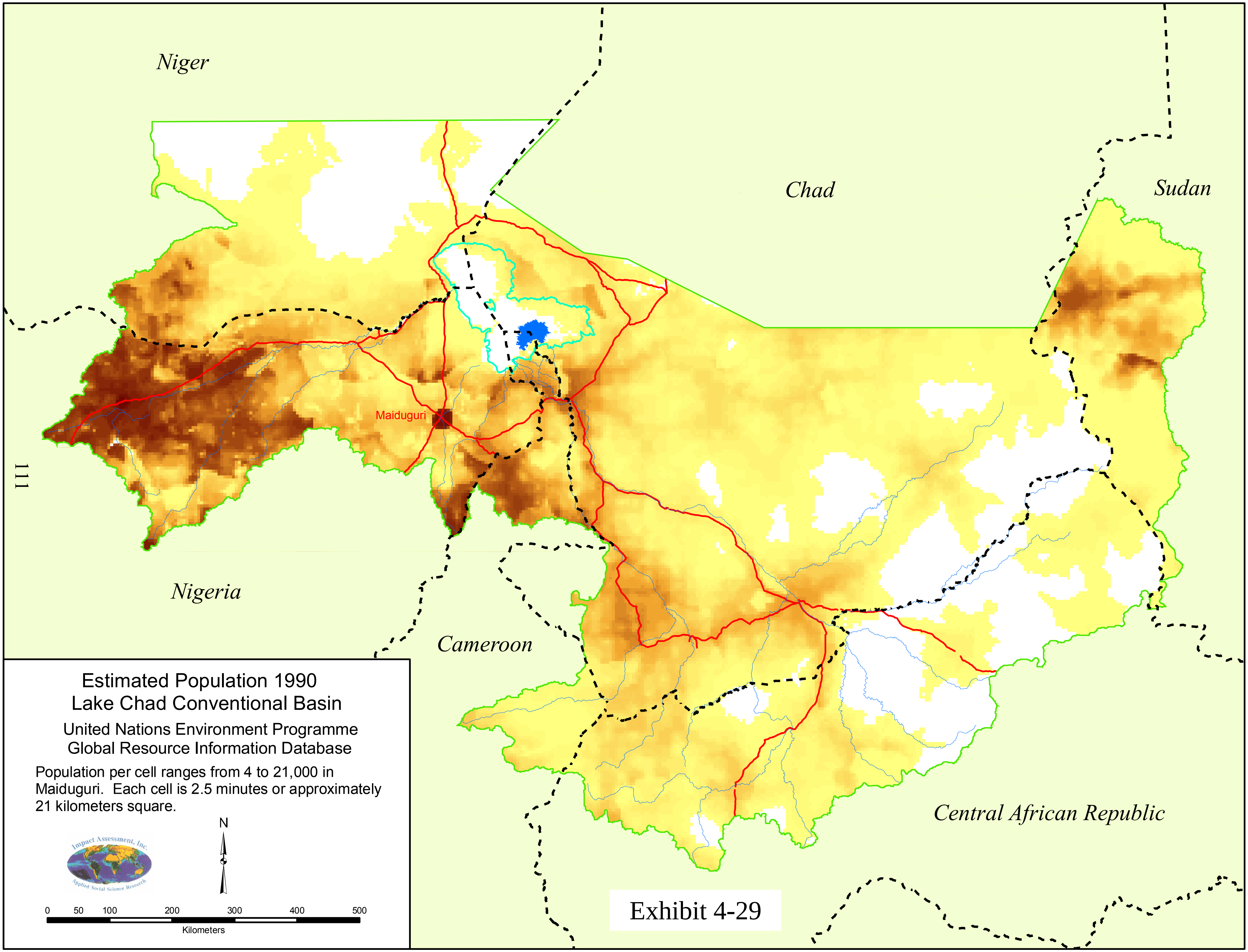
Exhibit 4-28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United Nations Environment Programme
Global Resource Information Database
Population per cell ranges from 4 to 21,000 in Maiduguri. Each cell is 2.5 minutes or approximately 21 kilometers square.
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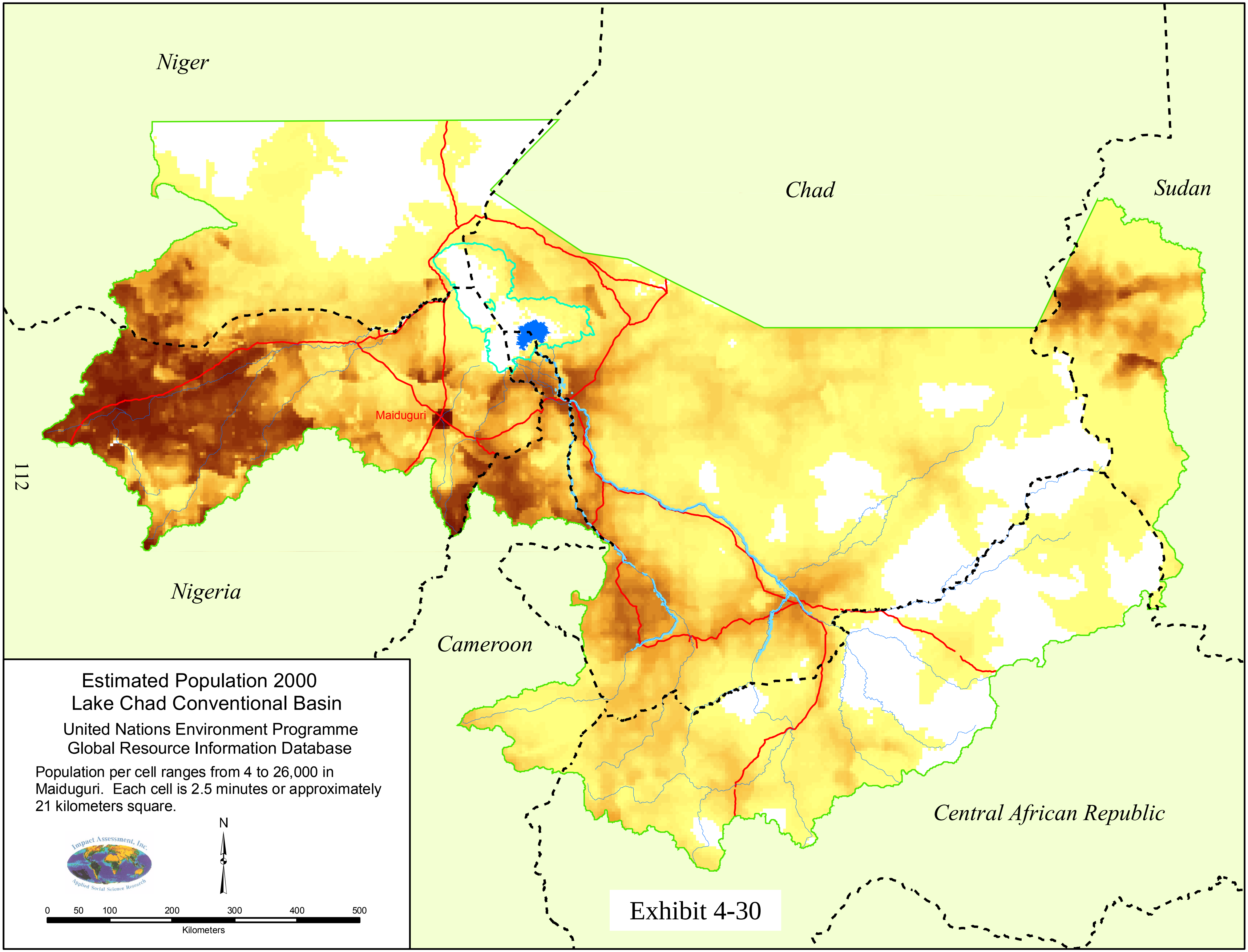
Exhibit 4-29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Nigeria
Cameroon
Central African Republic
Estimated Population 2000
Lake Chad Conventional Basin
United Nations Environment Programme
Global Resource Information Database
Population per cell ranges from 4 to 26,000 in Maiduguri. Each cell is 2.5 minutes or approximately 21 kilometers square.
Impact Assessment, Inc.
Applied Social Science Research
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0 50 100 200 300 400 500
Kilometers

Exhibit 4-30

Geographic Vulnerability Analysis

The objective of this geographic vulnerability analysis is to identify those populations subject to greatest risk from ongoing and impending environment disruptions (i.e., from changes in rainfall quantity, frequency, duration or geographic distribution). The two components of this analysis, therefore, are: (1) changes over time in the distribution and density of population in areas at high-risk of low, delayed, intermittent, or failed rainfall (over short- or long-term); and (2) the historical record of geographic distribution of rainfall over the conventional basin.

The analysis was carried out through the application of GIS tools to: (1) identify the geography of rainfall distribution over the conventional basin in each year from 1960-1996; (2) identify that portion of the distribution that fell below 300 mm of annual rainfall (the level at which rain-fed agriculture can be pursued); (3) identify that portion of the distribution that fell below 150 mm of annual rainfall (the level required to support livestock). This set of calculations resulted in the identification of areas of the conventional basin in each year receiving rainfall below the minimum thresholds. These geographic "shapes" were then applied to the corresponding population density maps to quantify the number of inhabitants living in areas in which rain-fed agriculture could not have been sustained – i.e., the number of inhabitants living in areas in which drought conditions prevailed. This absolute number (taken from UNDP population distribution estimates applied to intervening years) was then entered into a spreadsheet to calculate comparative estimates of exposure to high-risk rainfall conditions in each of the five member nations. We used, as our denominator for this estimate, only those populations of the five member nations living within the conventional basin.

The results of the analysis revealed that at no time over the period 1960 to 1996 did any significant portion of Nigeria fall within the high-risk exposure zone (on only a few occasions did any portion of Nigeria receive less than 300 mm of rainfall). No portion of Cameroon, located on the southern margin of the conventional basin, ever received less than the minimum rainfall necessary for rain-fed agriculture. The three northern tier countries of Niger, Chad, and Sudan, however, over periods of varying duration, and over varying geographic areas, experienced moderate to severe drought conditions on numerous occasions.

Application to the population estimates for the particular geography and period involved reveals the following distribution of extreme at-risk populations over time for each of the three nations. For purposes of clarity, we have eliminated areas of the basin receiving less than 150 mm of rainfall from our analysis. Because these areas are already on the margins of the Sahara, are very sparsely populated, and are devoted primarily to livestock, they are already deeply embedded in the seasonal (transhumant) migration pattern and therefore perhaps better able to adjust to drought conditions than permanent farmers.

Exhibit 4-31 depicts the annual distribution of rainfall in Niger. As indicated, the Niger portion of the conventional basin has experienced several of the largest, and most enduring, droughts over the last 40 years. The droughts of the early 1970s, early and late 1980s, and early 1990s have occurred over lengthy periods (sometimes over 4-5 years) of time, magnifying the impact on affected communities. What is also of import is the relative size of the affected populations. During the drought in the late 1960s and early 1970s, the geographically concentrated population directly affected, in each of the drought years, was in the range of 200-250,000 inhabitants. This number, in the year 1970, represented as much as 30 percent of the total Niger population within the conventional basin. The inhabitants of Niger have been, and will likely continue to be, one of the principal populations at-risk in the event of future drought or famine in the conventional basin.

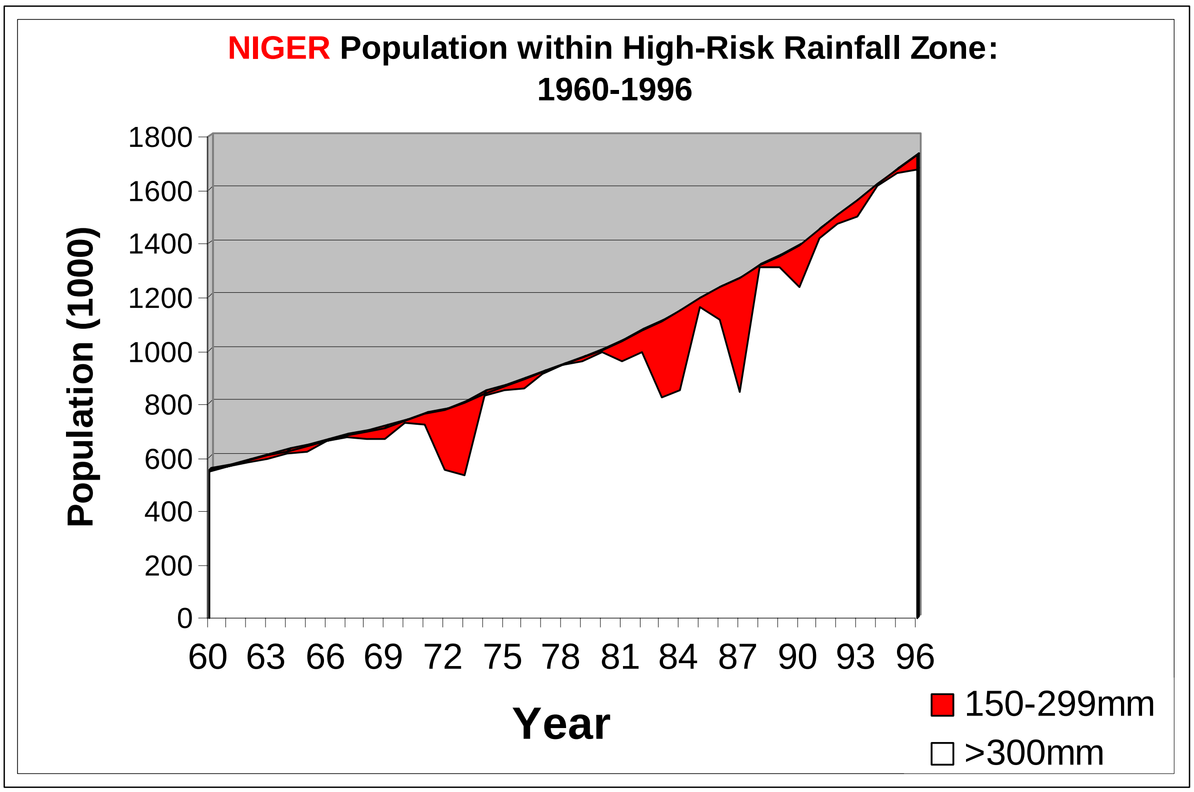


Exhibit 4-31: Niger; Population in High Risk Rainfall Zone: 1960-1996

The border region of Sudan, on the eastern margin of the conventional basin, has also experienced several periods of drought. In general, the duration of these droughts has been limited to a single season. They have, however, also encompassed a relatively large number of inhabitants. During the drought of 1984, over 1,000,000 inhabitants, nearly the entire population (93 percent) of the Sudanese portion of the conventional basin, was directly affected. The drought in western Sudan in 1987 affected nearly 440,000 (35 %) inhabitants of the 1.26 million Sudanese population of the conventional basin. The drought of 1990 affected 340,000 (25%) of the 1.36 million inhabitants of the conventional basin. The drought of 1996 affected approximately 56,000 (3%) of the 1.72 million inhabitants of the conventional basin.

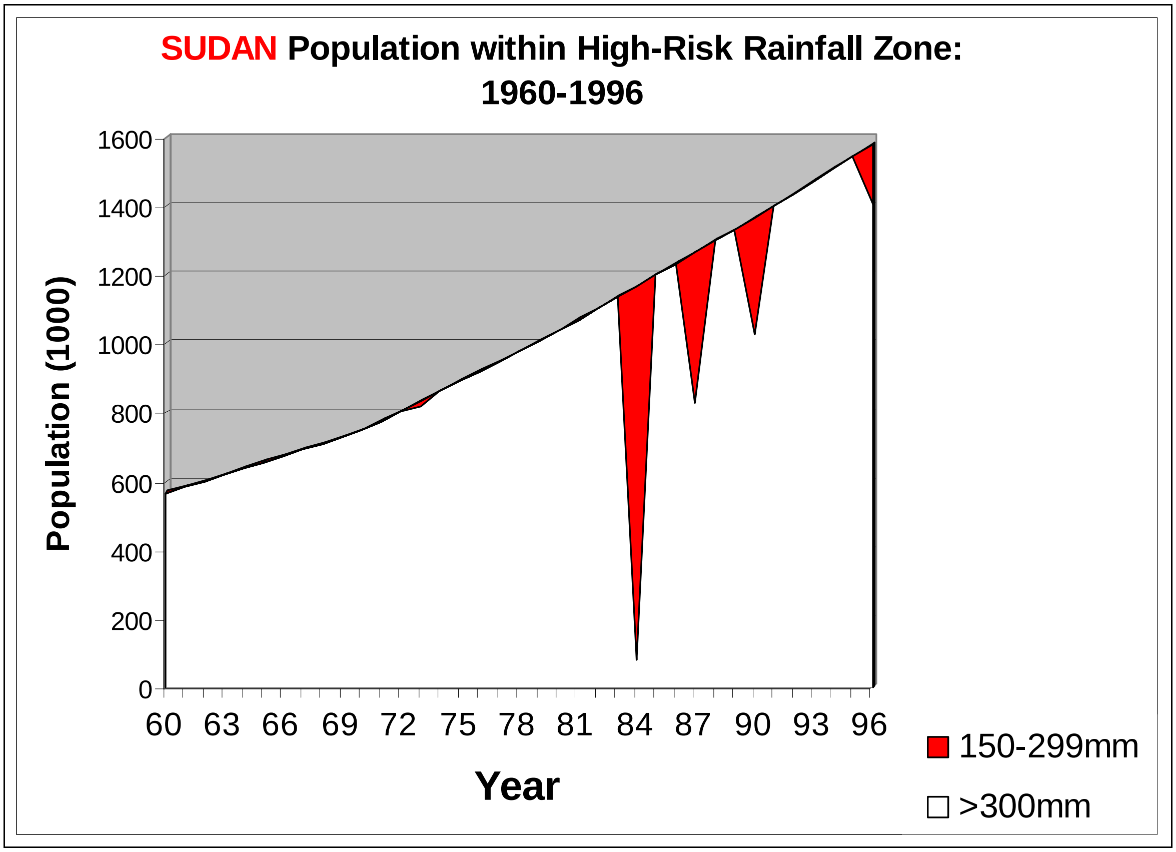


Exhibit 4-32: Sudan; Population within High-Risk Rainfall Zone: 1960-1996

The history of drought in Chad is one of almost persistent but modest droughts since the late 1960s. The 1968-1969 drought period affected about 54,000 (2% of a basin population of 2.4 million) and 91,000 (4% of 2.5 million) Chadian inhabitants of the basin. The 1971-1973 drought affected 130,000 (5%), 150,000 (6%), and 227,000 (8%) of total Chadian inhabitants of the conventional basin. The more extended drought of 1981-1987 affected 210,000 (6%) in 1981, 175,000 (5%) in 1982, 210,000 (6%) in 1983, 354,000 (10%) in 1984, 210,000 in 1985 (6%), 148,000 (4%) in 1986, and 295,000 (8%) in 1987. This represents one of the longest and most persistent periods of drought in Africa. Following two years of "normal" rainfall, 1990 experienced another drought affecting 340,000 (8%) of the 4.2 million Chadian inhabitants of the conventional basin in that year (1990). Again, in 1996, they experienced another drought affecting 320,000 (6%) of the 5.1 million inhabitants of the conventional basin in that year.

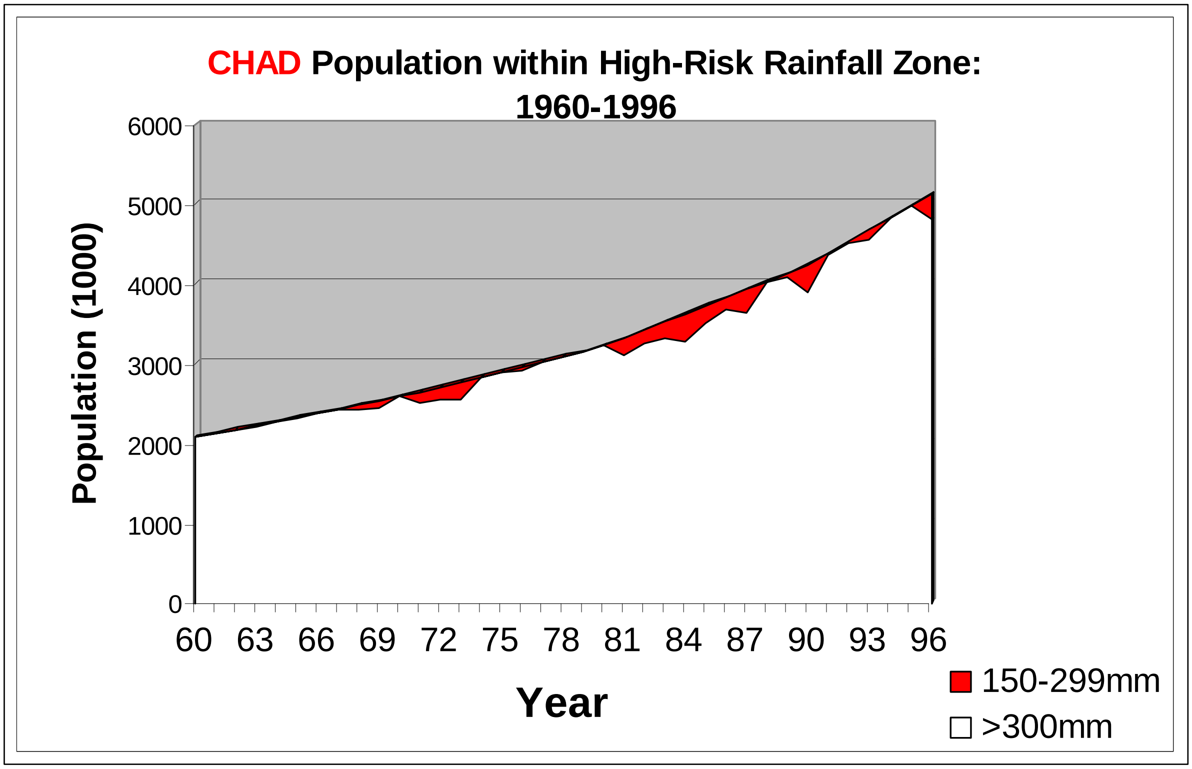


Figure 4-33: Chad; Population within High-Risk Rainfall Zone: 1960-1996

Conflict

Armed conflicts on the borders between nations, among and between ethnic groups based on social, cultural, economic and/or religion differences, are endemic to this region of Africa. Because local populations must move or risk almost certain property destruction or death, their lives are shattered. They are, at all phases of the process, in grave jeopardy – during the initial incursion, invasion, or occupation, during transit from their point of origin, during their settlement in camps, during their stay in the camps, and, eventually, during the process of repatriation and resettlement.

Conflicts continue on the borders between Cameroon and Nigeria, and on the northern border between Central African Republic and Chad. Sometimes the conflict is internal to the nation, resulting in internal displacement and local economic adjustments, and sometime the conflict is between groups using the borders as a shield. Conflict continues on the border (Darfur) between Chad and Sudan, for example, between elements of the South Sudan rebel forces on one side, and the Sudanese Government and the government-backed Janjaweed militia on the other – a conflict that has left over 50,000 people dead (WHO), and over 1.3 million displaced. In Niger, internal ethnic and border area conflicts recently ended between the Saharan ethnic (Touareg) communities and the central government in Niamey. Low level conflict continues on the northern boundaries of Lake Chad, in the N'Guigmi region, with a population of 52,000, which had been one of the active zones of armed conflict in Niger in the 1990s. The country was also torn by strikes, student protests, and mutinous soldiers. Chad has been plagued by numerous wars and conflicts, since 1965, including a lengthy and very costly civil war from 1965-1990. The country was also invaded by Libya in 1979 and again in 1981. They have also experienced several successful and unsuccessful military coups, including two in 1992, and the recent attempt in 2006. Areas of the border between Chad and Niger, just to the north of Lake Chad remain unstable and insecure.

These violent conflicts have one thing in common – they result in a total breakdown of law, security, community structures, and cultural and religious values. This absolute breakdown in social values results in wonton murder, rape, theft, and destruction. Internal and cross border raids in search of resources, retaliation, or simply recreation have had, and continue to have, a major impact within the conventional basin – with the most vulnerable populations of farmers, herdsmen, women, children, particularly young girls, bearing the brunt of the costs. Internal ethnic, religious, and economic-based conflicts, attempted military coups, and areas of general social disorder create large areas in which normal agricultural, pastoral and general economic activities cannot be pursued. These conflicts also affect particularly vulnerable remote farmers and the poor indirectly, as conflicts result in the massive diversion of national resources to “security” issues within and between countries.

Population and Health

Population is comprised of concrete individuals who perform multiple roles in these various institutional areas, and make up the membership component of organizations within their functional spheres ("institutional organizations"). Populations can be regarded as statistical aggregates with their own dynamics, but when population health is considered their "social" character is very much in evidence.

The population system includes characteristics and dynamics of population quantity (fertility and mortality) and quality (morbidity and population health), dispersion (migration) and distribution (settlement and residence). In the Lake Chad Basin all are problematic.

Despite recurrent drought conditions and widespread internal displacement, fertility rates in the Sahel remain high, so much as to call into question the "carrying capacity" of these marginal lands. On the other hand, mortality is likewise high, although Caldwell (1975) believes the impact of the 1974 drought event was greatly overstated.

In that event, he believes migration was the preferred coping behavior, but now they are facing greater obstacles, however, due to political barriers. In the 1983–1984 drought, Nigeria closed its borders with Niger, although other factors were also involved. Rosenblum and Williamson (1987) speculate that the cumulative impact of the 1984 drought has fatally interrupted the nomadic cycle, and intensified urbanization trends. In addition, some government sedentarization policies have encouraged agropastoral diversification and perhaps also desertification.

The implication of that circumstance for regional development is apparent. Again using Nigeria by way of contrast, it has developed comparatively diversified national economy, although centered more in the west and south of the country, but with significant potential for future investment and growth, whereas the other member states are relatively disadvantaged in natural resource endowment and economic development.

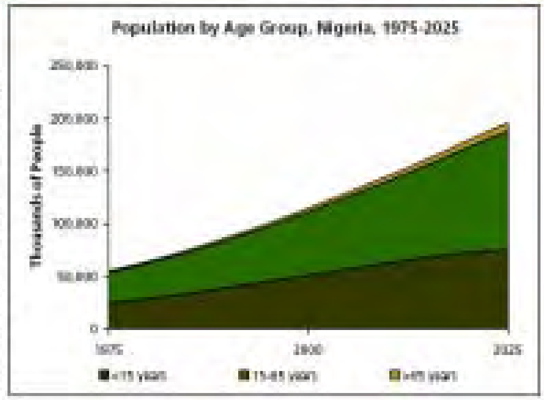
It follows that population increases in Northern Nigeria, with a broader economic base to sustain them, are not equivalent to increases elsewhere in the Lake Chad Basin. At the same time, as shown in Exhibit 4-34, the unequal distribution of wealth in the country has left much of the population living in deprivation. Despite substantial differences in national wealth, performance on core health indicators is similar to those for Chad (Exhibit 4-35).

Exhibit 4-34. Population, Health, and Human Well-Being -- Nigeria

Population, Health, and Human Well-Being-- Nigeria

Earthtrends Country Profiles

Demographic and Health Indicators	Nigeria	Sub-Saharan Africa	World
Total Population (in thousands of people)			
1950	29,790	176,775	2,519,495
2002	120,047	683,782	6,211,082
2025 (projected)	202,957	1,157,847	7,936,741
Population Density (people per square km), 2000	123.3	25.3	45.1
Average Annual Population Growth Rate, 1980-2000			
Total	2.7%	2.7%	1.6%
In rural areas	1.3%	1.9%	0.9%
In urban areas	5.1%	4.7%	2.4%
Percentage of Population:			
Under age 15, 2002	45%	44%	29%
Over age 65, 2002	3%	3%	7%
Living in Urban Areas, 2000	44%	34%	47%
Average Total Fertility Rate (a)			
1975-1980	6.9	6.7	3.9
2000-2005	5.4	5.6	2.7
Infant Mortality Rate (b), 2000-2005	79	89	55
Under-Five Mortality Rate (b), 2000	184	175	83
Life Expectancy at birth (years), 2000-05			
Female	52.2	49.8	68.1
Male	52.0	48.3	63.9
Births Attended by Trained Personnel, 1994-2000 (c)	42%	39%	57%
Adults and Children Infected with HIV/AIDS, 2001 (number)	3,500,000	28,500,000	40,000,000
Percent of Adults Ages 15-49 Infected with HIV or AIDS, 2001	5.8%	9.0%	1.2%
Number of Children Orphaned by AIDS since the beginning of epidemic, 2001	1,000,000	11,000,000	14,000,000
Safe Water and Sanitation (c)			
Access to Improved Sanitation, 2000			
Urban	66%	72%	85%
Rural	45%	44%	40%



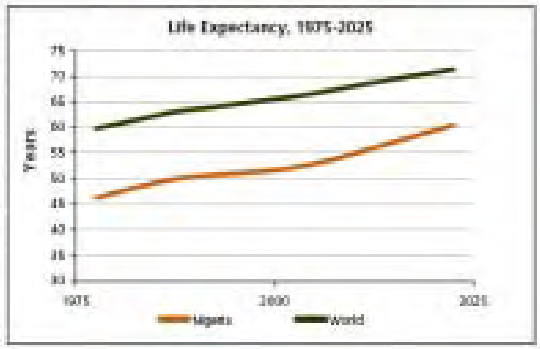


Exhibit 4-35. Core Health Indictors, Chad, 2003–2005

Chad

Indicator	Value (year)
Life expectancy at birth (years) males (?)	45.0 (2004)
Life expectancy at birth (years) females (?)	48.0 (2004)
Healthy life expectancy (HALE) at birth (years) males (?)	39.7 (2002)
Healthy life expectancy (HALE) at birth (years) females (?)	41.7 (2002)
Probability of dying (per 1 000 population) between 15 and 60 years (adult mortality rate) males (?)	497 (2004)
Probability of dying (per 1 000 population) between 15 and 60 years (adult mortality rate) females (?)	422 (2004)
Probability of dying (per 1 000 population) under five years of age (under-5 mortality rate) males (?)	212 (2004)
Probability of dying (per 1 000 population) under five years of age (under-5 mortality rate) females (?)	188 (2004)
Total expenditure on health as percentage of gross domestic product (?)	6.5 (2003)
Per capita total expenditure on health at international dollar rate (?)	51 (2003)
Population (in thousands) total (?)	9,749 (2005)
Per capita GDP in international dollars (?)	1,199 (2004)

Projected Population Dynamics

As a foundation for LCBC planning, however, the present study required a more ambitious objective – to construct a projection of present environmental and human changes into the future as a foundation for long-term LCBC planning and policy decisions. The combination of surging urban population, increasing per capita consumption, and declining rainfall and groundwater resources represent an impending crisis.

In order to project the pace, and quantify the dimensions, of this impending crisis, we analyzed the characteristics of population growth and distribution within the basin from 1960 to 1970, from 1970 to 1980, from 1980 to 1990, and from 1990 to 2000. This yielded a conservative fifty-year average growth rate of 26% (versus the 1990-2000 actual growth rate of 33%). While this more conservative 50-year average growth rate (rather than the actual accelerating rate) is considered the more likely trajectory, because of the unusual characteristics of the past growth sequence in the basin, we chose to revert instead to the use of the more common decelerating growth rates characteristic of urbanizing conditions for purposes of future population projections. We settled on an assumed, conservative, decennial growth rate of 25 percent, or 2.4% per annum (although decennial growth rates between 23-29 percent are all plausible). Thus, for the period 2000-2010 we employ an annual growth rate of 2.4%, a 2.3% rate for 2010-2020, and a rate of 2.1% for the period 2020-2030 (worldwide population growth rates, by comparison, are currently at just under 2% per annum). These statistical projections were then integrated into our GIS system and, using proximity growth distribution tools, allocated the increases in accordance with the actual 1950-2000 growth distribution pattern. The results of the analytic distribution of this population are represented in Exhibits 4-36, 4-37, and 4-38. Based on the above growth and distribution assumptions, the population of the conventional basin will be about 40 million in 2010, 50 million in 2020, and 62 million in 2030.

We would note, however, that the very rapid formation of new population centers along the Nigerian portions of the receding lake bed have not been captured in our analysis, due primarily to the very low original population densities and the atypical nature of the penetration. A similar expansion is expressed in the analysis along the eastern (Chad) and northeastern (Niger) boundaries of the lake (i.e., at the margins between the Lake Chad and Chitati sub-basins), but relatively limited on the dryer northwestern portions of the lake bed (on both the Nigeria and Niger territories). Third, it is to be noted that all of the population distribution models show little or no growth penetrating into the desert. The northern boundary of the Sahel is retained in the population projection model as a product of the abrupt north-south cell transition histories over the period 1960-2000.

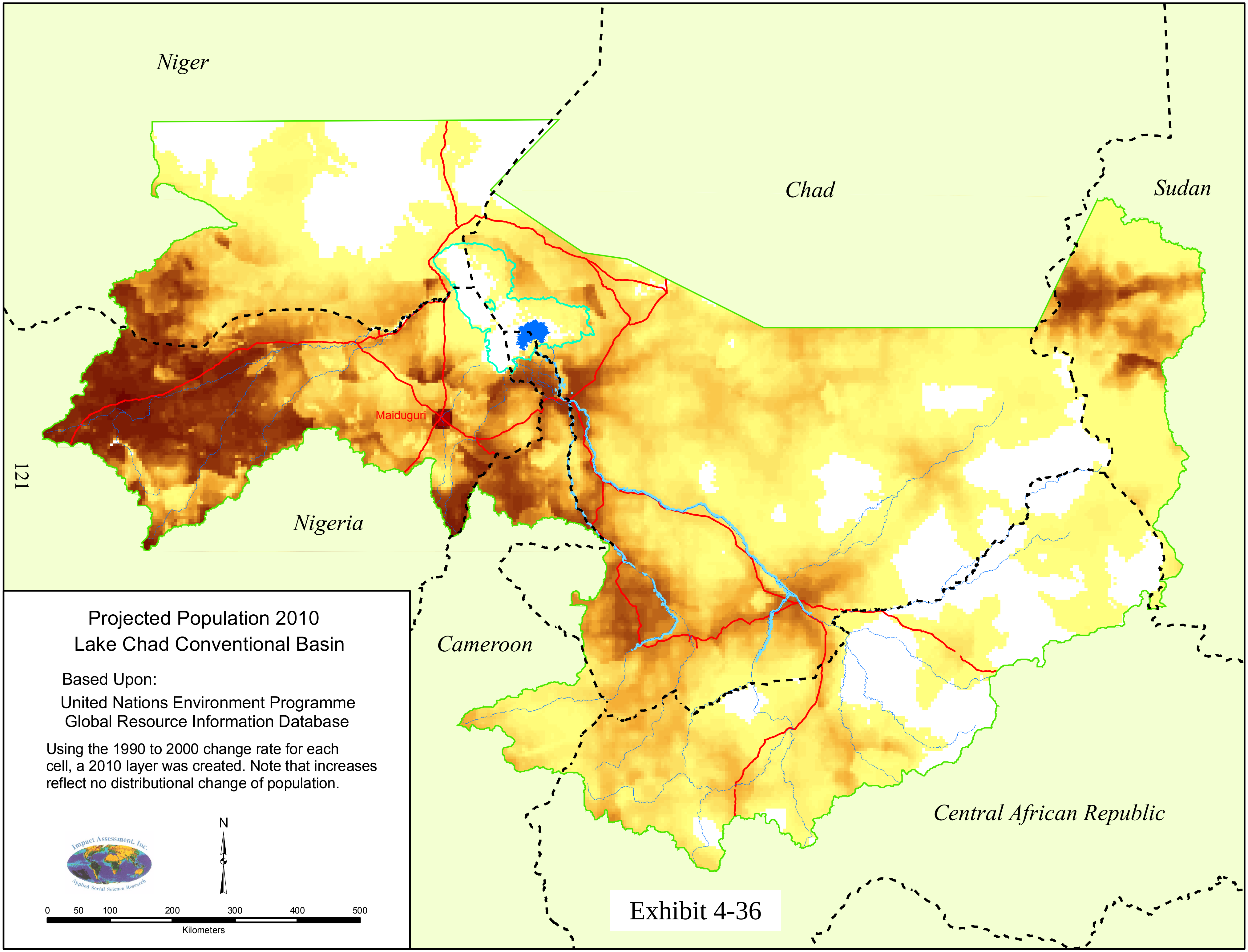

Niger
Chad
Sudan
Nigeria
Cameroon
Central African Republic
Maiduguri
Projected Population 2010
Lake Chad Conventional Basin
Based Upon:
United Nations Environment Programme
Global Resource Information Database
Using the 1990 to 2000 change rate for each cell, a 2010 layer was created. Note that increases reflect no distributional change of population.
Impact Assessment, Inc.
Applied Social Science Research
N
0 50 100 200 300 400 500
Kilometers

Exhibit 4-36

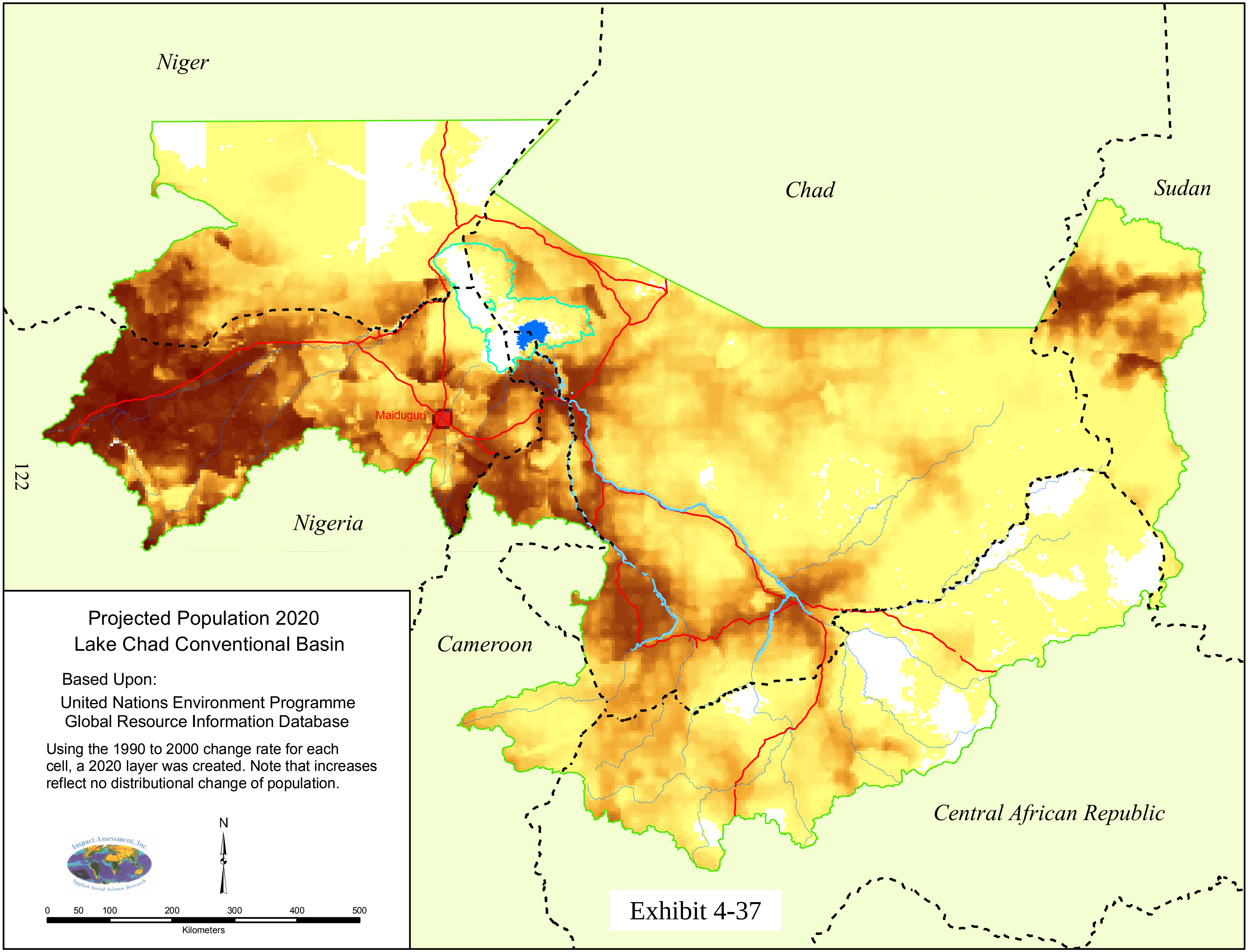

Niger
Chad
Sudan
Nigeria
Cameroon
Central African Republic
Maiduguri
Projected Population 2020
Lake Chad Conventional Basin
Based Upon:
United Nations Environment Programme
Global Resource Information Database
Using the 1990 to 2000 change rate for each cell, a 2020 layer was created. Note that increases reflect no distributional change of population.
N
0 50 100 200 300 400 500
Kilometers

Exhibit 4-37

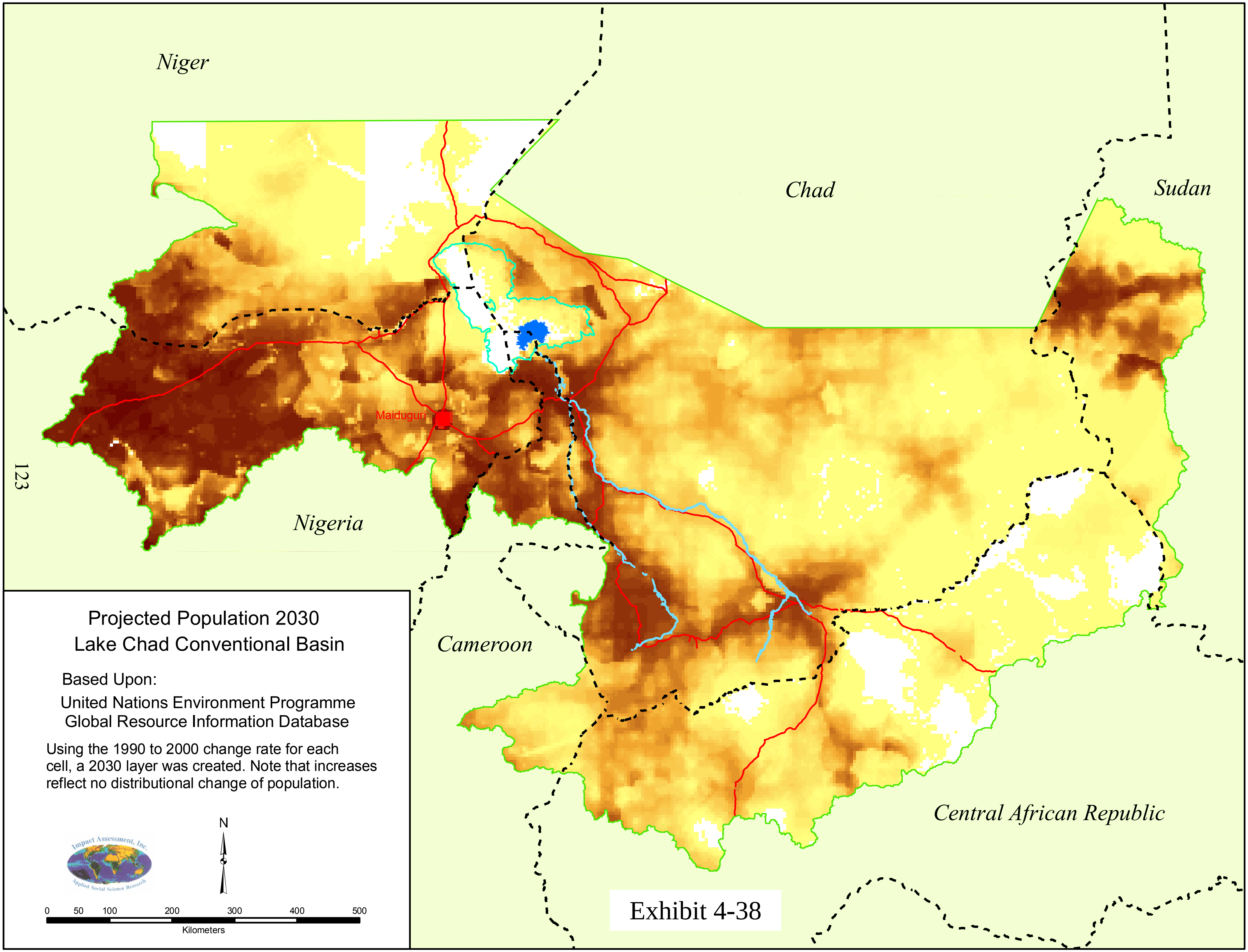

Niger
Chad
Sudan
Maiduguri
Nigeria
Cameroon
Central African Republic
Projected Population 2030
Lake Chad Conventional Basin
Based Upon:
United Nations Environment Programme
Global Resource Information Database
Using the 1990 to 2000 change rate for each cell, a 2030 layer was created. Note that increases reflect no distributional change of population.
N
0 50 100 200 300 400 500
Kilometers

Exhibit 4-38

Several features of this exercise merit emphasis. First, predictably, the concentration of growth over the projection period continues to be centered in the urban areas. But past patterns of growth employed as a basis of our analysis also predict a gradual geographical spreading of these urban areas, first in the immediate vicinity of the cities, then extending out along the interconnecting major roads (particularly between relatively populated centers), and then out along the rural roads (see Exhibit 4-39), again concentrating primarily around existing smaller population centers. This is logical, since all of these communities were established, for one reason or another, as suitable locations for permanent residence and are likely serve the same selective purpose in the future. Our projection also points to a second phenomenon, the extension and spread of population places within the Lake Chad lake bed itself.

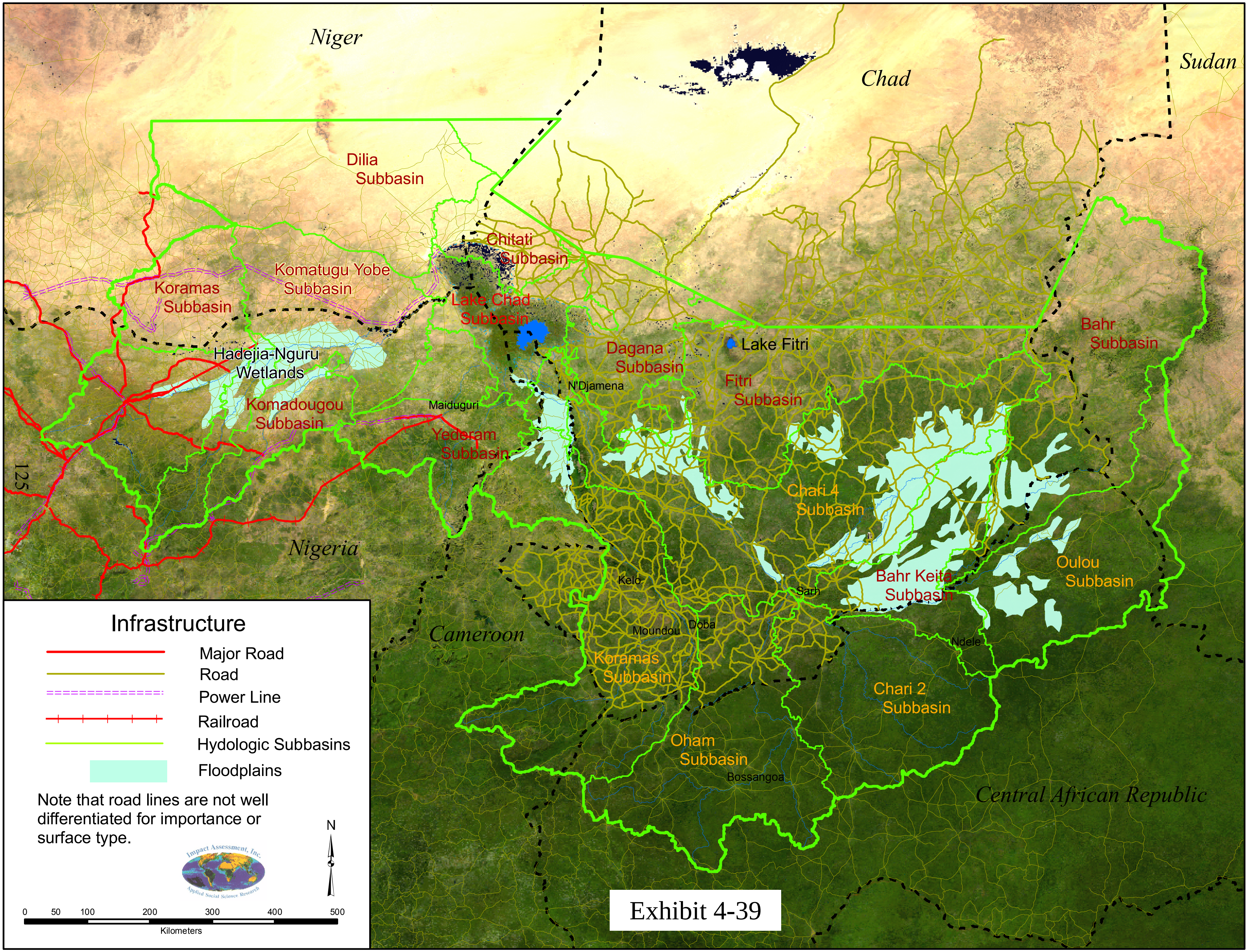

Niger
Chad
Sudan
Dilia Subbasin
Chitati Subbasin
Komatugu Yobe Subbasin
Koramas Subbasin
Lake Chad Subbasin
Lake Fitri
Bahr Subbasin
Dagana Subbasin
Hadejia-Nguru Wetlands
N'Djamena
Fitri Subbasin
Komadougou Subbasin
Maiduguri
Yederam Subbasin
Chari 4 Subbasin
Nigeria
Oulou Subbasin
Bahr Keita Subbasin
Kelo
Sarh
Cameroon
Moundou
Doba
Ndele
Koramas Subbasin
Chari 2 Subbasin
Oham Subbasin
Bossangoa
Central African Republic
Infrastructure
Major Road
Road
Power Line
Railroad
Hydologic Subbasins
Floodplains
Note that road lines are not well differentiated for importance or surface type.
N
Impact Assessment, Inc.
Applied Social Science Research
0 50 100 200 300 400 500
Kilometers

Exhibit 4-39

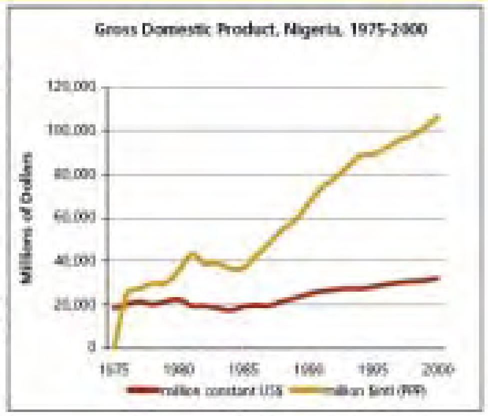
Economic Environment

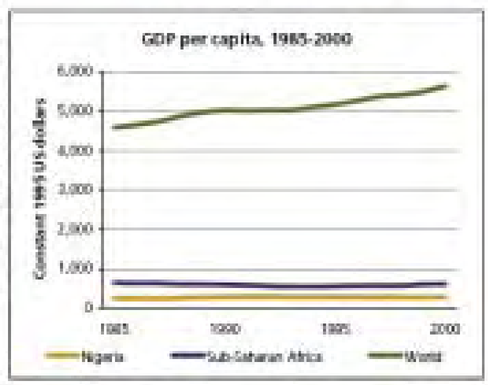
Although beset by numerous difficulties, especially in the capacity and reliability of electricity, Nigeria appears to be poised for rapid growth. The special economic position of Nigeria in the region is indicated in Exhibit 4-40. Moreover, as the dominant economic force in the region, they may be expected to take a leading role in regional development as well (infra). Elsewhere however, the economic outlook has ranged from bleak to tragic.

Exhibit 4-40. Economic Indicators -- Nigeria

Economic Indicators -- Nigeria

Gross Domestic Product, 2000	Nigeria	Sub-Saharan Africa	World
GDP in million constant 1995 US dollars	32,184	362,493	34,109,900
GDP PPP (million current international dollars) [a]	113,663	1,053,452	44,913,910
Gross National Income (PPP, in million current international dollars), 2000 [a]	101,604	994,240	44,458,520
GDP per capita, 2000			
in 1995 US dollars	283	617	5,632
in current international dollars	998	1,797	7,416
Average annual growth in GDP, 1991-2000			
Total	3%	2%	3%
Per capita	0%	0%	1%
Percent of GDP earned by:			
Agriculture, 2000	30%	17%	X
Industry, 2000	46%	31%	X
Services, 2000	25%	53%	X
International Trade			
Trade in Goods and Services (million current $US)			
Imports, 2000	X	80,988	X
Exports, 2000	X	78,438	X
Exports as a percent of GDP, 2000	52%	33%	X
Balance of Trade, 2000 (million current $US)	4,639	1,213	X
Official Development Assistance (ODA) and Financial Flows			
ODA in million US dollars, 1998-2000 [b]	180	8,040	59,073
ODA per capita in US dollars, 1998-2000 [b]	2	17	10
Current Account Balance (million $US), 2000	6,983	X	X
Total external debt, million $US, 1998-2000 [b]	31,226	224,885	X
Debt service as a % of export earnings, 1995-97 [b]	11.9%	X	X
Foreign Direct Investment, net inflows (million current $US), 2000	1,083	6,664	X
International Tourism Receipts, 1995-1997 (million $US)	75	X	X





Special mention should be made of the region's potential for irrigation agriculture, which earlier attracted several large-scale development schemes, now for the most part abandoned. Only a small portion of potentially irrigable land is presently under cultivation—1,130 of 1,600,000 km^2. Recession of the lake's shore has opened up sizeable tracts of fertile bottom land while increasing pressure on lake fisheries.

Member states, particularly Nigeria, are taking vigorous steps to revitalize the agricultural sector, to the extent of subsidizing the importation and domestic production of fertilizer, thus increasing pollution risks from agricultural runoff. Thus far the freshwaters have remained low in salinity and sediment loads, but with the agricultural intensification and extensification to meet growing population needs, that condition could deteriorate.

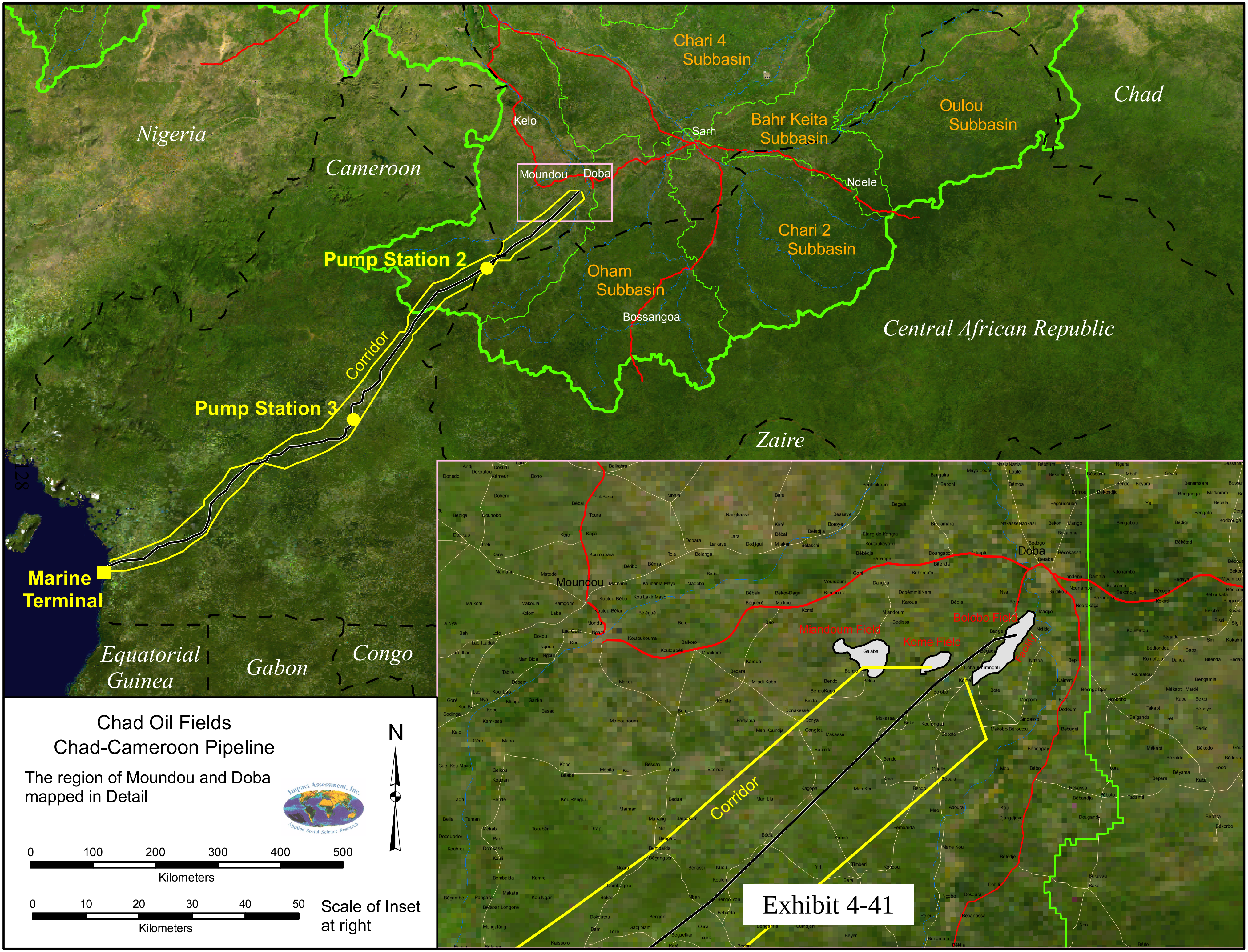
Chad Oil Development and Pipeline System:

Despite the high concentration of population involved in agriculture, recent developments in the oil sector hold great potential for dramatic improvements in national income, for both Chad and Cameroon.

As a consequence, the team was also asked to consider the social risks associated with oil development in southern Chad, and their bearing on future water demands and concerns within the conventional basin (see Exhibit 4-41). An estimated 3 billion barrel field was discovered near Doba in 1975, although little was to follow until the Chad civil war was brought to a close in 1988. After protracted negotiations, an agreement was reached between Chad, the World Bank and the Exxon-led consortium, allowing for development of the Doba oil fields (there are 320 operating wells, spread among three concentrating field – at Komé field with two or three concentrating rigs, one at Bolobo with a single concentrating rig, and one at Miandoum field also with a single concentrating rig). Negotiations with Cameroon, in turn, led to an agreement to construct a 1050 km, 30-inch diameter, buried pipeline, capable of carrying 250,000 barrels/day across the country to terminal facilities at the port of Kribi, on the Gulf of Guinea .

The facility is currently producing a flow of 225,000 barrels/day at peak capacity. This oil development project has given rise to considerable international and local concern, first in terms of its immediate direct social and economic impacts on affected communities and on the environment, which continues, but also in terms of the distribution and use of the national revenue generated. It is the third issue that captured international attention during our field visit (the others being violent regional responses to perceived religious affronts contained in a published cartoon, and the sudden and widespread appearance of avian flu). President Idriss Déby had created an international stir with his unilateral decision to utilize a portion of the revenues allocated, during its negotiations with World Bank, to poverty reduction, to other purposes – in this case to fund military expenses he argued were the result of Sudanese militia incursions into Chadian border regions. An impasse resulted when the World Bank froze the oil accounts and threatened to withdraw its support for the accords. A compromise was achieved, when the President agreed to adhere to the original agreement, and the World Bank agreed to resume its funding agreement. It was at or near this point in our field study that a fourth event brought Chad into international news. Several disaffected former Chadian generals withdrew their support for the President and joined the opposition forces. A subsequent attack on the capital by a small, poorly organized, force was easily repelled, but the general sense of security in N'Djamena had been shattered.

While the effect of these initial oil relationships continues to be of concern, their effects on the local economy and communities have been relatively modest, and an elevated level of attention has been paid by the consortium in establishing local and national support for the Doba operations. Of perhaps greater interest to the study team, however, particularly with respect to future social risks and vulnerabilities, is the prospect of dramatic expansion of oil development (and oil pipeline inter-ties) in this and other regions of southern Chad, southern Sudan, and northern Central African Republic. It is fair to assume, given current dramatically elevated oil prices, that the known and prospective oil reservoirs across the Sahel will soon be aggressively pursued. With specific reference to the Lake Chad basin, a report from the Energy Intelligence Group, a oil industry consulting firm, claims that


Chad
Oulou Subbasin
Chari 4 Subbasin
Bahr Keita Subbasin
Chari 2 Subbasin
Oham Subbasin
Central African Republic
Nigeria
Cameroon
Kelo
Moundou
Doba
Sarh
Ndele
Bossangoa
Zaire
Pump Station 2
Pump Station 3
Corridor
Marine Terminal
Equatorial Guinea
Gabon
Congo
Chad Oil Fields
Chad-Cameroon Pipeline
The region of Moundou and Doba mapped in Detail
Impact Assessment, Inc.
Applied Social Science Research
N
0 100 200 300 400 500
Kilometers
0 10 20 30 40 50
Kilometers
Scale of Inset at right
Miandoum Field
Kome Field
Bolobo Field
Corridor
Exhibit 4-41

international oil companies now control 440,000 km2 (or 170 square miles) land surrounding the present extraction area. These companies claim the associated reservoirs contain 15 billion barrels of oil, five times the confirmed reservoir at Doba. The point of importance is that initial public estimates (e.g., 3 billion barrels for the Doba field) commonly understate, by large factors, actual reserves as exploration and development continues, and there is no reason to think that 15 billion now represents the upper limit in the immediate vicinity, much less across the vast areas of these three countries (i.e., southern Chad, northeastern Central African Republic, and southern Sudan) with nearly identical geologic potential. We anticipate that southern Chad will continue to evolve as an important node of onshore oil development throughout the Sahel, with much larger implications for national revenue and for magnified environmental risks, as well as social and economic risks (and benefits) to the affected local populations.

There is also international concern that oil revenues allocated to, and received by, Cameroon appear to have been misappropriated or lost, since there is no effective monitoring of the distribution of these resources – i.e., a failure to comply with international accords.

4.1.4 Political Environment

"… what is political risk?"

> Some have defined it as the risk of a political change or political instability. Others have seen it as the result of a change in politics and the probability that certain events will occur and, therefore, change the prospective profits of an investment. Even today, there is no agreement upon the definition of "political risk." Political risk is sometimes considered as a particular aspect of the broader "country risk" and sometimes as the "probability that a political event will intervene and modify the economic situation" … [or] as the more general "possible trends in the international credit market." Obviously, as the definition changes, so do the variables considered in analyzing political risk. (Weber 1997: 144)

After this bout with uncertainty, the author settles on a fairly conventional definition: "political risk" is

> … the product of the negative effects of political events on economic and financial decisions. Political risk is a sort of "uncertain strategy" which can be quantitatively defined as "the product of the probability for a political event to occur with an intensity determined over a precise period of time, based on the damage related to such event." (Weber 1997: 146)

Lake Chad Basin can be characterized politically as a collection of failed and fragile states.

> The Fund for Peace, a United States-based monitoring organisation, recently released a report outlining the Failed States Index for the year 2006. The index, using data gathered on 146 countries all over the world, classified Nigeria as critically unstable (in the red alert category) among 14 other African countries. (Akosile 2006)

Nations of the region have endured chronic political instability, punctuated by outbreaks of violent conflict as currently in the case of Darfur. Reacting to defend his embattled regime, Chad's President Idriss Déby abrogated the agreement with the World Bank on managing oil revenues:

> It took Chad, which began pumping oil in late 2003, just two years to get sucked into a bitter quarrel with the World Bank, which funded its pipeline construction, over an agreement on an oil management law. According to that law, 10 percent of the revenues generated from oil were supposed to be saved into a "Future Generation" fund as a cushion in a post-oil economy. Also, the big part of the remaining revenues was, by law, supposed to be spent on poverty alleviation.
>
> But in December last year, the Chadian government, arguing that it needed money to buy arms to beat back a rebellion, suspended that law and revoked all the spending curbs. It was immediately rebuked by the World Bank, which cancelled all loans to Chad and froze the country's foreign assets. (Biryabarema 2006)

The dispute was resolved after a fashion, but the question remains what kind of commitments member states can undertake and uphold, now and in the future. It does not increase confidence that along with fragility these governments also come out at the top (or bottom) of Transparency International's Corruption Index.

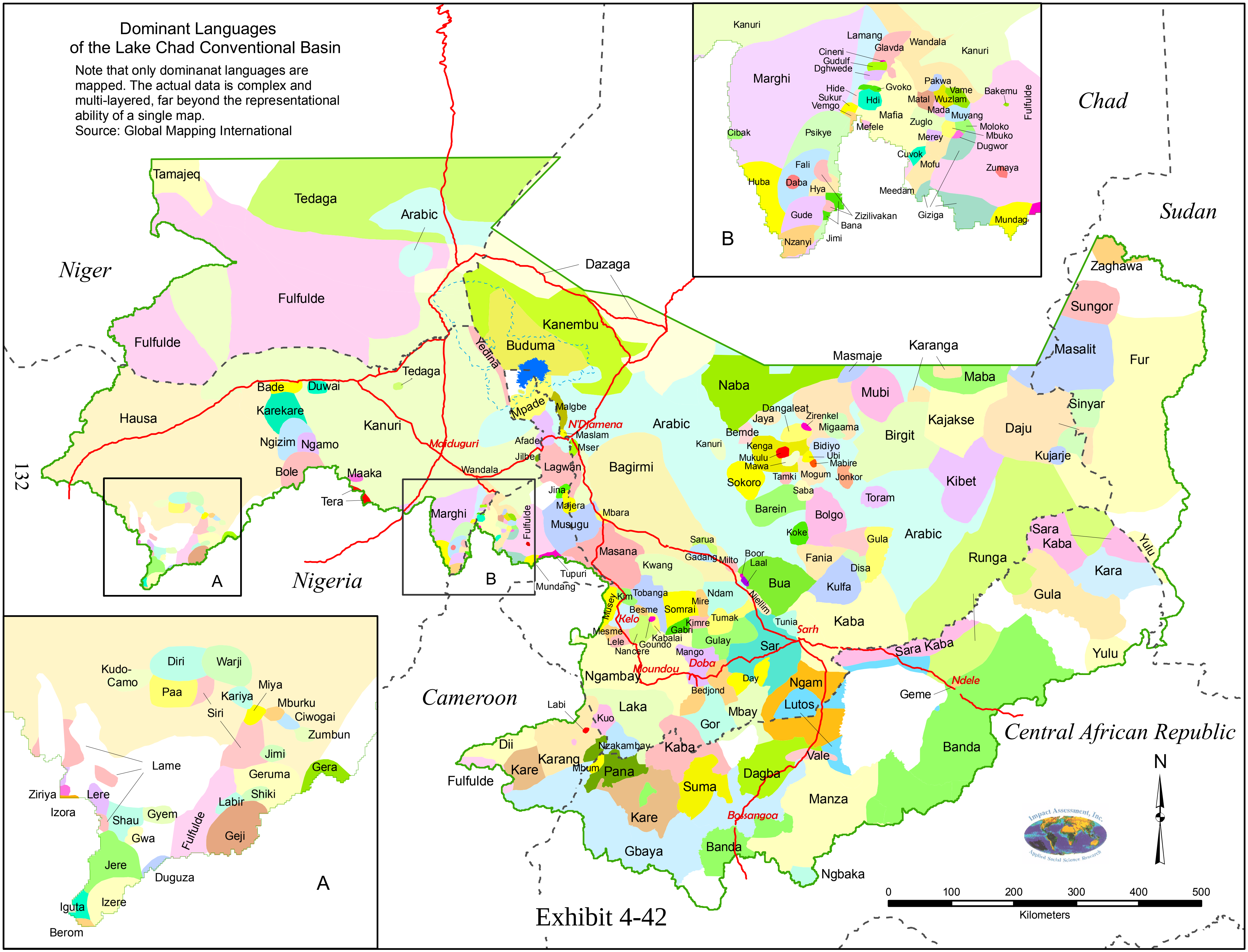
Increasingly over the past decade, "good governance" has been recognized as indispensable to international development. What this might mean for environmental governance in the Lake Chad Basin is open to question. Certainly it would include, at a minimum, member states' compliance with provisions of the Convention, and wide consultations throughout the decision process with all interested and affected parties in the region.

Beyond that is the imperative for regional integration to engage regional and global problems of environmental management. In the case of LCCB region, forming coalitions and forging consensus involves parties that are manifestly unequal in power, wealth, and prestige. As the dominant regional power, it is incumbent on Nigeria to take a leading role in this endeavor, while respecting and supporting the interests and concerns of its partners.

4.1.5 Vulnerability Analysis

To understand the potential social vulnerability due to environmental change in the Lake Chad conventional basin, one must consider the many factors that dictate social relations in the region. While independent 'nation states' have been established in the post-colonial era on the basis of historical conquests by western nations – maps that were constructed primarily on the basis of global trade, rather than on cultural, religious, or language affiliations. In reality, the inhabitants of the Lake Chad conventional basin represent a broad and highly varied cultural history, one of extreme social, cultural, and economic complexity. The population is composed of literally hundreds of linguistic groups, many dozens of culturally similar population clusters, representing numerous religions, occupations, and ecological adaptations. They have adapted to their ecological environments, some exceedingly small, many of great uncertainty and variability, and to cultural differences and an extremely complex social environment.

Continuing environmental changes and the rate of population growth, particularly the emigration component of that growth, has and will continue to increase the complexity and test the utility of their traditional social adaptations. In any case, some of these groups will be positively 'pre-adapted' to changes already underway – others will be negatively pre-adapted to them. We do not here elaborate on the array of cultural and social variables predisposing populations to adverse consequences from environmental disruptions, or protecting them from such disruptions. We will, however, consider the importance of a single social variable affecting the vulnerability of broad reaches of the conventional basin. That variable is language.



Dominant Languages
of the Lake Chad Conventional Basin

Note that only dominanat languages are mapped. The actual data is complex and multi-layered, far beyond the representational ability of a single map.
Source: Global Mapping International

Exhibit 4-42

Language, above all other defining social characteristics, determines the boundaries of individual groups in a certain area. People who speak the same language and share a relative cohesiveness (religion, cultural practices, etc.) make up the small bands and tribes that are the foundation of social order within the basin. As indicated in Exhibit 4-44, and noted previously, the conventional basin consists of hundreds of small, linguistically coherent, population groups. These groups, in general, are often conversant in the languages of their immediate neighbors, but rarely conversant in the languages of their neighbor's neighbors. Chilton observes that,

> Furthermore, if one considers the language that people speak over a geographical area, one frequently finds one speech community shading off gradually into another, without a sudden break. Such linguistic spaces are known as 'dialect continua' Adjacent dialects are mutually intelligible, though differences are perceived and may be exaggerated and associated with feelings of hostility, but between certain points along the chain mutual intelligibility decreases and ceases. (Chilton, XX 179)

The role linguistic variability plays in the ability to migrate is immense. Unlike most nations in the rest of the world, the five nations that make up the Lake Chad conventional basin do not have a population joined by linguistic uniformity.

Migration into and out of linguistically bound communities has continued, over time, throughout the region, but the mechanisms of that migration are tightly and locally controlled – people move by family connections into and out of communities, and are accepted only if they can be socially "vouchsafed" by local relatives during their transition. Actual "integration" occurs along lines of family first, and then ethnicity (and sometimes religion). Ethnicity, like language, does not regard or respect the state boundaries imposed between the nations of the conventional basin.

These cultural and linguistic groupings, in turn, contribute both positively and negatively to vulnerability. They have proven their utility in surviving past droughts and famines, with families and communities working together to overcome shared hardships. On the other hand, linguistic similarities and cultural bonds also represent a form of rigidity, in terms of adaptive strategies, migration, and relocation alternatives – particularly in response to acute events, such as droughts, that affect a broad geography. As Chilton notes:

> . . . the existence of ethnic groups is based on discontinuities. Ethnic groups are not continua, but groups, large groups usually. Groups have group boundaries; they do not merge into one another. In case of double membership one is simultaneously a member of two different groups. In the case of ethnic groups, these boundaries are marked by cultural discontinuities. Language, occupation, customs, and traditions frequently very abruptly differ when one moves from one ethnic group to another. Often it is precisely the neighbouring parts of two ethnic groups who most strongly stress the differences, by referring to the same features the observer has noticed himself, or to quite different ones. Ethnicity is expressed at the border (Barth 1969).

These social, cultural, and linguistic boundaries and borders are the principal social obstacles standing in the way of mass migration. In claiming identity, people associate by ethnic grouping before they associate by nationality. This is, once again, due to the fact that the nations of the basin are not bound by any kind of linguistic or ethnic uniformity, and only partially aligned by virtue of their common colonial language.

> What we have here is a continuum: language and culture change gradually, and also the feeling of belonging shifts continuously (Elwert 1989: 445).
>
> But at the same time, in this world of constant change and migration, there are the increasingly important invisible lines of state and society that dictate where the people of one area cannot go without exposing themselves to incredible risk. This restriction on mobility, when mobility is absolutely critical to the survival of the people in a land with limited resources, creates huge potential for conflict in the region. (Schelee, 2005)

The changes that are beginning to occur in the Lake Chad conventional basin as a consequence of global climate change and accelerated population growth are going to continue to accelerate. The extreme linguistic and cultural variability of the basin will tend to magnify the social vulnerability of certain populations,

National border and inhibitions to migration also affect social vulnerability to an acute environmental event. While the border delineating the different nation-states do not play a major role in the identity of the inhabitants, that does not mean that those border can be crossed with impunity. It is at the borders and customs offices that national identities play an emerging role, particularly at borders that can be easily monitored, such as river crossings, where people can be denied entrance/exit from a country based on their nationality. Nationality also plays and important role where the borders separate belligerent states, or where camps have been established to deal with internal and international refugees and displaced persons. All countries are motivated to prevent open emigration and prefer to retain economic and political refugees in the immediate vicinity of their home countries. This is because one of the principal underpinnings for migration, as well as for the detention of migrants, is resource-based, and the receiving country is loathe to accommodate and support large numbers of desperately poor populations, either at their borders or in their cities or communities.

> Another scenario that can be understood in terms of this dilemma is what is known as the 'tragedy of the commons', in which a collective good, for example common land, reaches a point of over-use and diminishing returns because it is rational for individuals, acting non-cooperatively and non-communicatively, to maximise their exploitation of it. Such a scenario potentially leads to conflict over the sought after resource, e.g. oil, fishing rights. (Chilton 184)

Resource-based conflict is expected to increase over time among the inhabitants of the Lake Chad conventional basin. As the isohyets shift south, so also do the areas that are able to sustain animal, plant, and human life. Therefore people will be compelled to follow the rainfall regime south. For farmers, this will mean locating and gaining access to lands outside of their traditional land ownership structure, acquiring lands in areas that speak an unknown language, acquiring lands in communities already fraught with internal conflict over the allocation of existing resource among its own residents. The influx of immigrants, in fact, tends to increase the vulnerability of the receiving communities to abrupt environmental change.

Unfortunately, the vast majority of valuable lands to the south have already been spoken for, and there is little in the way of arable "common property" lands available for distribution (although sale is always an available option if resources allow). In fact, many of the populations living on the margins of the Sahara are there because lands were available, sometime in the past and even today, at a cost (or merely by access) that is not prohibitively expensive or difficult. In exchange, the farmer accepts extreme vulnerability to the vagaries of the environment – in terms of variability and uncertainty.

> Human societies are also able to coexist peacefully if they make use of different niches. In many places, the herders and the farmers are ethnically different: they speak different languages and follow different customs. Ethnic groups have specialised into different occupational niches and this way avoided competition. (Schlee 103-104)

It is the less desirable occupational and environmental niches that are imposed upon migrants, because otherwise they threaten to upset the delicate balance already maintained in a region. Any perceived competition is a threat to the well-being of the pre-existing group, be that an ethnic, linguistic, or national one. This is an atmosphere in which economic, social, and religious tensions can easily escalate into violence.

The preceding environmental characterization and demographic analysis independently portend of significant water shortages (from a continuing shift in the distribution, quantity, timing, and duration of rainfall associated with global climate change, and a doubling of both urban and rural demand by 2030). The intersection of rainfall declines and human population growth point to a gradual but persistent increase in conflict (e.g., between and among different user groups, upstream and downstream population groups, communities, and nations), agricultural production declines (in terms of productivity per hectare), and increased urban and rural pollution. Most importantly, the analysis highlighted the social and economic disparities that contribute to the inequitable distribution of social vulnerability among the different population groups of the Lake Chad conventional basin.

The populations of the Lake Chad conventional basin are not, by any means, at "equal" risk from future environmental or social disruptions, whether abrupt or chronic. This is because, within any population, some are better positioned economically or socially to withstand the consequences of, for example, a major drought or famine. As is the case in almost any environmental or technological disaster, it is the poor, aged, women, children and disabled who will bear the brunt of the impacts, since it is this population that lives at all times on the very margin of survival. The rich are not in direct jeopardy from droughts or famines. Only the poor and destitute perish. The social and economic disparities of Africa, disparities that determine who will bear the human costs of future droughts, floods, or famines, are well represented in the Lake Chad conventional basin. These disparities are large and pervasive.

The five member nations of the LCBC are very differently situated with respect to future acute or chronic environmental disruption. In order to appraise the relative state of national development, the UNDP created an Human Development Index (HDI) which evaluates each of the world's nations on three measurable dimensions of human development. The three measures are: (1) living a long and healthy life; (2) being educated; and (3) having a decent standard of living. The index thus considers objective measures of life expectancy, educational achievement, literacy and income to create a more balanced assessment of development.

On this international scale, Niger has the lowest measured HDI of the 177 nations of the world – and an annual per capita income of $835. Chad ranks 149th, with an annual per capita income 50% greater than Niger ($1,210). Nigeria is ranked 158th, with an annual per capita income 25% greater than Niger ($1,050). Central African Republic has an HDI ranking of 154, also with per capita income 25% greater than Niger ($1,089). Finally, Cameroon is ranked 124th on the human development index, with an annual per capita income of $2,118, over 250% greater than the annual income in Niger.

While it is true that the populations of all five countries fall among the lowest tier on the Human Development Index, the population of Niger stands out as the most vulnerable. The relative vulnerability of Niger communities to acute or chronic environmental stress, however, is not adequately captured by this index, since vulnerabilities are often the product, not merely the sum total, of all of the effective environmental fragilities. We believe a more accurate representation of real differences must reflect not only income, education, and life span, but also rural-urban disparities, male-female disparities, access to financial and social capital, to institutional support, to general infrastructure (including access to roads, wells, equipment, supplies, markets, and so on), and a host of other social variables. On all of these measures, the population of Niger is in greater environmental and social jeopardy than any other member of the LCBC.

Relative social vulnerability can be evaluated across a broad array of social variables. The male/female sex ratio is an important measure, reflecting characteristics of birth, infant, early childhood, and adult mortality. Emigration ratios indicate differential patterns of migration between rural and urban areas, or between nations. Other ratios, such as the percentage of total population involved in agriculture, the percentage of men and women involved in agriculture, and so on, each provide different, but often reinforcing representations of differential social vulnerabilities. The following figures are provided merely to highlight the relative scale of the differences between the five member states of the LCBC on several of these measures.

This first figure (Exhibit 4-43) depicts the absolute distribution of population between urban and rural components among the five member states of the LCBC. Several points are important to note. First, the population figures employed here are "national" level statistics, not merely the portion of the country within the conventional basin. Second, the figure depicts a population disparity of immense proportions the population of Nigeria dwarfs the combined totals of all other member countries of the LCBC. This is a fact of profound implication and must be recognized and acknowledged at the outset.

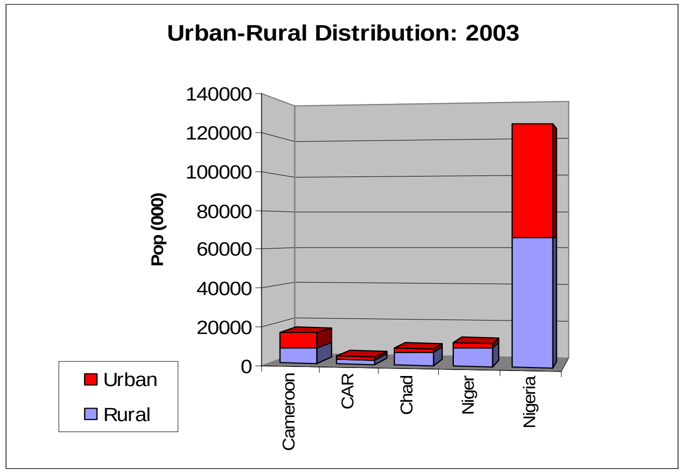


Exhibit 4-43. Urban-Rural Distribution: 2003

Exhibit 4-44, depicts the same information, but in the form of relative percentage – i.e., in the form of a 100% graphic. The information, presented in this format, illuminates another important set of differences between the member nations in terms of their relationship to the primary agricultural base. The vastly larger population of Nigeria is nearly 50% urban, as are the populations of Central African Republic and Cameroon, whereas the populations of Chad and Niger remain over 70% rural. This is also of profound consequence in terms of estimating relative social vulnerability to future acute and chronic environmental events (e.g., flood, drought, and famine).

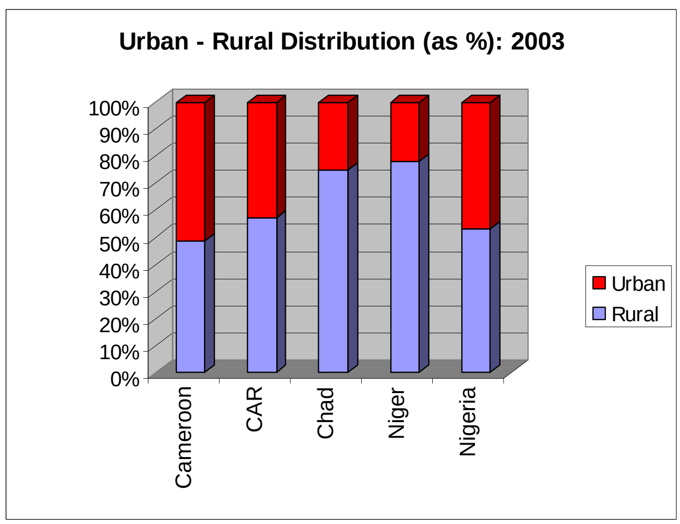


Exhibit 4-44. Urban-Rural Distribution: 2003

Exhibit 4-45 depicts the ratio of agricultural to non-agricultural populations in the five member nations. The difference, for example, between Nigeria, with less than 30 percent of its population devoted to agricultural pursuits and Niger, with over 80% dependence on agriculture reflects a profound difference in exposure to global scale environmental changes as well as the tremendous inter-annual variability characteristic of rainfall patterns in the conventional basin.

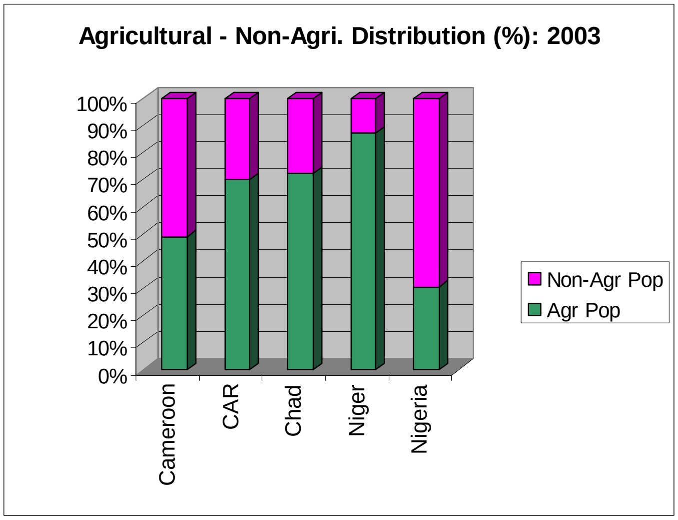


Exhibit 4-45. Agri – Non-Agri Distribution: 2003

Finally, Exhibit 4-46 depicts the percentage of males and females involved in economic activity for each of the member nations. While the percentage of males involved in economic activity is nearly identical among all of the five nations, ranging between 25 and 26 percent, the percentage of direct female involvement in economic activity ranges from 14.4 percent in Nigeria to 16 percent in Cameroon, 19.8 percent in Niger, 20.5 percent in Chad, and 21.7 percent in Central African Republic. In relation to Nigeria, female involvement in economic activity is 38 percent greater in Niger, 43 percent greater in Chad, 51 percent greater in Cameroon, and 12 percent greater in Central African Republic. The nature of female involvement in economic activity, of course, differs significantly between Cameroon and Niger, based not only on occupational options available, but on broad cultural and historical differences as well, magnifying or offsetting particular social vulnerabilities.

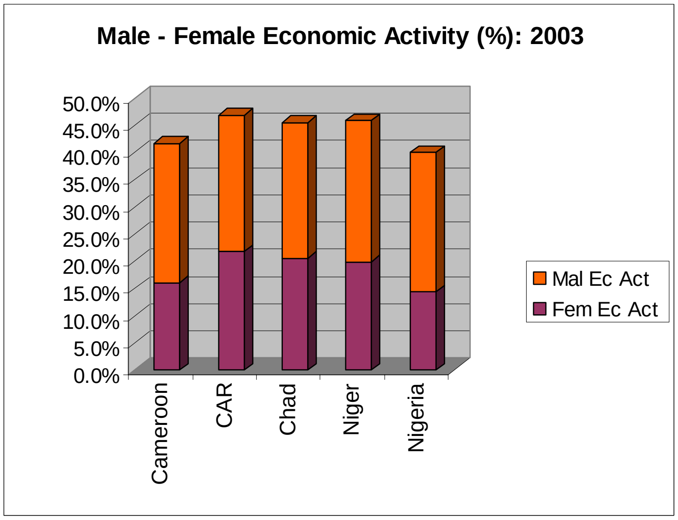


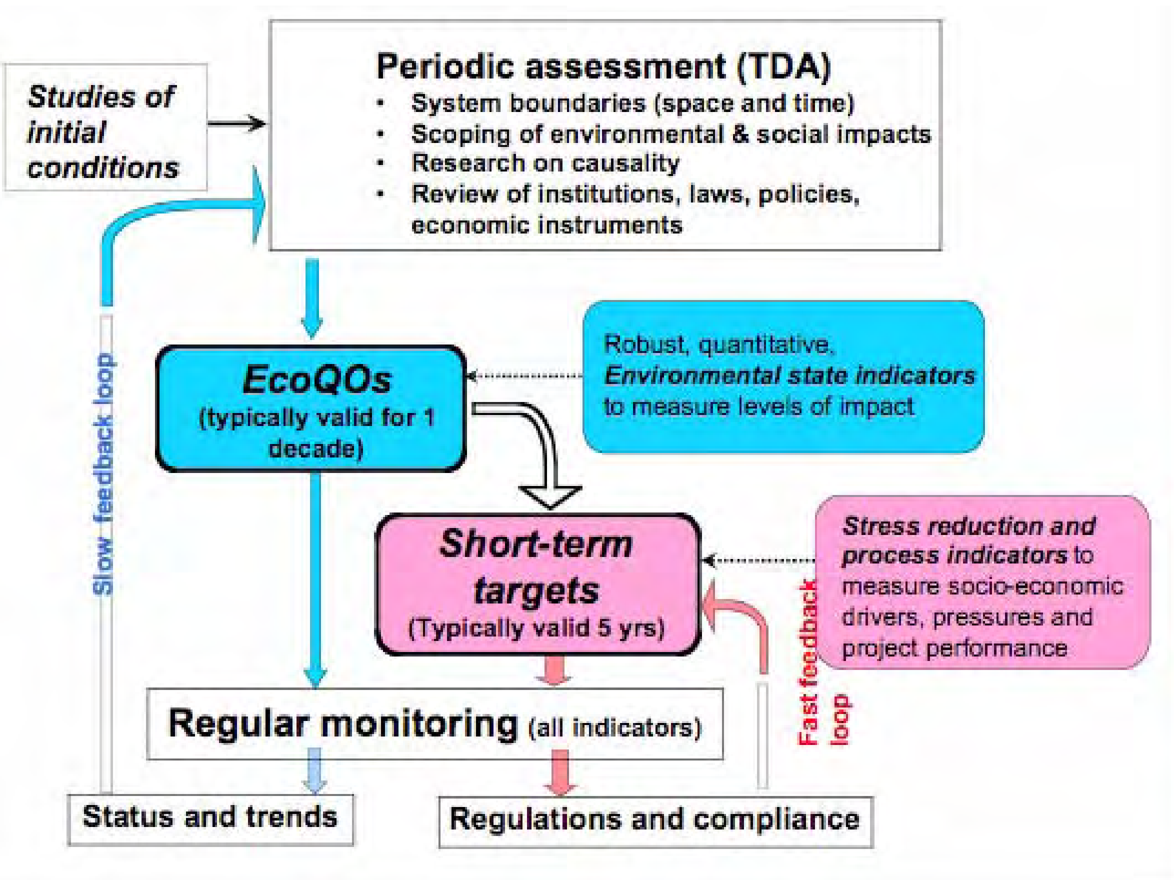
Exhibit 4-46. Male-Female Econ. Activity: 2003

4.2 Topical

The ToR stipulates that attention be given to three cross-sectoral topics: monitoring and evaluation, decision support framework, and adaptive management.

The combined results of sectoral analysis provide a framework comprising the outlines of an operational monitoring system. The empirical referents of its concepts and variables can then be measured or estimated to yield the present values (states and levels) of existing and evolving systems and conditions. In turn, this framework provides an ongoing basis for decision making and its implementation through program management actions. Exhibit 4-47 shows the connections envisioned in GDF's Logical Framework Approach.

Exhibit 4-47. Logical Framework Approach



> The Logical Framework Approach (LFA) is the tool for developing and monitoring the logical relationship between inputs, outputs, and objectives/goals that determines the implementation of a project via identification, formulation, appraisal, implementation, monitoring, and evaluation. Indicators are quantitative or qualitative statements that can be used to describe existing situations and measure changes or trends over time. In the context of the LFA, an indicator defines the performance standard that, when reached, represents achievement of an objective. (Duda 2002: 12)

4.2.1 MONITORING AND EVALUATION

As stated in the ToR (p. 2), ESRA will be used primarily as a tool for monitoring and evaluation and for erecting a decision support framework:

> The results of the study will be used to design and implement a monitoring and evaluation system for adaptive management. The implementation of the monitoring and evaluation system will help to make early warning and mitigate any adverse effects of human activities and natural disasters within the basin.

The necessity for monitoring arises because of the inherent uncertainty of impact predictions. The necessity of evaluation arises because of the need to interpret indicator performance in relation to program objectives as a basis for policy adjustments and management interventions to increase program effectiveness.

Besides testing the validity of impact predictions, including policy impacts, monitoring is useful, indeed indispensable, for monitoring compliance with conditioning imposed through the approvals process on proponents—including and perhaps especially governmental agencies. This presupposes the existence of such a process, which may in fact be absent in many development situations. In that event, until instituted and enforced the whole monitoring exercise is rendered futile.

Perhaps most important, monitoring programs are required to evaluate the adequacy of mitigation measures intended to offset predicted adverse impacts. Commitments to compensation should be formalized in binding agreements between proponents and host communities, as in the “community impact agreement” entered into by Ontario Hydro and the Town of Atikokan.

Monitoring should also exercise surveillance on project design modifications that are introduced after a formal assessment process has been concluded.
Environmental and social assessment cannot be regarded as a one-time exercise to satisfy the approvals process. Rather, they should operate continuously to inform and guide management actions in support of policy effectiveness.

The Design of Monitoring and Evaluation Systems

Monitoring system design involves erecting a system structure to collect, collate, and codify information relevant to the program’s substantive focus. The structure represents the essential system variables to be monitored; the contents represent the present states (levels) of those variables.

As shown in Exhibit 4-48, GEF guidance on monitoring and evaluation indicators for International Waters projects (Duda 2002) recognize three types: process, stress reduction, and environmental state, illustrated by reference the World Bank’s Aral Sea Basin Program (1998).

Exhibit 4-48. GEF Guidance on Monitoring and Evaluation

Process indicators:

- Adoption of a regional water and salt management policy
- Agreement among the five participating nations on interstate water use and environmental sustainability
- Adoption by the governments of each nation of national policy, strategy, and action programs to reduce salinity and reduce irrigation water use by 15 percent.

Stress reduction indicators:

- Reduction of irrigation water use by 15 percent, which increases effective water flow to delta wet- lands by some 15 percent
- Reductions in soil salinity in line with targets
- Achievement of sustainable levels of investment in the effective management of water resources and salinity from private and public sources.

Environmental status indicators:

- Decreased salinity levels of delta lake
- Increased dissolved oxygen levels in delta lake
- Increased flows to delta lake
- Increased number of migratory birds
- Environment of the delta lake is stable and sustainable from a biodiversity standpoint
- Income of local population rises

Applied to LCB, process indicators refer to institutional systems in member countries; stress reduction and environment status indicators refer to analytic systems for monitoring environmental systems and states in the region.

Institutional aspects of M&E arise in regard to the question of who monitors and evaluates" and how. Answers range from remote sensing by space agencies to "ground truthing" by anthropologists (see Busch and Trexler 2003). Special mention should be made of opportunities for participation by local communities as part of a broader effort at engagement and involvement.

Ecological Monitoring

- A candidate M&E model for consideration by LCBC is the U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP) designed to answer a number of leading questions for policy decision makers and publics (Saul, Thornton, and Linthrust 1992: 496-97):

- What is the current status, extent, and geographic distribution of our ecological resources (e.g., estuaries, lakes, streams, wetlands, forests, grasslands, aird lands)?

- What proportions of these resources are degraded or improving, where, and at what rate?

- To what levels of environmental stress and pollutants are these ecological resources exposed?

- What are the possible causes of adverse or improving conditions?

- What ecological resources are at risk?

- Are adversely affected ecosystems responding as expected to control and mitigation programs?

EMAP attempts to answer these questions by mounting

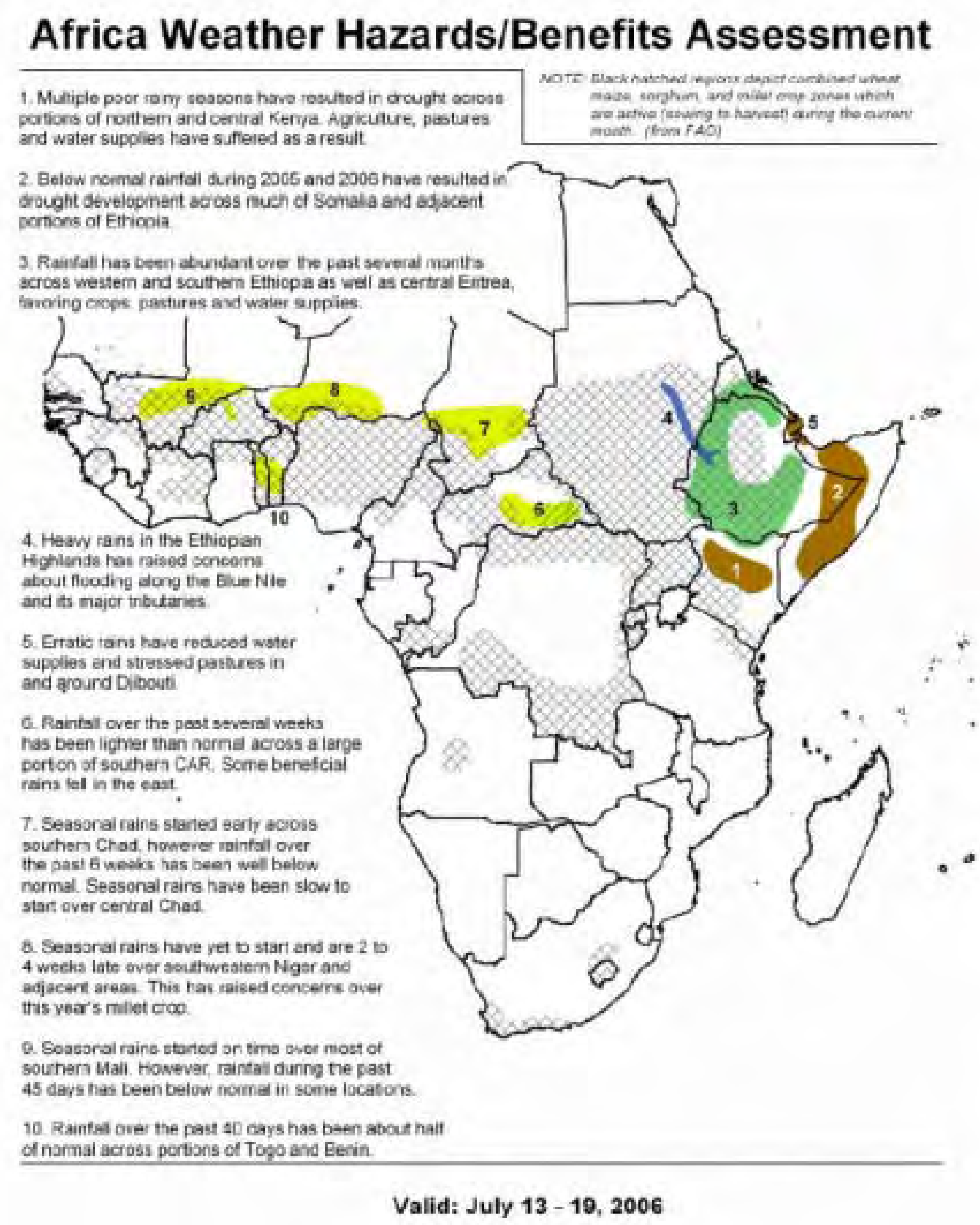
> … a research program to develop the tools necessary to monitor and assess the status and trends of national ecological resources. EMAP's goal is to develop the scientific understanding for translating environmental monitoring data from multiple spatial and temporal scales into assessments of current ecological condition and forecasts of future risks to our natural resources.
>
> EMAP aims to advance the science of ecological monitoring and ecological risk assessment, guide national monitoring with improved scientific understanding of ecosystem integrity and dynamics, and demonstrate multi-agency monitoring through large regional projects. EMAP develops indicators to monitor the condition of ecological resources. EMAP also investigates designs that address the acquisition, aggregation, and analysis of multiscale and multitier data.

In contrast, systematic social monitoring has hardly progressed beyond occasional collections of quality of life indicators essentially unrelated to social policy formulation and implementation. The policy linkage is salient however in regard to early warning systems (EWS).

Early Warning Systems

Previously EWS have been oriented mainly toward forestalling and alleviating crisis conditions. An example is shown in Exhibit 4-49. In recent years, however, USAID's Famine Early Warning System Network (FEWS NET) has initiated a "sustainable livelihoods" approach which in effect "normalizes" the process.

Exhibit 4-49.



Evaluation

As noted previously, "evaluation" in the present context refers primarily to whether program and project activities are effective in achieving their intended objectives, as gauged by performance indicators built into the monitoring system. This is the proper sphere on "evaluation research," the post hoc assessment of actual impacts.

Through IA, plans are assessed in terms of their undersigned-for impacts (or, in other words, their unintended consequences, externalities, spin-offs, or side-effects). IA asks: regardless of whether the motivating objectives are met, what else occurs? (Boothroyd 1995: 53)

As also noted previously, the validation of evaluative criteria requires a major effort at engagement and involvement of interested and affected parties. For reasons discussed above, the potential benefit of community monitoring would seem especially pertinent to explore in this connection. This would also imply the application of indigenous indicators as features of traditional knowledge, and the sensitization of local communities to wider environmental concerns.

"Environmental evaluation" of ecosystems is a procedure "… to identify what benefits an ecosystem may be providing, to establish their value to society and to compare this value to the value of proposed alternatives" (Manning and Sweet 1993: 2).

> Environmental evaluations of ecosystems can fulfil a number of functions in the process of planning and implementing development projects. The most important function of an evaluation, however, is to help decision makers recognize and understand ecosystem benefits that may be ignored by more established planning and decision-making tools. Environmental evaluations can be an important tool in building an awareness and understanding of the relationship between social and economic development and the natural systems upon which all life depends.

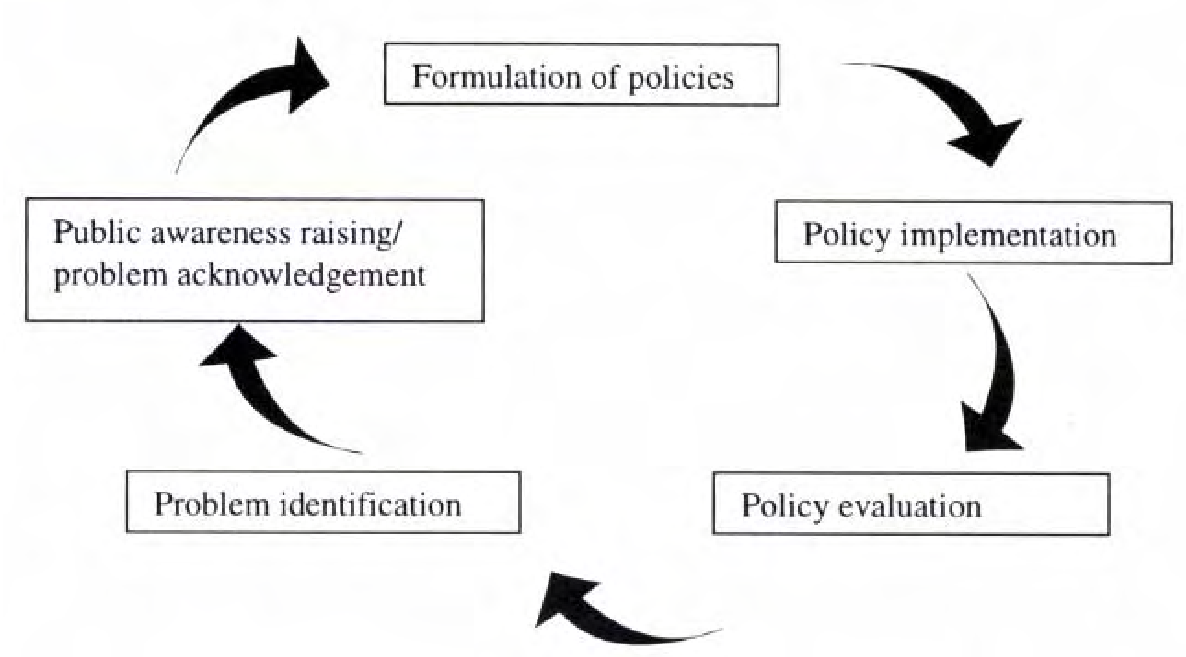
4.2.2 DECISION SUPPORT FRAMEWORK

Monitoring and evaluation form a basis for decision making by providing estimates of the situation to which decisions are directed and by indicating criteria for making those decisions.

Decision Analysis

To confirm the relevance of the present project to LCBC, it is necessary to undertake a decision analysis that poses leading questions regarding who the decision makers are, what decisions they make, under what circumstances, with what effect, and on whom. This process is illustrated in Exhibit 4-50 (Moldan 1997).

Exhibit 4-50. The Decision Cycle



The decision process can be traced through a cycle of problem identification and analysis, formulation of alternatives and selection of a preferred alternative, coalition and consensus building for implementing agreed policy, and evaluation of program effectiveness in securing policy objectives.

The cycle repeats with management adaptations and policy adjustments made in response to that evaluation, based on actual experience in implementation. Answers to these questions have implications for future institutional design and performance, for example in regard to capacity development and community involvement.

Decisions are required or implied at each step of the assessment process. The obvious first step is to decide the boundaries of inquiry that enclose a particular situation of concern. Exactly where these should lie, or even how they should be delineated, are by no means foregone conclusions. In the case at hand, what basin is at issue is by no means a simple question. When it comes to problem identification, is "the problem" one of "saving the lake" or adapting to changed environmental conditions? The complexity becomes acute at the formulation of "reasonable alternatives" step (5.1.2), and further multiplies throughout the series.

Decision support occurs throughout the decision process through the application of impact assessment methodology, which itself constitutes a framework for that process.

Decision Strategies

Two complementary strategies for decision making are risk-based and knowledge-based. The former identifies priority risk factors and components and concentrates resources on their prevention, avoidance, and mitigation. Applications of this approach are mainly focused on industrial hazards such as toxic materials (Bingham and Rall 1997) and dam safety, but also on natural hazards such as flooding and natural resource development and management in the water resources and energy sectors (Haimes and Stakhiv 1985; McMillan, Magaw, and Carovillano 2001), among others.

Knowledge-based decision making and development generally draw their inspiration from a social learning process described by Armington (1998: 97):

> In the past the World Bank has generally tried to force the pace of development through a supply-driven process …. Moreover, it has generally bet on the efficacy of a top-down process, whereby the knowledge branded as "best practice," together with money to provide incentives for action by officials, is funneled into the country at the top of government and cascades downward toward intended "beneficiaries."
>
> The new lending strategy for the Bank … advocates a leisurely, demand-driven approach that relies on local discovery through the open learning model of knowledge-based development. It bets on the efficacy of a bottom-up process, whereby locally-reinvented best practices in the gathering and use of information, together with intrinsic motivation of citizens and a minimum of outside money, empowers communities to advocate in their own behalf, and where the impulses for change at the upper levels of government are originating from the ground.

This strategy inquires into information requirements for decision making and mobilizes information resources to match them. A modest beginning for Lake Chad Basin is found in Annex 11. Naturally information requirements will vary according to topic and context, but there is always a question of “how much is enough?” In the case of policy decisions, Lee, Jr. (1974: 35; original emphasis) gives this response:

> *The Optimal Amount of Analysis Is the Minimum That Will Distinguish between Policy Alternatives.*

He continues,

> Being able to distinguish between policies means only that the differences between the two (or more) choices need to be identified, and only with sufficient precision and reliability to evaluate the policies. Providing more than this is technically wasteful in that the capacity is not needed, and politically counterproductive in that irrelevant information distracts from the relevant. Why, then, produce more than the *minimum*?

Decision Support Systems (DDSs)

A defining characteristic of DDSs is computer-assisted data processing and information management. Those features are discussed below under the Lake Chad Basin Model (4.3.3). Model-based decision making is a logical extension of both risk-based and knowledge-based decision strategies, as are indicator models in relation to index construction.

From the foregoing it follows that decision support would ideally occur throughout the decision process by application of impact assessment methodology applied to the substantive focus of interest.

4.2.3 Adaptive Management

Lake Chad Basin management can be considered in two categories, environmental and social. Environmental management involves the implementation of policies to restore, protect, and enhance ecosystem functioning in the region. Social management involves the implementation of policies to support, sustain, and enhance the quality of life of the region's inhabitants.

As discussed above, significant risks and uncertainties attend policy formulation and implementation in both categories. Their proper management therefore entails a high level of flexibility and agility. "Adaptive management" is designed to serve these needs.

The concept of "adaptive management" originated in the field of business administration and was introduced to the practice of environmental impact assessment by Holling and his associates in their 1978 volume, *Adaptive Environmental Assessment and Management*.

In terms of the Main Pattern schema, "management" completes the assessment cycle—which however iterates and regresses frequently in multiple feedback loops. "Adaptive" may be fairly said to characterize the entire assessment process, including impact management. Three components of AEAM that may be employed in environmental and social resource management are (ESSA 1982: 4):

1. The concepts of *Adaptive Management*—the practice of recognizing uncertainties and designing policies or management strategies that can be used to learn and adapt in response to unexpected events, accumulation of knowledge, or active experiment;

2. The methods of *Systems Analysis*—the collection of quantitative and qualitative tools used to characterize, mimic, and simplify dynamic systems, and

3. The procedures of *Modelling Workshops*—intensive, highly focused "brainstorming" sessions which develop and use simulation models to provide a forum for communication and collaborative problem solving.

AEAM's key features are as follows (ESSA 1984: 2-3):

1. Ecological and environmental knowledge is incorporated with economic and social components at the beginning of a strategic analysis rather than at the end of a design process.

2. Since linked resource/social systems are dynamic rather than static and linear, techniques of simulation modeling, qualitative modeling, and a policy design and evaluation are chosen to reflect these features.

3. Scientists, managers, and policy people are involved and interact from the beginning and throughout the process of synthesis, analysis, and design so that learning becomes as much of a product as does problem solving.

4. Direction, design, and understanding are in the hands of those from the region who analyze, select and endure policies rather than in the hands of a separate group of analysts who lack the knowledge of needs, the responsibility, and the accountability.

5. Although prediction can be improved, the uncertain and unexpected lie in the future of every design. Hence policies are designed both to explore opportunities and pitfalls, as well as to fulfill immediate social needs.

According to the U.S. Bureau of Reclamation (2000: 8-23), adaptive management may be carried out according to the following steps after determining measurable goals for management measures:

1. outline their understanding of system functions and outputs,

2. establish quantified objectives and controls,

3. initiate the action,

4. monitor and evaluate the outcomes,

5. review goals and objectives, and

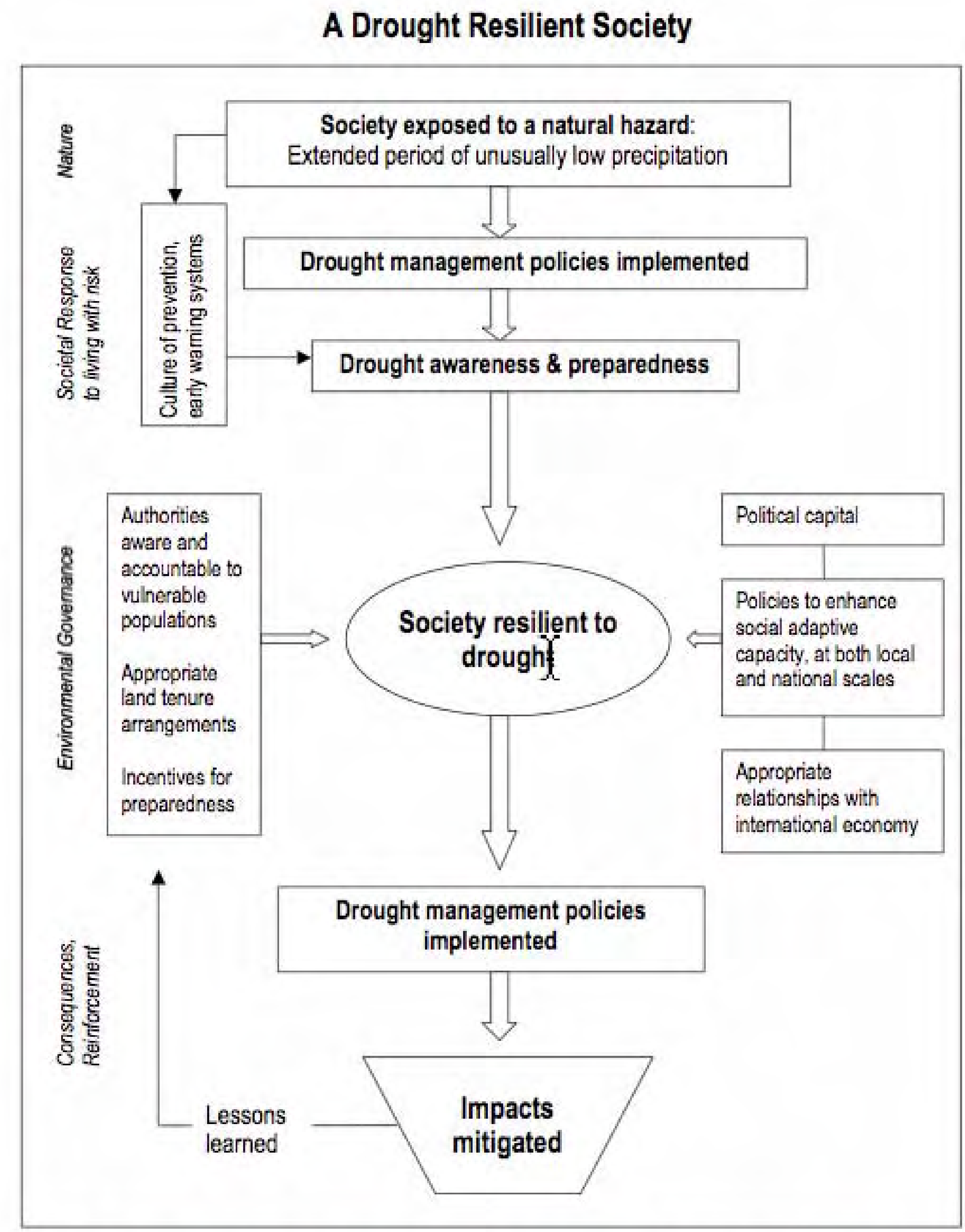
6. redirect the action, if necessary.

While these procedures are clearly meant to enable decision makers to manage risk and uncertainty, as Boothroyd (1995: 115) points out, they do not preclude efforts toward uncertainty reduction where that is possible, such as improving predictive methods. This admonition is embodied in the familiar "precautionary principle," which counsels against making and undertaking risky *and irreversible* decisions and actions:

> When interventions into fragile and/or self-regulating and/or self-making systems such as ecosystems or cultures are being considered, the proper response to uncertainty is not to wade in, intending to deal with problems as they arise, which adaptive management … [advocates] propose, but to hold back and get better information and understanding. Thus building adaptive management (or action-research) capacity into government is necessary but far from sufficient.

In the case of Lake Chad Basin, a major challenge to adaptive management is the problem and possibility of increasing ecosystem resilience and the adaptive capacity of area residents, as a complement to indigenous coping strategies and skills. In recent years several initiatives have been launched in support of such efforts, at scales ranging from local to global. One of these, by the United Nation's International Strategy for Disaster Reduction (ISDR), is depicted in Exhibit 4-51.

Exhibit 4-51.



U.N. Inter-Agency Ad-Hoc Working Group on Drought, ISDR, Geneva 11-12 March 2003

The overall pattern closely resembles the generic risk model sketched earlier (3.3); the features shown indicate some aspects of work on vulnerability assessment and adaptive capacity development now receiving widespread attention (see for example Adger and others 2004).

4.3 Regional

4.3.1 Regional Assessment

Although regional assessments of various descriptions have been conducted for many years, for example the Ohio River Basin Energy Study (ORBES) in the 1970s, by far the most ambitious transboundary program to date is the GEF/UNEP's GIWA, the Global International Waters Assessment, covering 66 sub-basins and 9 megabasins worldwide.

> The Global International Waters Assessment (GIWA) is a holistic, globally comparable assessment of the world's transboundary waters that recognises the inextricable links between the freshwater and the coastal marine environment and integrates environmental and socio-economic information to determine the impacts of a broad range of influences on the world's aquatic environment. (UNEP 2006)

According to Belausteguigoitia (2004: 7),

> The Global International Waters Assessment (GIWA) was created to help develop a priority setting mechanism for actions in international waters. Apart from assessing the severity of environmental problems in ecosystems, the GIWA's task is to analyze potential policy actions that could solve or mitigate these problems. Given the complex nature of the problems, understanding their root causes is essential to develop effective solutions.
>
> The GIWA provides a framework to analyze these causes, which is based on identifying the factors that shape human behavior in relation to the use (direct or indirect) of aquatic resources.
>
> Two sets of factors are analyzed. The first one consists of social coordination mechanisms (institutions). Faults in these mechanisms lead to wasteful use of resources. The second consists of factors that do not cause wasteful use of resources per se (poverty, trade, demographic growth, technology), but expose and magnify the faults of the first group of factors.
>
> The picture that comes out is that diagnosing simple generic causes, e.g. poverty or trade, without analyzing the case specific ways in which the root causes act and interact to degrade the environment, will likely ignore important links that may put the effectiveness of the recommended policies at risk.

GIWA's comparative methodology combins of two main parts, Causal Chain Analysis (CCA) and Policy Options Analysis (POA), using standardized categories for comparative purposes which however permit adaptation to specific regional conditions (Exhibit 4-52).

Exhibit 4-52.

TABLE I. PRE-DEFINED GIWA CONCERNS AND THEIR CONSTITUENT ISSUES ADDRESSED WITHIN THE ASSESSMENT

GIWA concerns	Environmental issues
Freshwater shortage	Modification of stream flow Pollution of existing supplies Changes in the water table
Pollution	Microbiological Eutrophication Chemical Suspended solids Solid wastes Thermal Radionuclide Spills
Overfishing and other threats to aquatic living resources	Overexploitation Excessive by-catch and discards Destructive fishing practices Decreased viability of stock through pollution and disease Impact on biological and genetic diversity
Habitat and community modification	Loss of ecosystems Modification of ecosystems
Global change	Changes in hydrological cycle Sea level change Increased UV-B radiation as a result of ozone depletion Changes in ocean CO_2 source/sink function

Causal Chain Analysis

The pattern of causal chain analysis is shown in Exhibit 4-53.

Exhibit 4-53. GIWA Causal Chain Analysis

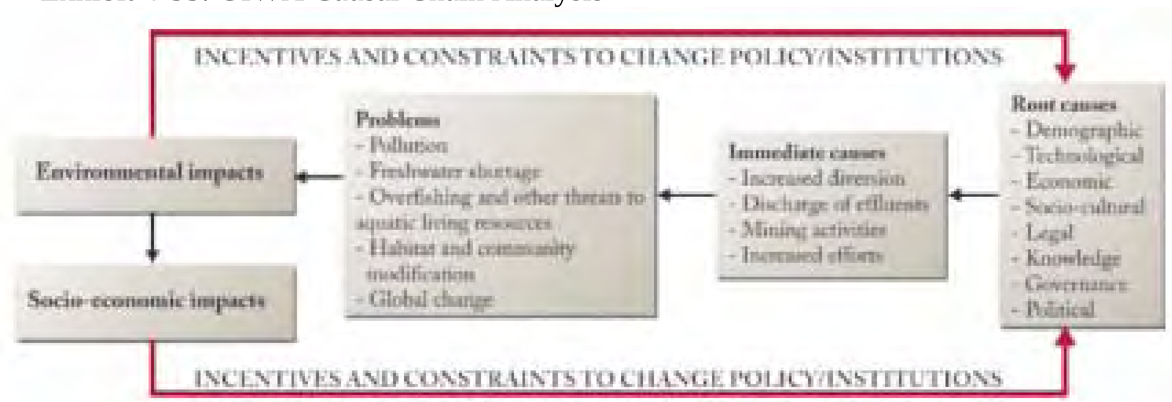


FIGURE 1. THE GIWA CAUSAL CHAIN ANALYSIS

As described in the GIWA program summary report (UNEP 2006: 106-7),

> … causal chain analysis (CCA) traces the cause-effect pathways of the prioritised transboundary issues; from the socioeconomic and environmental impacts back to their root causes. The CCA aims to identify the most important drivers of the aquatic concerns, so that they can be targeted by policy measures in order to prevent further degradation of the region's aquatic environment.
>
> Root causes are not always easily identifiable because they are often separated, spatially or temporally, from the actual problems they cause. The GIWA CCA was developed to help identify and understand the root causes of environmental and socio-economic problems in international waters and is conducted by identifying the human activities that cause the problem and then the factors that determine the ways in which these activities are undertaken. However, because there is no universal theory describing how root causes interact to create natural resource management problems and due to the varying local circumstances, the GIWA CCA is not a rigidly structured analysis but rather a guiding framework.
>
> A causal chain is a series of statements that link the causes of a problem with its effects. Recognising the great diversity of local settings and the difficulties in developing broadly applicable policy strategies, the GIWA CCA focuses on a particular system and the issues that have been prioritised during the scoping assessment. The prioritised issue and its related environmental and socio-economic impacts are the starting point for the CCA. The next element in the chain is the immediate cause, defined as the physical, biological or chemical variable that produces the GIWA issue. For example, for the issue of eutrophication, the immediate causes may include:

- Increased nutrient inputs and concentrations
- Trapping of nutrients in stagnant water
- River and stream alterations
- Run-off and storm water

The sectors of human activity that contribute most significantly to the immediate cause are then determined. Assuming that the most important immediate cause in the example is increased nutrient concentrations, the most likely source of those nutrients would be from the agricultural, urban or industrial sectors. After identifying the sectors that are primarily responsible for the immediate causes, the root causes acting on these sectors are established. For example, if agriculture is found to be primarily responsible for the increased nutrient concentrations, the root causes may be:

- Economic (e.g. subsidies for fertilizers and agricultural products)
- Legal (e.g. inadequate regulation)
- Failures in governance (e.g. poor enforcement)
- Technology or knowledge-related (e.g. lack of affordable substitutes for fertilizers, or lack of knowledge regarding their application)

An application of causal chain analysis is shown in Exhibit 4-54.

Exhibit 4-54. Major Concern – Global Change

MAJOR CONCERN V – GLOBAL CHANGE

PROBLEMS	ENVIRONMENTAL IMPACTS	SOCIO-ECONOMIC IMPACTS	POTENTIAL TRANSBOUNDARY CONSEQUENCES
CHANGES IN HYDROLOGICAL CYCLE	1. Land cover change 2. Habitat/Biodiversity 3. Shifts in Boundaries between sea and fresh waters 4. Feedback to global climate change 5. Changes in thermohaline circulation 6. Extreme events (frequency and intensity) 7. Changes in precipitation, evaporation and snow accumulation and melting	1. Freshwater availability 2. Food security 3. Employment security 4. Changes in productivity of agriculture, fisheries and forestry 5. Changes in resources distribution and political jurisdiction over them 6. Human migration 7. Damage to human life and property 8. Response costs for extreme events 9. Costs for avoiding navigation hazards	N.B. Climate Change is by its very nature a Transboundary cause of environmental and socio-economic issues, many of the impacts of which are themselves transboundary
SEA LEVEL CHANGE	1. Intrusion of sea water to fresh water 2. Modification of aquatic habitats 3. Loss of land, damage to coastal zones including productive land	1. Increased cost of coast protection and emergency response/forecast 2. Loss of income and employment 3. Loss of property & capital assets 4. Human migration	
INCREASED UV-B RADIATION AS A RESULT OF OZONE DEPLETION	1. Damage to flora and fauna at the water surface and sub-surface 2. Decrease of productivity	1. Loss of incomes and foreign exchange from fisheries 2. Loss of opportunity for investments (both domestic and foreign) 3. Increased costs of human health care	
CHANGES IN OCEAN CO_2 SOURCE/SINK FUNCTION	1. Feedback to global climate change		

Policy Options Analysis

The policy options analysis (POA) consists of two main tasks:

Construct policy options

Policy options are different courses of action that aim to solve or mitigate environmental and socio-economic problems in the region. Although a variety of policy options could be constructed to address each root cause identified in the CCA, only those with the greatest likelihood of success were analyzed by GIWA.

Select and apply the criteria against which the policy options will be evaluated.

Although there are many criteria that could be used to evaluate any policy option, FIWA focuses on:

- Effectiveness (certainty of result);
- Efficiency (maximization of net benefits);
- Equity (fairness of distributional impacts);
- Practical criteria (political acceptability, implementation feasibility).

Socioeconomic impact categories encompass:

- Economic impacts: The key economic and public service sectors that are affected by the degradation of the aquatic environment should be identified and their relative importance to the regional economy assessed. The degree to which the quantity and quality of their output has been reduced and their costs of operation increased should be similarly assessed. Finally, the frequency and duration of the impacts should be determined.
- Human health impacts: The approximate number and types of people affected should be identified, the nature and degree of severity of the health impacts should be assessed and the frequency and duration of the impacts should be determined.
- Other social and community impacts: The number, size and principal characteristics (e.g. presence of vulnerable groups) of the affected communities should be determined, as well as the aspects of community life affected. The extent to which community life is affected and the frequency of these impacts should also be assessed.

Three broad criteria are considered when scoring on a scale of 0-3 the perceived degree of severity of the impacts:

- Size of the population or economic and public sectors affected (categorised as: very small; small; medium; and large).

- Degree of severity of the socio-economic impacts experienced (minimum; small; moderate; severe).

- Likely duration of the impacts (ranging from very occasional/very short)

As indicated above, this methodology has been applied to major aquatic ecosystems globally, including Lake Chad Basin, in which several LCBC staff participated. A review of that experience is reported in a subsequent draft.

4.3.2 The Basin-wide Framework

The 1992 Master Plan calls for the formulation of a "basin-wide framework," which was approximated in the 1998 Strategic Action Plan. The framework in question then refers to LCBC development policies and plans for the region and their implementation through program and project actions.

Given development experience since 1992, however, the conception of this framework as a "blueprint" for regional development may appear flawed. Moreover, following a decentralized approach to policy formulation and implementation (infra), the kind of indicative planning such a "blueprint" might embody is difficult to preconceive.

On a different viewing, the kind of framework desired might be better conceive as an analytic framework, conceptualized in terms of the approaches previously discussed (3.2). Their empirical referents need to be identified, measured or estimated, and codified in a data structure here called the "Lake Chad Basin Database."

The Lake Chad Basin Database

The Lake Chad Basin Database (LCBD) is conceived as a repository for data series and sets centering on the region, including World Bank and UNDP development indicators, national statistics, and remote sensing images. A modest beginning can be reported on the latter.

While many informational resources are available, data sets and series are scattered and fragmented. Annex 9, "Basin-Wide Framework," is a first approximation of a comprehensive and integrated knowledge base for the Lake Chad Basin (LCB) erected through the systematic application of these assessment methodologies. As such, it provides the broad outline for a decision support system "to address transboundary priorities and monitor project interventions."

Sets and series of environmental and social data to be collected, collated, analyzed, and interpreted include archival, statistical, and observational in the various contexts and categories discussed in this report. In the case of social data, for example, institutional, cultural, and behavioral data all have relevance for the assessment, especially in combination for "triangulation" purposes. Data structure is established by indicator values of the empirical referents of the structural and processual concepts and variables employed in this assessment.

Data problems can be anticipated in respect to the disaggregation at the national level and with data accessibility and quality generally.

An indicators approach will be followed in compiling an codifying data, implying further operations of indicator selection and validation, measurement and estimation, and index construction, leading to the construction of indicator models. One such concept is the Lake Chad Basin Model.

4.3.3 THE LAKE CHAD BASIN MODEL

The Lake Chad Basin Model (LCBM) is conceived as a structure for organizing knowledge and ordering data of interest to regional development. It is intended as an accounting system to compile, collate, and coordinate information; a monitoring system to track and project existing and future systems and conditions and to simulate outcomes of alternative policy scenarios.

The model structure is given in the structure of environmental and social systems being modeled, as delineated in their system profiles; model dynamics are given in their internal processes and external linkages.

Model exercise and utilization has potential applications in numerous environmental and social management contexts, such as impact forecasting. In light of the view of policies as experiments, policy modeling can be simulated to evaluate alternative scenarios and interventions.

Model development is indicated in all these respects; while technically feasible, large-scale modeling has proved problematic for a variety of reasons, mainly database maintenance and management.

5.0 Results

Results of the project are reported in terms of findings, their implications for LCBC, and recommendations for their implementation.

5.1 Findings

Findings are reported focusing on priority ecological considerations in the context of the overall program goal of reversing conditions and trends of resource degradation in the Lake Chad Basin. A number of approaches and actions for achieving this purpose are reviewed and analyzed. The work of the ESRA project team is then summarized in direct response to the Terms of Reference (ToR).

5.1.1 REVERSAL OF RESOURCE DEGRADATION TRENDS

Assume for the moment that the problem as stated in the program title—to reverse resource degradation trends in Lake Chad Basin—is correctly identified.
The preceding discussion has analyzed an assortment of environmental and social drivers, pressures, states, impacts, and responses operating in the situation. The categories are there to behold, but what is known with certainty about their contents and systemic linkages? What specific information can be mustered to lend them substance and significance?

The questions are better than the answers, yet that is the essence of *risk* assessment—not knowing with confidence, but nevertheless confronting a situation of fact that presents the necessity of choice and action. Here is hope: learning is possible; practice makes better.

Two complementary solutions come immediately to mind: relieve the pressures and improve the responses. If deficient rainfall and population pressure are foremost among the former, where is help? No sovereign solution is readily apparent, although small measures such as rain harvesting and family planning may yield a significant cumulative impact.

On the response side, however, a panacea is conceivable in form of heroic engineering works to effect inter-basin water transfer. While plausible and perhaps feasible, the question remains: what is gained by supporting an ever-larger population under conditions that are marginal at best and perhaps inherently unsustainable. If the desert is not to be deserted, perhaps it must be accepted on its own terms. Human adaptation rather than environmental modification may provide an answer.

In fact, the situation under discussion is highly diverse and offers abundant opportunities for decisions and actions that are environmentally sensitive, economically feasible, and socially acceptable.

Ecological Risk Assessment

Reflecting on the ESRA experience, the project team endorses the following precepts.

A common misconception exists that to invest in conservation is somehow contrary to investing in peoples' livelihoods. However, it is now increasingly widely recognized that investing in ecosystem services (sustaining natural capital) is good value for money. The costs of managing ecosystems sustainably are often less than the costs of developing artificial facilities once natural services are lost (IUCN 2005). This is the fundamental basis for an ecosystem risk assessment approach.

It is critical not to reduce systems into a series of disconnected parts, but to address them at the lowest functioning level of sub-systems as possible. The Southern African Millennium Ecosystem Assessment (SAfMA) report (Biggs and others 2004) indicate that the "good" social responses most likely to succeed in addressing problems related to ecosystem services and human well-being will:

Exhibit 5-1. SAfMA Problem-Solution Matrix

1. *Recognize complexity.* Ecosystem services and the people who depend on them comprise complex socio-ecological systems. Narrow, single-issue or single-sector perspectives are likely to promote unwanted consequences in other sectors. Responses that take all relevant sectors into account when planning for any particular sector are more likely to avoid unexpected surprises (ecological shifts beyond known resilience thresholds), and are better prepared for those surprises when they come. These so-called surprises are in fact usually simply natural perturbations (for example, floods) at time scales greater than human life spans and often provide key opportunities for natural system renewal, to which those systems are adapted.

2. *Look at the whole picture.* Strive to create positive synergies. Where tradeoffs must be made, decision makers must consider and make explicit the consequences of all options. Various tools can assist decision makers in visualizing, understanding, and communicating the issues at stake.

3. *Be made through an inclusive process.* Making information available and understandable to a wide range of affected stakeholders is key. Asymmetries in society give rise to asymmetries in information, education, and income availability. These are usually translated into unequal distribution of ecosystem service benefits, and reduced adaptability and responsiveness. Collectively, these asymmetries increase the vulnerability of disenfranchised communities. In addition, benefits derived from ecosystem services are pervasive throughout society. The priority ecological considerations awareness of these benefits among different groups needs to be raised, and social and economic development need to incorporate these benefits (without raising unrealistic expectations).

4. *Enable natural feedbacks.* The ability of ecosystems to continue providing ecosystem services depends on natural feedbacks that can be seriously compromised when they are dampened by inappropriate management, policies, and governance models. Perverse subsidies (such as certain agricultural subsidies) are amongst the most damaging of incentives that promote inappropriate behaviors, and their eradication is an urgent priority. Responses must also avoid creating artificial feedbacks that are detrimental to system resilience. Frequent, careful, and rigorous monitoring helps to indicate whether feedbacks are functioning.

5. *Be implemented at the appropriate scale.* The scale of a response must match the scale of the process; often, a multi-scale response will be most effective. In particular, tenure systems, institutional arrangements, and the role of privatization have important implications for the continued provision of ecosystem services. That said, there are no "silver bullet" tenure arrangements for managing ecosystem services, and each situation demands a unique, scale-appropriate response based on situation-specific knowledge and consultation with stakeholders.

6. *Acknowledge uncertainty.* Given the complexity of social-ecological systems, it is usually impossible to fully understand the structure or functioning of a system to be able to predict the outcome of a response. In choosing responses, we must understand the limits to our knowledge, and we must be prepared for surprises. Hence the need for a conservative approach (e.g. invoking the 'precautionary principle').

7. *Enhance the adaptive capacity* of managers and of ecosystems. Resilience is increased if managers have the capacity to learn from past responses and adapt accordingly. Resilience is also increased if the capacity of the ecosystem to deal with change is enhanced or maintained.

8. *Assess and re-assess* the feasibility of alternative responses. A change in one or more of the system drivers can lead to a previously unfeasible response becoming feasible, or vice versa. Care must be given to the prevailing social and cultural context in which the question is framed.

The framework depicted in Exhibit 5-1 clearly outlines the theoretical linkages and dependencies as described the points above from the SafMA report (Biggs and others 2004), which goes on to say:

> Problems in complex systems require complex responses. Decision makers, whether ecosystem users, managers, or governments, need to design responses that can meet such challenges (i.e. they must be at least at the minimum subsystems function level).
>
> Responses made in isolation are not likely to succeed, and coordination between those who choose and implement responses is needed across sectors and scales. This will require greater cross-communication between diverse actors, and the free flow of information between them. While responses must acknowledge the limits to our knowledge about complex systems, we must strive to constantly improve upon it.

Policy Changes and Incentives

Incentives structures are recognized as being important determinants of rural household behavior. How farmers and pastoralists respond to the incentives they face, and the subsequent repercussions for the conservation of natural resources, is a key area of research. Moreover, the design of policies to encourage the sustainable use of these natural resources can benefit from an understanding of these linked decision making and natural processes.

Where natural resources are particularly fragile, as is the case in the Sahel and other dryland areas prone to desertification, the need to ensure that government policies and management regimes have the desired effect becomes even more critical.

In many cases, farmers are aware of the potential for their lands to degrade but may be constrained or discouraged from making the necessary improvements. Market and policy failures may be primarily at fault: since farmers do not reap all the benefits of improved land management, the socially optimal level of investment in land improvements will not occur.

Government policies may aggravate the situation by creating the wrong incentives for conservation instead of correcting for market failure. Current thinking on the causes of resource degradation emphasizes the role of market and policy failures, inappropriate institutions and government policies, as well as the interaction of compounding or "disabling" factors such as poverty, population growth and income or asset distribution.

Given its endowment of natural, human and technological resources, the household makes decisions under the constraints or incentives imposed by the enabling environment. In this regard, tenure and other factors both create and limit the opportunities available to the household.

Variable incentives determine the net returns, risks and other pecuniary elements entering into the decision making process and, in this sense, the structure of variable incentives imposes further constraints (and opportunities) on household decision making. Changing incentives or net returns signal to the farmer that the use of household resources for a particular purpose may no longer be desirable and that resource reallocations may be necessary.

Many options are available if farmers wish to respond to perceived changes in their production environment. Whether these activities will have a positive or negative effect on NRM depends on such factors as how they are carried out, what crops/animals are involved and whether they are maintained over time, amongst others. Feedback mechanisms close the loop and lead either to self-reinforcing improvements in NRM or spiralling degradation, which can eventually culminate in the collapse of the farming or grazing system.

Draft animals may substitute for tractors, manure or mulches for inorganic fertilizer and integrated pest management (IPM) for pesticides. The extent to which substitution may actually occur will depend on how perfect these practices substitute for each other, their relative prices/costs and their availability: manure and mulches are often limited in supply and thus cannot fully substitute for inorganic fertilizers.

Furthermore, modern agrochemicals have at least some role to play in the process of agricultural transformation in Africa, and there is little evidence of over-use of these inputs and the associated damages at present, except in areas of intensive land use.

Some specific concerns regarding subsidies, input usage, and variable incentives include the following:

- Inorganic fertilizers have both positive and negative consequences for NRM, as they contribute to beneficial intensification but can displace more sustainable options or mask underlying soil depletion, so that subsidies may be good or bad;

- Pesticides can cause well-known damages when applied excessively or incorrectly and subsidies can contribute by encouraging the over-use of calendar or pre-emptive spraying or, in the area of IPM, by artificially lowering the damage thresholds at which spraying is done;

- Irrigation water subsidies, particularly when combined with inappropriate pricing mechanisms (e.g. unit area pricing) encourage overwatering and degradation, leading to declining profitability and further diminishing prospects for cost recovery and investment in system upkeep; and

- Mechanization (tractor) subsidies can distort production decisions long after they are dropped because of the lifespan of such capital equipment, while substitution effects vis-à-vis draft power are complex because of the mixed benefits and costs of this latter technology.

Protectionism in some West African countries creates incentives for the economically inefficient and potentially damaging cultivation of irrigated rice and wheat. The Sahelian Zone has been described as rich in land area but poor in land quality and physical and financial assets. Combined with a highly variable and harsh climate, the incentives to choose between extensification and intensification become a critical issue, and probably favor the former. But there are many cases in which there is a divergence between the national interest in the conservation of natural resources and the private interest of the farmer, which suggests a need to examine farm-level incentives.

Developing an understanding of farmers' perceptions of the causes and effects of degradation and of their likely response to alternative means of conservation and differing incentives is also an essential element in the design of any program.

Good soil and water conservation need not involve the construction of conventional structures for the entrapment of soil and water. Instead, it may be achieved with better land husbandry, particularly the use of land management and tillage systems which maximize in situ water capture and retention, thereby both reducing potentially destructive run-off and improving conditions for crop growth.

These practices do not require substantial inputs of capital or credit, but instead rely upon support for indigenous methods or the transmission of new knowledge and information to farmers. Increasingly, it may be the enabling incentives associated with these support services which can produce the greatest benefits for NRM, rather than smallholder credit programs or land tenure reforms, both having largely failed in the past. Yet extension services that support sustainable agricultural technology and provide appropriate knowledge to farmers and pastoralists are critically lacking in Sub-Saharan Africa.

Guaranteeing the necessary support to producers is crucial, so that they can make sustainable modifications in their farming practices, but requires commensurate inputs from public agencies. A "farmer first" approach, employing participatory methods and in which households are active partners in research, may be appropriate.

5.1.2 Analysis of Alternatives

Three types of alternatives will be considered here: alternative scenarios, alternative policies, and alternative strategies for policy implementation. The initiating question is what range of “reasonable” alternatives should be brought into consideration.

The Rule of “Reasonableness”

Future Scenarios of Priority Concerns

The continued existence of Lake Chad even into the not-so-distant future is not assured. Population pressures for water, land, and food will continue to mount. Water in the region will increasingly become even scarcer than it is at present. The regional impacts of global warming of the atmosphere have as yet to be determined, although many researchers believe that the first signs of global warming have already appeared in the area surrounding Lake Chad.

A recent report on climate change and the hydrologic cycle suggested that of all the major basins in the world, probably Lake Chad has been affected most by climate change. There is no doubt that future climate change will directly and indirectly play an important role in determining the future severity of freshwater shortage and subsequently the other inter-connected concerns. The number of rainfall events in the region will be influential in provisioning freshwater inputs and consequently, if water resources continue to be used at an unsustainable level in the LCB, freshwater shortage.

The influence of future climate change in the Central Africa region has yet to be determined because there are presently no accurate models for confidently predicting future precipitation over the region. Some predictions have envisaged greater aridity and a scenario between 2001 and 2020 similar to the recent history since 1973 based on a future scenario of increased global warming.

Available water supplies will be further overexploited if planned water development projects go ahead. An IUCN study estimated that in the Hadejia river system the potential water requirements are at least (not taking into account evaporation losses) 2.6 times greater than the mean surface water resources. Although currently the water requirements in the Jama’are and Yobe river basins are met by available water resources, if the construction of the Kafin Zaki Dam is completed they could be over-stretched.

Potential water requirements for the Jama’are river system could consequently be more than 1.8 times the available water resources in a mean year. The average population growth for the LCCB is predicted to be 2.6% which could lead to an estimated population of over 56 million by 2020. This will increase the pressure on natural resources and therefore increase water use, habitat modification and pressure on the fisheries.

A larger population will inflict further stress on the ecosystems of the LCB, which may lead to a greater employment of unsustainable practices by communities to allow them to subsist. The further southward advance of the Sahara due to desertification will lead to greater migration from the northern provinces to the south and exacerbate the major concerns faced.

For the foreseeable future water demands in the Lake Chad drainage basin are expected to increase, as the population becomes more dependent on irrigation agriculture. Increasing demand for protein foods such as fish will result in greater pressure on the Lake Chad fisheries. Future technological improvements in the fisheries have also the potential to expand fisheries production, leading to further decline.

Formulation of Alternatives

The above may be taken as a "base case" for policy decisions and program actions taken in their implementation. Even so, there is a dispersion of opinion around it regarding alternative scenarios, alternative policies, and alternative strategies. The first of these may be understood as projecting "most probable futures," based on existing conditions and trends. Alternative policies vary according to different conceptions of "most desirable futures," based on normative planning assumptions and convictions. Alternative strategies are various means of changing the trajectory of future histories from most probable to most desirable.

Alternative Scenarios

If these prospects outlined in above in the "base case" are to be taken seriously, as LCBC in their 1998 Master Plan insist (2.4, "Criteria for a Sustainable Development Strategy"), a wide array of policy and planning alternatives should be conceived and considered. The Commission recognized "optimistic" and "pessimistic" scenarios, opting for the latter on advice of the precautionary principle:

> … general climatic changes of human origin are phenomena that cannot be discounted. This is why, among the various pessimistic and optimistic scenarios described by experts, it would be wise to make provision for a continuing decline in hydrological conditions in the Lake Chad basin. In any case, even in a more optimistic scenario, the effects of the current drought will be felt for many years to come….

They go on to state, "Integrated actions to manage water resources in the Lake Chad basin must therefore be based on the assumption of a random level of resources, oscillating around the mean level over the past 25 years."

Alternative Policies

In the realm of substantive policy choices, alternatives present themselves in terms such as "rural vs. urban" and "low (or intermediate) tech" vs. "high tech." The rural development alternative proclaims "farmer first" policies to maintain and benefit agricultural producers in their traditional pursuits. For long however this has (allegedly) been opposed by a tilt toward "urban bias," which focus on urbanization trends and opportunities.

The "high" vs. "low" tech dichotomy (really a continuum) might uphold the Israeli model for making the deserts bloom, say in environmentally controlled greenhouses, and the adoption of plant strains and seeds genetically modified for increased drought tolerance. In contrast, low-tech advocates place reliance on farmer-friendly "appropriate technology" that is easily available and manageable. Needless to say, the two diverge on infrastructure, asset, and input requirements.

This leads directly into a radical opposition posed by the 1988 OECD Futures Study of the Sahel Countries, 1985–2015, who plainly state (p. 107 that present trends in the region "… cannot continue for very long: the deterioration of the rural environment cannot go on indefinitely, nor can the growing dependence on the outside world."

The opposition they portray is one of "increasing dependence or structural transformation" where the latter represents a decisive break from traditional livelihoods and lifestyles toward urban-industrial development. It should not be supposed however that this will lessen dependence on external resources and supports; rather ongoing and impending globalization trends are more likely to intensify such dependence.

There is however a possibility that a situation of "mature dependency" will emerge which acknowledges the reality of regional and global interdependence and responds with renewed efforts toward regional cooperation and integration.

Alternative Strategies

One contrast drawn at the beginning of this section between alternative strategies between adaptation and intervention.

Cernea (1991: 29) draws a contrast between two models of social science knowledge and its application, "enlightenment" and "social engineering":

> Enlightenment counts on dissemination of sociological knowledge through education, which is a useful but obviously insufficient strategy. Enlightenment alone implies a tortuous uncertain, and slow way to return the benefits of social knowledge to society and influence its progress.
>
> The social engineering action model is rooted in knowledge of the social fabric and dynamics. It postulates the translation of social science knowledge into new know-how and change tools, and it uses this knowledge purposively to organize new social actions and relationships.

Perhaps the sharpest contrast however is to be found in Karl Marx's dictum: "The purpose of philosophy is not to understand the world, but to change it." Cernea himself notes the complementarity of the two approaches, as in the combination of social learning with action research.

More fundamental however is the "locus of control" issue between centralized and decentralized ("participatory") implementation strategies. There is now widespread agreement that participatory approaches to community and regional development are vital ingredients in effective policy formulation and implementation. The implications of this circumstance may not yet have been fully appreciated, however—for example, the conditions of achieving "meaningful" of intended beneficiaries in poverty reduction program planning and execution.

It must also be acknowledged that there is a downside to decentralization that must be confronted, as in "The Ngiugmi Rural Development Project: Success Story or Cautionary Tale?" (Exhibit 5-2).

Exhibit 5-2. The Nguigmi Rural Development Project*

The rural development project at Nguigmi, in the extreme southeast of Niger, on the banks of Lake Chad, was initially conceived as an emergency programme to provide immediate and longer-term aid for populations who had been affected by the retreat of the lake's waters in the droughts of the early 1980s. The project aimed to increase agricultural production by contributing towards hydro-agricultural schemes, to create added value by financing facilities for the storage and processing of agricultural produce, and to encourage local initiatives by setting up a development fund. The sums allocated under this project amounted to US$3.24 million, of which US$1.88 were financed by UNCDF and US$1.26 million by UNDP—this contribution being essentially for technical assistance.

The area covered by the project includes two arrondissements of the department of Diffa, namely Nguigmi and Bosso, with a sedentary population of about 20,000, not including the nomadic population. The chief ethnic groups are Kanouri and Mobeur; there are also Mange, Boudouna and Daza nomads. Before the droughts, he sedentary peoples lived on livestock, farming, low-water crops grown on seasonally-flooded land on the banks of the lake and its defluents, rain crops, fishing and trade across the Nigerian border. Irrigation was only a very marginal activity: for example, in the pond lands of the Komadougou river.

The droughts of the 1980s particularly affected livestock farming, the sedentary peoples' chief source of wealth, and also the floodwater crops on which they depended for a secure food supply. Irrigation as a food-security alternative was encouraged by the few projects that ought to assist this region at the time. UNCDF, which had ascertained that the region had large unexploited underground water resources, had good reason to believe that irrigation should be given top priority in agricultural schemes. The UNCDF project consequently proposed to replace the traditional wells by a smaller number of concrete-lined wells to be shared by users of abandoned traditional wells. It also proposed to increase the irrigated land areas by drilling some 20 new boreholes. It was foreseen that these various infrastructures would allow two irrigated crops to be grown on about 400 ha, and that some 1700 families would thus be able to produce around 1700 t of cereals.

Considerably less was actually accomplished … The project's agricultural components were … a complete failure.

The project was founded on the idea that the numerous development institutions that had been created in Niger could be used to support grassroots participation. However, as in other projects, the possibilities and characteristics of these bodies were misjudged: the cooperative system and the village development councils are not genuinely grassroots institutions, but instead reflect a pyramidal, centralized institutional system.

… the most important problem involved in this project … is political: instead of having fostered participatory practices, the project in fact reinforced the power of those who were, by social status, most opposed to them … The project thus appears to have involuntarily helped to strengthen sociopolitical systems that are by their very nature opposed to greater social equality, as they would be destroyed by truly democratic participation. The risks of traditional forces exploiting the economic power brought by development project exists in all cases … experience shows that counter powers can emerge as long as the participatory management structures for a project's activities are run strictly according to the rules. This approach can enable new elites independent of the traditional hierarchies to come to the fore. It can also oblige these hierarchies to accept new, more democratic rules of play in the economic sphere.

In Nguigmi, no strategy was put into effect with a view to developing counter-power mechanisms of this type.

*Grigori Lazarev, *People, Power and Ecology: Towards Participatory Eco-development* (London: Macmillan, 1994), pp. 176-81.

As in the other polarities discussed, the proper course to pursue is one that includes and balances the various interests in the development situation. All have constructive roles to play; none can success in isolation from the others.

5.1.3 TERMS OF REFERENCE REVISITED

ToR Analysis and Response

ESRA Terms of Reference seek a clear and succinct understanding of the following principal questions and issues of pertinence to the Lake Chad Conventional Basin:

(1) What are the major risks due to human activities?

The major risks to the physical environment associated with human activities derive primarily from the consumption, mismanagement, pollution, and discharge of the water resources of the Conventional Basin. These contributions to environmental degradation, in earlier decades and at vastly lower consumption levels, represented only a modest component of the overall risk array affecting the basin water regime. Over time, however, human contributions have accelerated and now far surpass the contribution of global climate change (which, in turn, is also derived from human activities at a planetary level). In turn, both factors, taken together, represent the principal long-term problem facing the member countries of the LCBC.

(2) What are the major stressors?

The major persistent and growing environmental stressor affecting the Basin is a declining rainfall regime, compounded by an increasingly variable pattern and sequence of rainfall (with longer or more erratic periods of in-season rainfall interruptions). The most persistent and accelerating human-induced stressor affecting the Basin derives from population growth. Between 1960 and 1987 the population of the basin doubled (from 11 to 22 million), consumption of basin water resources doubled, pollution doubled, urbanization doubled, etc., at the same time the volume and surface area of Lake Chad declined to 5 percent of its size in less than 30 years. Between 1987 and 2006, the population has subsequently increased another 65% (from 22 to 36 million), while the surface water area of the lake declined to less than 3000 km^2 today.

(3) What is the collective impact of stressors on the health or condition of the aquatic biota?

First, the Conventional Basin consists of several sub-basins, some of which are little affected by human intervention, others whose water resources have been fully committed to human resource development purposes, and some that are over utilized. Overall, however, it is fair to say that, with the exception of the water resources of the Chari-Logone sub-basin, the water resources of the basin are under full utilization - effectively preventing any of these other river systems from delivering water to the terminal Lake Chad. As a consequence, the health of the aquatic biota of the Lake itself have been on a continuous and precipitous decline. The impact, in turn, of mismanaged water releases, and extended settled water in several sub-basins has had the effect of fostering the spread of a highly prolific and detrimental invasive species (typha grass), that have so congested wetlands as to have prevented effective agriculture and extremely constrained fishing activities. Human-induced pollutants, in turn, are increasing not only in terms of volume (in the form of human and industrial wastes, and agricultural pesticides), but in terms of the severity of their associated human health risk, and the duration of their residual environmental availability. Again, these risks to the aquatic biota are increasing throughout the basin, at an accelerating rate, but are typically concentrated in certain sub-basins in the geographic vicinity of urbanizing high-density population areas.

The proposition here is to assess cumulative impacts across sectors and levels. Naturally this should not be confined to aquatic biota or any other environmental and social system component; it is an outcome of the operation of the total system. Cumulative impact assessment is a way of becoming comprehensive.

In regard to cross-sectoral impacts, impact matrices are often erected to rate and rank the directional or mutual influence of components on one another, say a particular pollutant on a particular species. This somewhat mechanistic procedure may not capture the synergisms and other dynamics involved in such interactions, however.

The interaction of cross-level (multiscale) impacts is a familiar “part-whole” question of macro-micro linkages, in which the latter generally represent the fine structure of the former. The very concept of “levels” indicates discontinuities of scale, however, which is why discrete levels are distinguished in the first place, implying nonlinear relations between them.

While phenomena on some levels may be reducible to their constituent parts, others may exhibit “emergent” properties which are the distinguishing characteristic of that level.

The health of ecosystems has been addressed in terms of biological integrity and ecological resilience. In the case of complex adaptive systems, the latter implies a cumulative process of dynamic equilibrium rather than stabilization.

(4) What is the relative contribution of each stressor (chemical, physical, and biological) to the condition of the resource?

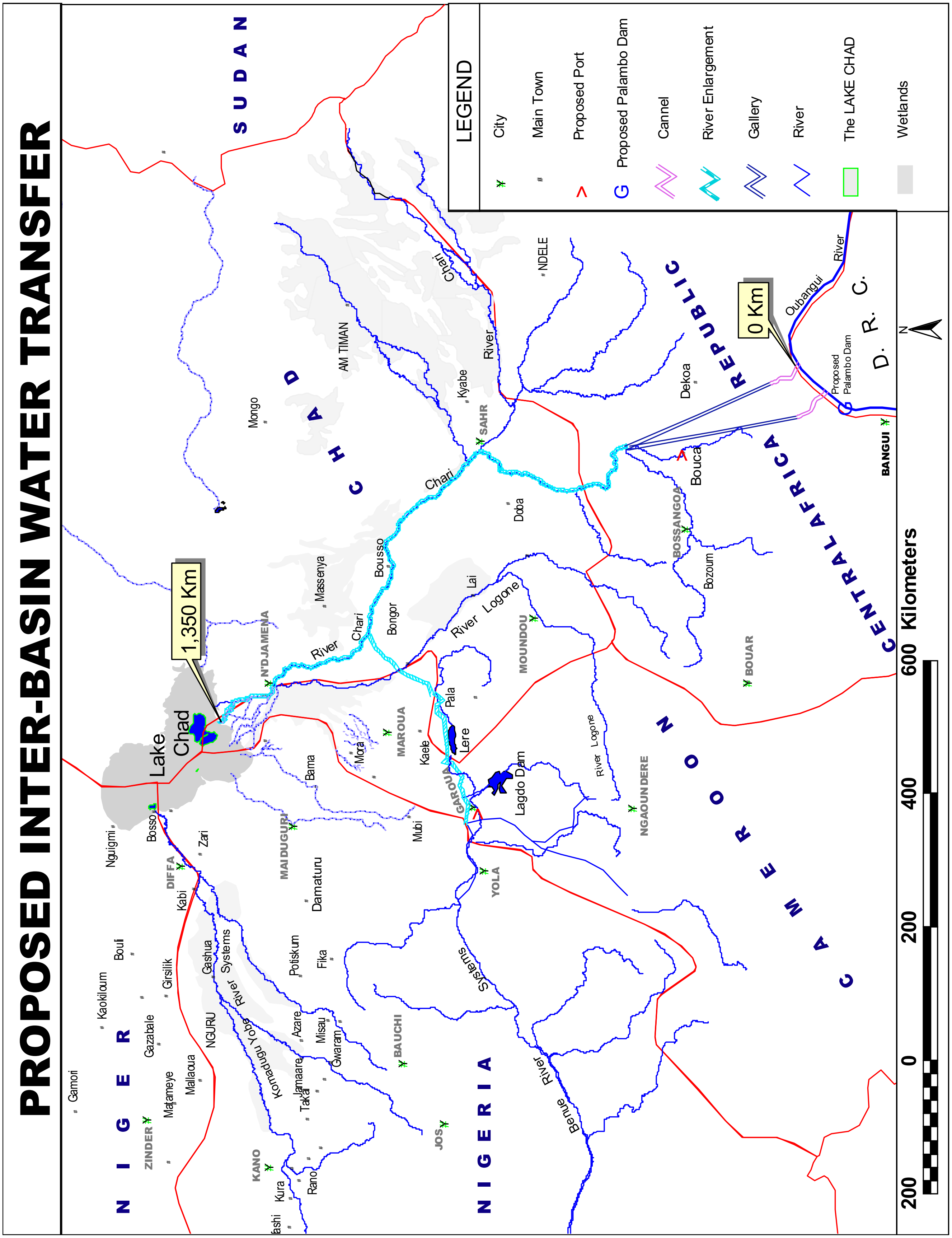
This question, again, given the complexity and geographic size of the Conventional Basin, is not subject to a simple answer. In terms of relative risk, however, we would argue that it is the underlying physical decline of Basin-level rainfall, in combination with increasing human population demands, that warrants the greatest concern at the level of the LCBC. All of the other problems (e.g., chemical pollution, typha grass) are either entirely, or to some extent, derivative of this degenerating relationship. On the other hand, the only means by which LCBC or its member nations can address these issues is through management of the human systems that retain, release, distribute, consume, or discharge the basin's water resources.

Only one long-term solution now under consideration involves the actual transfer of additional resources from adjoining water basins (i.e., the Oubangui - Chari inter-basin water transfer project). All of the remaining management options available to the LCBC concern improved sub-basin management of a continually declining water resource base. The member countries of the LCBC are in general agreement concerning the prospective benefits of the proposed inter-basin water transfer and have agreed to sponsor, and Nigeria has agreed to fund, completion of a feasibility study that will evaluate the prospects for, and impediments to, the proposed dam and inter-basin pipeline and channel system.

Given the potentially profound future implication of this proposed project, Dr. Petterson, of the field team, was dispatched by the LCBC staff to Bangui, Central African Republic, to discuss with the local Lake Chad Basin Commission representative, local government representatives, and university faculty the general perspectives and potential prospects of the Inter-basin Water Transfer Project under consideration between the Oubangui river and Lake Chad basin.

The proposed project involves the construction of a hydroelectric dam and water transfer system connecting the two basins (see Exhibit 5-3). The Oubanqui River, a tributary of the Congo River, represents an abundant, and generally acknowledged, largely unutilized water resource that travels untapped to the sea. The proposed quantity of water to be transferred represents only a small percentage of total flow and would, arguably, represent little loss to water resource users below Banqui.

The anticipated benefits of the proposed project are potentially profound. The proposed dam would generate large quantities of power at very low cost. The agricultural users in southern Chad, in Cameroon, and in the immediate vicinity of Lake Chad would be the primary beneficiaries. The resulting increase in water flow through the Chari river would help to alleviate poverty, by producing an increase in productive lands, in potable water, and in associated employment, while also reducing refugee pressures within and between the participating countries. The increase in water flow would also help to address the larger



PROPOSED INTER-BASIN WATER TRANSFER
LEGEND
City
Main Town
Proposed Port
Proposed Palambo Dam
Cannel
River Enlargement
Gallery
River
The LAKE CHAD
Wetlands
1,350 Km
0 Km
Lake Chad
Proposed Palambo Dam
Lagdo Dam
N I G E R
S U D A N
C H A D
N I G E R I A
C A M E R O O N
C E N T R A L A F R I C A
R E P U B L I C
D. R. C.
N'DJAMENA
MAROUA
GAROUA
MOUNDOU
SAHR
BOSSANGOA
BOUAR
BANGUI
NGAOUNDERE
YOLA
MAIDUGURI
DIFFA
ZINDER
KANO
JOS
BAUCHI
NGURU
NDELE
AM TIMAN
Mongo
Massenya
Bousso
Bongor
Lai
Doba
Kyabe
Bouca
Dekoa
Bozoum
Pala
Lere
Kaele
Mora
Mubi
Bama
Bosso
Nguigmi
Kabi
Zari
Damaturu
Potiskum
Fika
Gashua
Girsilik
Boui
Kaokiloum
Gazabele
Gamori
Matameye
Mallaoua
Azare
Misau
Gwaram
Jamaare
Takai
Kura
Rano
River Chari
River Logone
Oubangui River
Benue River
Komadugu Yobe River Systems
200 0 200 400 600 Kilometers

Exhibit 5-3

environment consequences of rainfall decline, allow reentry into abandoned areas, restore habitat, inhibit desertification, and improve erosion control.

The field reconnaissance took place over a period of 5 days with the local LCBC representative, local officials, government agency representatives, and university faculty (economists, social scientists, environmental scientists, and historians). These discussions revealed a fairly consistent perception among the respondents that the proposed hydroelectric dam and inter-basin water transfer project represented an immense undertaking, and that little public or media attention has yet been paid to the prospective enterprise. Even the most informed representatives had only a vague notion of the project scope, none was familiar with the exact proposed location, and several had no prior familiarity with the project. In general, it is fair to say the proposed project was seen as only a remote consideration and at some great distance in the future. Much of the information offered by officials and university faculty about the potential social risks and concerns, potential benefits, as well as potential environmental impacts, was conjectural and of little direct or substantial relevance to the analysis. Various reports concerning the particular geography, and existing social and economic activities at the identified dam and inundation site were collected.

Two potential routes are under consideration from the Oubangui River dam sites via tunnels through the intervening mountain range, to a tributary of the Chari River in southern Chad, from which the water would then pass through Chad to the lake, some 1,340 km to the north. The lands of a substantial number of small villages, of a single primary ethnic and language group, would be submerged in the process of constructing and filling the dam (which would be located just above Bangui on the Oubangui tributary of the Congo river). Because the proposed hydroelectric facility, and associated flooding, would be located on the border with the Democratic Republic of Congo, an international accord, and some sharing of power or revenue, would likely need to be negotiated between these two countries. It is important here merely to note the general perception, both inside and outside of the basin, is that the potential beneficiaries of the project live in the Lake Chad basin (principally Nigeria), the financial costs are expected to be borne by international donors, and the social and economic risks are to borne by the residents of CAR.

(5) What is the relative contribution of each source (atmospheric, terrestrial, and aquatic in origin) for each stressor affecting the condition?

At the level of the Conventional Basin, we concur with the basic representation of Coe and Foley that, prior to 1975, stressors of human origin represented perhaps 5% of the total contribution to declining lake levels, relative to effects caused or precipitated by global climatic changes, and that by 1987, stressors of human origin represented nearly 50% of the contribution. We believe this ratio to be a suitable surrogate for the entire range of human-induced stressors. Given population growth since 1987, we would estimate that upwards of 70% of the total stressors affecting the environment today is the direct consequence of human activities.

The relative contribution of human-induced activities to atmospheric, terrestrial, and aquatic degradation is difficult to quantify. However, it is fair to say that in comparison with more advanced industrial economies, human-induced contributions to atmospheric degradation are relatively minor. While there are the effects of vehicular pollution from vehicles that are poorly maintained and inadequately equipped for pollution reduction, as well as pollution from cement, coal, and other primary production industries that can be locally severe, these impacts remain concentrated in or near the urban centers. In the vicinity of the few significant cities of the region, the human contribution to local atmospheric contamination can be significant. Basin-wide, however, this contribution represents only a tiny percentage of the pollutants generated by a similar-sized population area in any of the world's advanced economies.

Human-induced stressors to terrestrial resources, in the form of increased use of pesticides, abusive agricultural practices, etc., have increased at a pace that has actually exceeded population growth. This is because of the accelerated adoption, in previously uncontaminated areas, of pesticide, herbicide, and other pest control measures. The rate of growth of these uses, given the relative rarity of such uses just two decades earlier, is thus exaggerated.

Human-induced aquatic stressors, particularly the ubiquitous typha grasses affecting the river beds, streams, wetlands, and lakes of broad areas of the basin, have had a highly detrimental, short- and long-term impact on agriculture, aquaculture, and commercial fishing. These stressors are generally understood to be the product of river flow management and ill considered dam releases combined with inadequate local control efforts. They represent an apt example of the importance of careful advance consideration of water management public policy, and of flexible and more responsive management practices. Urban runoff and intentional discharge of human waste and industrial pollutants into rivers and streams is a rapidly accelerating problem in the vicinity of several of the larger cities of the conventional basin. A concerted national-level effort must be encouraged to control the volume and prevent the spread of these pollutants downstream and into the agricultural and fisheries sectors.

It is of critical importance, in understanding the objective of this question from a LCBC policy foundation, that the human stressors of importance, and therefore their relative contribution to a particular problem, derive from the unique conditions of a particular geography - in general, the particular sub-basin in which they dominate. Any solution to be applied, in turn, will need to be configured to those same unique and localized sub-basin conditions.

(6) Given these contributions, what alternative management options are available to achieve the local, regional, or national expectations for the system in question?

Local response options are relatively well understood, are highly targeted to specific issues, but are quite limited in terms of scale or general consequence. While we cannot offer any specific new or innovative recommendations for improving local level response options, we do believe that local organizations represent the essential front-line for addressing the manifest management or distributional inequities that must inevitably arise in human water allocation systems. Regional responses, at the level of the LCBC or other multi-national organizations, while insightful, have been notoriously difficult to implement. This is because the dominant sources of concern occur at local and national levels, and differ in major ways even among sub-basins within the same country. The LCBC, for example, cannot impose its will on any particular member country, and is limited in the range of tools it can apply to problems at the basin level as well as in the nature of the guidance it can offer. It is our opinion that such regional organizations including, in particular, the LCBC, should be seen to represent the larger interests of the entire basin. They should be utilized as a mechanism to overcome or address issues that span more than one nation (so-called "transboundary" issues), and as a means of insuring a generally equitable distribution of multinational programmatic costs and benefits.

We believe the major shortcoming in the present and future of the Lake Chad water management regime, and the principal bearer of the burden of addressing those shortcomings, lies at the level of the participating nations. This fact is already evident in the scale and impact of past national water regime interventions – including, for example, the construction of the Maga dam, a 27 km., 400 km2, 680Mm3 earthen dam and spillway, Challawa Gorge, a 100-km2, 969Mm3 mostly earthen dam, the Bagauda and Tiga Dams, as well as construction of several hundred other smaller earthen dams, initiated at the direction, and in support of the goals, of national governments (and members of) the LCBC. It is at the level of national governments that concerted and immediate action must be taken, action that addresses at the same time the mutual interests of the residents of the individual countries but also the larger interests of the multi-national Lake Chad Basin Commission.

It must also be acknowledged that the cumulative achievements of national, international (e.g., LCBC) and other NGO intervention projects, however, if measured against the scale of the problems facing human adaptation to changes affecting the basin-wide water regime, are of relatively minor consequence. This is because the two fundamental underlying social and environmental components of risk – unsustainable population growth and global climate change – continue to advance at such a perilous pace.

(7) How is the resource affected by multiple stressors at multiple scales and how does it respond to the change(s) caused by the management action?

What is “the resource”? Presumably it is environmental, but there are also human and cultural resources that mediate the relation between stressors and resources, and may, consciously or unconsciously have initiated the interaction between them through their own interventions, rather than ascribing that to “natural causes” (such as variations in rainfall patterns).

Regarding “multiple stressors at multiple scales,” the former is characterized by Swanson (2005) as follows:

> Currently, a rigorous, theoretical method for evaluating the risk from multiple stressors does not exist. Even with the abundance of observational data and the development of cause and effect interpretation tools, there “are no tools that allow a confident, a priori, prediction of ecosystem response to multiple stressors.” (quoted in Brooks, Keye, and Novotny 2005: 4)

These authors continue:

> Current risk assessment procedures can be categorized as two fundamental approaches, identification of patterns and identification of processes. Pattern based assessments use observation evidence to correlate response patterns with stressors.

Process based assessments require experimental evidence of cause and effect relationships between measured stressors and environmental responses.

Ideally these should be regarded as complementary with elements of both applied and combined in specific applications, as in the case of multistressor indicator selection.

Regarding “multiple scales,” the kind of analysis indicated is cross-level as well as cross-sectoral, where the levels in question are both spatial, such as community and landscape, as well as organizational (hierarchical). That is the essence of integrated impact assessment (Section 3.2).

(8) Characterize the numerous stressors, interconnected pathways, and multiple endpoints.

The tracing of systemic linkages raises obdurate questions of the relations between population, development, and development (PED), such as “population and economic growth” and “poverty and environment.” These have been addressed in the development literature, extensively and somewhat inconclusively (Panayotou 1994; see Annex 3).

5.2 Implications

5.2.1 Environment and Development

Natural and Social Capital

Ultimately, interventions to improve ecosystem resources and services will fail if they compromise ecosystem integrity; rather, they will compound problems they were intended to remove or relieve. As Forrester (197l), demonstrated in regard to the counterintuitive behavior of social systems, such responses are typical of complex adaptive systems (see also Holling 1977).

Natural systems are not only complex but also highly interconnected. They cannot be fully understood in isolation from one another. Although certain properties of components may be analyzed separately, the linkages between components are critical to their functionality. Correspondingly, to be effective environmental management decisions and actions require that critical linkages and strategic intervention points be identified through assessment of the total system.

Natural and social systems are flexible and resilient, but within limits; they are not infinitely adaptable. They may also exhibit recurrent cycles of slow growth and sudden collapse, as in the case of a fisheries "crash," usually from over-fishing; the lake system functions as before, but at a much depleted level of primary productivity. Social systems are likewise constrained by environmental factors such as the rate of renewal of resources, climatic conditions, susceptibility to disease, and availability of water.

Environmental limits can be stretched, up to a point, by technological applications, but these tend to be "targeted" to specific outcomes without regard to maintaining systemic balance. As a result, the system may 'tip over' into a new, unstable state as other components are taken beyond their ability to adapt to novel circumstances. Again this underscores the need to identify the key components and linkages that keep the system in dynamic balance.

One approach to forging these linkages is to trace the formation and allocation of natural and human capital. Humans are entirely dependent for their survival on access to the biophysical resource base of "natural capital" in a functioning state. At a global scale, the Millennium Ecosystem Assessment (UNEP 2005) has clearly shown that human well-being (and indeed survival) depends on four types of *ecosystem services* flowing from the planet's natural capital.

- *Supporting Services* (required by all the others), including soil formation, nutrient cycling, water cycling and primary production;

- *Provisioning Services*: the provision of food, water, fuelwood, timber, fiber, and genetic material, for example. In developing countries, many daily necessities are extracted directly from nature, such as water, fish, grazing for livestock, bushmeat, honey, fruits, medicinal plants, and housing materials;

- *Regulating Services*: for example, climate moderation, natural detention of floodwaters, and dilution of water and filtration of air pollutants;

- *Cultural Services*: natural features provide the setting and substance of cultural activities such as outdoor recreation, images, ideas, myths, totems, and traditions, and scientific and spiritual understanding of the world.

Conventional economics identifies three factors of production, land, labor, and capital, meaning financial investment capital for mobilizing productive resources, to which are sometimes added technology and management organization. These correspond roughly to the categories of biophysical services described above:

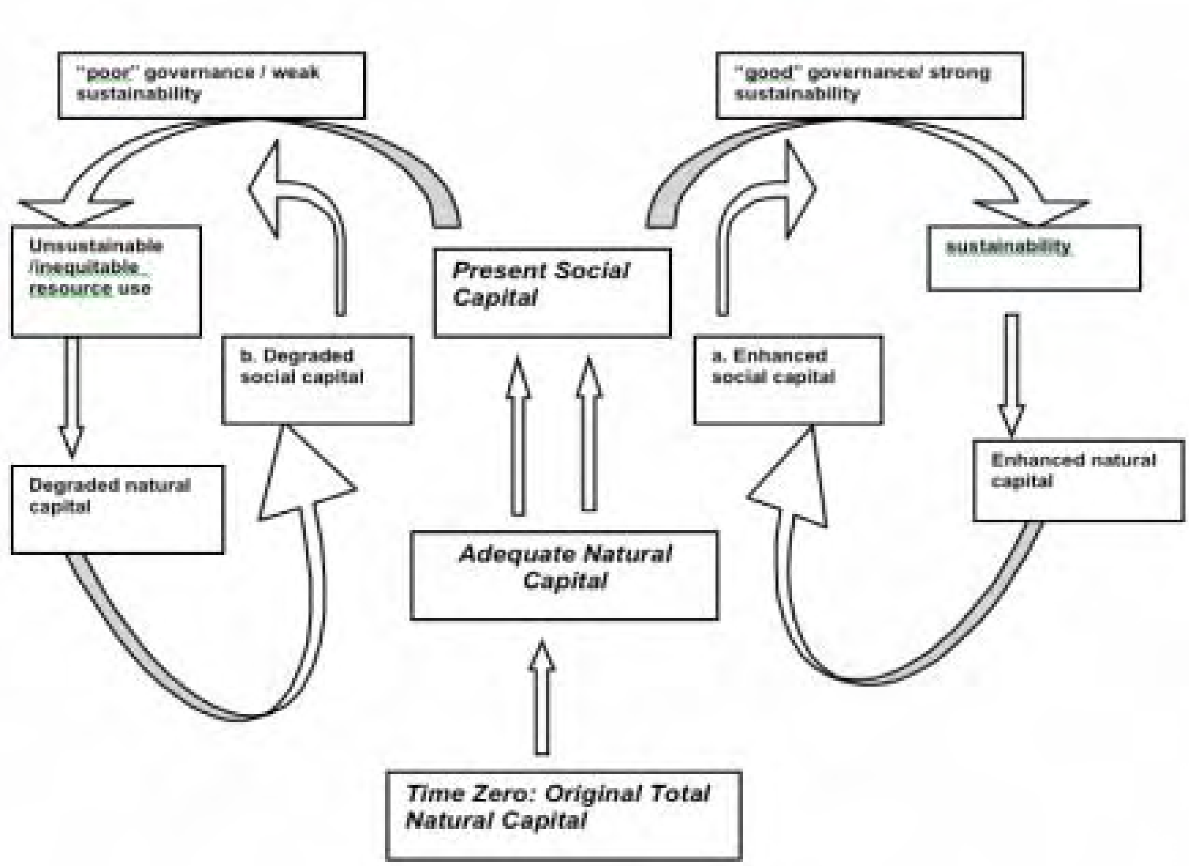
- *Natural Capital:* consists of the planet's stock of non-renewable resources such as oil and minerals, and renewable ones such as fisheries and forests, the latter occurring in mostly unmanaged ecosystems that provide essential goods and services at little or no cost to consumers;

- *Cultural/Social Capital*: includes the knowledge and traditions people use to make decisions, exploit resources (and each other), manufacture products, and create values;

- *Cultivated/Manufactured Capital*: includes crops and plantations, buildings, and other material goods, all derived from natural capital (although this fact is usually overlooked). Unlike natural capital, however, cultivated and manufactured capital requires external energy sources and labor to produce and/or maintain them. Thus they demand significant resource input (investment of social and financial capital) before any output is realized.

It is important to recognize the linkages between natural capital and social capital (the latter including economic capital) and how they interconnect and complement. This is not a simple one-to-one relationship of two equal but separate parts being traded-off against each other; rather it is a complex system of each superimposed on the other in multiple feedback loops, as depicted in Exhibit 5-4.

Exhibit 5-4. Natural and Social Capital



Natural Capital providing the basis for Social Capital, which in turn provides the governance which determines the ongoing sustainability or degradation of Natural Capital, which in turn drives enhanced (a) or degraded (b) Social Capital through desirable or undesirable feedbacks respectively.

From this superimposition it is apparent that a minimum amount of natural capital (incorporating provisioning services and underpinned by supporting services) must be present initially to enable the formation of any and all social capital. As this relation has evolved, however, today it is largely the social capital that determines the condition of the natural capital base and its ability to continue delivering services.

Thus a requirement exists for the "right" social capital to support the political governance in the social system necessary to sustain that minimum natural capital which, in turn, provides the basis for social capital formation in a continuous positive feedback loop. Conversely, the "wrong" social capital will lead to degradation of the natural capital resource base, and consequently to degradation of the now unsupported social capital and ultimately collapse of both natural and social systems.

This circularity has been amply demonstrated by numerous cases worldwide, for example, the introduction of Nile Perch to Lake Victoria, causing significant biophysical degradation and the consequent erosion of social capital based on the previous natural capital base. The "right" and "wrong" social governance interventions lead to sustainability and nonsustainability, respectively. Such outcomes clearly demonstrate the operation of *integrated* socio-ecological systems.

The Southern African regional component of the Millennium Assessment (SafMA) (Biggs and others 2004) has shown that livestock, and livestock management is central to the identity and livelihoods of Sub-Saharan Africa's rural communities, and even many urban communities. Those owning livestock have savings and status, can cultivate and fertilize crops, and wield important decision making powers in the community. The report highlights the many tradeoffs and feedbacks that exist between livestock ownership and other ecosystems services such as crop production and water quality, making livestock "ecosystem-dependent social capital."

The authors go on to observe however that livestock owners can also exert strong negative effects on the productivity and resilience of rangelands, the costs of which are shared with others in the community regardless of livestock ownership. Status conferred by livestock "wealth" can under some circumstances allow owners to exercise undue sway over decisions affecting the community as a whole, even when they alone accrue the benefits while others accrue the costs. Such decisions tend to further entrench disparities in wealth and power, thus forming a negative feedback loop that undermines social capital through degradation of natural capital and inequitable distribution of benefits.

As the Millennium Assessment (UNEP 2005) has shown, the global stock of natural capital has already been depleted to such an extent that it can no longer support the development aspirations of less-developed countries. Ecosystems and biodiversity specifically support all life on Earth, and require a critical mass to continue providing the life-supporting goods and services that nature provides free of charge, simply by being there and being allowed its natural function.

The issue of conversion of natural capital into manufactured or social capital is crucial, particularly where countries or companies deplete their natural capital without replacing it with sustainable manufactured or social capital. This is "poor" social governance, not only in regard to promoting sound biophysical conservation principles but also to providing equitable access to resources. It is generally accepted that below some threshold of natural capital reserve sustainability is at risk. For Lake Chad, that might be a minimum extent of open water to sustain its fisheries.

Only a "strong sustainability" regime manifested by "good" social governance and the presence of adequate natural capital, is suitable and acceptable in Africa and elsewhere in the world (see Costanza 1994). Weak sustainability does not fully account for externalities; in a finite world, weak sustainability then entrenches social inequities at a wider (up to global) scale by constantly drawing on resources from a wider natural capital base.

Protected areas are a part of a social commitment to strong sustainability and retention of adequate natural capital, without denying equitable access to needed resources by marginal and vulnerable groups which are usually on the receiving end of externalities. For both environmental sustainability and social justice, sound social governance demands this conversion and transfer of natural to social capital be managed equitably as well as effectively across all sectors of society, including agriculture, infrastructure, forestry, fisheries, energy, transport, water and sanitation (IUCN 2005).

This model redraws the usual sustainability diagram of overlapping environment, social, and economic circles to indicate that whereas historically natural capital has formed the main resource base, social capital now holds the key to attaining and maintaining the functional capacity to generate sustainable livelihoods without squandering natural capital.

Agriculture is a case in point; crops are not self-sustaining but demand costly direct and indirect subsidies, from the first clearing of the land (which brings its own biophysical costs such as increased run-off, soil erosion, and loss of biodiversity, not accounted for by traditional methods) to the massive inputs of energy, fertilizers, herbicides and pesticides for crop production, to others for harvesting, processing, distributing, and disposing.

One remedy (Milton and others 2005) calls for replacing tracts of monoculture with mosaic landscapes of cultivated land and natural cover which can retain some of the functioning and benefits of untransformed land, without the need for manufactured inputs. Thus water catchments, protected areas, and vegetative cover on fallow fields for erosion control all contribute to natural capital formation to support social development. Particularly in water-stressed countries in Africa, it is neither practical nor economical to convert natural areas, with their variety of drought-adapted plants and animals, to cultivated crops.

Other human activities such as mining, forestry, and urbanization, directly consume natural capital. Damaged land yields fewer services; it holds less soil, less water, fewer nutrients, supports less game or livestock, and supplies fewer products such as fuel or timber.

Urban dwellers are largely oblivious to such natural capital depreciation, but rural people pay a high price as they spend more time and effort to gather the basic necessities of life such as water, fuel and medicinal plants. Continued depreciation increases social costs, through reduced nutrition, reduced opportunity, emigration to the cities, and the collapse of social structures and traditions.

Almost without exception, the activities which have led to destruction of natural capital have benefited a few affluent individuals who live far from the area, while local residents bear the costs. Milton and others (2005) have calculated that restoring, managing, and marketing biodiversity-based resources in the communal areas of Bushbuckridge, Mpumalanga Province, South Africa could boost the sustainable flow of goods from US$200/ha/yr to between US$500 and US$800/ha/yr to the benefit of local producers.

Human interventions usually take the form of treating symptoms of land degradation at the component level—for example, by adding increasing amounts of costly and polluting chemical fertilizers as land becomes less productive. For system rehabilitation, however, interventions need to be located at causation levels.

In the example given in Exhibit 5-2, this would mean progressively re-vegetating the upper reaches of catchments together with reducing stocking rates and overgrazing, leading to increased vegetative cover, improved soils, improved water retention, and quality, improved livelihoods—the "domino effect" in reverse. With this comes huge opportunity for alternative livelihoods, for example, payment for ecosystem services (PES) to local people to re-vegetate land. Ready markets for such activities are available, such as charging downstream water users who benefit from increased flows.

A huge opportunity also exists under the UN's Cleaner Development Mechanism (CDM) for "carbon-sequestration trading" whereby developing countries can earn payments for re-vegetating lands. This is particularly appropriate for the Lake Chad Basin in terms of providing alternative livelihoods plus all the attendant benefits of improving the ecological systems. A further opportunity exists in tandem with re-vegetation to replace cattle with indigenous game species which are better able to handle the dryer local conditions and less prone to create overgrazing problems. A common misconception exists that to invest in conservation is somehow contrary to investing in peoples' livelihoods.

It is now increasingly apparent, however, that investing in ecosystem services (sustaining natural capital) is good value for money. The costs of managing ecosystems sustainably are often less than the costs of developing artificial facilities once natural services are lost (IUCN 2005). This is the fundamental lesson learned from the ecosystem risk assessment approach.

5.2.2 Integrated Impact Assessment

Field development in all areas of impact assessment may potentially benefit the LCCB program. Some bare suggestions are offered below.

Theoretical Development

The demand for theory in ecosystems analysis is noted by Brooks and Novotny (2005: 3), "Currently, a rigorous, theoretical method for evaluating the risk from multiple stressors does not exist. Even with the abundance of observational data and the development of cause and effect interpretation tools, there 'are no tools that allow a confident, a priori, prediction of ecosystem response to multiple stressors'" (Swanson 2005 quoted). Although the ESRA project cannot satisfy that and similar demands in related fields, impact hypothesis formulation and testing that may go point some directions in satisfying the need for causal knowledge.

Methodological Development

There are abundant opportunities for methodological innovations available throughout the current project, not least being the cultural interpretation of remote sensing data.

Institutional Development

Knowledge gained through this project may go some distance in defining the conditions for institutional development in the region, and identifying resources for meeting them. The mobilization of such resources is clearly beyond the scope of study, however.

Professional Development

Although significant GIS capability is present in LCBC and kindred bodies, our emphasis on applications in that area may serve to provide some impetus to further development. Capacity development in this and related areas should extend beyond professional colleagues to include all interested and affected parties in the region.

The categories of field development discussed above may provide some guidance in assessing capacity development needs and designing programs for implementing them, subject as usual to the availability of organizational resources.

5.3 Recommendations

5.3.1 Environmental and Social Management

Overview of requirements for ERA in reversing land and water degradation:

ERA summarized to the following key high-level management interventions:

- Address system holistically, encompassing ecological components and key social stressors as an integrated system using an SEA approach;
- Reduce full integrated system to functioning sub-systems for ease of management interventions, but not to individual component levels, which leads to unforeseen additional problems;
- Do cumulative impact assessments on interventions to determine indirect consequences;
- Set realistic targets for the desired state of 'optimal' system functioning (e.g. fisheries output/productivity) to be achieved incrementally in both time and geographic space;
- Establish 'base-line' or 'ecological reserve' limits beyond which the system cannot function and make provision for automatic management interventions to be invoked where such limits are approached;
- Address interventions at both local site-level scale and catchment scale e.g. for land restoration and re-vegetation, starting in the headwaters on a hectare by hectare basis but incentivized by changes in macro-policies;
- Simultaneously address political and governance structures at the highest levels (e.g. the harmonization of regional regulations and enforcement measures such as institutional capacity to enforce minimum net mesh size in all LCCB countries) as well as local level incentives such as PES;
- Establish a monitoring and evaluation system based on an information system for which data can be readily collected and analysed at two levels—ecological integrity and management processes, impacts and outcomes.

5.3.2 Capacity Development

GEF appear committed to providing the resources necessary to capacitating the institutions and instruments of regional environmental governance (Global Support Programme: Capacity Development for Environmental Management: 2005 Report).

The GEF Strategic Approach to Enhanced Capacity Building (2003)
The Strategic Approach proposes four linked Pathways: an initial national capacity needs

self-assessment (Pathway I) is intended to guide subsequent capacity development (CD) initiatives, through regular GEF projects (Pathway II), stand-alone capacity development projects (Pathway III), and country action programmes in Least Developed Countries and Small Island Developing States (Pathway IV).

A summary of progress with the Strategic Approach was reported to the GEF Council meeting November 2005 in an Information Paper (GEF/C.27/Inf.12).

To date, implementation of the Strategic Approach has been limited to Pathway I, the National Capacity Self Assessment (NCSA), which has developed into the most extensive GEF Enabling Activity, with over 150 countries participating, as reported below. In 2005, the first countries completed their capacity assessments and prepared follow-up Action Plans.

Pathways II, III and IV are intended to form a strengthened programme of capacity development in each country, guided by the NCSA. To date, there has been little activity to promote or facilitate this country programme approach, and there is a need for further guidance to countries completing their NCSA how they should proceed. There has been a tendency to use the NCSA to design separate capacity building activities or single follow-up projects, rather than serving and strengthening the main strategic themes of environmental management, i.e. through the focal area programmes. (p. 1)

5.3.3 Lessons Learned

In summary, this report has estimated the current state of the art, science, and craft of environmental and social risk assessment and how that can be improved and applied in the overall LCBC/GEF ecosystem program, In effect, it has performed an initial scoping for a full-scale assessment to be carried out in preparing the TDA. The result obtained must now be reviewed and ratified by all interested and affected parties, particularly the Technical Task Team.

In the course of this project, it has been necessary to think through the entire assessment process, as concretely as possible, in terms of realistic procedures and real data, giving specific examples and useful directions on how best to proceed in future projects aim at reversing degradation trends in the Lake Chad Basin. This report is offered as one contribution to that end.

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