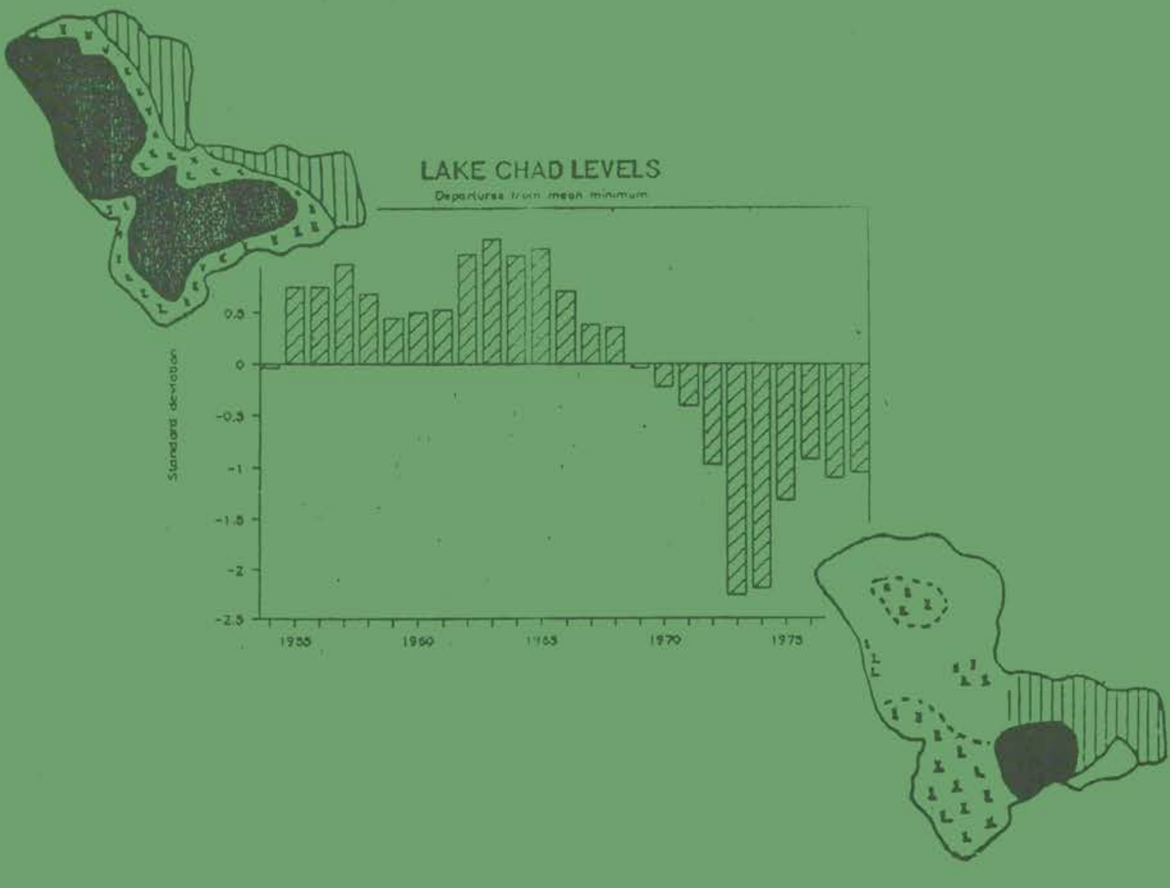
The Lake Chad Conventional Basin



A Diagnostic Study of Environmental Degradation

The Lake Chad Conventional Basin

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LAKE CHAD CONVENTIONAL BASIN
DIAGNOSTIC REPORT: EXECUTIVE SUMMARY

The Lake Chad Conventional Basin: A Diagnostic Study of Environmental Degradation summarizes the symptoms of environmental "ill health" in the basin, 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, and plant and animal life within the conventional basin and to suggest and to set priorities for strategies for healing the basin's environmental wounds. This report is diagnostic. It does not include the project designs, cost estimates, environmental and socioeconomic assessments, national government priorities, and methods of attracting donors that will appear in the Action Plan.

The impetus for the report can be traced the signing of the Convention of Fort Lamy (now Ndjamena) in 1964. The Convention, signed by Cameroon, Chad, Niger, and Nigeria, formed the Lake Chad Basin Commission (LCBC), which, supported by UNDP and UNSO, has attempted to coordinate regional water resources management and, more recently, some aspects of soil, plant, and animal resource management. The more immediate impetus for this report was a request by UNEP. Funding for the technical consultations has been provided by UNEP's EMINWA Program for inter-African river basins and by UNSO.

The report has three parts. Part 1 provides a background on the ecological, water, and human resources of the conventional basin. Part 2 describes specific locations, causes, and major concerns by dividing the conventional basin into more practical hydrographic and ecological units, referred to as "diagnostic basins." Part 3 gives the overall diagnosis for the conventional basin with regard to conservation as well as to development and contains a summary of recommendations in tabular form.

Part 1: Conventional Basin Background

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.

Ultimately, economic welfare relies on unpredictable rainfall that varies annually and monthly due to irregular timing of storms, patchy spatial distribution, and the many distinct infiltration and water-holding capacities of the soils. In addition, production of food, fish, trees and grazing pastures depends on floodwaters of perennial and ephemeral rivers, water from three distinct types of lakes, and groundwater from three distinct aquifers.

The report warns that statistical uses of average or extreme hydrological events can lead to unprofitable investments as well as environmental degradation. It emphasizes the need for all development projects to have "type-year" scenarios that define and analyze project impacts and economics according to very wet, wet, "normal," dry, very dry, and a series of consecutive dry years. "Worst" case scenarios (consecutive dry years) may not be intelligible from statistical analysis.

The report emphasizes that there are many kinds of droughts (Section 1.3) and that they are not necessarily related. For instance, pastoralists and rainfed farmers are most concerned with rainfall variability. Fisheries and floodplain and run-of-the-river agriculture, as well as floodplain grazing, are more concerned with river flow. Channel flow and rainfall are not necessarily related. In fact, channel flow has been more variable than rainfall at Ndjamena. Finally, Lake Chad water levels are not necessarily correlated with either channel flow or rainfall, and designs in many lakeside development projects have been both costly and inadequate. Defining type-years according to rainfall, channel flow, lake levels, and flooding is considered one of the highest research priorities for the conventional basin (Section 3.3.2) and is a necessary precursor to a flexible development policy, advocated by this report, that can adjust rapidly to changes in water supply.

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 temperatures with shade plants, increasing ground humidity, and reducing evaporative losses on reservoir surfaces and irrigated fields. The major 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 aquifers, and use of poor quality groundwater in irrigation projects. Reliable urban water supply and urban water conservation are increasingly crucial.

Soil stability and fertility are the "natural capital" that will determine the conventional basin's long-term ability to feed its citizens and attain economic security. According to the French classification system, there are twenty major soil classes with different production and conservation potentials. Major concerns are sheetwash erosion, wind erosion and deposition of topsoil, fertility and tilth reduction, alkalinization and salinization, sand barrier formation, and compaction of top soil.

Given soil stability, plant life is the ultimate source of yearly wealth within the Lake Chad Basin. Phytoplankton 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 of existing conventional basin vegetation which shows actual (vs. theoretical) plant communities and their state of health.

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

Animal resources provide crucial protein in the forms of fish, livestock, and some game. Lake Chad and its perennial tributaries, with 130 species, are one of the richest fisheries in the world. In the last decade, the fisheries have suffered from drought, diversion or blockage of instream flows by dams, increased fishery effort by displaced farmers and nomads, smaller mesh sizes, increased juvenile catch, and a growing black market in fish sales. The fisheries have not been monitored since the civil strife in Chad.

Certain wildlife species provide income from tourism as well as pride to citizenry for being part of a national heritage. Other species are important from the planetary point of view. Species of special concern within the conventional basin include the oryx, Damas gazelle, Dorcas gazelle and slender-horned gazelle; elephants and black rhinocerous; the Lake Lere manatee, and all water-dependent species (sitatunga, hippo, crocodiles, waterbuck). Bird concerns focus on nesting areas for the Black-crowned crane and wintering grounds for the intercontinental migrants such as the ruff. The reptile skin trade is neither monitored nor controlled. Wildlife has suffered greatly from the spread of automatic weapons, the medium-term drought, and a lack of trained, financed cadre to protect, maintain, and restore populations.

The back-to-back droughts of the 1970s and 1980s have devastated domestic livestock production. Many symptoms of pastoralist collapse are evident within the conventional basin. These include overgrazing and browsing, tswitching to small ruminants and camels, settling of formerly nomadic communities, loss of floodplain pastures to agriculture or upstream dam projects, development of watering holes not coordinated with grazing rotations, forcing of pastoralists into marginal lands by urban and agricultural projects and civil unrest, depletion of the pastoralist labor pool, and trekking of livestock further south. Disaster symptoms (e.g., livestock death, relief aid, collapse of carcass prices) have occurred twice. Regional coordination of disease prevention has not been successful, especially during the "drought disaster wanderings" of pastoralists with dying herds.

The most precious landscapes in the conventional basin are all associated with water. Lake Chad itself is the second largest wetland in Africa. The Yaeres floodplains of the Logone River support more economic activities (e.g., recession agriculture, pasture growth, forest regeneration, fish breeding and production, drought fallback security, Waza National Park tourism) than any other area besides Lake Chad. The northern ouaddis, the Niger/Lake Chad watershed divide, Lake Fitri, and the Borno wetlands all deserve special care and attention when combining conservation with development projects.

Part 2: Diagnostic Basins

As explained, the human and natural resource management concerns are very localized within the conventional basin. Table 2.1 and Figure 2.1 show how the conventional basin can be subdivided into planning units ("diagnostic basins") that make more sense from the development, conservation, and planning points of view. There are eight diagnostic basins: Lake Chad (includes Kanem Lakes), Lower Chari, Lower Logone (includes the Yaeres and El

Beid), Mayo Kebbi and other Mandara mayos, Borno Drainages, Komadougou-Yobe, Northern (includes Bahr el Ghazal), and Lake Fitri. Part 2 contains the "meat" of the report with a review of present information and future diagnostic basin needs, including human resources.

Part 3: Conservation and Development

There is no separation of conservation from development activities. There are no quick fixes to natural resource degradation. Land and soil rehabilitation takes decades. Donors, citizens, and national governments must be prepared to make long-term collaborative commitments. A readjustment of national vs. local control will require years of conflict resolution and revision of legislation and codes, as well as the establishment of viable appeal procedures. "Long-term" refers to a period of about ten to fifteen years. Patience is a necessity, especially when new user groups and national codes need to be created.

Single-purpose (e.g., irrigated agriculture) projects tend to fail or else produce undesirable results. Projects need to be multipurpose or "packaged." Short-term benefits must counterbalance the labor sacrifices required to insure long-term natural resource management. With this in mind, the report recommends the integration of irrigated crops with food storage and famine prevention programs. It recommends diversifying irrigated agriculture by incorporation of tree regeneration, forage production, and other agroforestry interventions that improve water and soil conservation. It recommends no new large-scale water projects in the near future. Instead, the report proposes a review of existing waterworks, repair of the environmental damage caused by specific projects to downstream and floodplain users, and integration of large-scale water works into a famine prevention program. Water priorities should shift from irrigated agriculture to downstream users (e.g., fishers, recessional agriculture, pasture, groundwater recharge) and to multiple use of wetlands (e.g., for wildlife tourism and economic production). Projects with large recurrent costs (especially energy costs) should be given low priority.

Part 3 itemizes over 60 important policy dialogues and project design guidelines; changes in priorities for funding and administrative organization; research, monitoring, education, and training needs in natural resources management and conflict resolution; national legislation and code concerns; soil, water, plant, and livestock project priorities, and international cooperation (especially Lake Chad Basin Commission) priorities. The number of tasks presented emphasizes the great need for policy changes and new projects to combat the severe environmental degradation caused by drought and human activities. Existing antidesertification policies and national conservation strategies serve as a solid basis for future work.

Examples of high priority projects include adjusting the boundaries of the conventional basin so that better water resources management can occur, the reform of land and resource tenure legislation to encourage local groups to invest in and take a more active role in the long-term management of natural resources (Section 3.4.2), the incorporation of type-year scenarios by both donors and governments in environmental and socioeconomic assessments, giving Logone River floodwaters and instream flow the highest priority water right, focusing international aid on the small, rural farmer, performing research on the hydrogeology of all aquifers and creation of sustainable yield policies, resurrection of the fisheries monitoring program, creation of an international "peace park" to provide adequate habitat and long-term tourism along the Chad, Cameroon, and Nigerian borders, and increased education and training for all extension staff in water and soil conservation.

Finally, the report recommends a review of the structure and function of the LCBC with 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 more 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 meeting.

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LIST OF ACRONYMS

ACDI or CIDA	Agence Canadien de Developpment International/Canadian International Development Agency
ADB or BAD	African Development Bank/Banque Africaine pour le Developpement
AGRHYMET	Programme for the Reinforcement of the Agrometeorological and Hydrological Service of the Sahelian Countries
AMCEN	African Ministerial Conference on the Environment
BELACO	Bureau d'Etudes et de Liaison Dioclèsaine
BIEP	Bureau Interministeriel d'Etudes et de Programmation du Developpement Rural, Government of Chad
BORADAP	Borno Agricultural Development Project, Nigeria
BSPE	Bureau de Statistiques, Planification et Etudes, Government of Chad
CAR	Central African Republic
CB	Conventional Basin
CCCE	Caisse Centrale de Cooperation Economique
CEAO	Conmunauté Economique de l'Afrique del'Ouest
CHADPLAN	Lake Chad Basin Action Plan
CIRAT	Centre Internationale de Recherce en Agronomie Tropicale
CORLAB	Committee on River and Lake Basins
COTONCHAD	Chad National Cotton Company
CRA	Centre de Recherche Agronomique
CTFT	Centre Technique Forestier Tropical
DANIDA	Danish Agency for International Development
DHV	DHV Consulting Engineers
EC	European Community
ECA	Economic Commission for Africa

LIST OF ACRONYMS, continued

EDF	European Development Fund
EEC	European Economic Community
EMINWA	Environmentally Sound Management of Inland Waters, UNEP
FAC	Fonds d'Aide et de Cooperation (France)
FAO	Food and Agriculture Organization of the United Nations
FENU-PNUP	Fonds d'Equipment de Nations Unies—Programme de Nations Unies de ?
FNI-FNE	Fonds Nationale d'Investissement—Fonds Nationale de'Equipement
GTZ	German Technical Cooperation
ICBP	International Council for the Protection of Birds
IDP	Integrated Development Project
ILC	International Labor Council
INADES	Institut Africain de Developpement Economique et Social
INRAN	Institut National de Recherche Agronomique Nigerien
IRA	Institut de Recherche Agronomique (Cameroon)
IUCN	International Union for the Conservation of Nature
LCBC/CBLT	Lake Chad Basin Commission/Commission du Bassin du Lac Tchad
LCRI	Lake Chad Research Institute, Nigeria
NCF	Nigerian Conservation Foundation
NRM	Natural Resources Management
ONAREF	Office Nationaled de Reforestation
ONHPV	Office Nationale .....?
ORSTOM	Institut Francais de Recherche Scientifique pour le Developpement en Cooperation

LIST OF ACRONYMS, continued

PADADD	Projet d'Appui au Developpement Agricole du Departement de Diffa, Niger
SECADEV	Secours Catholique pour le Developpement
SCIP	Southern Chad Irrigation Project, Nigeria
SEMRY	Societé d'Expansion et de Modernisation de Riziculture de Yagoua, Cameroon
SODECOTON	Societé du Developpement du Coton, Chad
SODELAC	Societé du Developpement du Lac, Chad
UNDP/PNUD	United Nations Development Program/Programme des Nations Unies pour le Developpement
UNEP/PNUE	United Nations Environment Programme/Programme des Nations Unies pour l'Environnement
UNICEF	United Nations Children's Fund
UNSO	United Nations Sudano-Sahelian Office
USAID	U.S. Agency for International Development
USAID-PAM	U.S. Agency for International Developement—Programme l'Alimentation Mondiale
WB	World Bank

FOREWORD

Over fifteen years ago the United Nations Conference on the Human Environment (Stockholm, June 1972) adopted the Action Plan for the Human Environment. In response to the conference the United Nations General Assembly decided to establish the United Nations Environment Programme (UNEP) to "serve as a focal point for environmental action and coordination within the United Nations system" (General Assembly resolution (XXVII) of 15 December 1972). The organizations of the United Nations system were invited "to adopt the measures that may be required to undertake concerted and coordinated programs with regard to international environmental problems," and the "intergovernmental and non-governmental organizations that have an interest in the field of environment" were also invited "to lend their full support and collaboration to the United Nations with a view to achieving the largest possible degree of cooperation and coordination."

UNEP — in cooperation with other UN agencies — has launched a comprehensive new program on Environmentally Sound Management of Inland Water (EMINWA) to assist governments in the integration of environmental concerns into the management of water resources. This program is in accordance with the Plan of Action for the Human Environment, the Mar del Plata Action Plan of the UN Water Conference, the recommendations of the Montevideo Programme for the Development and Periodic Review of Environmental Law and the UNEP Governing Council decision.

The African Inland Water Programme assigns high priority to water management and minimization of the effects of drought and is one of the main sub-programs of EMINWA. At the first African Ministerial Conference on the Environment (AMCEN) held in Cairo in December 1985, the problems of the Lake Chad Basin were given special attention. During the last twenty years, the recurring droughts and degradation of the vegetational cover have led to drastic changes in the environmental conditions of the Lake Chad Basin. The drying up of Lake Chad, the encroachment of the desert, and the decline of agriculture, livestock, and fisheries threatens the social and economic well being of over 12 million people living in the lake basin — in Cameroon, Chad, Niger, and Nigeria. Considering these threats, AMCEN decided to support "the Lake Chad Basin Commission for the integrated development of Lake Chad Basin, in order to halt the drying up of Lake Chad and use its waters and ecosystems rationally" as one of the "priority subregional activities." The Committee on River and Lake Basins (CORLAB, established by AMCEN) has also given priority to Lake Chad.

Due to the seriousness of the situation in the Lake Chad Basin, in 1988 the Water and Lithosphere Unit of UNEP carried out a Reconnaissance Study. The study report was presented to the 1988 Conference of the Ministers of the Environment of the Chad Lake Basin countries, held at Maroua (Cameroon). The conference requested UNEP to continue investigations and to prepare the Diagnostic Study on the environmentally sound development and management of the water, land, and biological resources of the lake basin. By defining specific environmental problems and their impacts and outlining possible solutions, the Diagnostic Study will contribute to a Plan of Action for Environmentally Sound Management of the Lake Chad Basin (CHADPLAN). Its implementation should follow the adoption of the international agreement of Chad Lake Basin countries on CHADPLAN. The implementation activities shall be financed jointly by the riparian governments, UNEP, other UN organizations, and various donor countries and non-governmental organizations.

The first meeting of the Working Group, established for preparation of the Diagnostic Report, was held at the UNEP premises in Nairobi in April 1988. The Group comprised national experts from Cameroon, Chad, Niger, and Nigeria, the representative of the Lake Chad Basin Commission (LCBC), and UNEP consultants on water resources management and desertification control. The Group agreed to compile basic information and data on the Lake Chad Basin by replying to the questionnaires prepared by the consultants. They acknowledged the need for a field mission by consultants, organized by LCBC. It was also decided that UNEP would assist the Working Group in collecting information made available by ORSTOM in France.

All the above decisions were implemented in the period of April to July 1989. The national experts provided a significant portion of information to the consultants who, in turn, searched for literature sources and began preliminary studies. ORSTOM provided a large amount of valuable data and information. Finally, from 3 to 19 July, 1989, the group of four consultants (in water, ecological, and human resources and in remote sensing) visited the LCBC and all four member countries. The visit included discussions with the Executive Secretary of the LCBC and his staff. The consultants received important contributions from UNDP, FAO, and UNICEF offices in Ndjamena. But above all, thanks to the LCBC's assistance, the consultants were able to travel extensively throughout the lake basin. In addition to becoming personally familiar with visual inspection of the basin area and other important issues, the consultants had the unique opportunity to establish direct contacts with a number of government officials, researchers, field managers, farmers, and other citizens of all four LCBC countries. The information received through these direct person-to-person contacts proved to be invaluable for better understanding of the problems and their constraints and possible solutions.

This Diagnostic Report was written by the consultants in the period July to September, 1989. They were greatly assisted by Baba Diguera (Director of Fishery and Forestry Division) and O.C. Iriu boje (Director of Water Resources Division) of LCBC. Enil Tutuwan (Cameroon), Koumbaye Belyo (Chad), Saidou Namata (Niger), and J.A. Hanidu (Nigeria) served as national experts for this project.

It should be noted that the hydrology and water resources of the Lake Chad Basin have been the subject of several previous investigations, including the 15-year long (1964-1979) investigations by ORSTOM, UNESCO's "Study of Water Resources in the Chad Basin" (1970), FAO's "Survey of the Water Resources of the Chad Basin for Development Purposes" (1972), and UNDP's "Lake Chad Basin Development Study" (UNDP, 1979). Many of these studies, however, were implemented before the drought of the 1970s and needed updating. The main tasks required by this report were updating and interpreting the existing knowledge and formulating recommendations for the future.

PART 1: PROJECT BACKGROUND

1.1 INTRODUCTION

Over many millennia the basin of Lake Chad has experienced episodes of flooding, drought, and epidemics as well as periods of prosperity. The national governments administering the Lake Chad Basin now feel strongly responsible for keeping the basin's citizenry from suffering from natural disasters. In addition, they wish to provide sustained economic security for the basin's populace. This requires peace, family planning, economic development, and conservation of the basin's renewable natural resources. This report focuses on the development and conservation of the basin's natural capital—its soils, water, air, energy, and plant and animal life.

This report was requested and funded jointly by UNEP and UNSO (see list of abbreviations, pages x - x to reference abbreviations used throughout this text) and organized through the Lake Chad Basin Commission (LCBC). Detailed terms of reference can be found in Annex A.

The goals of this report are:

— to "diagnose" the symptoms of environmental "ill health" within the basin. For example, symptoms include forced migrations of citizens because the land and water resources no longer can sustain them, uncontrolled spread of livestock diseases, erosion of formerly productive land, and dieoffs of trees that provide fuelwood due to groundwater overuse.

— to try, after describing the "symptoms," to pinpoint the causes. For instance, the reduction of fish can be caused by low rainfall, reduced channel flow from upstream dams, overpumping of groundwater or over-fishing.

— to suggest and to set priorities for strategies to treat the basin's environmental wounds and productivity problems.

The impetus for this report came from two directions. In 1964, the four nations that share the waters and lands of the Lake Chad Basin signed The Convention of Fort Lamy (now Ndjamena). Cameroon, Chad, Niger, and Nigeria created the Lake Chad Basin Commission to ensure the most efficient use of the basin's waters, to coordinate regional (vs. national) development, and to assist in the settlement of any disputes that might arise between the basin's participants. UNDP has helped the LCBC fund and plan for basin activities. We hope the present report will help update and clarify major basin issues for both the LCBC and the governments of the basin countries.

Further impetus for this report came from the UNEP's EMINWA program. This program produced an Action Program for the Zambezi River Basin, which was EMINWA's highest priority inter-African river basin. The Lake Chad Basin is its second project.

1.2 ACKNOWLEDGMENTS AND STUDY APPROACH

1.2.1 Acknowledgements

The consultants would like to express their thanks to the United Nations Environment Programme (UNEP) in Nairobi for coordinating the project leading to this report. At UNEP particular thanks are due to Dr. Jaroslav Balek, SPO Water and Lithosphere Division, and to staff member Dr. Habib El-Habr. The United Nations Sudano-Sahelian Office (UNSO) in New York commissioned the services of the Office of Arid Lands Studies at the University of Arizona; for their help in this process we thank Mr. Augustin Mandeng and Mr. Ibrahima Djibo. At the University of Arizona in Tucson the effort was managed by Dr. Robert G. Varady, who was assisted by Ms. Andrea Luery, Ms. Melanie McBride, Ms. Rachel Quenk, Ms. Nan Schmidt, and Ms. Mary Storie. The report was translated into French by Ms. Isabelle Houthakker, Mr. Mamadou Baro, and Ms. M. Zoltowska..

1.2.2. Study Approach

This report combines (1) an extensive literature search and review (see the Bibliography); (2) a three-week field survey by four expatriate consultants and two members of the LCBC; (3) interviews with ministries, potential donors, university professors, technicians, government cadres, and agency coordinators; and (4) questionnaires to the national experts.

The consultants selected for this report became a multidisciplinary team with expertise in anthropology, biological diversity, hydrology, natural resource management, and remote sensing. The team endeavored to write an integrated text emphasizing the interconnections between human communities and their access to and use of renewable natural resources. The hydrological, ecological, and human resources aspects are fully combined in Part 3 for recommendations on conservation and development. Tables 3.2 to 3.5 provide concise lists of these recommendations.

The report is confined to the conventional basin of Lake Chad as defined by the Heads of State for the LCBC (Figure 1.1). Nevertheless, there are instances when the concerns of the conventional basin cannot be separated from the upstream areas of the natural basin. In fact, there are instances when the conventional basin cannot be isolated from international concerns (e.g., the conservation of migrant birds or financing of environmental programs). In these cases, we have simply included the larger context (Figure 1.2).

This report does not repeat the extensive, general background material found in a multitude of publications. Instead, we wish to focus on the problem at hand: environmental degradation and possible strategies to prevent further degradation and to promote improvement of already degraded land, water, and biological resources.

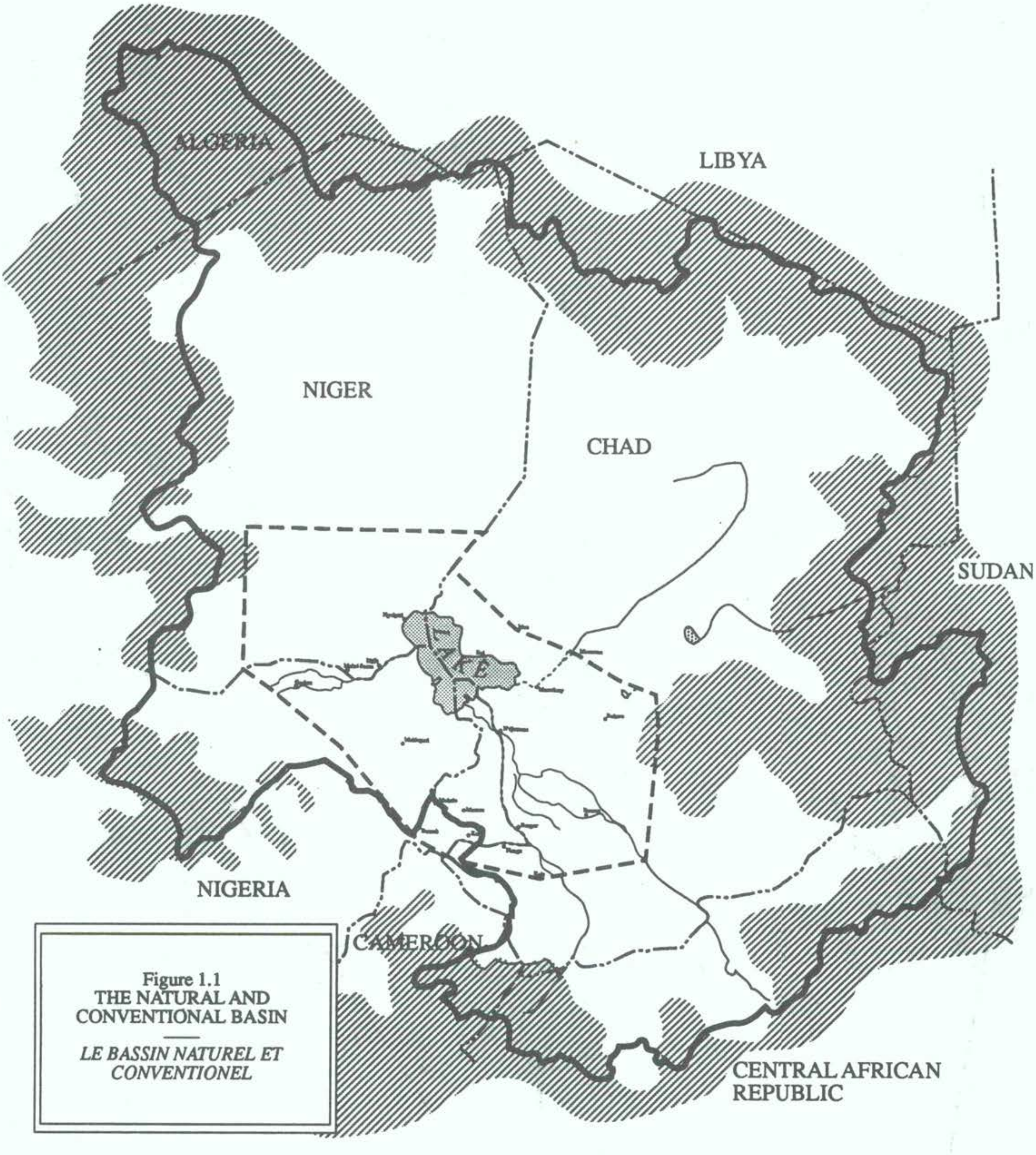


Figure 1.1
THE NATURAL AND
CONVENTIONAL BASIN

LE BASSIN NATUREL ET
CONVENTIONEL

Geographical Boundary (Lake Chad Basin)
La Frontière Geographique (Bassin du Lac Tchad)
Conventional Basin
Bassin Conventionnel
International Border
Frontiere Internationale
Above 400m
Au dessons 400m

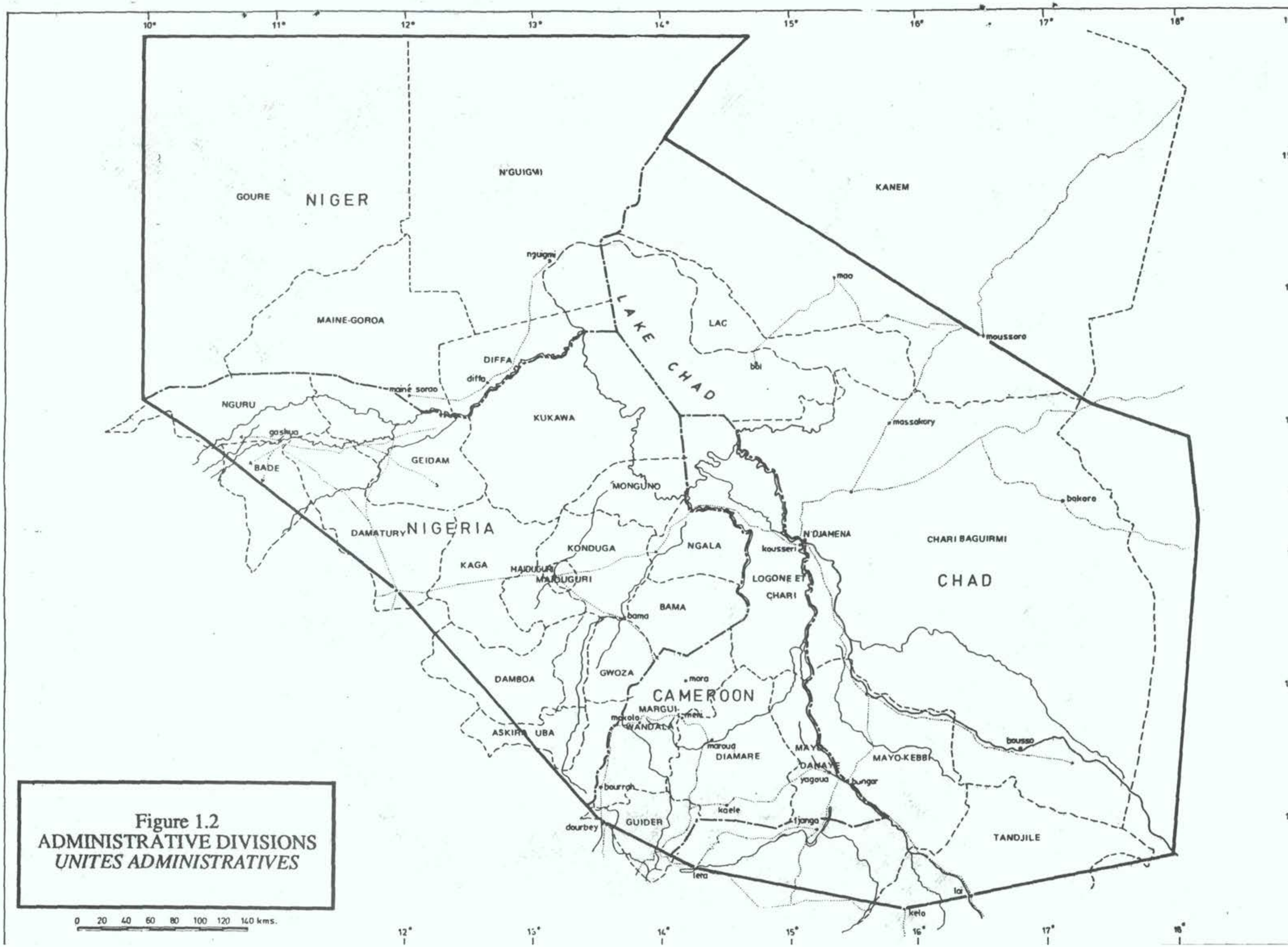


Figure 1.2
ADMINISTRATIVE DIVISIONS
UNITES ADMINISTRATIVES

1.3 CLIMATE, DROUGHT, DEGRADATION AND DESERTIFICATION

Drought is most simply defined as a deficiency of rainfall over a period of ten days, a month, a rainy season, a year, or a period of years. It is usually expressed statistically by consultants (Section 2.1.2) and phenomenologically by farmers and herders. Both descriptions can lead to problems in planning, policy strategies, conservation, and development projects. In recent discussions, drought,has been subdivided into **meteorological drought**, focused on rainfall; **hydrological drought**, focused on reductions in surface waters, groundwater, and infiltration, or increases in evaporation and evapotranspiration; **agricultural drought**, focused on deficits in the water-holding capacity or soil moisture required for crop growth at any point in the growing season (electrical conductivity of the soil water can also be used); and **ecological drought**, focused on reduced primary productivity of biomass in "natural" communities such as forests, rangelands, or lakes.

Drought has completely altered the basic parameters of economic development (e.g., terms of trade, job opportunities, kinds of work, community organization of labor, rules governing access to natural resources) and the biological diversity of West Africa. The back-to-back droughts of the 1970s and 1980s have left the Lake Chad Basin permanently changed. Some of these changes have been called "desertification":

— shrinkage of Lake Chad and Lake Fitri and decreased flows in the major rivers;
— falling of groundwater tables;
— disappearance of specific plant species and reduction of canopy cover;
— loss of wildlife populations and drought fallback "wild" food plants;
— increased soil erosion and/or loss of fertility;
— simple reductions in rainfed or even irrigated crops.

The term "desertification" has become popular for anything undesirable. We avoid the word as much as possible because of its overly vague usage, its confusion between human-caused vs. natural-caused degradation, and because we feel that West Africans have dramatically mobilized their human energies to replace the deficits of recent natural events. These include:

— farmers exchanging drought-adapted seeds and growing self-sustaining fruit trees;
— fishers moving their locations upriver, changing mess sizes, and diversifying ways to earn a living;
— pastoralists changing their routes (moving further south or remaining at well-watered areas) and changing the composition and marketing of their herds;
— farmers increasingly using groundwater to substitute for gaps in rainfall;
— farmers enthusiastically trying water and erosion control measures such as living fences and windbreaks;
— a few farmers joining irrigated rice and wheat production schemes on state-managed farms;
— all citizens moving to or circulating back-and-forth between rural and urban economies in search of wage employment and to trade;
— postponement of marriage as a technique to reduce family size or use of birth control to limit household size and conserve resources;
— changing from a barter economy to a monetary economy, especially for goods formerly traded between farmers and herders.

Some of these survival strategies have, at times, forced families to ransack their own natural resources. In Section 1.4, the impacts and socioeconomic causes of exploitation survival will be described. We describe the impacts as forms of degradation of the basin's natural capital (soils, water, and plant and animal production) within local watershed areas — an approach perhaps more tedious and piecemeal but, ultimately, one that we feel has more lasting and successful impacts (Part 2).

We further describe how degradation has political and socioeconomic causes as well as natural causes. The connection between drought and famine and between drought and long-term degradation of the resource base is not inevitable. For instance, in India, irrigation agriculture is focused on accumulating food surplus and storing it for difficult times. They are pre-planned programs for public works that occur only in years that rainfed farming fails. Despite equally devastating droughts, India has not suffered massive dislocations and starvation.

In this report, we will emphasize that the processes of degradation can be very fast. Within five-year periods, natural events can cause pasture changes, or upstream dams can cause fishery changes. The recovery and rehabilitation process can be very slow, especially for hardwood trees or in areas where seed stocks are lacking in the soil.

In the name of antidesertification, two of the consultants with extensive Sahelian experience have witnessed many grandiose projects (greenbelts, waterworks, pasture programs) fail over the past two decades. They have seen huge amounts of international aid wasted in the struggle to fight environmental degradation. Few projects have adequately addressed strategies (especially social organization strategies) that harmonize with climatic realities. We emphasize that, in order to minimize human-caused degradation, the unpredictable climate requires policies that are flexible, include drought insurance, and accommodate rather than fight human mobility. These policies need to be based on water type-years (Section 2.1.2) that adjust, like the climate, to wet, dry, or a sequence of dry years.

1.4 CONVENTIONAL BASIN BACKGROUND

This section reviews the ecological, hydrological and human resources of the conventional basin, which are important to an understanding of environmental degradation and future conservation/development actions.

Covering a surface of almost 2,500,000 km^2, the geographical basin of Lake Chad is a nearly circular region between the latitudes 6 and 24 degrees north and the longitudes 10 and 23 degrees east.

With two exceptions the basin is closed. In wet years, during flood periods, some of the Logone River is diverted past the Gauthiot Falls towards the southwest to reach the Niger River through its tributary, the Benue. At exceptionally high stages of the lake, some water may also be drained toward the Nile Basin via the Bahr el Ghazal. More than two-thirds of the geographical basin is situated in an arid zone and does not contribute actively to the surface flow towards Lake Chad.

The conventional basin of Chad Lake is the area under the mandate of the Lake Chad

Basin Commission constituted in 1964 to coordinate the activities of Cameroon, Chad, Niger, and Nigeria. The area of the conventional basin is less than 20 percent of the geographical basin.

1.4.1. Ecological Resources and Environmental Concerns

LANDFORMS

The diversity of landforms within the conventional basin is enormous. Three types of lakes are found: piedmont lakes in Cameroon and Chad; interdunal lakes in Chad and Nigeria; and hydrographic lakes such as Lake Chad, which spans all four nations. There are about fifteen types of landforms including active and relict deltas; sand barriers of recent and past lake shorelines; ergs, sand dune islands and other eolian landscapes; flatlands derived from quaternary lagoons; pediments from eroded massifs; fossil valleys and wadis; and incised stream and river beds. Each of these landforms and surfaces control the long-term productivity of the land and, to some extent, the species that can grow and utilize the surface. Since the goal of this report is to recommend the protection of the long-term productivity of the land surface, we must remember that not all geologies, landforms and soils have the same potential nor require the same conservation practices. Projects to protect soils and water supplies must carefully tailor their technical and social interventions to the specific landscape.

In the Lake Chad basin, human-influenced geomorphological concerns have been poorly documented. There is little information concerning channel form changes, sediment load, aggraded streambeds burying surface flow, dune reactivation ,and dune formation (WW). There is no mapping of downcutting or gullying on valley slopes.

In theory, human impacts on stream, river and wadi channels can be traced to urbanization, roads, upstream dams and/or diversions, and increased runoff and sheetwash from damaged hillslopes. Human influences on dunes can be traced to overgrazing, man-made barriers, offroad vehicles, and livestock trampling. Such actions are rarely detached from natural phenomena. The landscape changes interlace with natural causes such as tectonic events, long-term meteorological drought, and extreme runoff and channel flow events. In the arid southwest of the United States, over thirty years of debate have not resolved all the questions concerning human vs. natural influences on channel shapes.

SOILS

In the Lake Chad Basin, the most crucial aspect of environmental degradation concerns the soils. Generalized overviews (Figure 1.3) help define broad "top-down" planning efforts (see "Atlases" in Bibliography). But to understand local needs for soil conservation practices, site-specific surveys are indispensable. In addition, as farmers know, certain soils are useful only in particular hydrological type-years. Especially in the Sahel, farmers need to be able to use two or three soil types— each adapted to a different rainfall regime (Part 2).

There are a surprisingly wide range of soil conditions and types within the basin. Particle size ranges from gravels to sands to the finest clays; drainage varies from excessively

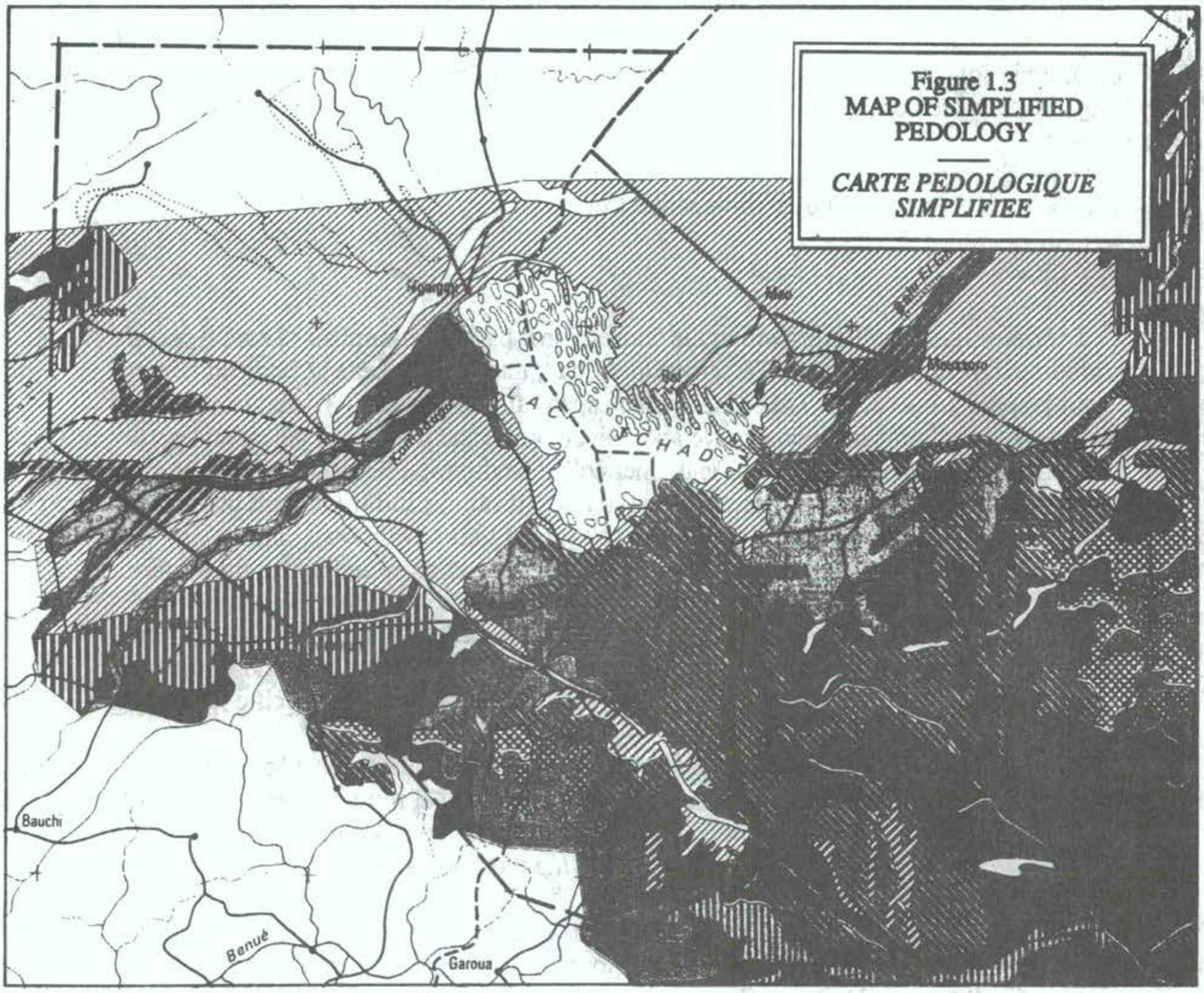


Figure 1.3
MAP OF SIMPLIFIED PEDOLOGY

CARTE PEDOLOGIQUE SIMPLIFIEE

LÉGENDE *LEGEND*

1. – Sols des déserts, sols éoliens
   Desert soils, eolian soils
2. – Lithosols
   Lithosols
3. – Sols régiques à faciès ferrugineux
   Soils of stony desert with ferruginous facies
4. – Sols peu évolués d'apport modaux ou hydromorphes
   Weakly developed soils formed by deposition or hydromorphic soils
5. – Sols peu évolués d'apport intergrade vers les sols halomorphes lessivés
   Weakly developed soils formed by deposition intergrade towards leached halomorphic soils
6. – Vertisols topomorphes et sols à gley vertiques
   Topomorphic vertisols and soils with vertic gley
7. – Vertisols - Lithomorphes, vertisols topolithomorphes, sols à alcali vertique
   Topomorphic vertisols, topolithomorphic vertisols, alkali vertic soils
8. – Sols bruns, sols peu évolués à faciès brun, à faciès brun-rouge, à faciès ferrugineux peu lessivé
   Brown soils, weakly developed soils of brown facies, reddish brown facies and weakly leached ferruginous facies
9. – Sols subarides, bruns et brun-rouge, de glacis
   Brown and reddish brown semi-arid soils on piedmont slopes
10. – Sols subarides brun-rouge, sols ferrugineux peu lessivés
    Reddish brown semi-arid soils, weakly leached ferruginous soils
11. – Sols ferrugineux peu lessivés à drainage imparfait
    Weakly leached ferruginous soils with unfinished drainage
12. – Sols ferrugineux peu lessivés à lessivés
    Leached and weakly leached ferruginous soils
13. – Sols ferrugineux lessivés sans concrétions
    Leached ferruginous soils without concretions
14. – Sols ferrugineux à lessivage oblique
    Ferruginous soils with oblique leaching
15. – Sols ferrugineux lessivés à concrétions et cuirasse
    Leached ferruginous soils with concretions and ironpan
16. – Sols rouges tropicaux
    Red tropical soils
17. – Sols faiblement ferrallitiques et sols ferrugineux tropicaux sur anciens sols ferrallitiques
    Weakly ferrallitic soils and ferruginous tropical soils on old ferrallitic soils.
18. – Sols à halomorphie, de nappe
    Halomorphic soils due to watertable
19. – Sols à alcali lessivés
    Leached alkali soils
20. – Sols hydromorphes minéraux, à pseudogley de surface ou d'ensemble
    Hydromorphic mineral soils with surface of pseudo-gley or pseudo-gley

drained to very poorly drained to seasonally waterlogged and flooded; soil depth varies from shallow soils over rock to very deep weathered regoliths; clays from montmorillonitic clays to those of hydrous oxides and kaolinite; and from strongly leached and acid soils through base-saturated and calcareous soils, occasionally with soluble salts and alkalites.

According to the French system of classification, there are twenty major soil classes used in Cameroon, Chad, and Niger (Fig. 1.3). The widespread soils are Ferrasols, Acrisols, and Luvisols (FAO classification) or Oxisols, Ultisols, and Alfisols (USDA classification). There are localized lithosols (shallow soils over rock), juvenile soils, halomorphic soils, gleys, and extensive vertisols (clayey soils with deep cracking also known as "black cotton soils") within the basin.

In general, soil water limits production throughout the basin. In wet years or, in the southern part of the basin, when water is plentiful, nitrogen (N) becomes the limiting factor. For unknown reasons, nitrification is low in Sahelian soils. In areas where water and nitrogen are not limiting, other nutrients become the limits to production. Phosphorus (P), in particular, limits legume growth. In assessing soils, water-holding capacity and the N:P ratio are crucial data. Soil degradation can be assessed by monitoring changes in total nitrogen, inorganic vs. organic carbon, total phosphorus, the N:P ratio and water holding capacity.

Soil profile, structure, and texture degradation are well documented in local areas. They are not well documented for the conventional basin as a whole. There is, for instance, no map or document specifying the areas of most serious soil degradation or areas that would profit most from immediate conservation practices.

The major concerns are sheetwash erosion, wind erosion of top soil (including deflation), abrasion of plant life by blown sand, fertility and tilth reduction, alkalinization, salinization, soil crust formation, sand barrier formation, and compaction of top soil.

These forms of soil degradation can come from burning, mechanical plowing, overcultivation, shortened fallows, overgrazing, poor irrigation practices, post-harvest devegetated fields, trampling, roads, and mine construction. They can be confused with the impact of natural events such as medium-term meteorological drought and extreme wind and sheetwash events.

Certain soils can degrade so severely that their reconstruction or rehabilitation can become too expensive or technically difficult (e.g., alkaline clayey soils of the conventional basin). These soils must be abandoned or wait—sometimes centuries or thousands of years—for nature to revive them. Symptoms of "badland" or "lifeless" soils include salt build-up, loss of mychorrhizal and microbial communities, and inability to support vascular plants. These degraded soils have been called "desertized."

It is important to remember that when rainfall diminishes, the plant canopy opens, the water table drops and/or surface infiltration slows, but the soils do not necessarily become mobile. For wind or water erosion to set in, the plant canopy and grass cover must be so sparse that raindrop erosion, runoff, and winds can move the top horizons. The northern sandier soils are obviously more susceptible to the harmattan because of increased wind speed, sandier texture, and less cohesive structure.

The degradation of soils is not new to the conventional basin. During the period between 1800 and 1925, there were many references to the impacts of humans and livestock that accelerated "desertification." As in the past, conservation of this natural resource depends on:

— the previous year's hydrological deficit and drought;
— the landscape forms of the location of concern; and
— the human pressure on the plant life required to satisfy both human and livestock needs.

PLANT LIFE

Plant life is ultimately the source of wealth of the Lake Chad Basin. Phytoplankton are the base of the food chain for the fisheries of the lakes and rivers. *Spirulina*, an algae grown in inland lakes, provides significant protein in food sauces and creates an important trade for local harvesters. Wood supplies almost all the energy for preparing food. A major part of the population's protein derives from range-fed beef, mutton, and goat, the quality of which varies with grass and browse production. Special varieties of crops such as flood-tolerant sorghums or drought-adapted millets produce nourishment in even extreme weather conditions. Specific wild plants supply drought fallback foods or supplemental income for marginal households.

The Lake Chad Basin falls within the Sahara-Sindian and the Sudano-Zambezian Regions of Africa (Figure 1.4). The Sahara-Sindian region shares an evolutionary development with Arabia, Iran, and India. The conventional basin borders on the southern and eastern Sahara. This domain has from less than 500 plant species (absolute desert) to about 1,000 species (in areas having >200 mm rainfall bordering the Sahel) in any 10,000 km^2 area. There are very few (about 16) endemic genera, i.e., plant groups unique to a domain or region.

The Sudano-Zambezian Region wraps around the rainforests of the Congo Basin. It is subdivided into the Sahelian and Sudanian Domains. The Sahelian Domain cuts across Africa from the Atlantic to the Red Sea and has ties to the vegetation of South Africa, the Somalia/Masai domain, and even Asia. There are about 1200 species (500-1,500 species per 10,000 km^2) with about 40 truly endemic plants.

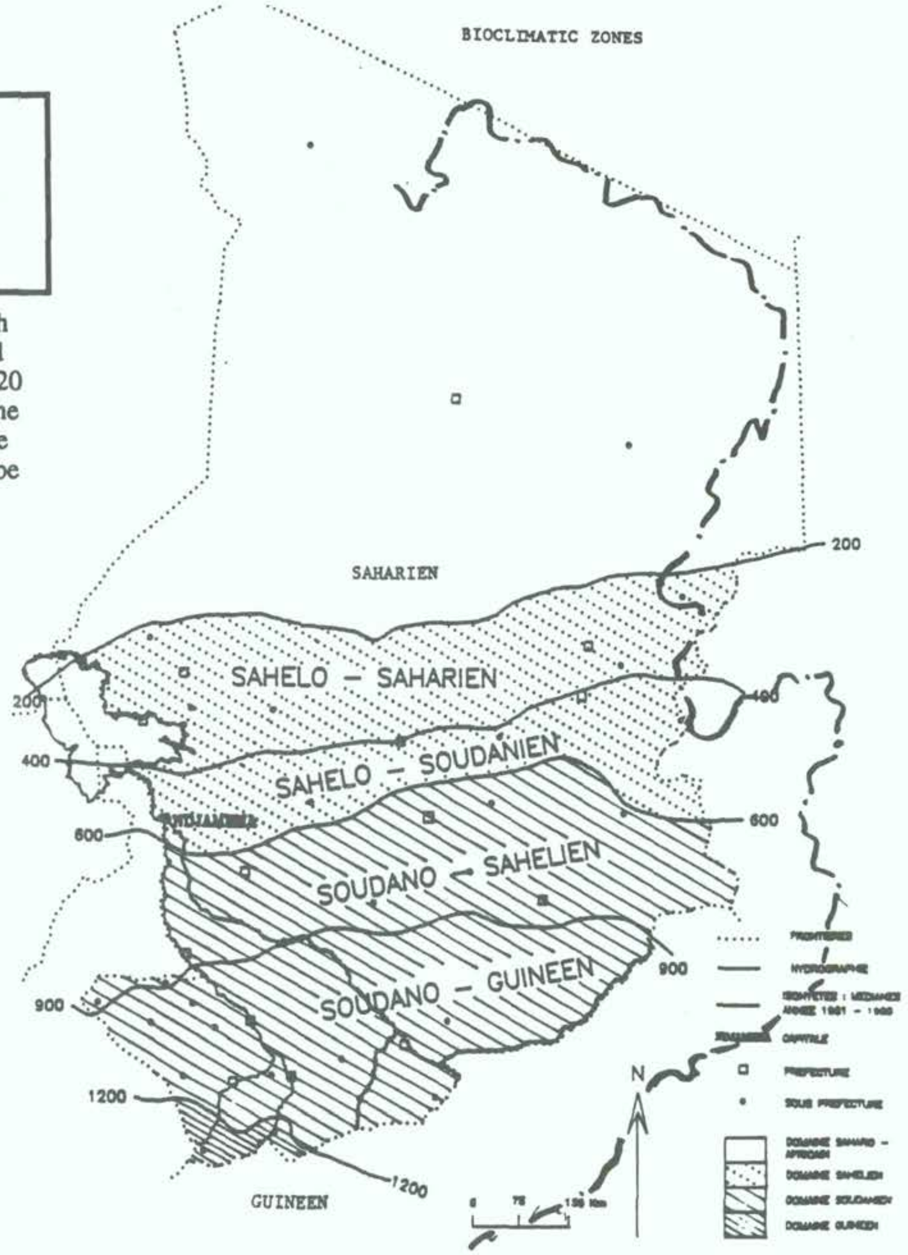
The Sudanian Domain has about 1,000 to 2,000 plant species per 10,000 km^2. There are probably no more than 2,750 species throughout the domain. About 900 species are endemic. The Sudanian woodlands taper off to the east of the Lake Chad basin (in Sudan) but widen to the west.

The widespread nature of the Sahara, Sahel and Sudanian Domains limits the importance of any one nation in the preservation of particular plant species. On the other hand, intact plant communities are rare.

This classification into two biotic regions and three floral domains is too idealized. The Lake Chad Basin has been occupied since the Neolithic (approximately 2750 B.C.) by human groups who have altered the density and composition of plant species (Seignobos,1981).

Figure 1.4
BIOCLIMATIC ZONES
ZONES BIOCLIMATIQUES

NOTE: Bioclimatic zones have altered with the back-to-back droughts of the 1970s and 1980s. Isohyets have moved as much as 120 km south. This map was prepared before the drought period. It is only for Chad. A more stable view of the plant communities can be found in Figure 1.5.



SOURCE: Hamel (1988)

SAHARAN: north of the 200 mm isohyet; rainy season of two months (July and August); representatives locations are Fada and Faya-Largeau. No crops can be grown without irrigation. Main prodcution is nomadic animal husbandry.

SAHELO-SAHARAN: between 200 and 400 mm isohyets; rainy season of three months July to September); representative locations are Bol, Mao and Abeche.

SAHELO-SUDANIAN: between 400 and 600 mm isohyets, with a rainy season of four months (june to September). Representative location is Ndjamena. This zone has both sedentary and transhumant livestock breeding exists along with extensive rainfed cultivation (millet, sorghum, cowpeas, and groundnuts).

SUDANO-SAHELIAN: between 600 and 900 mm isohyets with a rainy season of six to seven months (may to November). Representative locations are Mondou and Sarh. This is the traditionally preferred area for maize, cotton and floodplain and irrigated rice.

GUINEAN: south from the 1,200 isohyet. Rainy season of eight months (April to November). Representative Station is Baibokum.

There are no plant communities, including those within Waza and Mokogo National Parks, that are free of human influences. A more detailed classification is given in Table 1.2. Even this table oversimplifies the plant communities that have long been established under human influences.

In considering an action plan, human influences must be separated carefully from natural changes in vegetation caused by drought. It is not always easy to distinguish human from natural causes. The "natural causes" of fluctuation in plant production, especially rainfall and the level of the water table, cannot be altered easily.

There is no map of the conventional or Lake Chad basin that displays areas of vegetative degradation. The coverage of the conventional basin is spotty (CTFT, 1988). The major types of floristic degradation reported are:

— reduced canopy coverage that increases ground temperatures, increases soil water evaporation, and opens up the soil surface to raindrop and wind erosion;
— change of species from perennials to annuals and dicots;
— reduced biomass of forest products from lowered water tables or overexploitation;
— loss of root volume that increases soil erosion;
— reduced numbers of deep-rooted trees that recycle minerals locked in the soil;
— reduction in legumes that add nitrogen to soil;
— loss of species diversity by harvesting of the most valued plants, combined with medium-term drought.

In extreme, certain changes in plant life appear irreversible. That is, the costs of returning the land to a productive state become overwhelmingly expensive. Three symptoms of irreversible changes are: the lack of seed stock remaining in the soil; stump death, uprooting of trees, and loss of tree crown sprouting; and intense trampling by livestock that compacts the soil and prevents regeneration.

Human-related influences on plant life include: over-cutting trees for fuelwood, construction wood and livestock browse, overgrazing and overbrowsing by livestock, trampling, clearing for agriculture, and clearing for human settlements.

ANIMAL LIFE

The piedmont lakes, the seasonal ponds and marshes, the rivers, reservoirs, and Lake Chad itself support about 130 species of fish. The conventional basin contains one of the most productive freshwater fishing areas in Africa. Extremely detailed work has been done on the fisheries. But, since the civil strife in Chad, the monitoring system has collapsed.

Symptoms of degradation include loss of prized food species (*Alestes baremoze*), drying up of fishing areas, increased fishery effort by displaced farmers and nomads, increased black market in fish, smaller and smaller mesh sizes, increased juvenile catch, etc. All of these symptoms have been apparent for the last decade. Decreasing catch is not a symptom because catches can increase with drought from intensified fishing effort, more fishers, smaller mesh sizes, and concentrated stocks.

TABLE 1.1
PLANT COMMUNITIES OF THE CONVENTIONAL BASIN

A. Sahelo-Saharan Plant Communities
- a. Dunal formations with *Panicum turgidum*
- b. Small undulating dunes and sandy plains
- c. Fossil valleys and large depressions

B. Sahelo-Sudanian Plant Communities
- a. Sandy communities with *Acacia senegal/Guiera senegalensis*
- b. Silty sand communities with *Anogeissus sp.?*
- c. Saline sandy communities
- d. Human-shaped *Balanites sp.?/Acacia seyal* communities

C. Sudano-Sahelian Plant Communities
- a. *Anogeissus* sp. communities on sand and sand with concretions
- b. *Terminalia laxifolora* communities on riparian sands
- c. "Park savannas" with *Adansonia, Parkia, Faidherbia,* and *Hyphanaene*
- d. Diverse communities on hydromorphic soils

D. Sudano-Guinean Plant Communities
- a. *Isoberlinia sp.* communities on ferralitic sands
- b. *Daniellia sp.* communities on ferruginous sands
- c. Lateritic communities

E. Riparian Communities
- a. Riverbed communities of the largest rivers
- b. Creekside vegetation of smaller watercourses

F. Plant Communities of the Yaeres and Lake Chad
- a. Shoreline community of *Acacia* and*Mitragyna spp.?*
- b. *Hyparrhenia rufa* grass savanna
- c. Plant communities of the Lake Chad bed and open water areas

G. Plant Communities of the Mountains and Regs
- a. Woodland savanna and woodlands of *Isoberlinia sp.?*
- b. Woodland savannas of *Boswellia sp.?*
- c. Woodland savanna of *Anogeissus* and *Boswellia spp.?*
- d. Shrub savanna of *Acacia hockii*

There are about 60 to 65 medium- to large-sized mammals in the conventional basin. No recent survey of the mammals of Lake Chad Basin has been made within the conventional basin. Outside the conventional basin, SECA surveyed most of the major national parks and faunal reserves in Chad. In 1988, the antelope specialist group studied the four nations of the basin. Their report is not yet available. The civil strife, spread of automatic weapons, need for drought fallback meat, clearing of habitat, and the drought have combined to devastate many of these species. Species of particular pan-African and international concern include the scimitar-horned oryx, addax, Dorcas, Damas and slender-horned gazelle in the Sahelo-Saharan part of the basin. Elephant herds have been fractured and forced by war and drought into remnant habitats. International cooperation is required to accommodate elephant migrations. A few black rhinoceros still live in Chad. The Lake Lere manatee is an isolated inland population. All water-dependent mammals (hippo, sitatunga, waterbuck) suffered drastic population losses during the last decade. The status of two otter species is unknown.

There are approximately 500 bird species (excluding rarities) in the Lake Chad Basin. But, there is no known complete survey of the bird species within the basin. Birds have been censused by BIROE since 1984. These documents could not be obtained for this report. No particular species has been singled out as endangered. Major concerns include nesting areas for the black-crowned crane and wintering areas for Eurasian migrants such as the ruff. These areas have been replaced by irrigated agriculture or drained by waterworks projects.

There have been no population reviews of reptiles and amphibians. But trade in reptile skins (especially varan) has been intense. Crocodiles have suffered from drought and from overhunting.

Domestic livestock include cows, goats, sheep, camels, donkeys, and horses. The back-to-back drought has been devastating to this production system. Nigeria has essentially become dependent on Chad and Cameroon for meat. Classical symptoms of pastoralist collapse are widespread: overgrazing, switching to small ruminants and camels, settling of former nomadic communities, water development without ecological considerations, compression of pastoralists into smaller and more marginal lands by the spread of cultivation, exclusion of nomads from former drought reserve pastures, trekking of camels and cattle further south than previously recorded, transformation of interethnic, former trade goods and services from kind to cash economy, migration to cities for manual labor, and loss of labor pool for nomadism.

Extreme symptoms—death of livestock, plummeting prices of carcasses, and relief aid—have recurred twice. In the 1969-74 drought, for instance, Niger lost 80 percent of its cattle and Chad lost 90 percent. In the 1980s drought further herd reduction occurred. In addition, Latin American beef has replaced much of the Sahelian production in African coastal urban centers. The strife in Chad further forced nomads and pastoralists from favored pasture areas or crowded them into "sanctuary" areas in both Cameroon and Chad. Finally, some pasture has been lost to Waza National Park and large-scale irrigation schemes that have no provision for postharvest grazing.

BIODIVERSITY

Biological diversity focuses on maintaining species of plants and animals for their "existence value," their "option value," and/or the consumption/production value. Existence value refers to species of special cultural, national, or international importance that do not necessarily have an easily defined economic value. Option value is the preservation of genetic material (including cultivars and other forms of domestic plants and animals) that might contribute to economic wealth in the future. This genetic resource can be maintained by focusing on individual species but it is usually more practical to focus on the species habitat and ecological community.

Protected areas are summarized in Figure 1.5. The inclusion does not in any way imply the status or effectiveness of management. For instance, Mandilia Faunal Reserve has been damaged by strife and human encroachment. A map of protected forests was difficult to obtain and has not been included. From the planetary point of view, the most unique ecological communities and the ecological communities that contain the most intact food webs include:

— The Lake itself—the second largest wetland of West Africa and one of the most important in all of Africa; its flooded dune islands; its shallow, divided basins, etc;
— The Yaeres floodplains of the Logone and Mandara mountains, which feed Waza National Park;
— The wadis of the northern drainages (outside the conventional basin), which may still support remnant populations of scimitar-horned oryx, addax, dorcas and slender-horned gazelle;
— The watershed "divide" between the Niger River and Lake Chad Basin, which includes Gauthiot Falls and a series of lakes (one lake supports the West African manatee);
— Remnant wetland swamps in the State of Borno such as Sambissa and Nduru; and
— Lake Fitri (a closed-basin miniature of Lake Chad).

Not surprisingly, these communities are all associated with water. All these areas have existing or proposed national parks or faunal reserves (see Part 2). Again, "paper protection" is not the same as an active program of conservation. Special plant communities (which remain unidentified) and special geological formations such as those in the Hadjer and Rhumski areas should probably be included above.

Individual wild animal and plant species of concern have been addressed above. The domestic breed of major interest is the Kouri cow. Flood tolerant cultivars of sorghum, millet and rice and drought adapted millets are domesticated plants of major concern. A "pygmy" form of *Alestes* may be unique to Lake Chad.

1.4.2 Water Resources and Environmental Concerns

RAINFALL

The range of mean annual precipitation in the Lake Chad Basin, has varied from 1,400 mm to less than 200 mm. The rainfall pattern is unimodal, i.e., with one rainy and one dry season per year. Even in the rainy season, storms are likely to be highly irregular. But when

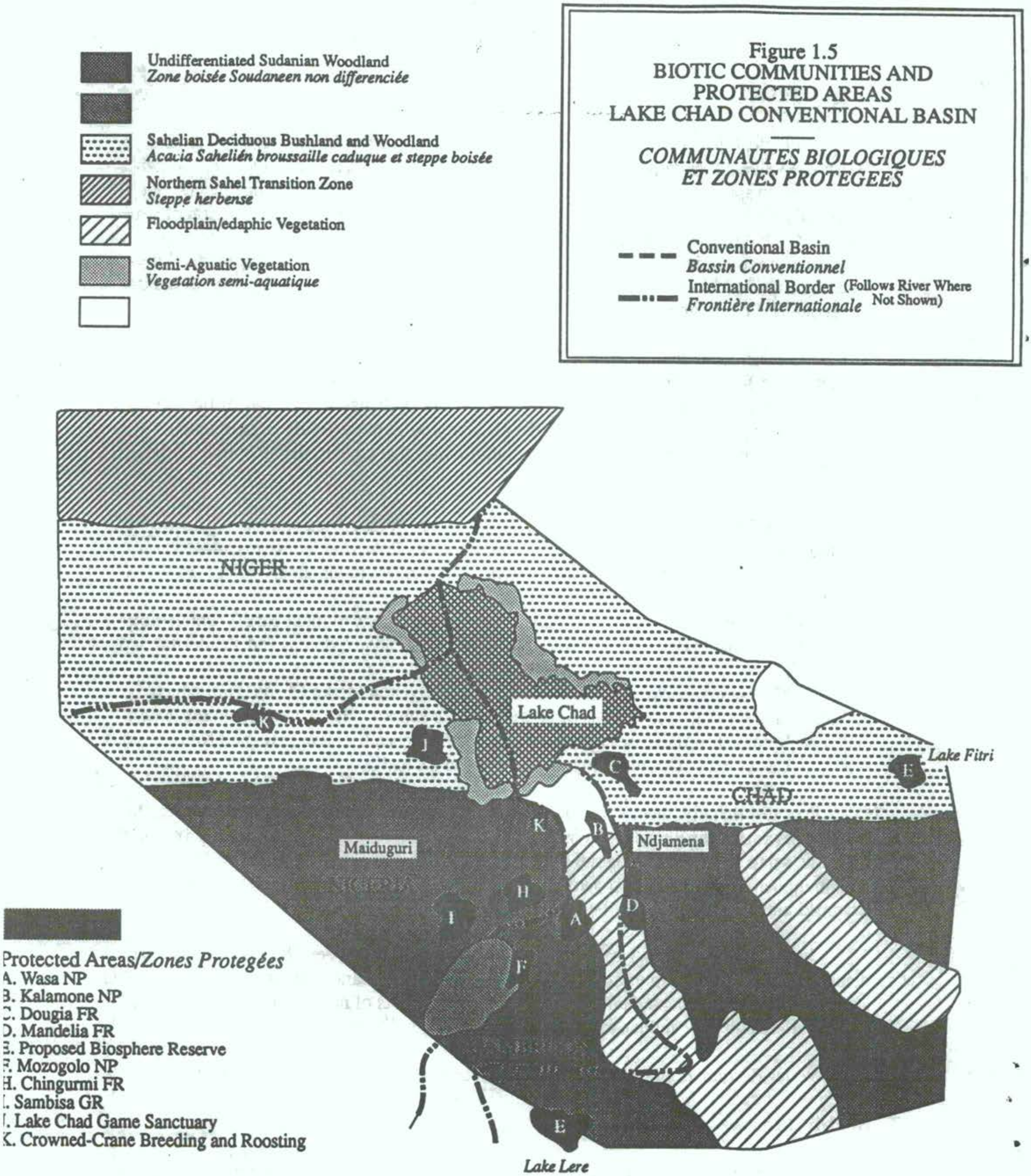


Figure 1.5
BIOTIC COMMUNITIES AND PROTECTED AREAS
LAKE CHAD CONVENTIONAL BASIN

COMMUNAUTES BIOLOGIQUES ET ZONES PROTEGEES they occur, they are often an event of high intensity. Average monthly rainfall may occur in only three or four short bursts. Violent showers have a maximum intensity ranging from 33 to 67 mm within 24 hours (Neasmiangodo, 1987).

In most of the arid world, rainfall is not normally distributed (especially monthly and ten-day means), hence standard deviation is not a particularly good measure of the spread of the data or of the probability of future precipitation occurrences in any particular location (Section 2.1.2). Generally speaking, rainfall variability, measured by the coefficient of variation, increases as the absolute value of the mean decreases—the lower the mean rainfall, the less chance of obtaining it in any one year. In this context, the south-to-north gradient of both decreasing precipitation and decreasing length of the rainy season are of fundamental significance for all water resources management considerations in the Lake Chad Basin.

Interannual rainfall variability also increases northwards. If measured by the ratio between maximum and minimum annual rainfall, it increases from about 1.8 at the latitude of Pala, through 2.8 at the latitude of Ndjamena, to almost 15 at the latitude of Bol. The risk of not obtaining sufficient rainfall in any one year increases substantially in the south-to-north direction.

Mean annual isohyets for the wet period 1950 to 1967 are shown for the western part of the basin for a "wet" period and for the dry period 1968 to 1985 (Figure 1.6). The shift of isohyets is much more pronounced in the Sahelian part of basin than in the Sudanian one. Mean annual isohyets are drawn from the entire period 1951 to 1980. To indicate how large rainfall may depart from the mean in a specific year, isohyets from the most critical year, 1984, are also shown (Figure 1.6).

Given the extremely high variability of rainfall both from year to year and within any single year, results of all statistical analyses of rainfall data must be treated with great caution (Figure 1.7). Rainfall data collected at several hydrometeorological stations in the Lake Chad Basin are usually sufficient to estimate probability distribution functions. But it is an open question how much information one really gets from such an exercise.

There is nothing to be done about rainfall quantity, timing, or location. Rainfall within the basin always will be irregular, unreliable and localized. Rainfall cannot be manipulated. The only strategy is to make the most efficient use of rainfall by increasing infiltration, soil-water-holding capacity, focusing runoff, and reducing evaporation and transpiration. The major concern is interstorm droughts that waste human labor. Seedlings sprout but dry out and die in between storms. For food security, a multiple crop strategy is standard within the Sahel and transition zones. Drought-resistant varieties also increase the efficiency of rainfall utilization. It is not yet clear that an early warning system can profitably help rainfed farmers avoid planting risks.

Further discussion of rainfall variability and its impacts on production systems occurs below and in Section 2.1.2.

CARTE DES PLUIES ANNUELLES
MEDIANES 1950 - 1967

MEDIAN ANNUAL RAINFALL 1950- 1967

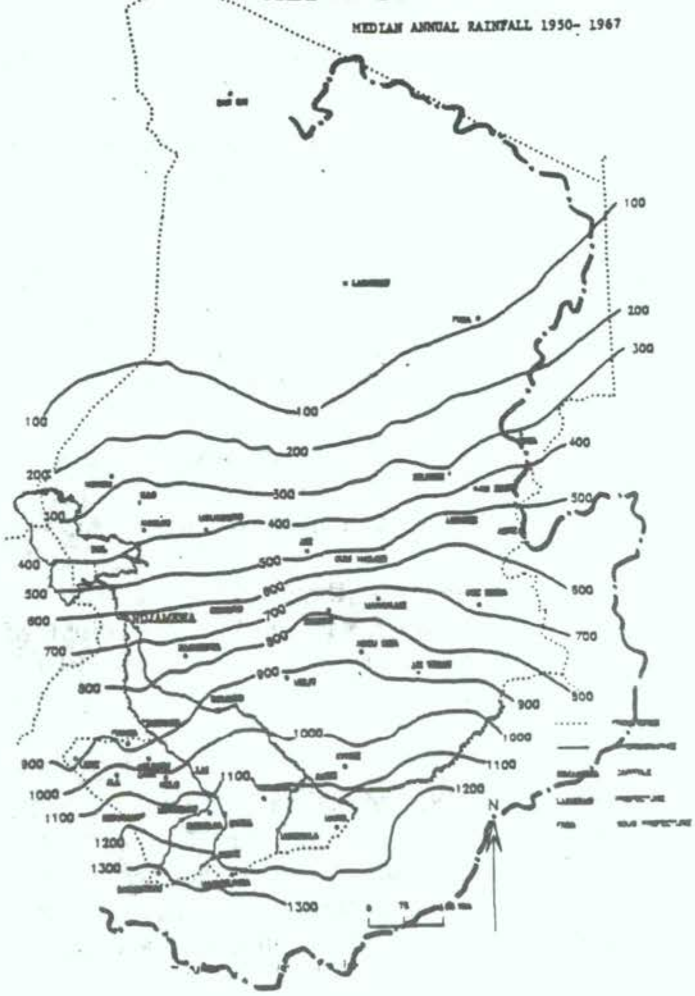
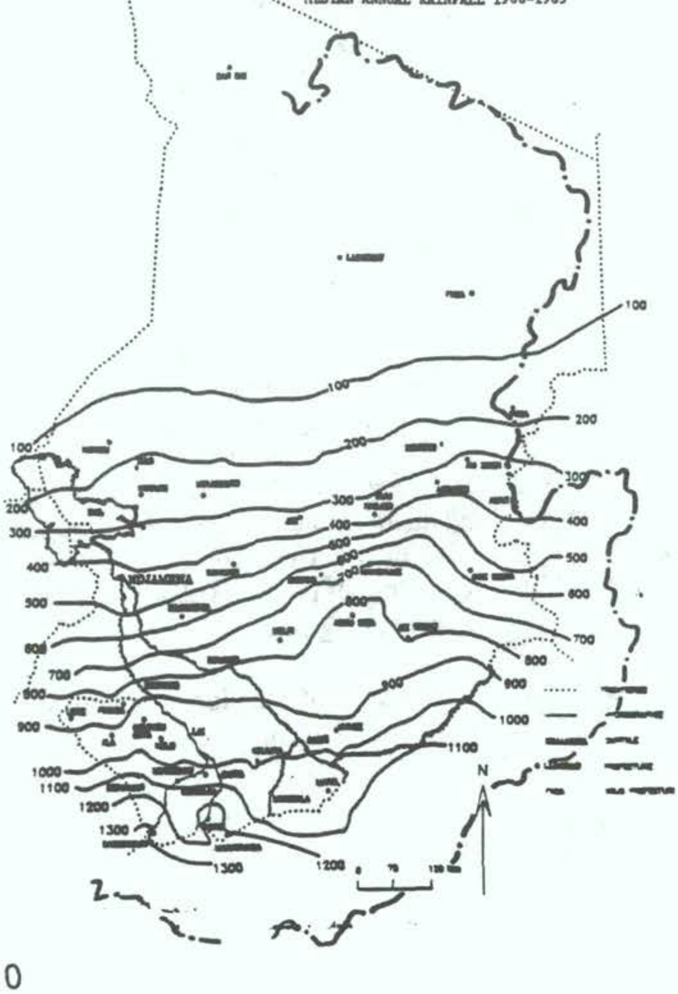


Figure 1.6
CHAD ISOHYETS FOR WET
AND DRY YEARS

CARTE DES PLUIES ANNUELLES
MEDIANES 1968 - 1985

MEDIAN ANNUAL RAINFALL 1968-1985



CARTE DES PLUIES ANNUELLES NORMALES
MEDIANES 1951 - 1980
AVEC DES CUMULS PLUVIOMETRIQUES ANNEE 1984

MEDIAN ANNUAL RAINFALL 1951-1980 WITH THE ANNUAL TOTAL RAINFALL FOR 1984

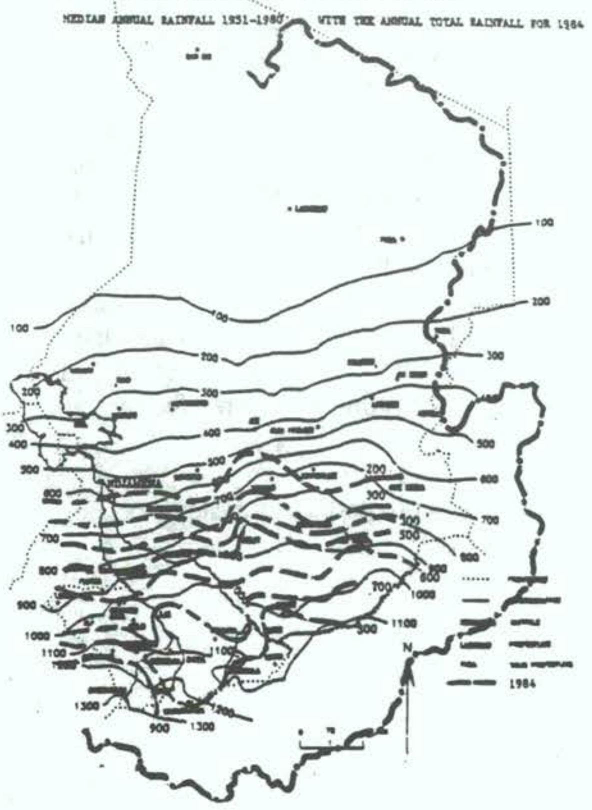
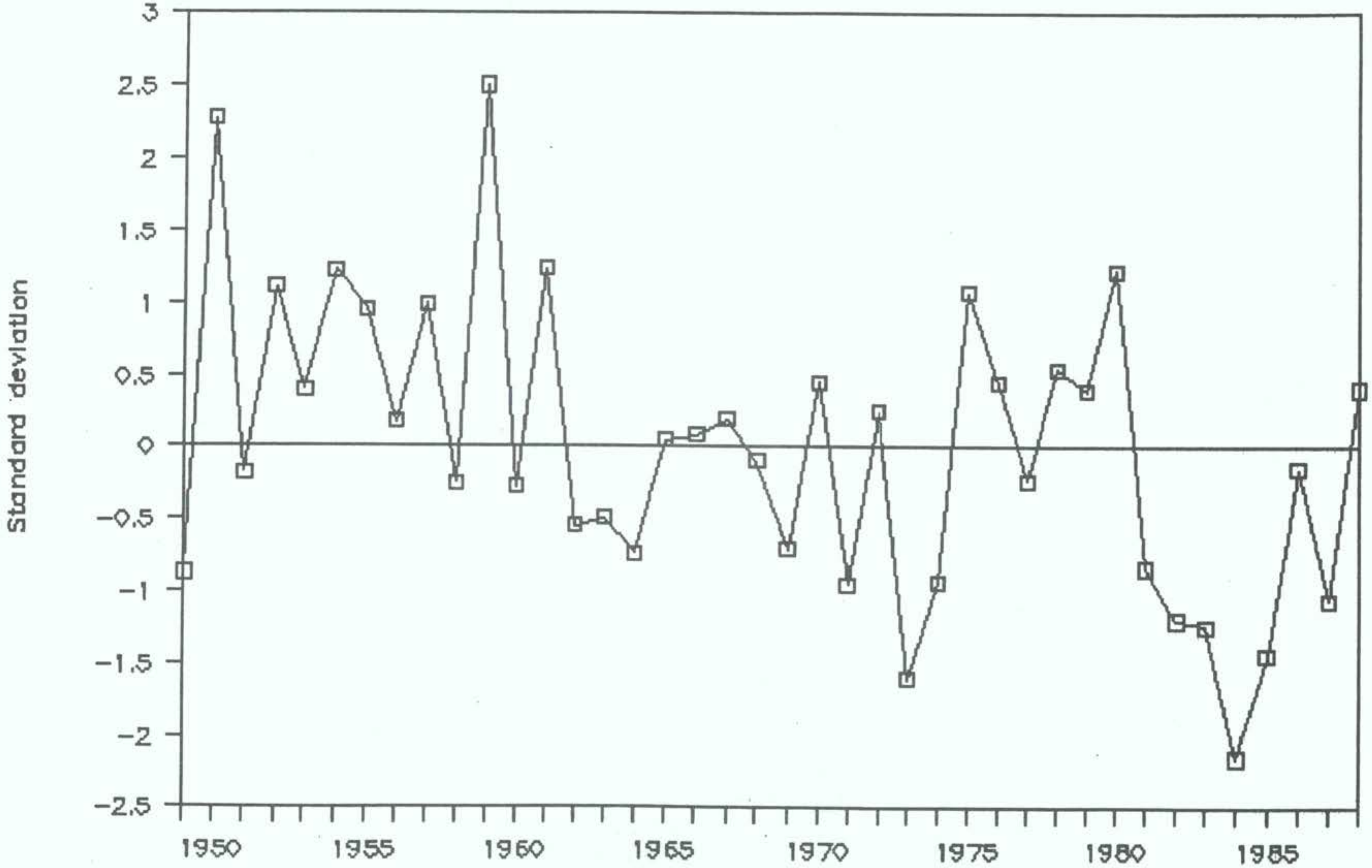


Figure 1.7
ANNUAL RAINFALL AT
NDJAMENA



TEMPERATURE

Low rainfall is accompanied by excessively high temperatures in all arid lands. The annual trend of temperature extremes is moderated by the onset of the rainy season producing, in the Lake Chad Basin, two annual hot-peak periods. The first, and somewhat higher peak, occurs before the onset of the rainy season. The second occurs just after the rains stop. During years of sparse cloud cover, the impacts of higher temperatures are more severe. No work correlating cloud cover, atmospheric dust, and ground temperatures could be found.

Exceptions to the temperature model occur in the most southern parts of the basin, where the rainy season extends considerably into the period of cooler weather. Although the annual means do not vary much throughout the basin, the increase in the mean temperature amplitude (Tmax - Tmin) from south to north is characteristic of the change from the Guinean to the Saharan climatic zone.

The major concern form high temperatures is their impact on evaporation and transpiration rates in plants, especially crops. Secondary concerns include increased fire hazard and accelerated reduction of standing water for livestock. Strategies to reduce the impacts of high temperatures include maintenance of high air humidity by reduction of wind and increased shading. In Lake Chad, increased and long-term high air temperatures impact the dissolved oxygen levels of the lake and, in extreme, can cause fish die-offs. The reduction of water volume by evaporation increases salinity, which also reduces fish habitat. There are no human solutions to these events.

HUMIDITY

Relative air humidity, used to assess the evaporative demand of the atmosphere (high values indicate low evaporation) is influenced by two factors: the advance and retreat of the rainbelt and the large bodies of surface water. Highest values consistently coincide with the peak rainfall months. For example, in August, the lowest average value of 84 percent was recorded at Nguigmi, a station with very low rainfall. Lowest values occur during the dry season, generally in February or March; the smallest, 11 percent, being the mid-day average at Ndjamena for both months (FAO, 1972). However, the monthly, daily, and even hourly variability of air humidity is substantial.

Control of air humidity on farmland is a major conservation goal. The higher the air humidity, the less crops transpire and the more water is conserved. On irrigated land, high air humidities can save pumping costs, and human labor and help reduce salinization. Wind breaks and living fences are typical techniques to increase local air humidity.

WIND

The dry season in the Lake Chad Basin is characterized by hot and dry winds from northeasterly directions (Figure 1.8). In the rainy season, the southwesterly monsoon winds are predominant. For the Lake Chad region, wind speed data and directional frequency analyses are given, among others, in the SCIP feasibility study (MacDonald, 1973).

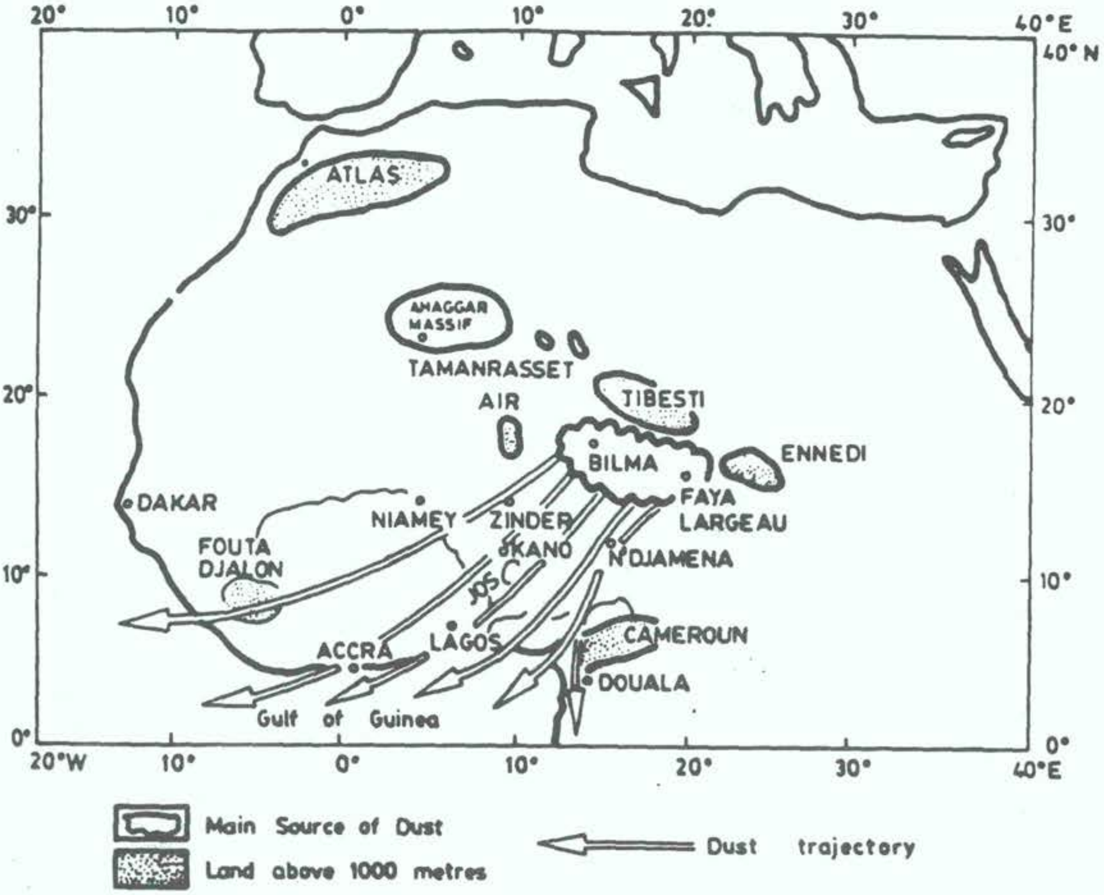


Figure 1.8
SAHARAN DUST TRAJECTORIES
ACROSS WEST AFRICA
TRAJETS AERIENS DE LA
POUSSIERE SAHARIENNE

Wind can be both beneficial and harmful. Its benefits include wind pollination of grasses, oxygenation of lakes (ie., stirring up lake nutrients and sediments, increasing biogeochemical turnover), and, during the rainy season, increased air humidity (by providing cool and wet air masses).

Wind is harmful to human production systems when it is dry and hot and sucks up soil moisture, stresses plant water balance, reduces air humidity, mobilizes soil fines (eolian erosion), accelerates dune movement, and causes abrasion of plants with wind-born sand. Many techniques are available to help minimize the harmful impacts of hot, dry, and powerful winds.

EVAPORATION FROM A FREE-WATER SURFACE

This hydrometeorological parameter is of particular importance in the Lake Chad Basin and its quantification is essential for all water balance investigations. Its value depends on all hydrometeorological factors discussed so far (including solar radiation), but direct measurement of evaporation raises a number of well-known difficulties. The FAO (1972) study gives data on mean monthly and yearly total evaporation from stations located in Ndjamena, Bol, Lai, Maidiguri, Nguigmi, Maine-Soroa, and Zinder. However, there are considerable variations between the stations and between measurement instruments used at specific stations. For example, at Ndjamena the annual figure of 2,263 mm given by Piche evaporimeter (ORSTOM) is to be compared with sunken pan figures of 2,510 mm (Pan S) and 2,834 mm (Pan A), and, if the Penman equation is to be accepted as most accurate, evaporation is 2,362 mm.

An average annual evaporation from the surface of Lake Chad was estimated by ORSTOM to be 2,150 mm, with the mean monthly values from January to December being 150, 152, 148, 137, 158, 180, 180, 190, 194, 311, 228, and 132 mm, respectively. In the SCIP feasibility study (MacDonald, 1973), the average value of 2,290 mm was used.

In all Lake Chad water balance models, evaporation is one of two key variables, along with lake inflow from the Chari and Logone Rivers. This model needs more thorough investigation based on field measurements in different hydrometeorological conditions. Every 100 mm of evaporation from the water area of 10,000 km^2 means a loss of 1 km^3 of water. Therefore, accuracy of all water balance calculations depends fundamentally on evaporation estimates. Recommendations made in 1972 (17 years ago!) by FAO to set up permanent evaporation measuring stations in the lake are still a high research priority.

Evaporation is important in preventing heat stress in plants and animals and in cooling soil and lake surfaces. Evaporation is a "cost" paid by living creatures to maintain their heat balance. On the other hand, evaporation removes water from the possible production of plant biomass and fish. The unnecessary loss of water by evaporation is a major environmental concern. Evaporative losses from artificial reservoirs (especially shallow reservoirs with large surface areas) as well as from overirrigation have not been adequately addressed within the basin.

TRANSPIRATION

In the Sahel and Sudanian zones, transpiration is about 10 to 30 percent of total evapotranspiration. The potential evapotranspiration can be defined as a "measure of the transpiration rate from an extensive short green cover completely shading the ground and adequately supplied with water" (FAO, 1972). This is not a very useful definition for the basin. Most recent potential evapotranspiration rates calculated with the Penman Formula for several stations in the Lake Chad Basin are given by FAO (1984). For example, annual totals for Bol and Ndjamena are 2,079 mm and 1,788 mm, respectively. Approximately one-third of the annual values correspond to the growing season of rainfed crops (July to October), one-third to the winter season of irrigated crops (November to February), and the remaining one-third to the rest of a year (Figure 1.9).

Transpiration is a necessity of all plant life. In order to grow, soil water must be utilized and "exhaled" as vapor. In order to decrease heat stress, leaves transpire as a cooling mechanism. Water, as water vapor, is less useful to farming and pasture and forest production than water in its liquid form. Therefore, a major goal is to increase production while, at the same time, minimizing transpiration.

Nature has already evolved many processes to reduce transpiration, especially the evolution of C3, C4 and CAM metabolism in plants. This genetic diversity has yet to be fully utilized by water conservation planners. In addition, increased air humidity has long been recognized as a method of reducing transpiration losses. On the other hand, improper application of fertilizers can cause accelerated growth rates and transpiration. This is a waste of soil water that can also lead to crop failure because of "fertilizer-stimulated" drought at the time of seed formation. Broadly speaking, natural rangeland transpires 1 mm per day during the growth period. Fertilized and irrigated cropland transpires 4 mm per day (i.e., 200 kg of water for each kg of dry matter).

Better understanding of the evapotranspiration processes in the lake and floodplain regions is crucial for all water balance computations and comparative cost/benefit analysis of water projects. Transpiration and evapotranspiration are "water costs" within production systems. They are a cost required to grow pasture, floodplain crops, trees, and fish habitat. In this sense, they are not a water "loss" as used by many agricultural engineers in water balance equations. The floodwaters serve the identical role as irrigation water in crop growth.

The goal in both floodplain manipulation and irrigated agriculture is to flood the soils in an appropriate manner—maximum production, minimal excess water, adequate salt leaching, etc. Since natural irrigation supports four to five production systems (recession agriculture, pasture growth, fish production, forest production, and wildlife tourism) vs. irrigated agriculture that, at the moment, supports one or two, it is important to understand how water is being "spent" (transpired) before diverting it to other uses.

SURFACE WATER RESOURCES

For all practical reasons, surface water resources do not exist north of Lake Chad owing to the extremely low rainfall, high evaporation rates, and high infiltration capacity.

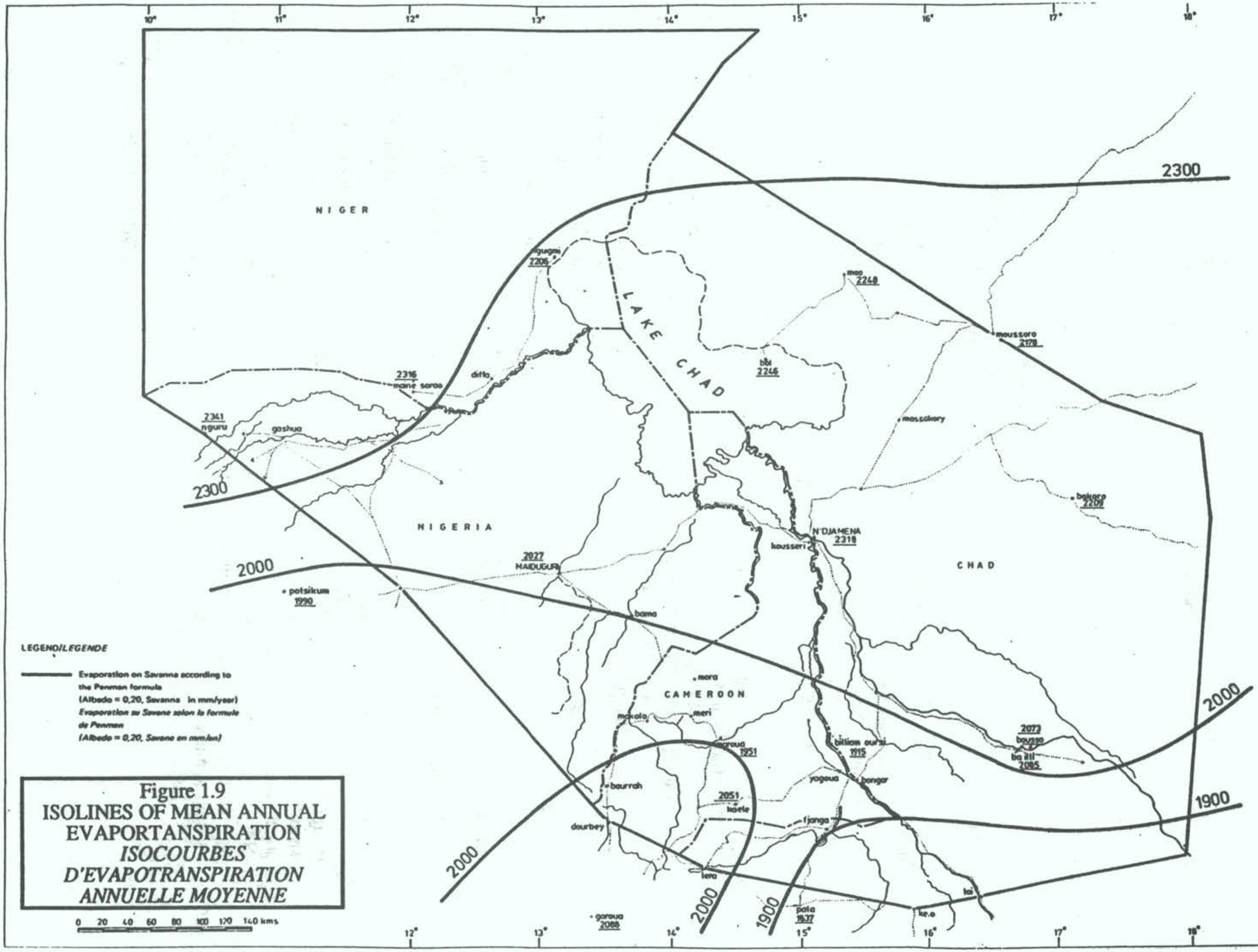


Figure 1.9
ISOLINES OF MEAN ANNUAL EVAPORTANSPIRATION
ISOCOURBES D'EVAPOTRANSPIRATION ANNUELLE MOYENNE

The main collection areas for water which feed the lake are:

- upper catchment of the Chari River rising in the Central African Republic and southeastern Chad, in particular the Bahr Sara tributary which joins with other tributaries downstream of the city of Sahr.
- upper catchment of the Logone rising in the Central African Republic and Cameroon and converging at Lai.

The lower reaches of these rivers act as dispersal zones in which uncontrolled irrigation and flood recession cropping is widely practiced. In these zones considerable overspills and evaporation take place.

The third largest river system in the Lake Chad Basin is the Komadougou Yobe. Its headwaters rise in the Kano-Jos highlands of Nigeria, but the flow arriving at Lake Chad does not exceed 1 percent of the total lake inflow.

In addition, two seasonal streams form Nigeria, the Yedseram, and the Ngadda, discharge a very small volume of water into the lake. Two other important streams, which feed the lake, are El Beid, discharging largely the overspill from the Logone via the Grand Yaeres, and Serbewel, an effluent stream from the Chari River.

Surface water resources of the Lake Chad Basin are discussed in detail in Part 2 of this report.

GROUNDWATER RESOURCES

The Lake Chad Basin has been a structural depression since early Tertiary time, and has been a locus of subsidence and sedimentation rather than erosion. The area is tectonically active. There are two broad troughs in the basin. The Tibetsi-Cameroon trough trends NE/SW and the Air Chad trough trends NW/SE. The cross point between the two is Lake Chad (Furon, 1960.).

Although many boreholes have been drilled in the area for urban and rural water supplies, exploratory drillings for oil, feasibility studies for various projects, etc., the data available are still not sufficient to resolve several controversies that have arisen over the hydrogeology of the basin. The youngest of the sediments are known as the Chad Formation, which contains the principal and most exploited aquifers of the basin. There is general agreement (Hanidu et al., 1989), that the Upper, Middle, and Lower Zones of Chad Formation are geologically different and they should rather be considered as Quaternary Deposits (with the phreatic aquifer), Lower Pliocene, and Continental Terminal (both with artesian aquifers of the same names), respectively. In fact, the same names have already been used by the FAO (1973) survey. A plan and three geological sections across the central and western parts of the basin are presented in Figure 1.10.

The thickness of Quaternary Deposits varies from 30 to 100 m but locally may reach 180 m. The phreatic aquifer is not continuous all over the basin area, and recharge conditions are poor. Natural recharge occurs not so much by infiltration of rainwater but rather through influent seepage from seasonal streams and perennial rivers that transverse the area. It is indicated by clear correlation of stream discharge with groundwater table fluctuations.

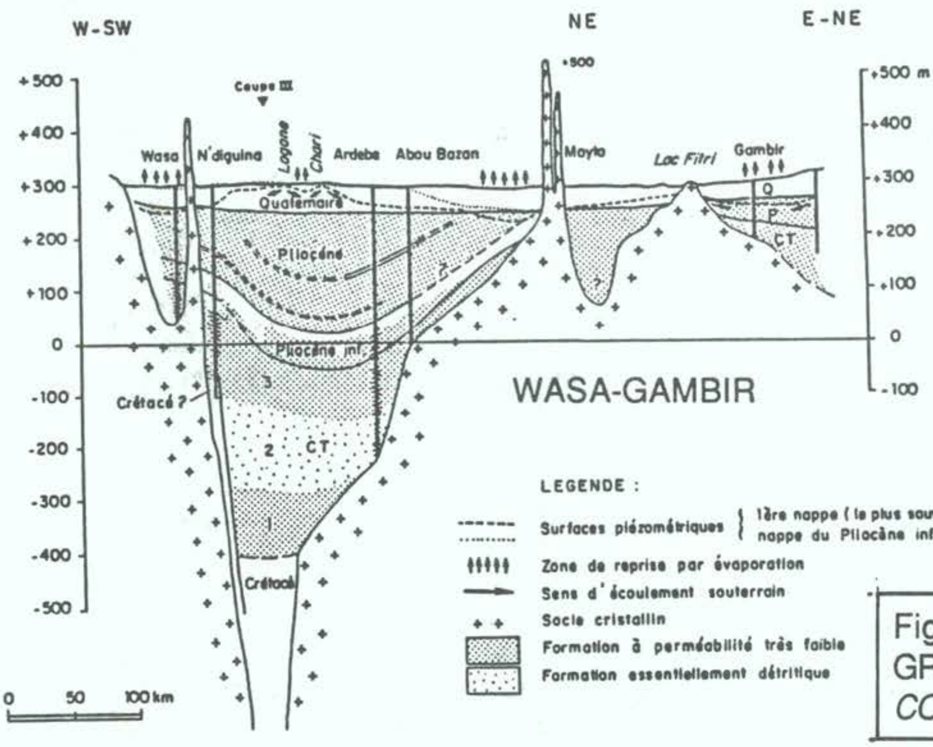
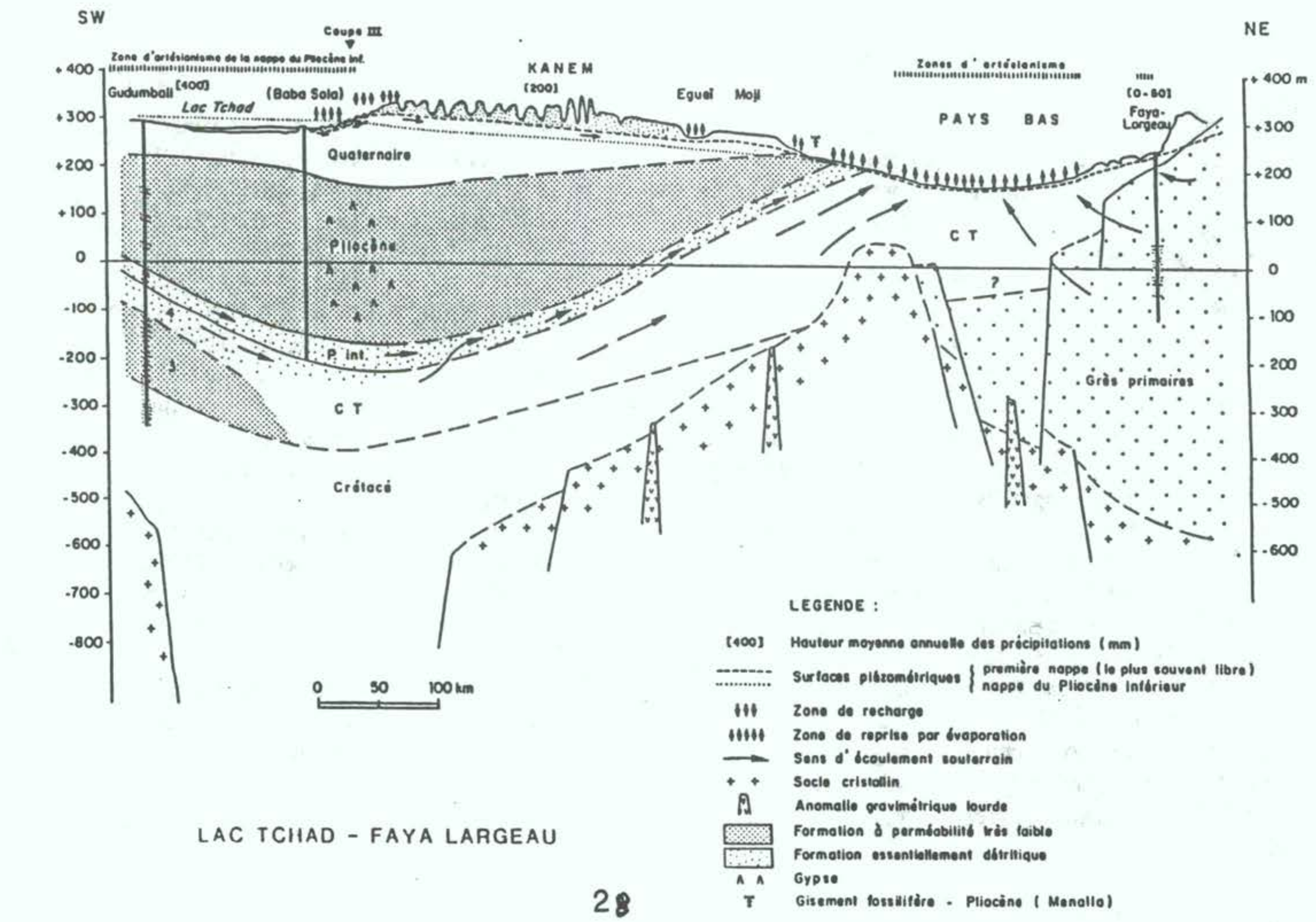
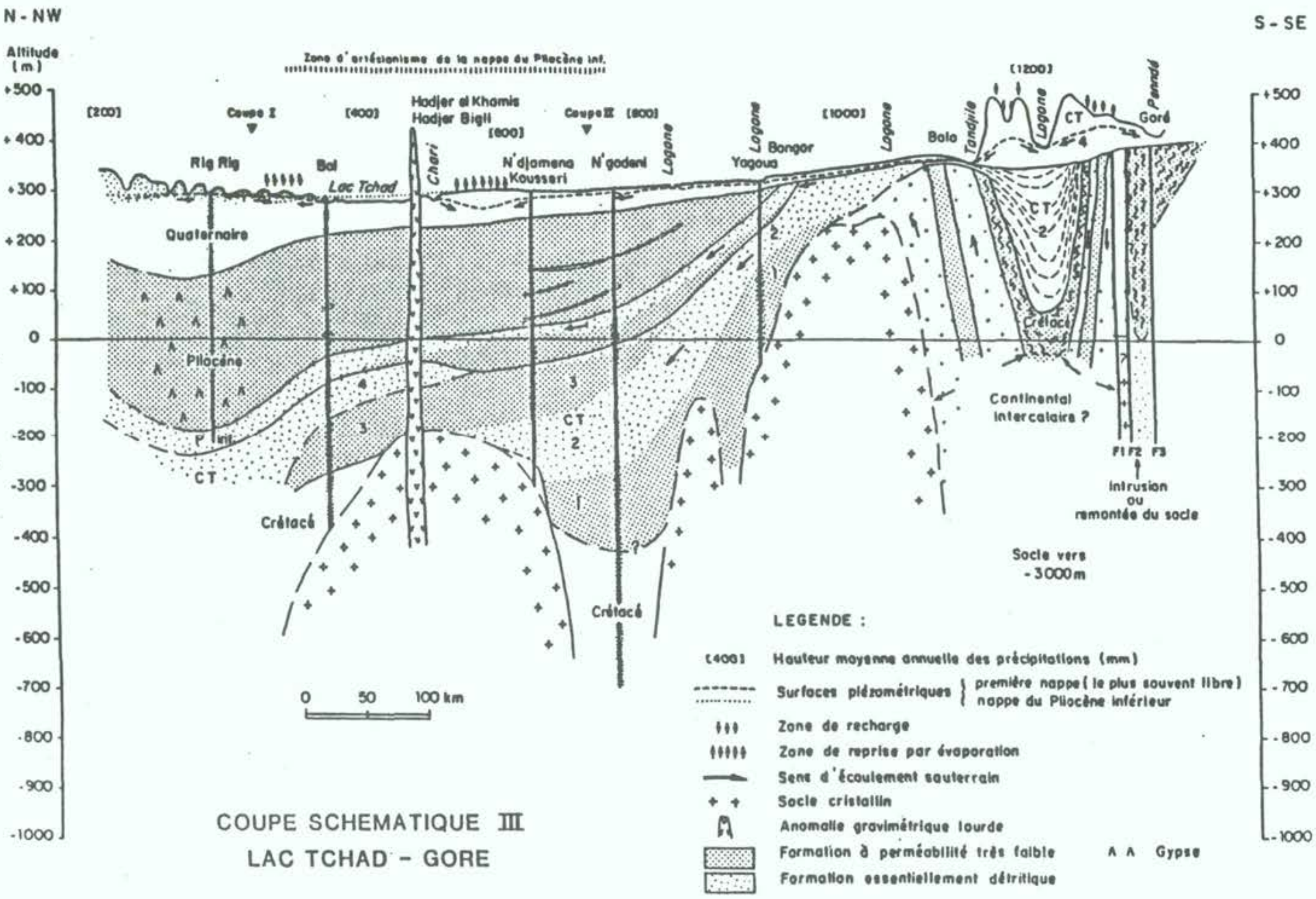
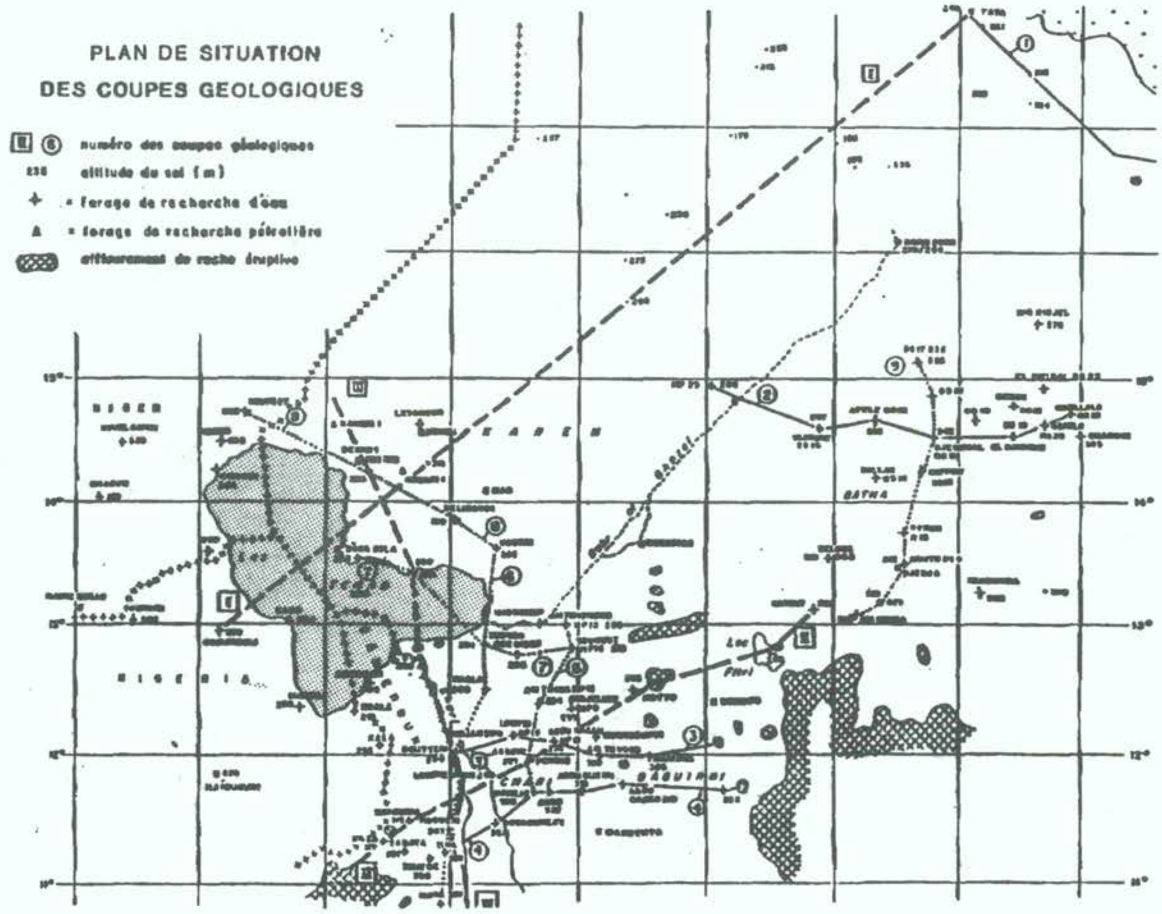


Figure 1.10
GROUNDWATER CROSS-SECTIONS
COUPE SCHEMATIQUE





COUPE SCHEMATIQUE III
LAC TCHAD - GORE



PLAN DE SITUATION
DES COUPES GEOLOGIQUES

The Lower Pliocene deposits are at least 200 m thick and contain one of the largest aquifers in the basin. The depth to the top of the aquifer varies between 150 and 400 m below ground level. Its total area is unknown, its extension to the northeast is undefined, and there are doubts as to the position of its southeastern edge. The surface area of the zone of artesian activity can be estimated at 87,000 km², of which 25,000 km² is occupied by Lake Chad (FAO, 1973). Understanding of how it functions is very incomplete (BRGM, 1986). The fact that its recharge is questionable (no visible outcrop) was noticed in the early days of its exploitation (e.g., Miller et al., 1968). But until the end of the 1960s, the rates of withdrawal were so low that no significant areal decline in artesian head has been observed.

The BRGM (1986) study illustrates the order of magnitude of groundwater resources of the Quaternary Deposits and Lower Pliocene deposits. For the Chadian part of the geographical basin only, mean annual recharge is estimated to be 3.6 x 109 m³ per year, while volume of exploitable reserves is somewhere between 94,600 and 206,010 x 109 m³. Compared to the volume of surface runoff (e.g., Chari River flowing on average about 36 x 109 m³ annually through the Ndjamena profile) it is clear that natural recharge of these aquifers is quite limited. The same source provides an estimate of the total mean annual recharge of all groundwater aquifers in Chad as 20.6 x 109 m³ per year.

The Continental Terminal deposits, usually encountered between 450 and 620 m from the surface, extend from Niger and Nigeria far into Cameroon and Chad. They contain a very extensive artesian aquifer, which is recharged in southern Cameroon and Chad. Yields in these two countries are unfortunately poor, contrary to Nigeria where the aquifer is heavily exploited and where serious declines in head have been noticed (up to 6 m per year). Also in the case of this aquifer, BRGM (1986) points out that its knowledge is very sketchy.

Vertical communication between all three aquifers appears to be very limited. Water quality is generally acceptable both for village and livestock use. The chemical qualities of water from the artesian aquifers make its use for irrigation purposes difficult (high values of residual sodium carbonate, aggressivity; Figure 1.11).

The Continental Terminal deposits overlay five major Cretaceous formations (Kerri-Kerri, Combe Sandstones, Fika Shales, Congila and Bima Sandstones) exposed by recent oil explorations at depths of 2,700 to 4,500 m. These sedimentary successions are laid on the Basement Complex platform.

The Kerri-Kerri formation is about 200 m thick, has an outcrop near Potiskum in Nigeria, and, according to one of the unconfirmed hypotheses, it recharges the Continental Terminal and Lower Pliocene aquifers from underneath. The Combe Sandstone has a maximum thickness of 350 m ,which thins down towards Lake Chad. They form good aquifers in the outcrop areas. Concerning lower formations, the available data are not yet sufficient for the quantification of the aquifer characteristics (Hanidu et al., 1989).

Major groundwater concerns include maintenance of flow in rivers to allow phreatic water table recharge; determining the extent of "fossil" water vs. rechargeable water; reserving groundwater for dry-years in order to prevent lowering of the groundwater table; increased pumping costs from lower groundwater; application of groundwater with high ion concentrations to irrigable farmland; and pollution risks in major urban areas.

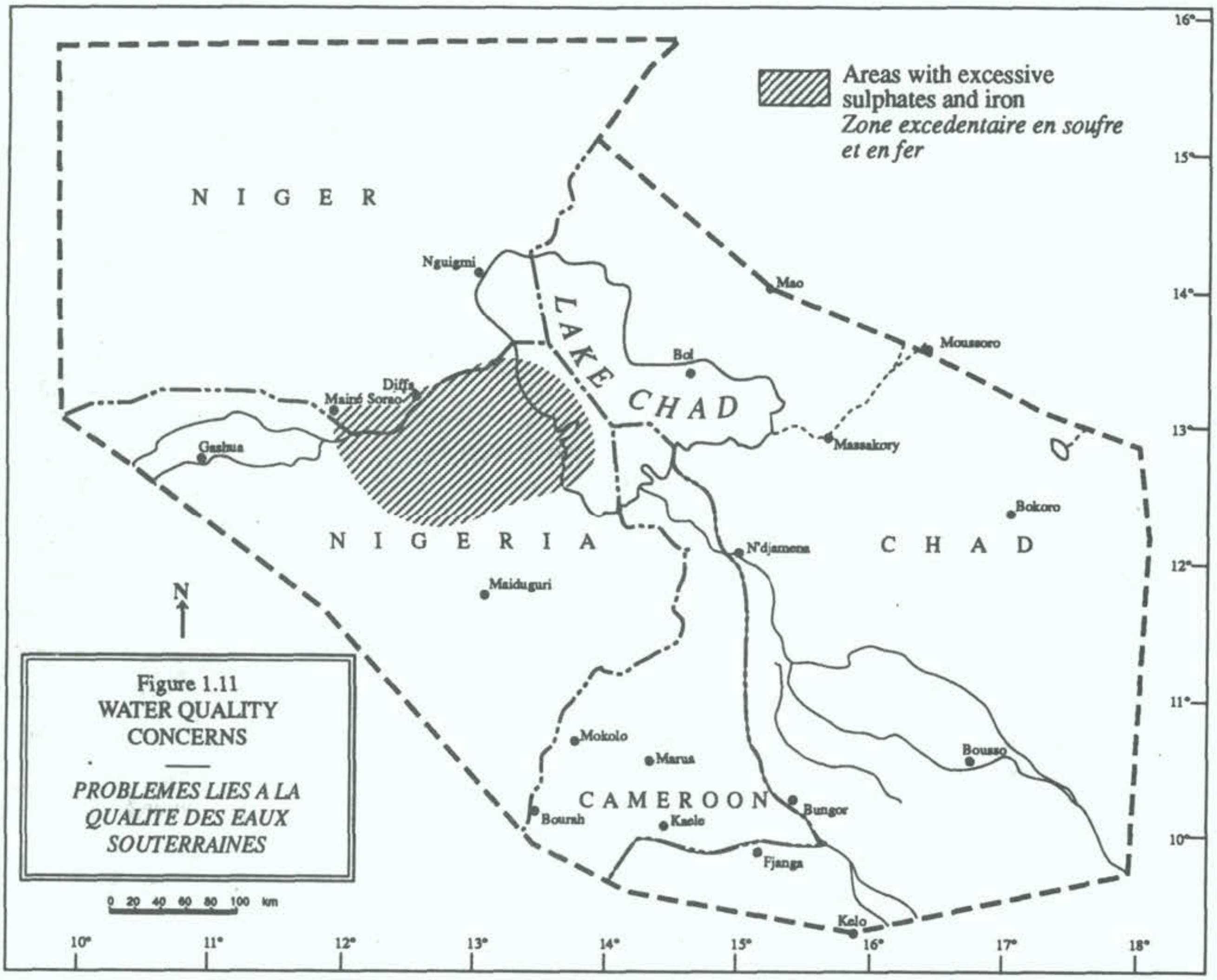


Figure 1.11
WATER QUALITY CONCERNS

PROBLEMES LIES A LA QUALITE DES EAUX SOUTERRAINES

1.4.3 Human Resources and Environmental Concerns

ETHNIC AND INSTITUTIONAL AREAS

The conventional basin exhibits a socio-historical unity based on a history shared by the established population groups, some of which straddle national boundaries. Many trading circuits remain controlled by the groups who have long considered them their specialty (e.g., the Hausa and Kanuri). The main languages used in the area reflect the political roles exercised during the pre-colonial period: Kanuri (Niger and Nigeria), Fulfulde (Niger, Nigeria, Cameroon), and Arabic (Chad). The old Islamicized states (Kanem, Bornou, The Peul Empire of Sokoto, Wadai, and Baguirmi) are largely responsible for the present distribution of populations in the conventional basin, including the small groups that took refuge in the Mandara mountains and the Mayo Kebbi regions. Altogether there are more than 70 ethnic groups in the basin, each exploiting the natural environment in a slightly different way (Figure 1.12).

Today, however, the status of conservation and development is more dependent on practices and policies in the member states than on shared natural and human resources. Niger and Chad speak French. Nigeria speaks English. Cameroon is officially bilingual but, within the conventional basin, French predominates. Only a few institutional options are common across the member states. For example, all of the states have opted for a state-led development and natural resources control policy.

INTERNATIONAL POLICY CONTEXT

The Lake Chad Basin Commission was set up in 1964 to regulate and coordinate water use schemes within the basin. Neither land, pasture, nor forestry resources are covered by the Lake Chad Basin Commission Convention. Use of water resources of the lake was founded on:

1) the Chad Basin Convention, signed in 1964;
2) the Statute relating to the development of the Chad Basin, annexed to the Convention; and
3) Agreements on Water Utilization and Conservation in the Lake Chad Basin.

The Convention established the LCBC as a coordinating body for information exchange and development in the conventional basin.

The Statute recognizes the customary law of each state to use part of the basin's water resources and provides for unilateral exploitation of the lake resources so long as it does not adversely affect the interests of other states. Member states agreed to consult within the LCBC prior to initiating water development projects likely to effect the flow of waters in the basin.

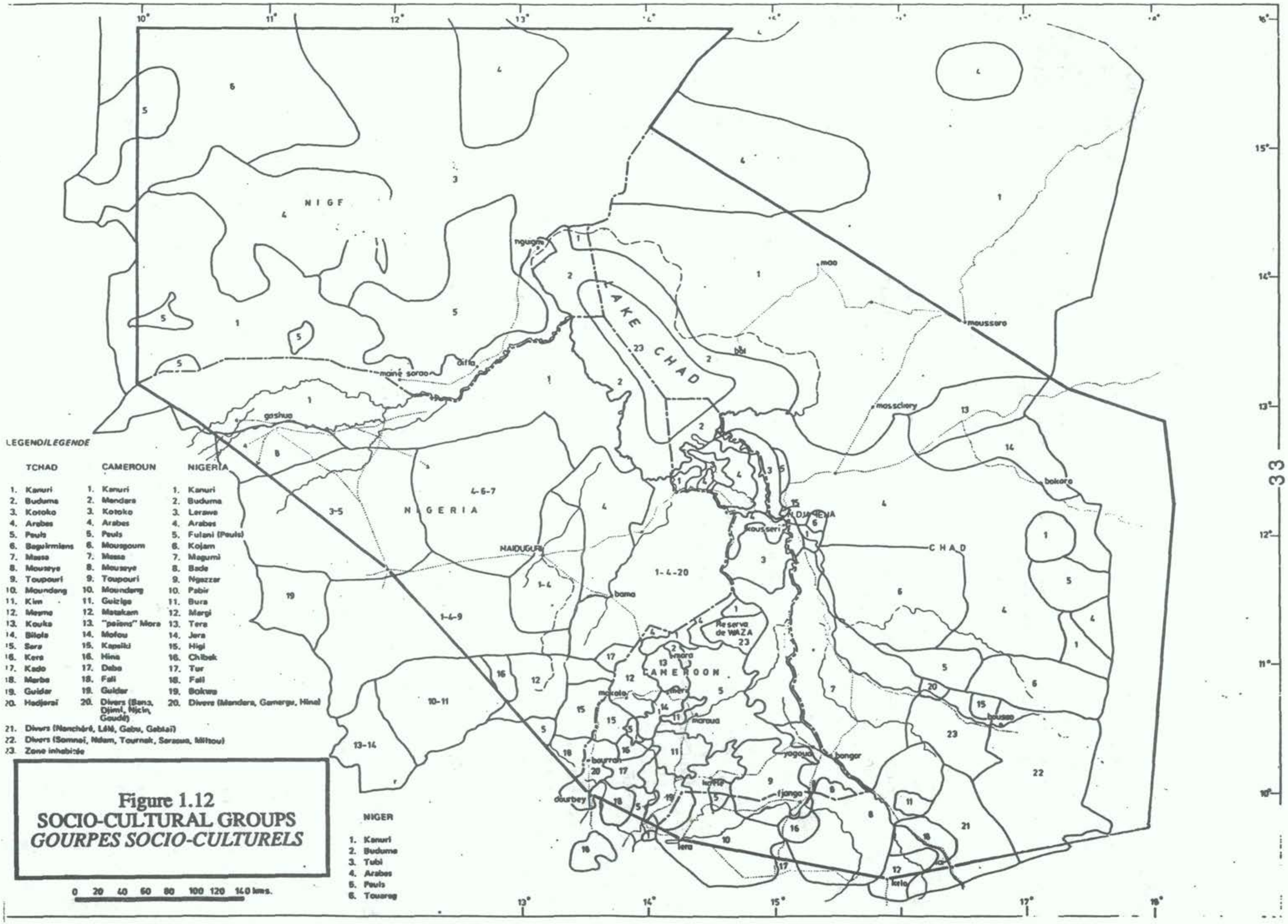


Figure 1.12
SOCIO-CULTURAL GROUPS
GOURPES SOCIO-CULTURELS

The agreement provides that each member state is entitled to a "reasonable and equitable share" in the beneficial use of the water resources of Lake Chad. However, international law holds that there is only a good faith obligation to negotiate informal accords on the use of shared water resources. The concepts of equitable share and equitable utilization are not always interpreted to mean that the parties are at par in the use of the natural resources of the lake.

The agreement indicates that each riparian state is allowed to use the water as it sees fit providing it does not wantonly disrupt co-riparian development. Water is available on a first come, first use basis. A state is not allowed to let its future aims prevent the immediate needs of other states from materializing simply because of financial or technical handicap.

The member states are obliged to take reasonable measures to ensure the conservation of water resources within the basin, to maintain natural flows and quality, to prevent misuse or pollution, and to plan projects in a manner conducive to integrated development of the conventional basin as a whole. Further, the agreement allows for the payment of compensatory damages if the damage is one that is subject to compensation under international law. The LCBC is mandated to see that member states comply with the rules in the agreement.

Subsequent developments sometimes seem to violate the spirit if not the letter of these agreements. Irrigation schemes along the Hadeja-Jama'are and Yobe Rivers in Nigeria do not fully take into account the ecological or economic impacts these catchments have upon downstream flows in either Nigeria or Niger (e.g., see Schulz, 1976).

The Moundou Agreement between Chad and Cameroon signed August 20, 1970, specifies limits of water level changes in the Logone permissible with the creation of control structures. Subsequent negotiations modified this agreement to reflect the realities presented by the construction of SEMRY II in the mid-1970s. Adherence to these agreements is voluntary, given the absence of an effective international monitoring or sanctioning body. In short, overall coordination of irrigation development plans between countries is minimal at present and probably will remain so unless adherence to a common plan and monitoring scheme can be agreed upon.

At the 24th session of the LCBC in 1977, the four member states adopted the Agreement on Common Regulation of Flora and Fauna. The accord contains provisions on means and methods of hunting and fishing, regulation of trade, improvement of resources, and collection of statistics. Lack of effective regulatory bodies limits the effectiveness of these resolutions.

NATIONAL ANTIDESERTIFICATION PLANS

Three of the four member states have adopted national plans to combat desertification upon the recommendation of the CILSS. Nigeria has sponsored several important conferences on desertification, which clarify the point of view of its government on these issues. These documentary resources provide an important point of departure for development of a basinwide strategy. Public management of the environment is taken as a given by the strategy statements (Table 1.2).

TABLE 1.2
ANTIDESERTIFICATION FEATURES IN NATIONAL STRATEGIES

1) recognition that aridity and drought cycles are normal and permanent conditions (Chad);
2) recognition of need for integrated approaches to natural area development (Cameroon, Chad, Niger);
3) recognition of importance of preservation of biological diversity (Cameroon);
4) accent on village or local area territory management (Cameroon and Niger);
5) accent on integration of antidesertification measures with production increases (Cameroon, Chad, Niger);
6) accent on integration of antidegradation measures into existing projects (Cameroon, Chad, Niger);
7) natural forestry management (Niger);
8) accent on perpetuity and long-term commitment to antidegradation efforts (Cameroon, Chad, Niger);
9) emphasis on extension of available knowledge (Niger)

The antidesertification plans generally focus on physical problems by sector. There is little emphasis on multidisciplinary strategies or on strategies to meet the needs of the majority of rural people for secure and sustainable livelihoods and assured access to resources. Incentives to manage natural resources are overly general or nonexistent. Furthermore, the plans neglect the issue of reducing human vulnerability to periodic drought of varying degrees of severity. Other significant gaps in the antidesertification plans are:

1) insufficient attention to direct transfer of technical and managerial competence to and between resource users;
2) overemphasis on "protection" as opposed to resource use with regeneration through proper management;
3) insufficient appreciation of flexibility and rationality of traditional resource-use systems and the need to integrate traditional and modern management approaches;
4) analysis by ecozones rather than subbasins and watersheds;
5) overemphasis on settling pastoralists and livestock, although temporal and spatial flexibility is one of the principle adaptations to climatic cycles;
6) inattention to genetic diversity of wild and domesticated flora and fauna (Niger);
7) lack of attention to the problem of localized population pressure (e.g., urban centers, Mandara Mountains);
8) apparent lack of admission that drought is a permanently recurring condition and that increased aridity may last for decades (Cameroon and Niger);
9) lack of emphasis on extension of available techniques and experiences from other Sahelo-Sudanian countries, such as Burkina Faso, The Gambia, Mali, Mauritania, and Senegal;
10) absence of discussion of inter-regional coordination in the antidesertification effort.

INTERNATIONAL AID

Annex B presents a list of selected development projects in the conventional basin. It is not exhaustive, certainly overlooking some of the smaller projects financed by NGO's. The table helps to evaluate the degree to which the funding agencies have paid attention to sustainable natural resources management.

Funding sources have paid the most attention to water resources. The development of groundwater and surface water resources for agriculture and human and animal consumption has been their primary concern. The resource has been treated in isolation from other resources, and the environmental impacts of water resources development have generally been neglected. Domesticated germ plasm, especially foreign cultivars destined for export production, such as wheat, rice, groundnuts, and cotton, has received the next largest allotments of donor moneies. Conservation and development of native ligneous species have received little attention from donors. In addition to development projects directly concerned with natural resources, donors have also paid some attention to policy dialogue and research. Policy dialogue has helped to produce the national antidesertification plans and the transfer of some management responsibilities from bureaucrats to local resource managers. Research conducted by international and national research organizations has begun to pay some attention to natural resources management, especially agro-forestry, and, to a lesser extent ,soils management.

Environmental monitoring, environmental education, training in resource management and natural conflict resolution, policy dialogue devoted to delegating resource management authority to the local level, and regionalizing resource management policies have not been addressed and these oversights contribute to environmental degradation.

SOCIOECONOMIC CAUSES OF ENVIRONMENTAL DEGRADATION

The economy of the conventional basin is characterized by a diversity of economic activities managed by the large number of distinct ethnic groups living in the basin. But these ethnic groups are not isolated. Changes in identification with an ethnic group creates great economic flexibility (Lambezat, 1961).

The economy of the basin is also characterized by flexibility, spatial and temporal mobility into and out of particular activities, and lack of assets, savings, or food security. Wetlands, essentially Lake Chad, smaller lakes, the rivers, and other seasonal water courses, provide drought fallback reserves. Wetlands are the only natural insurance besides public aid, mobility, and job-switching. In the past, extensive resource use was the rule in the conventional basin since extensive, low resource use technologies predominated. The Mandara Mountains constitute an exception. Intensive soil and water management was and still is practiced.

Dryland agriculture, recessional and irrigated agriculture, pastoralism, fishing, gathering of mineral resources and plant products, and trade in products continue to dominate the economy of the conventional basin (Figure 1.13A). During the best of times, the human ecosystems in the basin produce a surplus of complementary products for trading, ranging from natron, firewood, and construction materials, and medicines to cereals, meat, and fish. Intrabasin trade is critical to regional development, although no systematic study of its dimensions nor value has come to our attention.

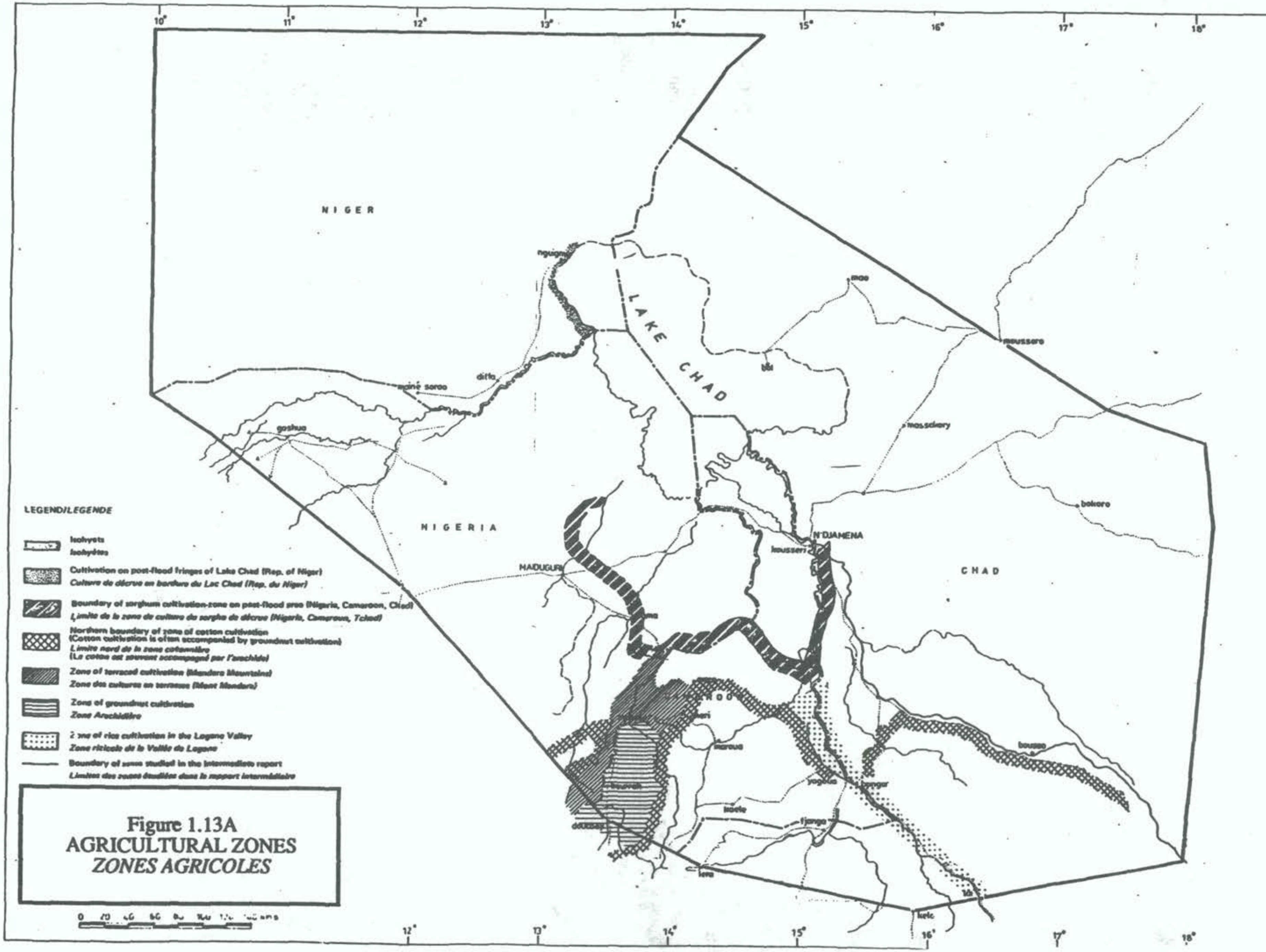


Figure 1.13A
AGRICULTURAL ZONES
ZONES AGRICOLES

Thirty years ago, a seasonal, north-south trade in gum arabic (*Acacia senegalensis*) was significant in the northern subbasins (e.g., Yobe, Termit Sud, Kanem) of the conventional Lake Chad Basin. For example, over 800 metric tons (T) were exported from the lower Yobe basin alone in the late 1950s. In the predrought period, some 120,000 T of fish were caught annually within the Logone-Chari basin and the southeastern part of Lake Chad. In the late 1950s, some 55 T were taken from the lower Yobe basin during the fishing season (Anon, 1958). Significant amounts of fish are still traded to Maiduguri and Maroua from fishing stations along the Logone and Chari Rivers and from the lake itself. The export of natron and salt from the northwest of Lake Chad to other regions is ages old. Niger and Chadian livestock are a crucial source of protein to the people of Nigeria and Cameroon. Studies of animal protein intake indicate, however, that fish from Lake Chad and the rivers, especially the Chari and Logone, contribute to decreasing chronic animal-protein shortages in Cameroon (Thys, Dineur, and Magis, 1984). Forty percent of the conventional basin's fish catch was consumed in Nigeria, 33 percent in Chad, and 26 percent in Cameroon (UNDP, 1979). There has been no evaluation of the shifts in fishing stations which have occurred since the early 1980s from Lake Chad to other regions.

Of the principle modern export products of the four countries only cotton (from Cameroon and Chad) is produced in the conventional basin. Of secondary export products, livestock, which is critical to the economies of both Chad and Niger, is produced in or transits through the basin. Basin production of livestock contributes at least 31 percent of national production for all basin countries. Basin production of fish accounts for 12.5 percent of national fisheries production (UNDP, 1979). Although no comprehensive data are available, the conventional basin is an important source of fuelwood and construction wood for the main urban centers.

Most of the enduring infrastructural development projects in the basin (SEMRY, SCIP, SODELAC) have displaced productive pre-existing subsystems (Figure 1.13B). They have provided some participants with new economic benefits (SCIP) and provided a palliative to the immediate effects of climatological drought in some regions (e.g., SEMRY III). However, neither they nor the cash crop development parastatals (e.g., SODECOTON) have provided a sustained contribution to the overall economic and ecological health of the basin because (1) farmers have become dependent on the state for both inputs and technical support; (2) producer prices have been kept low by the parastatals; (3) farmers have no dry-year strategy when low waters reduce or eliminate irrigated water supply (e.g., SCIP); (4) parastatal developments have not integrated water type-year (dry, very dry) farming with irrigated agriculture; (5) a naive belief that low water years are temporary aberrations has blocked policy development and investment in dry-year strategies; (6) some irrigated crops have no markets (e.g., SEMRY I and II are incapable of selling their rice crops at competitive prices); (7) poor understanding of international markets and price fluctuations has led to large investments in projects that produce little or no income (e.g., SODECOTON and COTONCHAD during the "cotton crash"); and (8) there has been confusion between "irrigated agricultural developments," which assume great financial and marketing risks, and "self-sufficiency" investments, which are risk-avoidance strategies seeking stable prices and assured markets.

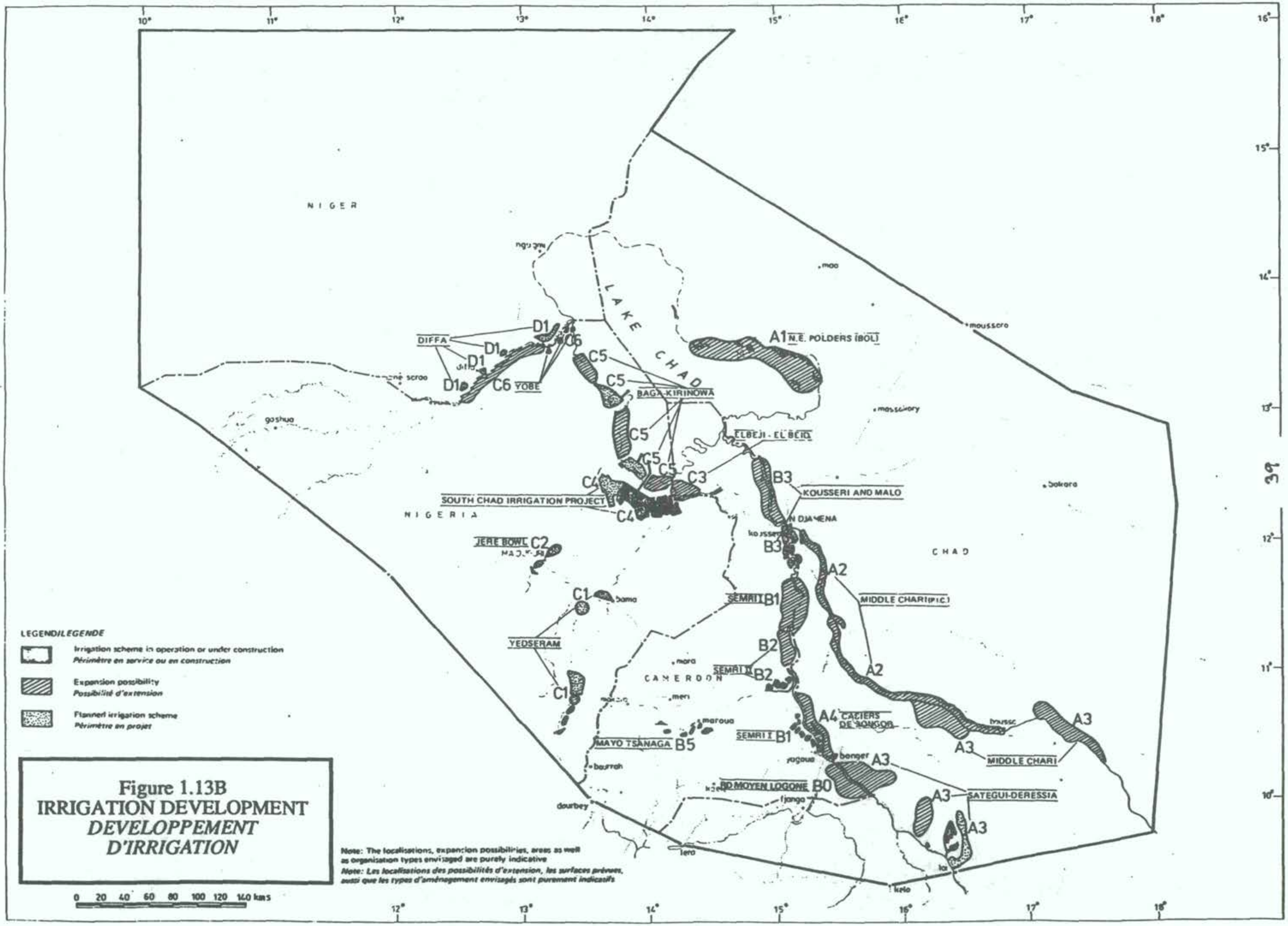


Figure 1.13B
IRRIGATION DEVELOPMENT
DEVELOPPEMENT D'IRRIGATION

The people of the conventional basin share not only overlapping, complementary systems of production and exchange but also confront severe water resource constraints to sustained productivity. The remarkable mobility of human settlements, agriculture, fishing, and pastoralism is the age-old human response to this constraint (James, 1987). A recent illustration is the movement of hundreds of villages since 1980 into the Lake Chad bed to farm the exposed lake bottom (Kolawole, 1988). However a number of traditional mechanisms for coping with climatological and hydrological drought have been constrained by recent developments. For example, mobility and flexibility in patterns of resource use have been limited by population growth and the existence of national frontiers. Traditional resource management systems have been vitiated by national resource tenure policies.

It is the position of this team that traditional systems of resource use are not in themselves to blame for environmental degradation. Climatological drought is the primary culprit. However, operating under current constraints, some current patterns of resource use are either directly or indirectly responsible for some of the environmental degradation.

a. Social Organization

Everywhere in the basin the traditional systems of social organization have been more or less transformed by the modern world system. Older systems of family and village solidarity have been modified or reduced in their degree of authority. Conversely, in some cases, new systems, such as village associations and cooperatives, women's and young people's associations, political parties, school groups, and the like, have been established. But, for the most part, these groups are young, often untried, and insufficiently trained for natural resource management work.

Generally, in the agricultural areas in the south, where population densities are relatively high and where there is a long history of cooperative, missionary, or extension activity, the local populations have technological abilities (including traditional ones) and a ready aptitude for organization and responsibility. In these well-watered zones, the role of outside assistance (from states and donors) may be limited to technical supervision of antidegradation measures.

By contrast, in the pastoral zone and in other zones of light population density, people have little cooperative experience or experience with sustained development activities. In these areas, the short-term capacity of the populations for organization for natural resource management is relatively weak. This can be improved with a major training effort focused on interventions that correspond to the needs of an inherently mobile and flexible population with few drought fallback securities. In these areas (the northern basins, Lake Fitri, Lake Chad) the involvement of the states and the donors must be correspondingly greater to provide necessary coherence and continuity.

b. Extension Education, Training, and Logistics

Effective extension cadre of personnel trained in holistic approaches to resource management, free of police functions, and provided with a logistical support are overwhelmingly lacking in the conventional basin. In Chad, competition between field agents and the lack of knowledge of applicable texts complicates the task of foresters and parks agents. The need for such cadre is particularly acute in Chad, where a number of NGO's have been filling the gaps in personnel and education problems have been exacerbated by civil strife and government disorganization. In Nigeria, a surplus of engineering cadre and a shortage of integrated midlevel extension teams has distorted the rural development orientation. In Cameroon, cadre have been oriented toward the more productive southern zones. High level staff appear to be adequate in numbers, while there is a shortage of multisectoral extension cadre. In Niger, staff profiles seem to more closely match development needs, but staff and logistical shortages are acute. It is likely that a doubling and retraining of all staff would be necessary to effect a basinwide transformation in current resource management practice towards a more holistic strategy attuned to traditional management techniques (Part 3).

c. Civil Unrest

Civil strife and unrest have directly disrupted ecosystems in several parts of the Lake Chad Basin. The existence of peace and civil security in the countryside is a prerequisite to improved natural resource management in the conventional basin. Warfare is inimical to the conservation of natural resources and discourages or negates local investment in resource management.

d. Diseases and Pests

Water-related diseases, whether those of stagnant waters (malaria, bilharzia, guinea worm, and cholera) or moving waters (e.g., onchocerciasis) are endemic across the region. Locusts, crickets, aphids, quelea, and other crop pests affect everyone as do the endemic livestock diseases (bovine plague, pleuropneumonia, anthrax, and sleeping sickness). Continued pastoral transhumance and the movements of commercial herds, facilitated by the proliferation of improved watering points, ensure the spread of animal disease vectors.

Malnutrition and poor maternal/infant health lead to high rates of infant mortality, which, from a natural resources point of view, is a waste of plants, livestock, and fish. Poor health and high rates of infant mortality promote high birth rates, especially among rural people, which further encourages boom-and-bust population cycles. The member states of the LCBC can ill afford continued waste of natural resources on populations that rapidly deplete resources, then die during epidemics and extreme drought (Figure 1.14). Stabilizing a smaller, healthier family unit would remove significant pressure on the basin's productive natural resources.

e. Land and Resource Tenure Policies

Land and resource tenure policies are critical elements of sound natural resources management. In the precolonial period, resource conserving policies were not uncommon, such as the Fulani Dina convention in the inner delta of Mali or the fishing rules imposed by water priests along many of the major rivers of West Africa, including the Logone, Chari, and Yobe Rivers (Lambezat, 1961). Collectively enforced conservation strategies also account for the extensive soil and water conservation structures in the Mandara Mountains.

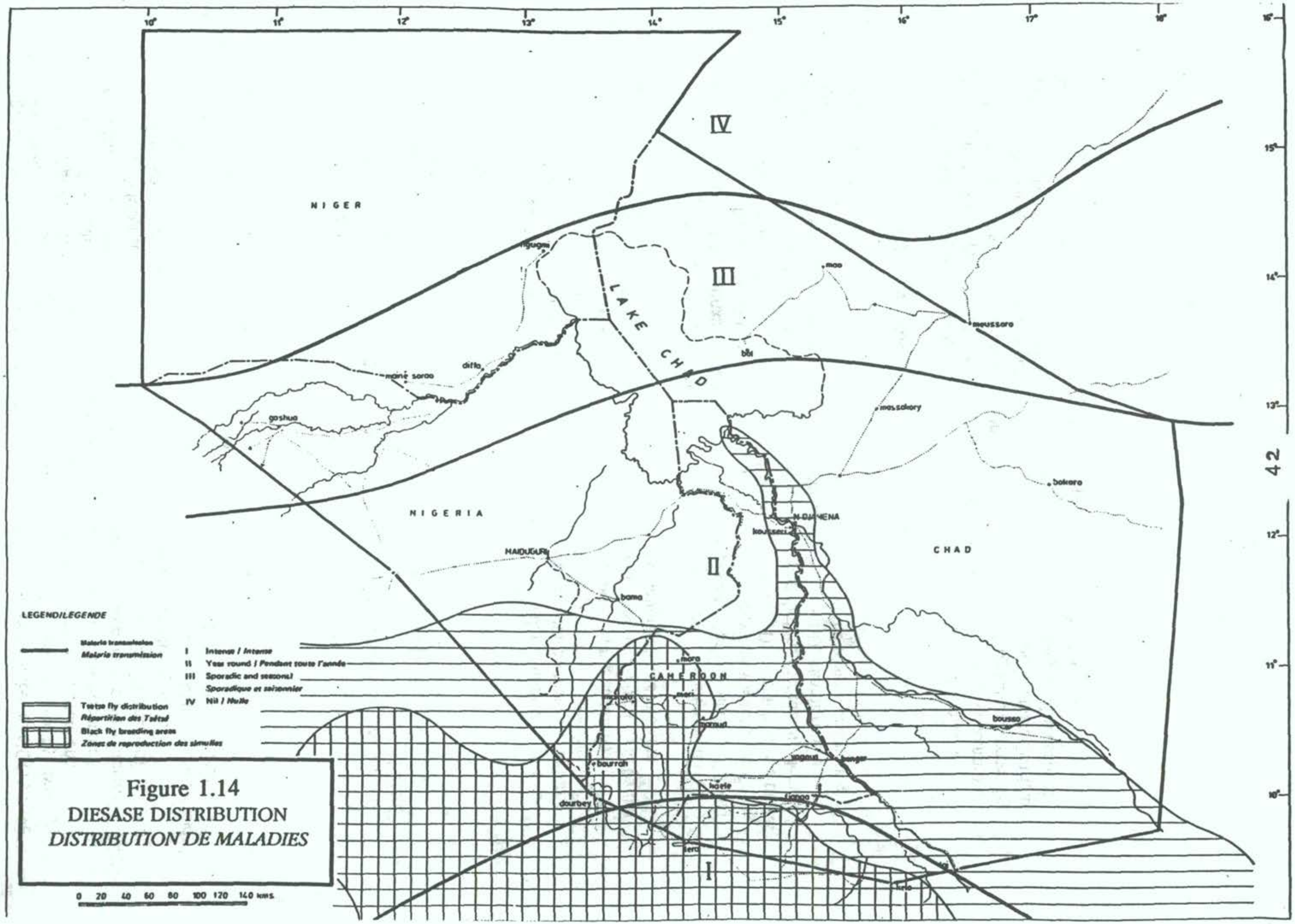


Figure 1.14
DIESASE DISTRIBUTION
DISTRIBUTION DE MALADIES

Colonial and postindependence policies have abrogated resource management authority to the state level; ultimate ownership of natural resources is held by the state. Nigeria's ten-year-old reform efforts have not led to a derogation of tenure rights to the average citizen (Francis, 1984; James, 1987). Among the member states of the LCBC, only Niger seems to have experience with cooperative local resource management. Rural resource tenure reform is still under study in Chad and Niger. Some reform is underway in Cameroon, especially on the SEMRY perimeters.

The results of the centralization of responsibility for resource management have been generally negative in the member states of the LCBC and in other Sahelian countries. Local people lack the authority to regulate access to common property resources such as forests and pastures or to punish exploitative users. Resource users who lack a stake in preservation of the resource use pursue short-term goals and often seek to thwart national resource use codes. Wealthy individuals can usually obtain easements or avoid prosecution of national or local resource use codes, thus setting a poor example for local resource users (Thompson, 1982; n.d.).

In spite of the current policy climate, dramatic improvements in stewardship of resources have occurred on a local basis in many West African countries where resource co-management schemes have been worked out amongst government, community, and donor authorities. These schemes have required derogation of resource management authority to the community and reform of resource tenure law (Shaikh et al., 1988).

Resource tenure law in the basin and its implications are briefly reviewed below.

f. Urbanization

The pronounced urbanization of the basin since 1979 is a major source of environmental degradation (Figures 1.15 and 1.16). Settling large numbers of people and animals in one place in an arid environment without adequate systems of renewable resource management has had catastrophic results, such as the destruction of the Mandelia National Park in Chad. Urbanization represents the extreme end of a continuum, which ranges from lightly stressed environments, to locales with deep wells and marketplaces, to villages, and to cities. Lack of adequate drought fallback strategies contributes to unplanned urbanization. Lack of inexpensive urban energy alternatives to wood burning leads to loss of vegetative cover for kilometers around major towns. Urban-based stock-raising also places inordinate stress on pasture and browse resources around the towns and may lead to the formation of extensive hardpans or the mobilization of dunes. Urbanization without adequate water and sewage treatment facilities contributes to groundwater pollution and concentrates human disease vectors (Biney, 1984). Urbanization depletes labor from the countryside that is needed for labor-intensive soil and vegetation rehabilitation projects. Despite these crucial problems, it should be remembered that Sahelian workers are traditionally mobile, with flexible and diverse skills. Incentives to live in the rural versus urban areas can easily turn these trends around. Many workers circulate (village to city and back) rather than migrate permanently.

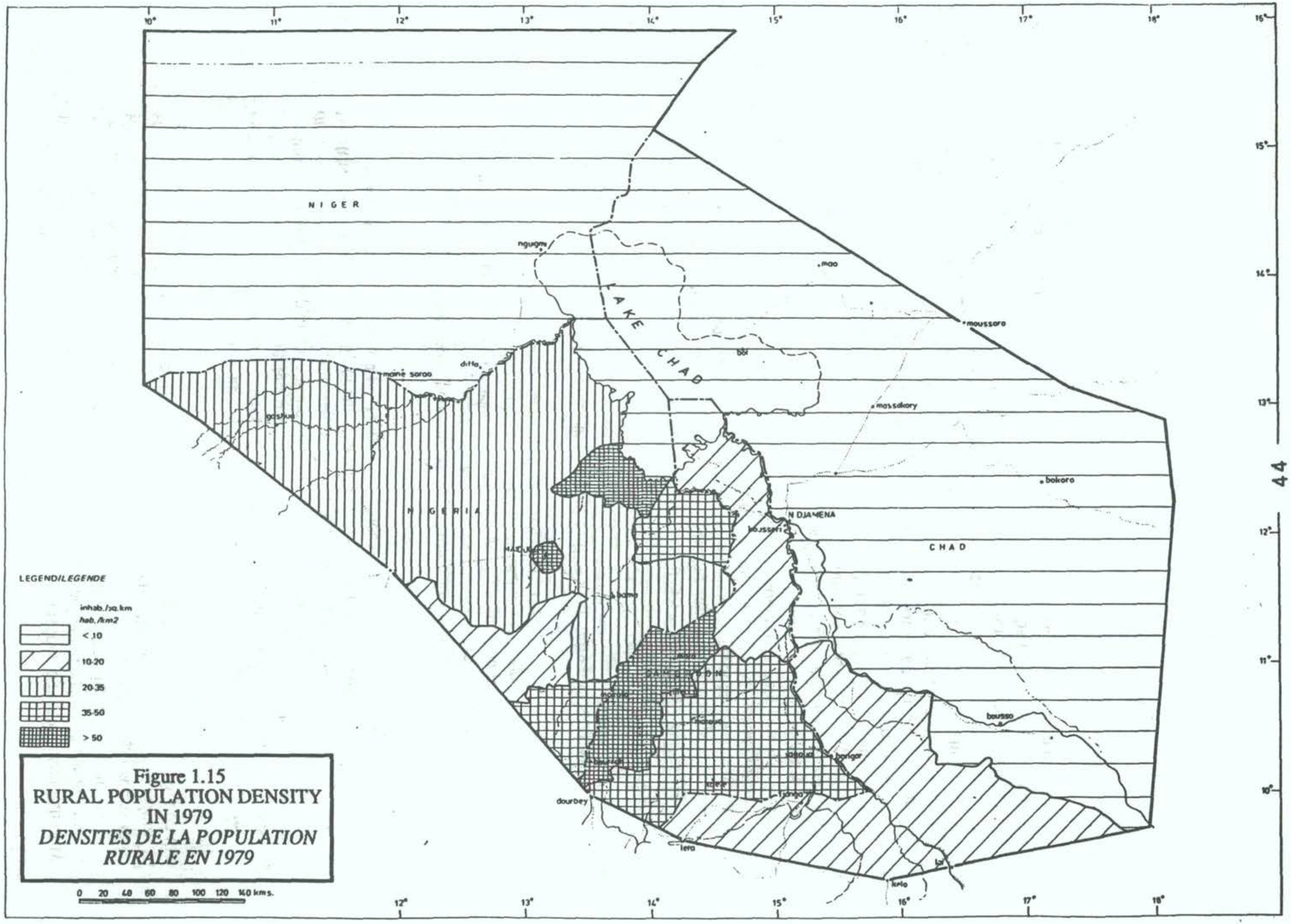


Figure 1.15
RURAL POPULATION DENSITY IN 1979
DENSITES DE LA POPULATION RURALE EN 1979

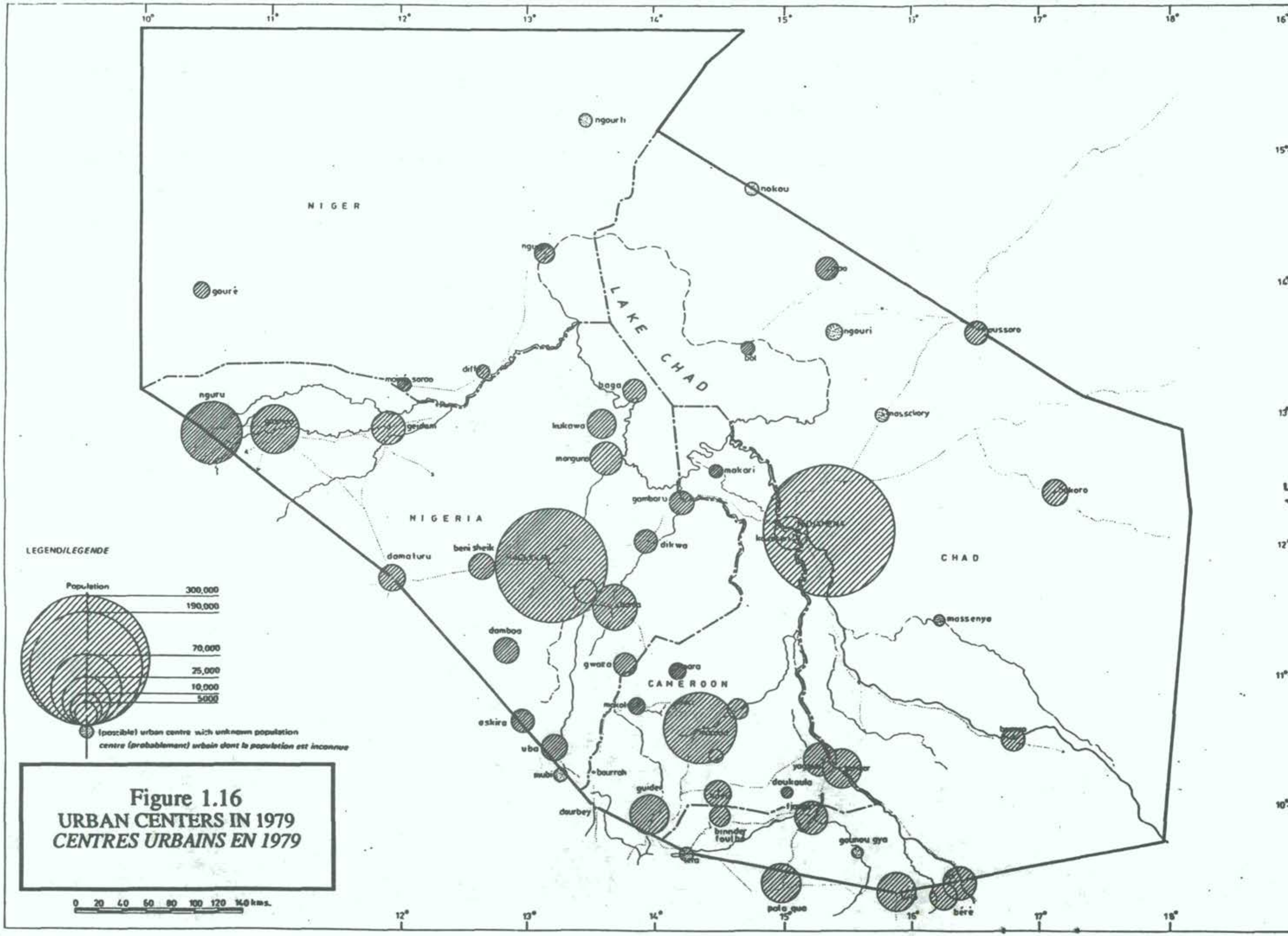


Figure 1.16
URBAN CENTERS IN 1979
CENTRES URBAINS EN 1979

g. Export Crops

National desire for export crops is another important factor in environmental degradation (Figure 1.13). Clear-cutting for the large-scale irrigation perimeters, dams, and reservoirs without adequate attention to reforestation and seasonal pastures is one of the principle causes of large-scale deforestation in the basin. Further, irrigation may contribute to salinization of some agricultural soils. Irrigation development without preventative design measures has also contributed to the increase in endemic waterborne illness (Gadzama, 1983). Promotion of cotton and groundnuts without provision for adequate, low-cost inputs, especially alternatives to petrochemical-based fertilizers and insecticides, leads farmers to cut corners and ultimately causes soil exhaustion. Even in the most optimistic scenarios, irrigated agriculture will only employ 4 percent of farmers within the conventional basin. The vast majority of natural resource users remain untouched by these projects, which attract an overzealous amount of foreign aid compared to projects addressing the needs of the vast majority of peasants.

h. Alternative Income Sources

As population increases and biomass and ecological diversity shrinks from drought, the demand for alternative income sources has intensified. In addition, the demand for imported manufactured goods has increased as prices for agricultural commodities have stagnated.

As dry years become more acute and/or more frequent, household savings, assets (e.g., cattle), and income sources contract. Without alternative sources of income or drought insurance, pressure on renewable natural resources increases. The forest resources of northernmost Cameroon, Nigeria and certain areas of Chad have been devastated by local populations. Herders with starving livestock and commercial herders seeking to maximize herd size ransack pasture and browse plants.

i. Resettlement

Migration and resettlement contribute significantly to environmental degradation, particularly if immigrants lack security of land tenure. The result of population increase in the Mandara mountains, "evenements" in Chad, Nigeria's economic boom, and the declining productivity of arid soils everywhere in the northern part of the conventional basin, has put special stress on resources with long renewal timetables (e.g., hardwoods, large fauna, fertile soils).

Resettlement and colonization of new agricultural land has driven livestock into increasingly marginal areas and has given rise to heightened competition for remaining fertile lands such as yaeres, wadis, riparian zones and national parks. Expulsions of humans contribute to environmental degradation, as well as civil strife.

Changes in inheritance patterns brought about by pressure on the land also contribute to degradation. Youthful members of large families may not receive land through inheritance under conditions of high population density and increasing cash needs. Such persons have been forced to emigrate to marginal lands such as the plains around Maroua or the already densely populated bush along the Chari and Logone Rivers.

j. Development Projects

Foreign and domestically financed development projects have played a role in both environmental degradation and maintenance. The net economic and environmental impact of the large irrigation perimeters appears to have been negative. However, no systematic impact evaluation that takes into account foregone benefits has been undertaken. Forestry interventions have had little impact at all due to the absence of popular participation (Nigeria), technical problems (Cameroon), or limitations of scale (Chad). Some small-scale interventions conducted by NGO's have improved field-tree densities (*Acacia albida* in Chad) or established village woodlots and windbreaks (Niger, Chad). Road systems have encouraged the export of forestry and fish, but at the same time encouraged chaotic exploitation of some resources.

The indirect impacts of nationwide economic development, especially the individualization of economic interests, have reduced the ability of traditional authorities to command the labor resources necessary for the maintenance of common resources. Thus, the flight of the economically active portion of the Mandara Mountain populace has lead to the degradation of terrace systems. Competition between collective fishing and individualized fishing diminishes the management efficacy of traditional annual fishing schedules on the Chari and Logone Rivers diminishes the management efficacy of traditional annual fishing schedules on the Chari and Logone and the yaeres. Furthermore, as cash crops replace subsistence ones, certain plant associations lose their economic value as drought reserve foods and are no longer maintained, (e.g., the disappearance of numerous populations of *Ficus* species in the Logone subbasin and the emergence of *Acacia albida* parks in the piedmonts of the Mandara, and the extension of *Azadirachta indica* and *Eucalyptus camaduensis* over large tracts of land.) These species changes reduce biodiversity but do not necessarily cause other forms of environmental degradation (e.g., soil erosion).

k. Access to and Use of Resources

Although the use of resources may be limited by techniques or knowledge, access to resources is limited by rules, tradition, laws, or previous occupancy. When the resource diminishes (due to drought), access problems become severe. The current situation is complicated by increased occupancy from increased populations, especially in the south. Limited resource access for share croppers, contract farmers, or herders results in abusive exploitation of the resources in which these people feel they have no stake. Projects which fix inflexible production use on farmers or herders (such as the CBDA irrigation schemes) diminish the producers' ability to respond to climatic fluctuations with alternate cultivars, a shift into other activities, or movement towards new resources.

l. Fragmentation of the Research Effort

The research effort devoted to environmental monitoring and impact assessment is divided between a number of institutions among which there seems to be little communication. Despite the urgency of the problem of environmental degradation there is insufficient monitoring data (climatic, hydrological, pedological, agrostological, demographic, etc.) to evaluate climatic fluctuation and secular trends. As a result there is an inadequate data base on the causes, extent, and consequence of environmental degradation. Despite major transformations in the economies of member states in recent years, there is little information on population movement or differential vulnerabilities to drought and resource degradation. Nor is there very much data on the differential success of the various population groups in coping with drought and resource degradation. It is rare to find a data base that treats in detail the relationship between human use and resource dynamics in particular contexts. As a result much of the documentation concerning the conventional basin is filled with out-dated information and opinion rather than hard evidence.

Summary By Nation: Human Resources Comparisons

CAMEROON's share of the basin is marked by pronounced ecological and ethnic diversity and high population densities. About 2 million persons live within the conventional basin, of which about 10 percent are urban dwellers. The average density is about 40 persons per km^2 (p/km^2) rising to 200 p/km^2 in the Mandara Mountains. The population of Maroua has grown from about 71,000 in 1979 to over 100,000 in 1989. The average density has risen from about 8 p/km^2 in 1976 (Pontie, 1976) and many rural inhabitants live in districts with population densities of 80 p/km^2 or more. Population densities fall off sharply north of the Mandara mountains, although the population of Kousseri seems to have grown substantially as a result of the Chadian "evenements". In general, all of the towns in the national basin have grown at the expense of the rural areas.

Relative to Cameroon as a whole, school attendance is lowest in the conventional basin (about 20 percent of the school-age population). Environmental education is lacking. Health infrastructure is relatively developed compared to the other countries (UNDP, 1979). Recently constructed infrastructure at Kousseri appears to be underused.

The renewable natural resource base is relatively rich and diversified, but most management efforts to date have been rather inadequate. The SEMRY projects and the cotton promotion schemes are typical of those that impose inflexible systems of management and production rather than build upon the inherently dynamic natural ecosystems.

Urbanization (Maroua, Kousseri, Yagoua), resettlement provoked by population pressure (Mandara), the search for alternative income sources from wood-cutting, commercial grazing, and fishing (Chari-Logone delta, Lake Maga), health problems, and environmentally disruptive development schemes (e.g., Maga Dam) are probably the most significant anthropogenic causes of environmental degradation in northern Cameroon.

CHAD's share of the basin is ecologically highly diverse, difficult to manage, and marked by profound ethnic, religious, and economic differences. Many administrative units are very small, reflecting the lack of political cohesion between clans and lineages, let alone regions. Further, basic service delivery systems, infrastructure, and trained cadre are inadequate. Some 3,600,000 Chadians live in the conventional basin, including over 500,000 in the capital (up from 300,000 in 1979 before the "evenements"). Ndjamena is by far the largest urban center in the Chadian national basin. Eighty percent of the population outside of Ndjamena is rural. The average population density is about 4.57 p/km^2 but ranges from 2.09 in the Kanem to over 20 p/km^2 in Mayo Kebbi Prefecture. School attendance is low and was severely disrupted by the "evenements" of the early 1980s. Mission-sponsored education in the southern Chad has resulted in a relatively high rate of scholarization there (60 to 90 pupils per 1,000 inhabitants; UNDP, 1979). Health facilities are under-equipped outside of Ndjamena and unequally distributed through the conventional basin. The lake and Mayo Kebbi prefectures are the best served inside the conventional basin (BSPE/MSP, 1989). Despite monumental difficulties, the long-run potential for resource development in Chad is great.

Resource tenure policy in Chad has been reviewed in the recent CTFT (1986) report. Land in Chad belongs either to the state or to corporate persons. State land is divided into public domain (e.g., classified forests), which is inalienable, and the private domain, which includes most land not otherwise registered by corporate persons. The juridical basis should permit individuals, producers groups, village communities, associations, and cooperatives to occupy their land resources without threat of interference or occupation. However, there are several ambiguities in the legislation. The legislation makes no distinction between those who use land and those who own the land through customary law. The legislation does not admit that the use rights enjoyed by someone might have been granted through customary relationships. Insofar as the state does not require registration of land claims, with all the attendant wrangling this would entail, the state refuses to deal with the problem of absentee ownership. The law also assumes that the person wishing to register land has the fortitude to confront the customary status quo and has the material and intellectual wherewithal to pursue the affair through bureaucratic channels. The legislation also supposes that the state and the regional administrations have the desire and the ability to enforce the property rights mandated in the legislation.

Chad lacks a forestry code, although one is being constructed. Currently ,use rights are protected on village territory, although this concept, drawn from customary law, remains undefined. Draft definitions of forested area, however, are so vague as to confound public property with village territory, and forests with pastoral areas. The legislation mandates private and communal plantations without specifying management regimes. Natural forest management experiences in the basin appear to be limited. The populations generally associate forestry agents with the paramilitary public agencies like customs or the police force.

Draft provisions of the forestry code reinforce, rather than amend the paramilitary status of the forest service. This is unfortunate since repression is incompatible with the extension mission that should be the major activity of the forest service. Farmers fined for cutting trees are unlikely to invest resources in planting them. Farmers will be unwilling to grow valuable trees placed on a protected species list because they will have to prove that they planted them in order to harvest them, which involves a laborious and uncertain process of obtaining a cutting permit.

The current forestry tax structure is extremely low and apparently aims solely to provide revenue without envisioning any particular management objectives. Further, the legislation is nation-wide rather than regionalized.

Among the principle anthropogenic causes of environmental degradation in Chad, the "evenements" of the early 1980s, resettlement, the search for alternative income sources, disease, and the lack of appropriate resource tenure agreements are the most significant.

NIGER is favored by minimal ethnic diversity within its part of the conventional basin. Its share of the conventional basin is Sahelian and Saharan, hence the population is sparse and the economic resources scattered. Some 186,000 people (down from 195,000 in the early 1980s) use the resources of the Niger part of the conventional basin. Ten percent live in towns. The urban population distribution has changed dramatically over the past ten years. Over the last ten years, Nguigmi, with about 10,000 persons, has gained population, and Diffa, with about 10,000, has held steady in terms of population. Towns have gained population at the expense of rural areas. The population density varies from about 21 p/km² in the Yobe basin to 4.3 p/km² in the cuvette region of Maine Soroa and less in the county of Nguigmi. The rate of school attendance is low (about 17 percent), unchanged since the late 1970s. Rural literacy programs reach only a tiny percentage of the population. There is no environmental education program (SEDES, 1986). Recent reforms favor development from the bottom up. Development activities in the basin are largely small-scale, labor-(rather than capital-)intensive, divisible, and incremental in nature.

Land tenure law in Niger has been under review for some time, but the new National Charter and texts establishing the nationwide "Societe de Developpement" provide for local management of and benefit from local investments. Several projects have negotiated local resource management agreements beneficial to both the state and resource users. The National Anti-Desertification Plan calls for the need to elaborate a water use code as well as a forestry code, a pastoral code and a code concerning land clearance. Previous policy conferences called for the establishment of a rural code to appear at the same time as the National Charter, but this code has yet to be finalized (Republique of Niger, Ministry of Hydrology and Environment/CILSS/Club du Sahel, 1985).

The principle anthropogenic causes of environmental degradation in Niger are development projects upstream of the Niger portion of the Yobe, unplanned groundwater development, and commercial grazing on fragile pastures in the Manga grasslands.

NIGERIA is favored by limited ethnic diversity within its piece of the conventional basin and enjoys considerable financial resources. Its share of the basin is quite productive. The immigration from neighboring states has swelled its population. The 1980 population was estimated at 5.2 million; the present population probably approaches six million (Ogunjemilua, 1984). Population densities probably range from over 40 p/km² south of the lake to over 70 p/km² near the Cameroonian border and over 35 p/km² in the southwest of the national basin bordering Hausa territory. About 80 percent of the population is rural. Maiduguri has grown dramatically from just 190,000 persons in 1979 to an estimated 500,000 to 600,000 today.

Because population densities are high, the need for maximally productive use of the environment has colored the goals of Borno state development projects.

Of the area's 12,000,000 persons, 15 percent live in towns and exploit resources within the basin. School attendance is higher than in other parts of the conventional basin, but well below Nigerian norms (UNDP, 1979). Development in the area is predominantly capital intensive and top-down. Grass roots interests have taken second place to those of national and expatriate engineering firms.

Several useful discussions of Nigeria's resource use law exist (Yerokun, 1983; Francis, 1984; James, 1987). Land law in Nigeria is regulated by legislation promulgated in 1978, which vested all land in the governors of each state to be "held in trust and administered for the use and common benefit of all Nigerians." Forestry legislation is mainly concerned with control of felling, through Borno State Edict No. 8 of 1987 and the felling of tree (control) Edict of 1986. The Chad Basin Development Authority Act of 1973 (amended in 1975) gave administrative control of the southern part of one-third of the lake within Nigerian territorial control to the CBDA.

The 1978 land law distinguishes urban and rural land, the latter to be administered by Land Allocation Committees. "Rights of occupancy" were to replace previous forms of title, these consisting of statutory and customary types; and occupiers' rights were privileged (in theory) in relation to "holders'" rights. The Act spelled out the principles of rural land occupancy for public and private corporate persons. Provisions for concurrent right, transfer and division, alienation and the like are unclear and in some cases internally inconsistent. Ground rent was abolished. Unlimited grants in land (each one no greater than 5,000 ha) could be obtained from the governors of the states for development purposes. State rights supersede all other claims. Several commentators agree that the Land Use Act has not achieved the supposed objectives of rational intervention in customary tenure. Rural land tenure remains undisturbed except when it conflicts with the interests of public or private capital holding developers in which case the urban-connected, capital-holders unfailingly prevail. In fact, the reform represents expropriation rather than modification of customary tenure rights. Furthermore, the Act has sown confusion in customary share cropping arrangements. In sum, in Nigeria title uncertainty remains a significant disincentive to investment in land and long-term soil, water, and vegetation management (James, 1987).

Rapid paced implementation of capital intensive development projects, cash crop production, and urbanization are among the principle anthropogenic causes of environmental degradation in northern Nigeria. The environmental effects of the search for alternative income sources from commercial grazing and wood cutting are also acute. The effects of resettlement have been felt most acutely in Nigeria. Thousands of farmers have been compelled to relocate as the CBDA pushes ahead with irrigation infrastructure development projects. Full implementation of the ECOWAS treaty on right of entry and residence scheduled for 1995, might trigger waves of immigrant influx into Borno State from the neighboring states with unforeseeable impacts upon the resource base (James, 1987).

PART 2: DIAGNOSTIC BASINS

2.1 INTRODUCTION

During their fieldwork, the team agreed on the two conceptual innovations that suffuse this report: defining the action plan by subbasins of the whole Lake Chad Basin and defining policies and projects by water type-years. These two concepts stem from the most important fact about the basin: water resources are patchily distributed and vary considerably from one storm, one year, and one decade to another.

2.1.1 Diagnostic Basins

The sketch of the diversity of climates, landforms, soils, plant life, and hydrology (Part 1) convinced the consultants to subdivide the conventional basin into more realistic units. Broad generalizations about the basin could not yield an accurate diagnosis nor a practical action plan. Following an earlier FAO report and World Bank studies, the conventional basin was divided into eight subunits that we call "Diagnostic Basins" (Figure 2.1).

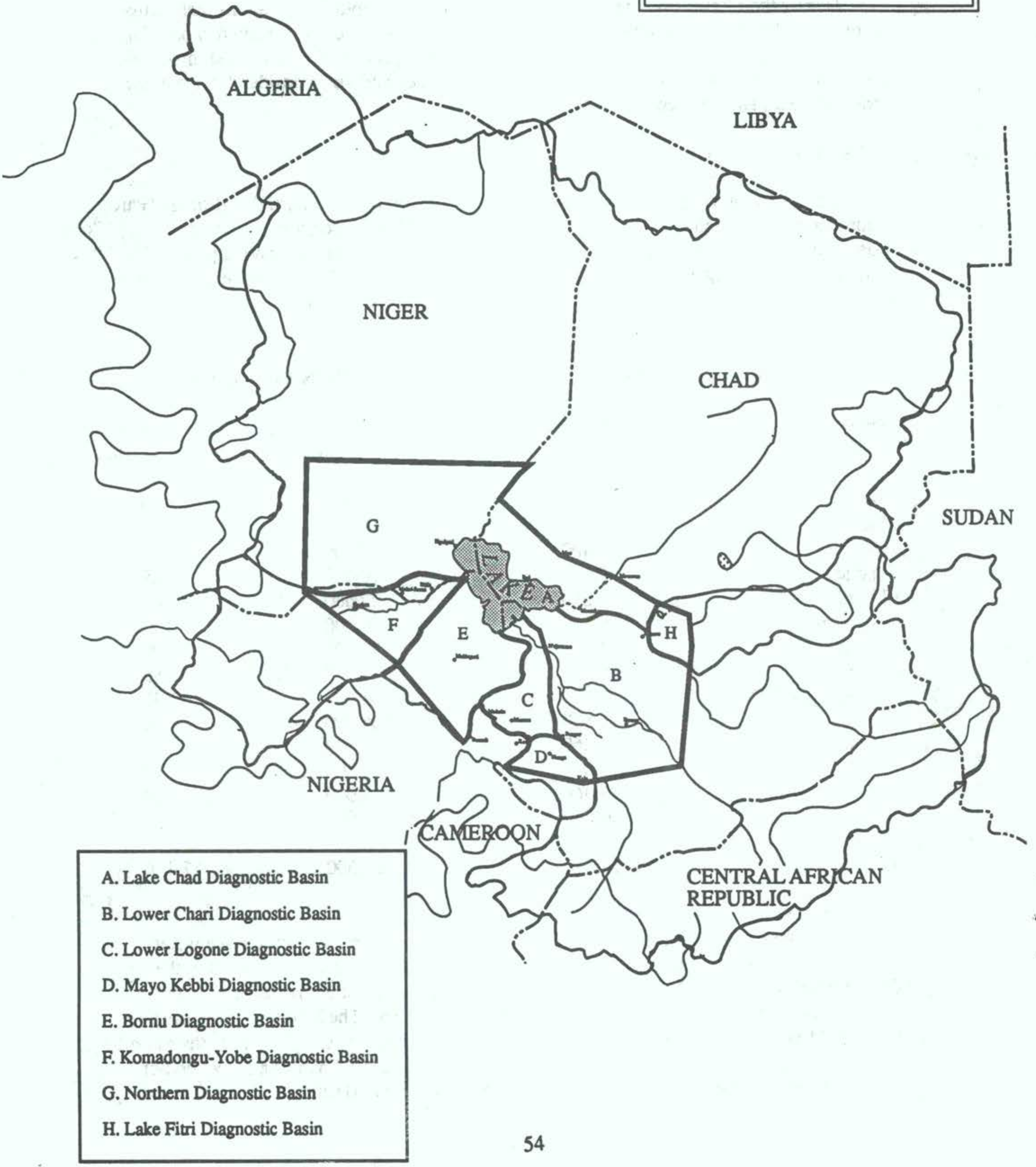
TABLE 2.1
DRAINAGE AREAS WITHIN THE CONVENTIONAL BASIN

Drainage Area	Geographic Basin Area (km2)	Conventional Basin Area (km2)	Percent Geogr. Basin
Lake Chad	25,000	25,000	100
Chari	472,960	47,400	10
Serbeouel	2,400	2,400	100
Logone	77,650	19,400	25
El Beid	22,650	22,600	100
Yedseram	16,320	16,300	100
Ngadda	14,400	14,400	100
Gubio	26,560	22,600	85
Komadougou Yobe	147,840	44,400	30
Termit Sud	738,850	105,000	14
Bahr El Ghazal	807,360	74,000	9
Batha	78,030	7,800	10
Mayo Kebbi	21,360	13,000	60
Benue	(not inc.)	13,000	
Total	2,451,370	427,300	17.4 %

In general, the boundaries of the eight diagnostic basins are based on surface water flow. The boundaries are watershed divides or other major ecological divisions. But, the Chari/Logone, Logone/El Beid, Lake Chad/Bahr el Ghazal and Borno drainages all have "divides" dependent on the depth of floodwaters between them. The Northern Diagnostic Basin and Lake Fitri Diagnostic Basin have no waterflow into Lake Chad. The southwestern part of the conventional basin drains into the Niger River - not into Lake Chad! We do not discuss the Niger River drainage of the Lake Chad Conventional Basin.

Figure 2.1
DIAGNOSTIC BASINS

BASSIN DIAGNOSTIQUES



By focusing on each diagnostic Basin, movement between various diagnostic basins and influences upstream (outside of the conventional basin) can be easily traced. For instance, many of the pastoralists migrate seasonally from one diagnostic basin to another in pursuit of water and pasture. Similarly, many fishermen change diagnostic basins depending on the type of water year (wet, dry, normal). The conventional basin only includes parts of the natural watersheds (Figure 2.1), which causes complications in planning for upstream/downstream and instream/offstream water resources policies (Table 2.1). Many of the groundwater aquifers cross surface watershed divides, further complicating "conjunctive use" (groundwater/surface water) policies.

Part 2 treats the hydrology, soils, ecology, and human resources of each diagnostic basin separately.

2.1.2 Type Water-Years

Despite extensive research and analysis, there are few documents that try to combine water resource indices, policy, development or conservation projects, and production systems (sectors) into one unified treatment. Project design and the evaluation of a project's environmental impacts are too often based on "average" conditions. Such thinking has handicapped ministries, extension cadres, and donors—leaving them unprepared for climatic variability ("expect the unexpected"). Donors and governments often fight financially wasteful battles against desertification or they rationalize the weather as an unexpected "aberration" that foils the project's success.

We hope to introduce a water "type-year" framework to planning and project design that will accommodate climatic fluctuations. Such a framework is used to determine the most economically and environmentally sound instream flow on regulated rivers in California.

The water "type-year" framework must be connected to some kind of mathematical analysis, such as means, medians, or percentile distributions. We intend to use statistics only as one "tool" among many, to play with statistical methods in trying to understand variations in results, to keep in mind the rather narrow economic and social significance of statistics, and to be skeptical.

In 1979, UNDP selected certain specific years (from the 29-year record of channel flows of the Chari River at Ndjamena) as "type-years." They were high (peak flow), median, and low (lowest of record) water conditions for the basin as a whole:

UNDP Water (1979)

Type-Year	Year	Flow (m^3/s)
Low	1972/73	539
Median	1958/59	1,090
High	1955/56	1,720

This median-and-extremes approach was adopted to characterize type-years for Lake Chad, not the Chari River. Because the median and extremes do not truly represent the hydrological conditions of the basin and the Chari River flow is not correlated with lake levels, this approach is not appropriate.

Lake levels do not correlate with Chari River flows because the river is responsible for only part of the lake's volume, whose inputs are more variable than rainfall (see below). Also, water may be left over from previous years. In addition, the lake divides itself into two pools which confuses lake level measurements. The "sill" or "grande barriere" between the north and south subbasins of Lake Chad fill and empty at completely different rates. A two- or three-year running average of Chari River flows might improve the correlation but, as yet, we have only an extremely short record. In short, be skeptical of using one hydro-index (river-flow) to plan a project reliant on another (lake level).

The extreme drought of the early 1980s called the median-and-extremes approach into question by significantly spreading the range of flows recorded. The difference between the high and lows now approaches an order of magnitude:

Water (1989) Type-Year	Year	Flow (m^3/s)
Low	1984/85	213
Median	1942/43	1,030
High	1955/56	1,720

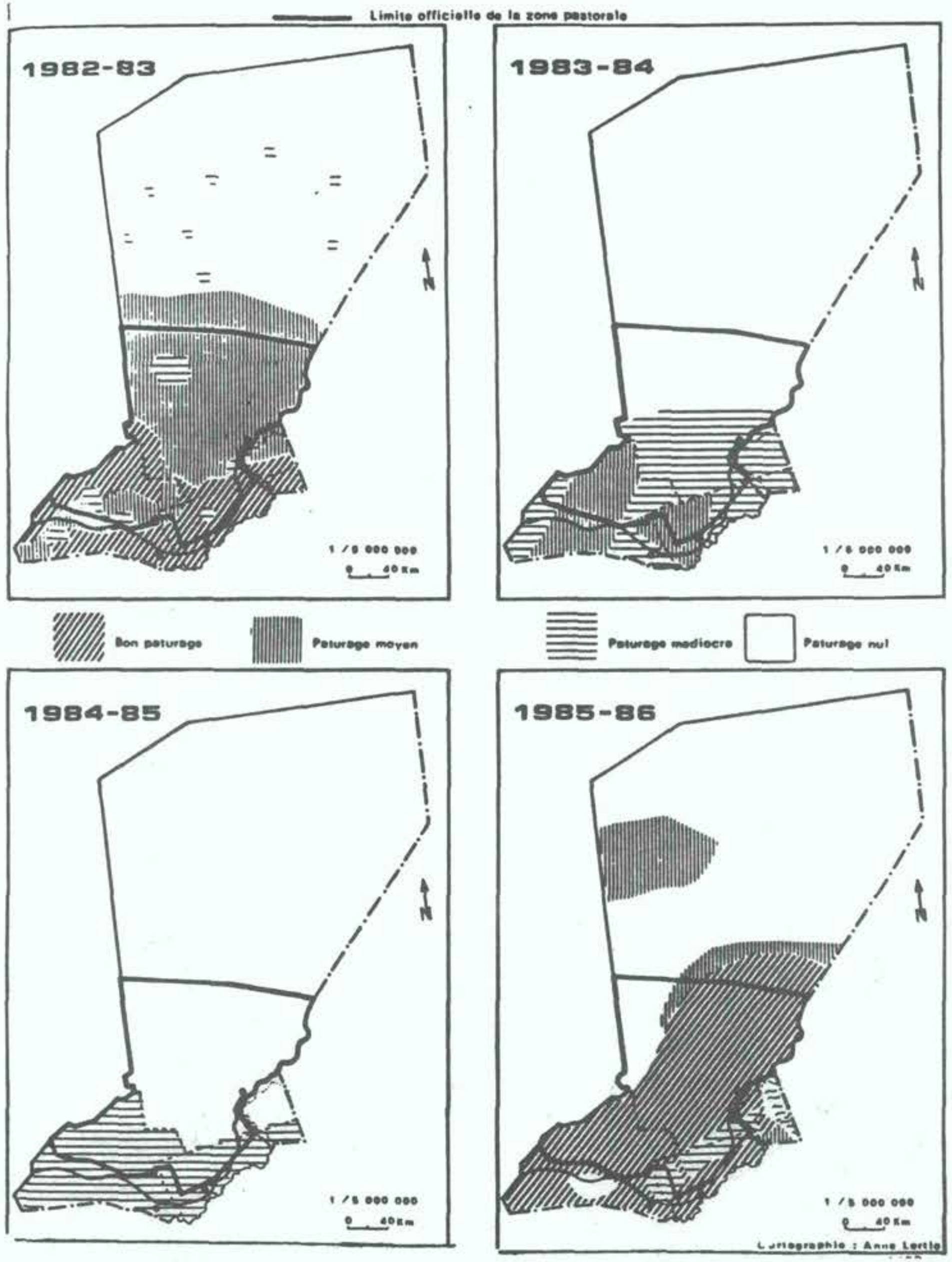
From the policy/projects point of view, the median-and-extremes approach has little significance regarding long-term trends, deviations from median conditions, or (with such small samples) the general likelihood of extreme values. (See box on long-term climatic change).

We will also try to use statistical method(s) appropriate to the specific development/ conservation projects and data from the same (or most closely analogous) diagnostic basin.

The Lake Chad Basin has an enormous number of water-dependent production systems ("sectors") that are active in many different environments. Their connection to water resources differs between sectors and, only in special circumstances, do these hydro-connections strongly influence each other. These production systems include rainfed, recessional, groundwater, run-of-the-river and reservoir-fed irrigation and combination farming. Forestry, pastoralism, fisheries, even artisan products and diesel-generated electric power stations, all rely on different parts of the water cycle.

Rainfed agriculture and rainfed-livestock raising are very closely tied to the most variable process in the water cycle. Figure 2.2 shows Nguigmi rainfall and the dramatic spread and contraction of Sahelian pastures and browse production. The coefficient of variation (CV) for Nguigmi rainfall is 0.494. (In contrast, the coefficient of variation of rainfall at Ndjamena is 0.283.) The rainfed production systems are the most volatile sector of the economy. Rain gauges need to be placed as close as possible to the project site.

Because a river basin such as the Chari Basin collects water from a very large area and its headwater is in a climatic zone with more abundant rainfall, most hydrologists familiar with northern river basins would anticipate interannual variability of channel flow to be much less than rainfall (Figure 2.3). However, this is not the case. The flow of the Chari River at Ndjamena varies more than rainfall. (Ndjamena rainfall CV is 0.283; Ndjamena flow CV is 0.375).



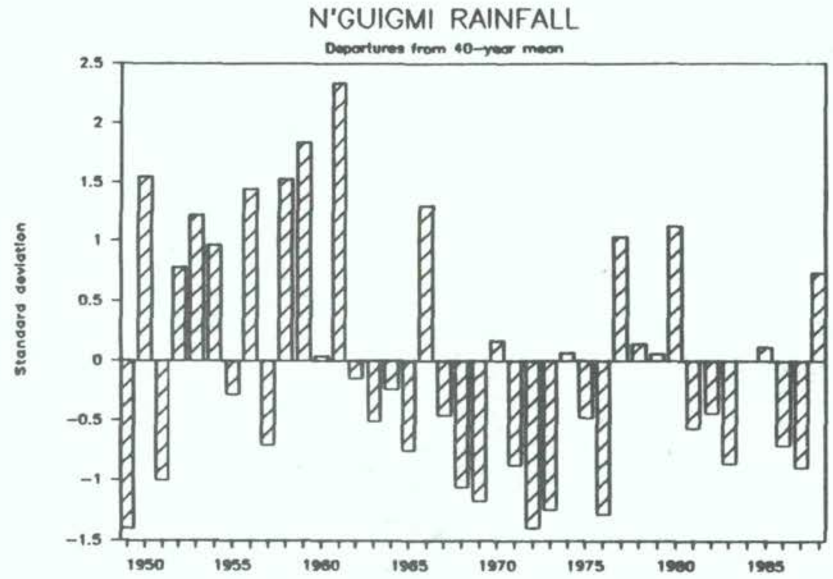


FIGURE 2.2
RAINFALL VARIABILITY AND PASTURE QUALITY

The area shown is in the Komadougu-Yobe and the Northern Diagnostic Basins of Niger. Lake Chad borders the southwest edge of the area. Pasture quality is extremely sensitive to rainfall, deteriorating and recovering quickly, though not necessarily with the same species. The rainfall is unpredictable from year-to-year necessitating a very flexible transhumant pastoralism. The official "pastoral zones" are only occasionally relevant. There is a good year-to-year correlation pasture quality with rainfall. Perennial plant abundance and production may modify this assessment of quality.

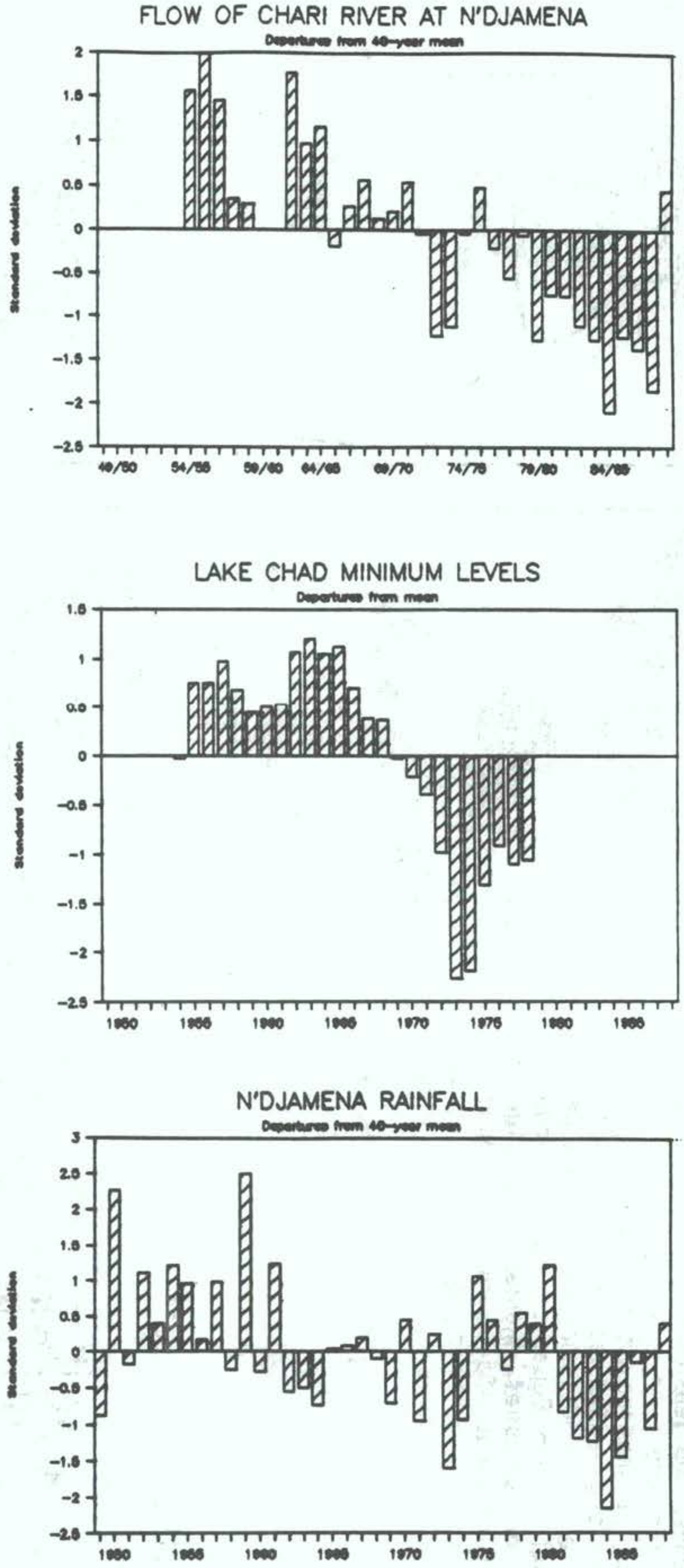


FIGURE 2.3
VARIABILITY IN RIVERFLOW, RAINFALL AND LAKE LEVELS

IS THERE CLIMATIC CHANGE?

The severe droughts that assailed Lake Chad Basin in the last 20 years have raised the issue of a possible climatic change in the region (Thambyahpillay, 1984). It is extremely difficult to determine empirically whether change has already occurred because the length of the climatic record is so short. It is apparent, however, that comparable droughts have occurred several times within the region during the past 300 years (Rasmussen, 1988).

It is now a highly charged debate whether climate change is imminent due to industrial pollution causing changes in the composition of the atmosphere. But, as yet, there is little agreement among the major global circulation models (GCMs) about specific changes that might occur in the Sahel due to carbon dioxide-induced warming (Mitchell, 1989). Moreover, at lower latitudes such as those of Lake Chad Basin, projections suggest that changes in temperature are likely to be significantly smaller than those at middle and high latitudes (Parry et al., 1988).

Regardless of its relative magnitude, there does seem to be general consensus about the probable directions of change. Annual rainfall in the Sahel will remain the same or may decline. Similar forecasts are made for temperatures, with means remaining nearly the same or slightly increasing. Thus, regardless of the scenario, the Sahelian situation will probably not improve, but could significantly deteriorate (Hutchinson, 1989).

A closer look shows that run-of-the-river irrigation, fisheries, riparian forests, recessional farming, and pasture are better insulated against climatic shocks because they rely on rainfall and shallow groundwater, as well as on channel flow. The channel flow itself does not stabilize and (in wet years) increase productivity so much as it staggers water inputs by rainfall and arrival of riverflow. The Chari-Logone Diagnostic Basin can also rely on groundwater to survive the "drought" between rainfall and the arrival of riverflow. This hydric stability is, of course, the well-known "drought sanctuaries" for the rural population and, during droughts, experiences the heaviest environmental exploitation and degradation. In short, planners require three hydro-indices to properly capture the dynamics of water-dependent economics: riverflow, rainfall, and flood levels. (Only one hydrological index would increase the chances of failure and poor planning.)

A water type-year hydro-index for flood height, areal extent, and duration is most obviously lacking. This index impacts hundreds of thousands of people economically dependent on the yaere (Section 2.4) and surrounding areas. A type-year index for project and impact planning might be developed by using a combination of ground-truthing and satellite photos (Part 3).

Finally, the Lake levels should have even less variability. In fact, the CV of lake level at Bol is 0.005. But Lake Chad's shallowness and division into two pools causes very small variations in lake level to have very large effects on lake surface area and distribution of water depth (Section 2.2.) . The lake is so unique that the north pool might be considered a wet-year lake and the southern pool a variable delta that sometimes floods by return flow from the

Grande Barriere. The term "lake level" is actually misleading and has confused planners and engineers. Data have been collected for one station (Bol), where "average" conditions have very little relation to Nguigmi (north basin) and, because of water distribution and El Beid inputs, only an ambiguous relation to the SCIP intake. In the examples of Lake Chad and the Chari River, a series of rainfall and channel flow hydro-indices are needed to define "type-years." One single index will lead to poor economic planning assumptions and project designs.

Although we argue for skepticism, the standard deviation does seem to indicate how reliable the mean measurement might be. Viewed as normalized observations with confidence limits, mean measurements can provide both a measure of relative magnitude of an observation and a suggestion of its frequency (e.g., Figure 2.3). In defining water type-years, it is possible to divide annual observations by percentile distributions or according to their distance from the mean (1, 2 or 3 standard deviations). Economic planning should give particular weight to possible lows and the confidence limits of the means. "Worst" case scenarios (consecutive dry years) may not be intelligible from statistical analysis.

2.2 LAKE CHAD DIAGNOSTIC BASIN

2.2.1 Water Resources Background (includes Kanem Lakes)

LAKE CHAD (Figure 2.4 and 2.5) is situated at an altitude of about 280 m above sea level. In recent history, its waters have spread over an area of between 3,000 and 25,000 km^2. The volume of water retained in the lake varies between 20 and 100 x 10^9 m^3.

The lake is fed by a land area that covers about 25 percent of its total basin (mainly the Chari/Logone watersheds). Lake levels, volume, and surface area vary enormously with the inflow from the Chari/Logone channel flow. In a "typical" year, the Chari/Logone/El Beid and Serbewel channels account for 99 percent of the channel flow and about 85 percent of total freshwater inputs.

Although Lake Chad is a closed basin within an arid zone, it has relatively low salinity because (1) there is no limestone in the watersheds and the river water carries a low ionic load; (2) biogeochemical sedimentation occurs in the lake, reducing salts by 45 percent; (3) considerable infiltration helps leach salts from the lake (especially in the north pool); (4) shell formation by molluscs hleps regulate calcium ion levels; (5) plant growth by macrophytes helpa regulate potassium and silicates; and (6) diatoms also help regulate silicates.

The salinity is remarkably stable despite huge swings in lake levels, due predominantly to the morphology of the lake. When the waters recede, marginal lake deposits form. Only a portion of these salts redissolve, when the lake level rises. Some remain in solid form and others are removed by wind transport.

In summary, altering the hydrological inputs and morphology of the lake should always take into account the impact on salinity concentrations, which may include polder development, reduced inflows (especially the Komadougou Yobe in the north basin), sill regulation, changes in floodplain return flows (especially the El Beid), and impacts on mollusc and macrophyte populations.

Figure 2.4
LAKE CHAD DIAGNOSTIC BASIN

LAC TCHAD
BASSIN DIAGNOSTIQUE

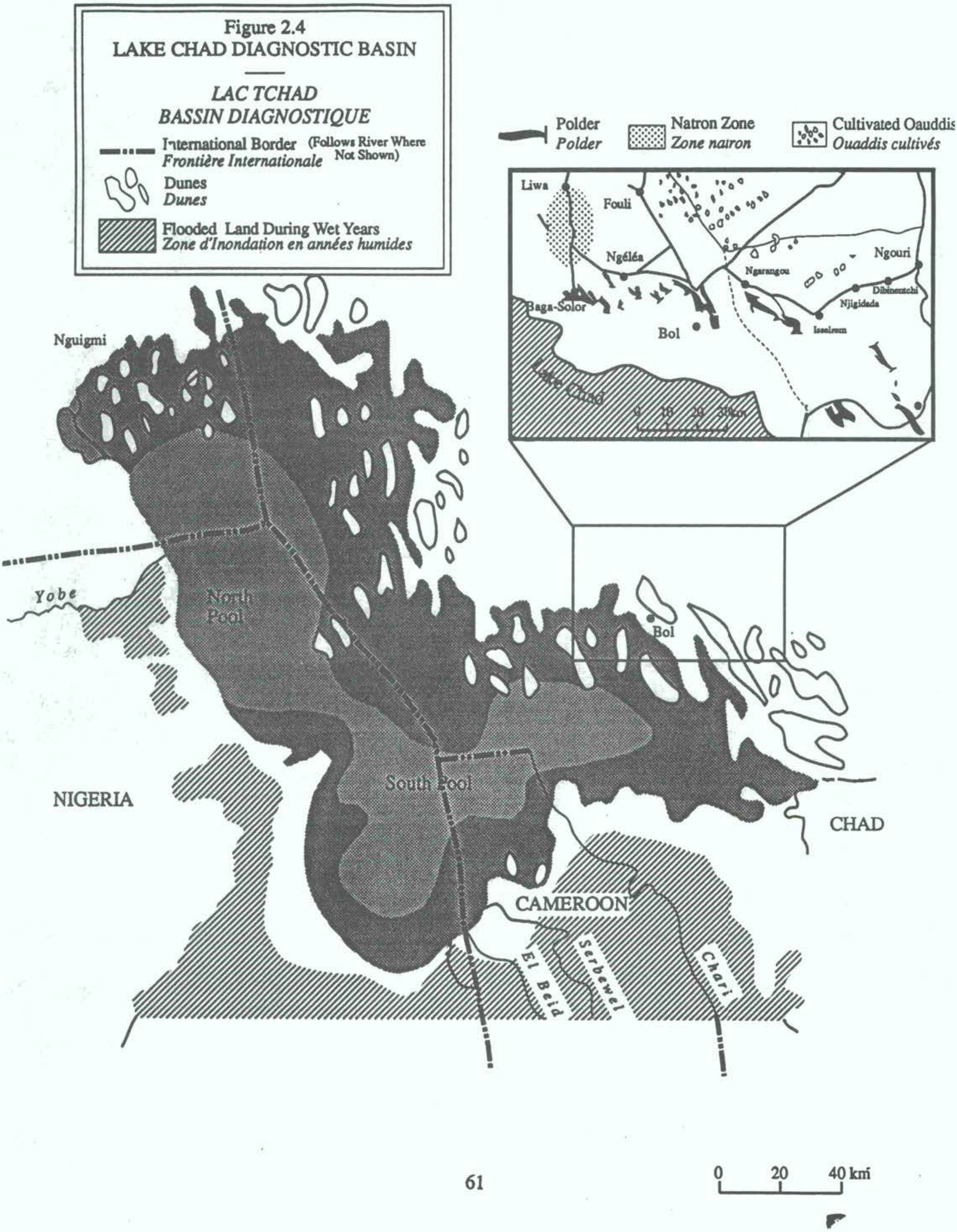
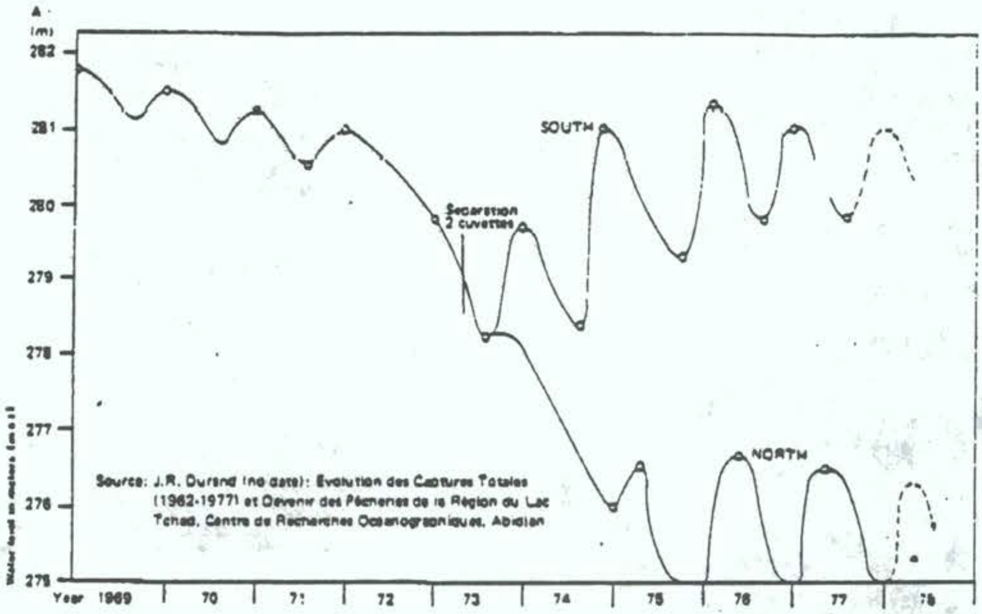
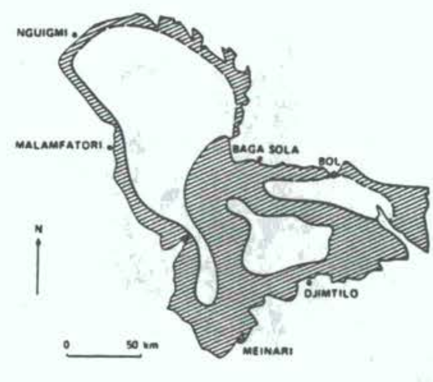
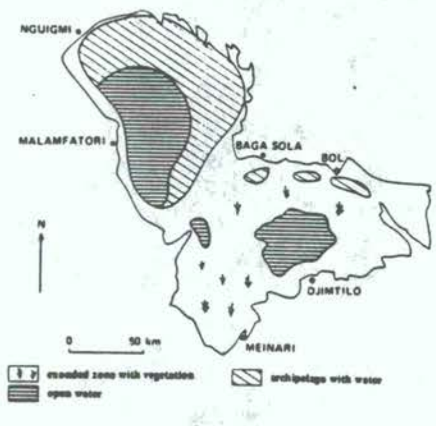


Figure 2.5
LAKE LEVELS AND THE TWO POOL MORPHOLOGY
LES NIVEAUX DU LAC ET LA MORPHOLOGIE

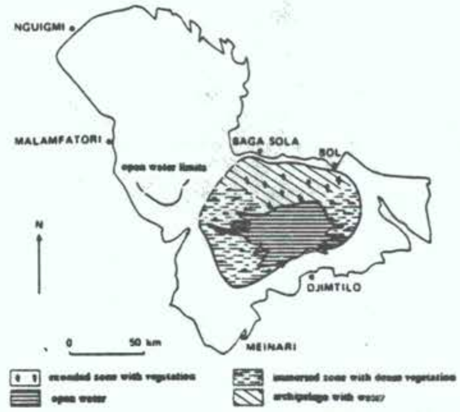




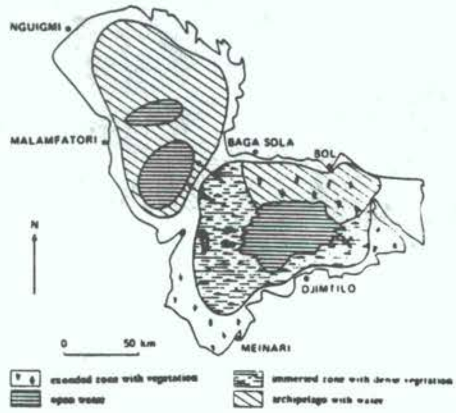
The 'Lesser Chad' in April 1973.



The 'Lesser Chad' in July 1973.



The 'Lesser Chad' in October 1973.



The 'Lesser Chad' in December 1973

The lake consists of two morphologically distinct pools. They become fully visible at a water surface elevation of about 279 m. At this elevation, a ridge known as Grand Barriers is visible between Baga Kawa and Baga Sola, subdividing the lake into northern and southern pools. When exposed, the ridge quickly develops a dense growth of plants, which additionally restrict sflow from the southern to the northern pool. The lake bed in the northern pool is, on average, about 2 m lower than that in the southern pool. The lake has been divided from 1973 (see Figure 2.5) into the mid 1980s. The river inflows and the rainfall during these years have been insufficient to overlap the Grand Barriere and balance water levels in the two pools. Some overflow occurring at higher levels and of short duration was subject to almost immediate evaporation, and the surface waters of the northern pool dried up completely.

The lake receives over half of its annual water supply between September to November. This seasonal inflow pattern, coupled with much more uniform evaporation, causes water level fluctuations of 1 to 2.5 m to occur every year. The average annual inflow to the lake is 38.5 x 10^9 m^3, but it has varied in the period of record from about 7 x 10^9 m^3 (1984 through 1988) to about 53 x 10^9 m^3 (1961 through 1962). During this period, lake levels and corresponding surface areas varied from a low of 275.35 m and less than 3,000 km^2 in 1984 to a high of 283.41 m and almost 26,000 km^2 in 1962. Even at the highest water levels, the lake has a large number of islands, and the percentage of the free water represents only about 70 percent of the total area of the lake. The average annual inflow to the lake is in the order of two-thirds of the average volume of water retained in a "normal" year.

Qualitatively, the inputs to and outputs from the lake are fairly clear. Evaporation and evapotranspiration from the lake are in the order of 48 to 50 x 10^9 m^3 annually and do not change much from year to year. On the contrary, river inflow (by the way of Chari and El Beid Rivers) and the amount of rainfall falling on the lake surface vary substantially. River flow and low rainfall are the main causes of low lake levels in some years, especially in the case of low rainfall in both the upper and lower parts of the lake catchment.

In summary, all policies for the lake (see Sections 2.3 and 2.4 for the floodplains) should be based on four understandings:

— large areas of the lake bed are likely to emerge or be flooded from one year to the next;

— the northern pool is more lake-like; the southern pool is more of a riverine delta;

— in wet years, the northern pool will be more stable than the south pool; in dry years, only the Chari delta will flood;

— profound changes in the ecological zones will always accompany the changes in this shallow lake. Some ecological zones may even temporarily disappear (see below).

KANEM

The water system of the wadis of Kanem is connected to the lake level of Lake Chad (south pool). The influences of water table flux are not clearly understood and are probably localized. Short-term depletion of wells takes place even with shadoufs, but they rapidly refill. No large changes in water level have been recorded in ten years, despite supposed connections to Lake Chad. Rainfall is more important to maintain the acquifer levels in the southern wadis.

LAKE CHAD WATER BALANCE RESEARCH

The hydrological water balances of the lake have been attempted by many organizations, first by ORSTOM (1969), on the basis of 1954 through 1966 monthly data. Two main anomalies were identified. First, evaporation and infiltration losses increase as the lake water level decreases. During periods of low levels, increased vegetation results in increased evapotranspiration, which may be greater than evaporation from the free-water surface. Second, water losses from the lake have been found to be significantly higher between August and February and lower during the rest of the year than would have been expected from the calculated Penman values. This might be due to wind set-up, errors in lake inflow and groundwater recharge measurements. The errors might also be caused by incorrect stage/capacity curves.

In 1972, a mathematical computer model of the water balance of Lake Chad was developed by Sir MacDonald & Partners (Evans, 1987), as part of the feasibility study for the South Chad Irrigation Project in Nigeria. The model included a number of additional parameters to correct the anomalies identified by ORSTOM. The model was updated in 1980 to simulate the lake's water balance in its split state into southern and northern pools. The model results have been quite satisfactory, although the authors made it clear that vegetation growth is an important parameter for which minimal information is available.

Concerning water balance computations made so far, it must be stated that they are all far from accurate and reliable. Several water balance elements (especially evaporation and infiltration) are not measured with sufficient accuracy to obtain satisfactory results. Greater attention should be paid to basic measurements and data collection in order to determine the true operation of the lake system.

Dunes that are maximally 20 and 40 m high predominate the landform. There is no directional flow between the seasonal and permanent lakes and ponds. They cover the bottoms of an ancient fixed erg. Viewed in terms of environmental degradation, there are two types of wadis that require different strategies:

(1) the isolated wadis in steep-sloped depressions separated by moving sand (e.g., Nokou, Mao).

(2) the more or less open wadis such as the Bahr el Gahzal, which is discussed under the Northern Diagnostic Basin. Not all depressions are wadis.

The bottoms of wadis (as opposed to simple dunal depressions) have a nonsandy soil ,and the water table occurs between 3 to 10 m of the surface. The isolated wadis have silty or silty-sandy soils in the bottom. The water is basic or neutral, with greater concentration of natron near Noukou, with 2 to 2.5 percent organic material in the upper horizons. Water levels depend on rains, as well as the water tables of Lake Chad and the Bir Louri (Chirati water table). At the moment, even though some wadis have a three-cycle crop season, there appears to be no loss of fertility.

The wadi bottom vegetation depends on the water quality of the pond or lake. Oligocarbonated waters support Phragmites, while meso-carbonated and poly-carbonated water causes stress. *Cyperus laevigatus* grows on the edge of the inundated zone. In eucarbanoted and hypercarbonated zones there is no wetland plant life. *C. laevigatus* is on the edges. *Spirulina*, the algae harvested to make proteinaceous sauces, thrives in meso-carbonated to the most carbonated water bodies.

The impacts of the drought on dune vegetation have been spectacular, with few trees surviving between Rig Rig and Nokou. On the dune slopes, there is often an anthropogenic steppe (with *Calotropis*, *Balanites*, *Zizphus*, and *Acacia*). In the south, some wadis have doum and borassus palms as well as *Acacia senegal*. Recently, *Prosopis* and *Parkinsonia* have been planted. The grass layer varies with rainfall and has changed dramatically since the drought.

The wadis also support date palm orchards, bananas, guavas, and citrus. Only the oligocarbonated water can support fish (*Tilapia*, *Hemichromis* and *Parophiocephalus*). Waterbirds visit the lakes opportunistically. Hippos are rare but do appear.

2.2.2 Water Resource Concerns

a. The possibility of irrigation has been under consideration in Borno for many years. By 1968, the use of Lake Chad water for large-scale irrigation was considered. In 1969, the North East State Government submitted a request to the UNDP for a feasibility study of the South Chad Irrigation Project (SCIP), covering an area of 66,000 ha, 16,000 ha of which would be available for immediate development. In 1971, the consultants were commissioned to carry out the feasibility studies. Project consultants later noted that "at a time of the conception of South Chad Irrigation Project, and indeed during the operation of the field studies, hydrology was considered to play a minor role; water of a good quality was available in large quantities in the vast natural reservoir of Lake Chad." (MacDonald, 1973). As the project studies developed, it became evident (especially in the autumn of 1972 with the lowest lake inflow on record) that the question of water availability should be seriously considered. The consultants concluded, however, "that the preoccupation with low lake levels is in some ways unfortunate; the present phase should be looked at in the context of a temporary short period within a long series of years" (MacDonald, 1973). This statement was typical of engineering consultants in the 1970s.

b. The designs of the SCIP canal intake and the main pumping station were based on the frequency analysis of the lake levels. The critical lake level adopted for the design was 279.9 m at Bol Dune. In 1973 and 1974, however, the minimum water levels recorded at Bol Dune were 278.12 m and 278.23 m, respectively (the all-time minimum from years 1907 to 1972 was 279.93 m). This may explain why the consultants stated that "for a period of two to three months at a frequency of once in five years (MRT, 1978)," the source of supply of irrigation water will be the boreholes.

The consultants also noted that the borehole water might need to be treated. Yet it should be noted that in 1973 the consultants associated with MRT (MacDonald, 1973) rejected the artesian aquifers of Borno as a potential source of irrigation water. They felt that neither the yields nor the quality of groundwater of the aquifers were suitable for irrigation use. Regarding the Quaternary Deposits, the same consultants felt that exploitable groundwater is "an exception rather than a rule in the New Marte area" (MacDonald, 1973).

The extremely dry years of 1973 and 1974 were followed by a few relatively wet years, and the leaflet issued in 1979 to celebrate inauguration of the SCIP project reads: "hydrological studies show that lake levels over 1870-1970 have, on the whole been at a higher level than now prevails; it seems logical therefore to regard the droughts of the early 1970s as temporary aberrations rather than indicating new low norms."

The shrinkage of Lake Chad in the 1980s has imposed serious constraints on the operation of SCIP. In June 1985, the nearest open water was about 70 km away from the intake channel. Although in 1988 the lake level was high enough to allow for irrigation of 8,000 ha of wheat in the SCIP area, there are serious doubts about the future of the project. The major cause of SCIP's underperformance in the recent past is that its design assumptions have not accounted for deep droughts, such as the one recorded in the 1980s. But with the highly variable levels of Lake Chad, the project efficiency will be always in doubt. An interesting study on SCIP and its underperformance has recently been published by Kolawole (1989).

Even in wet years, water quality is a concern because the SCIP intake mainly mainly waters from the El Beid. The first flood waters (July and August) are highly mineralized from salts that accumulate within the El Beid watershed during the dry season. "Lake" waters (a mix of Chari, Serbewel, El Beid and the previous year's water) can reduce crop production and damage soils during this period.

In summary, major obstacles to sustainable development, conservation of soils, and soil/water relations have been lack of environmental analysis and a policy of not "expecting the unexpected." Both economic production and long-term soil maintenance have suffered from poor predesign statements concerning drought fallback water supply (boreholes), water quality (El Beid and groundwater), reliability of water supply, and the impact of water quality on SCIP soils.

c. A major environmental concern in analyzing all impacts on Lake Chad is salinity control. The maintenance of this salinity is dependent on the "extra" flow necessary to accomplish leaching, enough flow to maintain dilution of lake water from previous years, and enough detritus (dead plant/algae material) to stimulate the biogeochemical sedimentation. This concern has not yet been addressed in the policy dialogue of LCBC.

d. The northeast border of the lake contains small interdunal valleys that flood seasonally as the lake rises. Others become moist from changes in the water table, which result from the rise in lake level. When the lake recedes or the trapped water infiltrates and evaporates, these "polders" become fields for the cultivation of wheat, corn, cotton, and potatoes. A complex series of events may occur with polder development. On one hand, the lake surface is restricted, and marginal salt deposit areas reduced. On the other hand, any localized increase in salt concentrations will limit crop production and long-term soil fertility. At this point, polder development may not be large enough to impact salinity in wet years. Impacts during prolonged drought may become an environmental concern.

e. Various consultants have claimed that large-scale irrigation projects will not impact Lake Chad. These estimates are based on questionable water balance models for the lake and are not based on water type-years. In addition, they do not take into account other impacts, such as groundwater leakage from the lake, isolation of north and south pools, and diking. Finally, the quality and distribution of waters have not been considered. In short, water balance models are interesting academic exercises but, when used to justify water diversions and irrigation developments, they should be treated skeptically. Unless the models incorporate the quality and distribution of waters, as well as land use changes, they cannot adequately address the development and conservation consequences of the project.

f. Further research is needed on groundwater movement between the north and south pool as well as leakage from the lake to surrounding aquifers under various pumping scenarios. Both have production and environmental consequences to fish, wildlife, lake-bed agriculture, and basin socioeconomics.

g. There has been a proposal to regulate the sill of the Grande Barriere in order to maximize lake level in the south pool at the expense of the north pool. This proposal should be carefully analyzed for all groundwater and water quality impacts in the north pool, water type-year regulation rules, and socio-political consequences.

h. The availability of water to cool the New Marte power plant and to dispose of its residual salts is an important water quality and supply concern. The power plant has not been functional during drought periods. Its wastes may cause environmental degradation. The economics of this development project are questionable.

i. General Kanem lake concerns can be found in the Section 2.9 (Northern Diagnostic Basin). This section focuses on the connection to Lake Chad and the wadis.

Many of the wadis have been spared by the drought. In 1988, the CFTFT recorded that the wadis of Mao were not impacted in any visible manner. Other wadis experienced:

(1) Sand sheeting, with sterile sands in the silty-clayey bottoms. There are nebkhas, rebdous at the foot of shrubs, trees, and palms. There was a need for wind breaks.

(2) Salinization, especially with an emergent water table. Salt crusts were caused by evaporation or capillary action, especially in areas where the water table was sporadically emergent.

(3) Loss of density and species on the dunes. (See Section 2.9, Northern Diagnostic Basin description of dunal change). As in Mao, Noukou has a radius of 20 to 25 km^2 in which human deforestation (vs. climatic) is apparent. Livestock browse and fuelwood supply were devastated.

(4) Possible overexploitation of palms for shadoufs and construction wood in the last remaining natural stands in Cheddra and Rig Rig.

(5) The disappearance of doums due to drought and overexploitation.

2.2.3 Ecological Resource Background

There are three main landscapes within the lake that vary in extent with the water type-year: the archipelago of islands on the east side, which are really the tops of dunes of a widely submerged erg, islands of vegetation (some floating, some rooted) with *Cyperus* or *Phragmites* as dominants, and areas of open waters.

The lake's shallowness has led some researchers to describe "Lake" Chad as no more than a deep wetland. This is supported by the fact that the fish species are all derived from river-adapted species.

There are 120 species of fish in the lake and the backwaters of the Chari delta. The distribution of these fish changes according to the distance from the Chari, El Beid, and, formerly, the Komadougou-Yobe delta and the landscape type (archipelago, open waters, vegetative islands). The open waters support fewer fish than the archipelago.

During wet years, the north basin supports more fish than the south because of its greater depth. During dry years, the depressed volume of the lake concentrates fish, reduces breeding habitat and shelter for juveniles, and increases competition between fish and vulnerability to fishing gear. Shallowness promotes resuspension of sediments that kills fish by blocking their gills or reducing their oxygen. The north pool dries up first and fish cannot move to the south pool because an anoxic barrier forms from the rotting plant life along the Grande Barriere. Because no species appears to be restricted to "Lake" Chad, regeneration of stocks is possible as long as floodplain habitat (the yaeres) remains intact and fishing is controlled.

2.2.4 Ecological Resource Concerns

a. In 1963, nylon gill nets were introduced, completely altering the fishing effort, fishing intensity, size of the catch, and the species and ages caught. Between 1962 and 1970, the time the local population spent fishing increased thirty fold. Thus it is difficult to separate the impacts of humans from the impact of low lake level years. During some drought years, the size of the catch increased because of the concentration of fish in smaller volumes of water.

In 1977, the commonly used net mesh size was already too small. It should not be smaller than 60 to 70 mm, too small to allow the fingerlings of many species to escape. By 1971, *Alestes baremoze* had been overexploited, independent of water levels and drought conditions.

There are many ecological research, monitoring, and management concerns that have caused species reduction, and poor utilization of catches and that have threatened the long-term viability of fish stocks and fisheries. These are addressed below and in Part 3. Present yield estimates do NOT include flooded plains — only the Lake Chad area itself. They are not addressed by water type-year.

b. The lake supports hippopotami, otters, and sitatunga. The population and habitat of the sitatunga, a swamp-adapted antelope, are of some conservation concern. Some elephant herds enter the lake bed seasonally. The lake is also important as a resting ground for intra-African and intercontinental bird migrants. Protection of lake and lake shore habitat for these species is a major concern.

There are two protected areas along the lake shore: the Douiga National Park in Chad and the Lake Chad Sanctuary in Nigeria. Little is known of the status of these protected areas.

2.2.5 Human Resource Background

The lake supports the following:

(1) a major fishery shared by all nations either adjacent to its shores or who engage in trade; (this fishery is completely dependent on river/lake migration and overflow from the Chari/Logone);

(2) a major livestock industry that depends on seasonal entrance into the lake bed for forage;

(3) a variable, water-based transport industry that occurs only at high lake levels;

(4) an undocumented gathering "production system" based on doum palms subirrigated by the lake, aquatic plants, and salt flats;

(5) an modern agriculture area along the Nigerian shore of Lake Chad that pumps water from the lake for irrigation and the cooling systems involved in electric production;

(6) a wildlife heritage and possible tourist industry consisting of wetland birds, crocodiles, hippos, elephants, and the sitatunga;

(7) a passive "pollution" control system that keeps Lake Chad water from becoming too saline;

(8) a groundwater recharge system that is little understood but may supply the polder agricultural developments on the northeast shores of the lake.

The lake shore and the insular areas were once dominated by Buduma, but with the retreat of the lake, the communities of Kotoko, Kanuri, Hausa, and others have pioneered agriculture in the lake bottom (Figure 2.6).

2.2.6 Human Resource Concerns

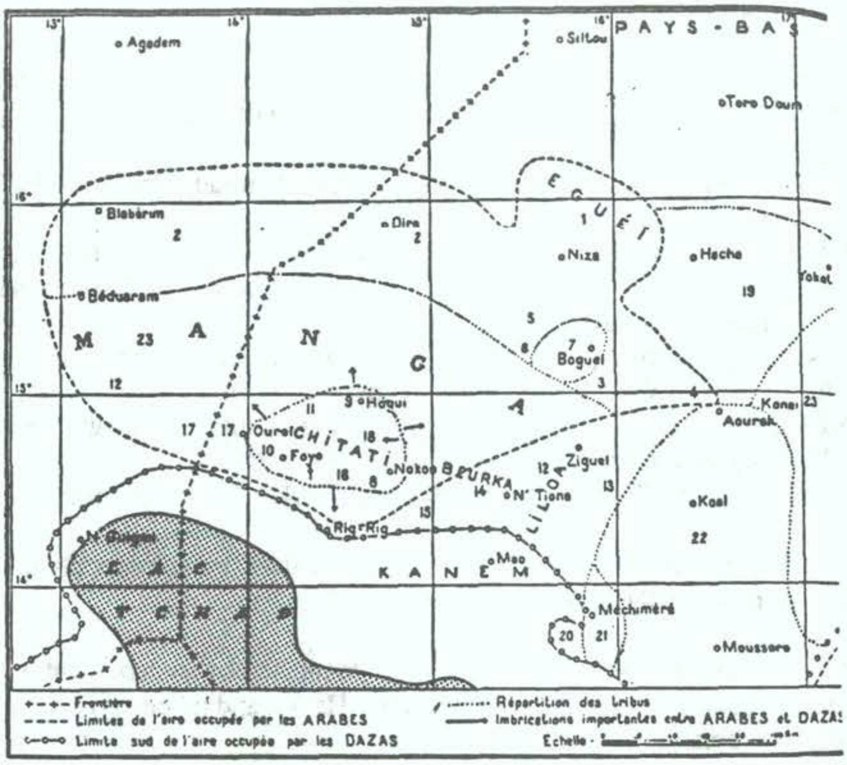
a. Many farming communities in the lake area have developed their own low-technology irrigation schemes. They have migrated into the lake bottom where crops may be irrigated by capillary action. They have produced up to 150,000 T of recession sorghum annually since the early 1980s for the urban markets, especially in Maiduguri. Seasonal lack of fodder and water, conflicting land-tenure claims, and waterborne disease in the lake floor are the main problems that the farmers must endure.

b. Environmental management problems associated with land tenure in the wadis (discussed in the section on Kanem and Bahr-el-Ghazal) exist in the environs of the lake as well.

c. The immigration of Hassaouna Arabs, Dazas, and Oueleds Slimans from the region of Noukou and Rig Rig and the descent of Kredas from the Mao region into the northern reaches of the lake have provoked intense resource competition with the Buduma for the bourgoutieres and other pasture resources. The mixing of livestock encourages the spread of animal disease.

d. In the south pool area there is an acute absence of recognized management authority over the farm lands and pastures exposed when lake levels fall. This situation has caused serious civil conflict. The recent establishment of definite boundary markers may serve as a useful landmark but it does not resolve the resource management issues.

Figure 2.6
ARAB AND DAZA GROUPS OF THE BAHR EL GHAZAL AND THE KANEM
GROUPES ARABS ET DAZA DU BAHR EL GHAZAL ET DU KANEM



++++ Frontiere/border
-------- Limite de l'aire occupée par les ARABES
Borders of Arab occupied area
.... Répartition des tribus/ Tribal divisions
-o-o-o- Limite sud de l'aire occupée par les DAZAS
Southern border of Daza occupied zonez

Old Ouled Sliman

1. New Ouled Sliman
2. Miaissa
3. Jebair
4. Chederat
5. Guedatfa
6. Mogharba

Hassouana Arabs

7. Am Rear
8. Ouled Mausour
9. Amana
10. Mahaboub
11. Ouled Billal

Daza of the Manga Kanem

12. Dogorda
13. Naria
14. Medelea
15. Goumsala
16. Gadoa
17. Kedelea
18. Worba

Other Daza

19. Djagad
20. Worda
21. Ankorda
22. Kreda
23. Kecherda

e. Animal health and fish transport are particularly difficult in Lake Chad because of the poor road system, unreliable boat transport and the insular population.

There is no internationally recognized institution controlling fishing effort, areas and seasons. There is a huge black market in fish sales, making it difficult to monitor species, amount, and age of fish. There are no enforceable rules on mesh size, species catch, fish "reserves," age of fish caught, etc. The lack of enforceable codes allows overexploitation of certain species and age-classes.

f. Models of Lake Chad have been too sectoral, concentrating only on hydrology and agriculture. Upstream channel flows need to be correlated with anticipated floodplain fish yields. The lack of hydrological indices to predict river/lake fish recruitment by flood area, duration, and height causes social conflicts, overfishing of juveniles, poor transport, and increased spoilage.

g. SCIP has distributed land by plots without considering the quality of soils. This has led to inequity in crop production. It also encourages overexploitation of the poorer soils.

During wet years, with irrigation, the environmental health of SCIP laborers is increasingly threatened by bilhrzhia and malaria associated with slow-moving water.

2.3 LOWER CHARI DIAGNOSTIC BASIN

2.3.1 Water Resources Background

As shown in Figure 2.7, the total drainage basin of the Chari River (excluding its Logone tributary), is 472,960 km^2. The upper part of the catchment has been subdivided into three subbasins with mean annual runoff values of 17.0, 5.0, and 5.9 x 10^9 m^3. These values decrease substantially eastward to the more arid northeastern parts of the basin. The eastern boundary of the Chari Diagnostic Basin is a region considerably drier than the other subcatchments and does not substantially affect Lake Chad levels. The most influential subcatchment is that of the Baha Sara, which joins with other tributaries downstream of the city of Sahr. This catchment, although less than half the area of the southwestern Bahr Aouk system converging around Sahr, provides nearly twice as much water to the Chari. Thus it must be regarded as the most important collecting area, and every effort should be made to conserve its water resources.

The lower Chari River comprises about 600 km of the river between Sahr and Ndjamena. At low flows the Chari River is contained within its banks and meanders within its coarse sandy bed. At high flows, however, there are several overspills. Especially important is the right bank overspill near Miltou; it is collected by the Bahr Erguig, which wanders through the extensive inundation plains of Massenya before finally discharging back into the Chari 300 km downstream from Miltou. A good description of flow losses and gains along the lower Chari is given by FAO (1972). When the discharge at Sahr is about 1,200 m^3/s and Bahr Sara contributes downstream about 2,300 m^3/s, the flow at Chagoua (just before the confluence with Logone) is in the order of 3,100 m^3/s (median flow conditions). The discharge is lost between Sahr and Ndjamena due to infiltration and evapotranspiration in the Chari flood plains.

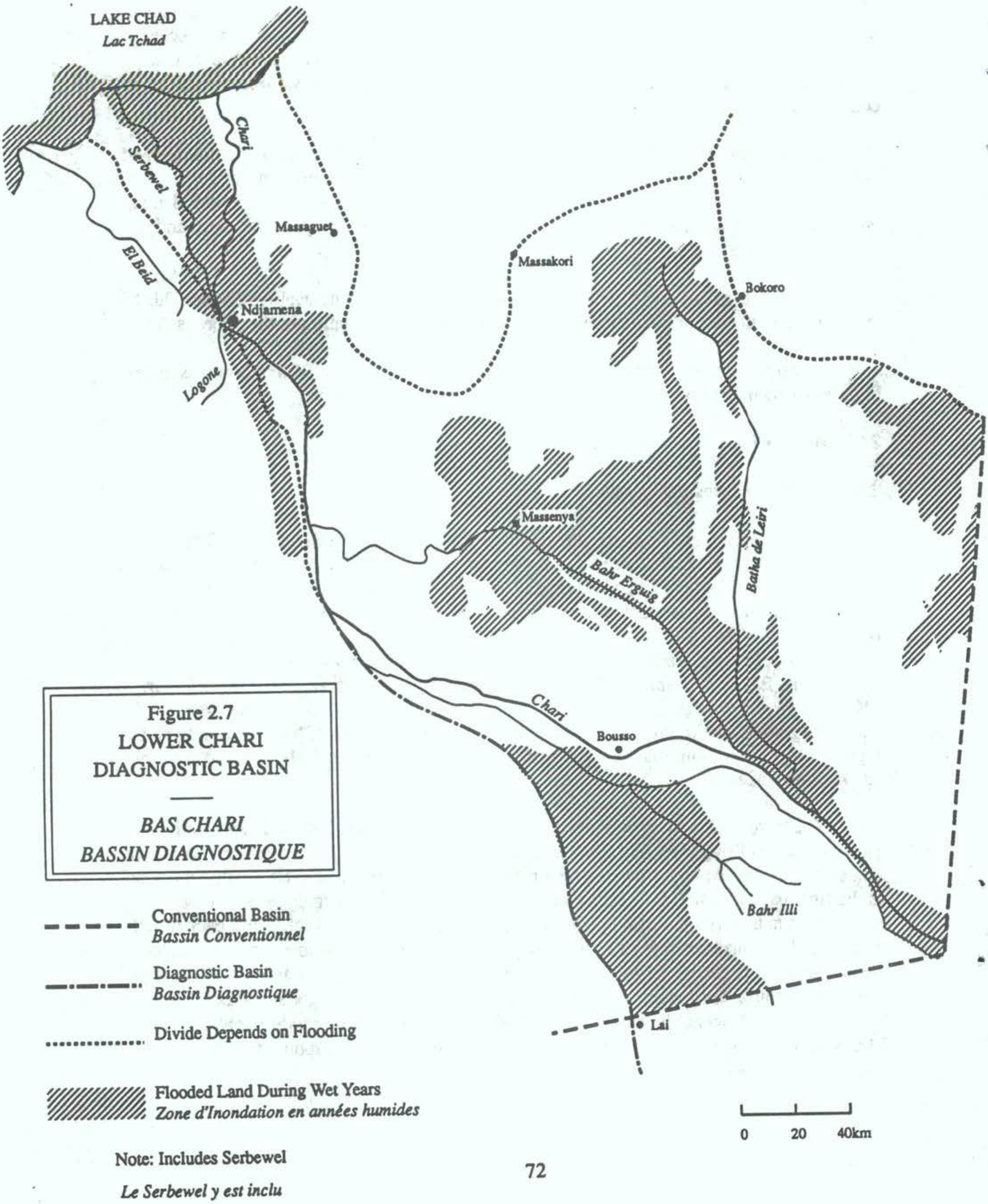


Figure 2.7
LOWER CHARI DIAGNOSTIC BASIN

BAS CHARI
BASSIN DIAGNOSTIQUE

The Chari delta proper begins immediately downstream of Ndjamena, 140 km from the Lake Chad, where the Serbewel River branches off from the left bank and follows its own course to the lake. The annual runoff of Serbewel River varies from 1.3 to 3.9 x 10^9 m^3.

2.3.2 Water Resource Concerns

a. The conventional basin is only a small part of the total Chari River Basin. Erosion or water diversions upstream, especially in the Central African Republic, are beyond the scope of this report. Nevertheless, they may have important impacts on the resources in the conventional basin.

b. The Serbewel is fed by high waters from the Chari and from the surrounding floodplains. A proposed channel from the Serbewel to the El Beid would prolong the channel flow of the El Beid and distribute waterflow closer to SCIP as well as lengthen the fishing season. This proposal requires careful assessment of the Logone/Chari River flows. It has the advantage of channeling flow AFTER it has been used for fish breeding and pasture growth. This proposal may provide an alternative to upstream dams.

c. The Semab dike from Katoa to Bongor needs review and placement within the general management of floodplain irrigation, channel flow, and peak flows for water type-year. Economic and environmental consequences of the dike have never been analyzed. Piecemeal diking of the Chari River may produce severe downstream impacts.

2.3.3 Ecological Resources Background

The conventional basin only includes the lower reaches of the Chari River. Nevertheless, this diagnostic basin has the largest permanent river. Its flat borders complicate watershed divisions. Its soils derive from ancient deltas, the southern mountains, the lake bottom soils of ancient Lake Chad, and ancient eolian sand dunes from the north. Many of the abandoned channels were once the channels of the ancient Chari River. The Massenya depression was once an interior delta.

The soils are varied and complexly imbricated with recent alluvial plains with clays, diatomites, and salts; a recent lakeshore complex, including the sand barrier of a recent higher lake; major stream beds from the Chari and Bar Erguig Rivers; old alluvial plains with ferruginous soils; a strip of eolian soils with weakly differentiated soils; and the old lake shore sand barrier from when the lake reached 320 m. The Massenya depression and other channels have halomorphic soils due to a near-surface water table.

Three soil groups are particularly interesting in terms of environmental degradation. Along the river channels and embankments there are weakly developed soils formed from deposition or hydropmorphic soils. In the ancient delta and Massenya basin, textensive hydromorphic soils with a surface of pseudo-gley and the leached alkali soils occur. These soils are extremely fragile. Already, by 1964, many of these soils were free of vegetation. The other major soil group is the brown soils (some with weakly developed brown or reddish-brown facies; others with weakly leached ferruginous facies).

The diagnostic basin spans the Sahelo-Sudanian Zone and the Sudano-Sahelian Zone. In general, the line between the zones oscillates north and south around the town of Massenya.

Almost the whole diagnostic basin supports shrub steppes, shrub savannas, and wooded savannas. There is one National Park (Dougia) and one Faunal Reserve (Mandelia) along the right bank of the Chari River. (Right and left banks are in relation to the downstream direction.) The Mande National Park and the Yimbe Classified Forest border the southern boundary of the Diagnostic Basin. The status of theoretically protected forests could not be determined.

2.3.4 Ecological Resource Concerns

a. There is no doubt that the drought has killed off or damaged many tree species. *Terminalia avicennoides, Anogneissus leiocarppus, Scleorcarya birrea*, *Lannea*, and, where the water table has dropped, *Acacia nilotica* have all suffered. Tree death has been apparent on both the slightly leached, ferruginous soils of the southeast and the isohumic soils of the north. Nevertheless, the long-term consequences vary for the different soil groups and locations.

The "halomorphe a alkali" soils form a crust when denuded. The crust reduces infiltration and increases runoff, sheetwash, and scouring. It also encourages the formation of sand sheets and nebkhas. The rehabilitation of these soils will be difficult. On the other hand, as long as flooding exists, the hydromorphic and gleyed hydromorphic soils between the Chari and Logone Rivers will regenerate naturally over time.

b. Around Ndjamena, soil degradation has spread among the brown soils, the hydromorphic soils, the ferruginous soils, and the alkaline soils. There are large bare areas with crusts. These degraded soils have little to do with drought. They are predominantly the result of devegetation by humans. Up to 120 km east of Ndjamena, the cutting of trees (*Acadia seyal*) in the sandy clays and the cutting of *Acacia nilotica* from the hydromorphic soils is severe. *A. nilotica* has almost entirely disappeared. The most severe degradation is east of Ndjamena. On the other hand, in the less populated areas of this diagnostic basin, the last twenty years of drought do not seem to have had any impact on the soils (Hamel, 1989).

Anogeissus leiocarpus, Terminalia ,and *Combretum* have also been devastated in Ndjamena's area of influence by landclearing for farming and wood supply. The forest has lost its diversity and, probably, near-term hopes of natural regeneration. *Balanites, Guiera, Boscia, Calotropis,* and *Zizphus* — all depauperate tree and shrub communities — are now common.

c. The drought has influenced species loss by making brushfires more deadly. Fire has an especially strong impact on the slightly leached tropical ferruginous soils in the southeastern shrub and tree savannas. In this sense, the drought has added to the human impacts of cutting and land clearing.

d. The loss of *Acacia seyal* and *A. nilotica* is also the result of spreading berebere cultivation in the clayey depressions. Not only is the land cleared, but the branches of surrounding trees are used as fences to protect the fields. These "dead fences" require large quantities of wood.

e. During the civil war, the area of the Chari floodplains south of Guelengdeng received many refugees from both north and south. Since 1980, the borassus and doum palms of Ngam and the Bongor region (sandy soil forests) are completely overcut. These already degraded forests are part of an export trade in construction wood to Nigeria and Cameroon as well as to Ndjamena. The timber harvest is completely uncontrolled. Part 3 recommends an immediate, intense agro-forestry project for this area.

f. The southerners cleared land for cotton by ringing the trees and burning. This has led to species loss, homogenization of the landscape, and deforestation. But on the vertisols, soil erosion is not yet visible.

g. Between Guelengdeng and Kim, the farm areas have only relict trees and wooded "parkland" scarred with ringed trees or deliberately set fires.

h. Grazing pressure has increased in the southern part of the Chari Diagnostic Basin with the retreat of tse-tse and glossina as well as the drought in the north. Some pastoralist groups that moved north are now sedentary. Their environmental impact is not well documented.

i. Mandelia Faunal Reserve (138,000 ha) was created in 1967. It is a Sahelian floodplain park plagued by poaching, farms, villages, military installations, and a lack of staff and equipment. Most of the large mammals have migrated to Cameroon sanctuaries such as Waza. The administration has considered declassifying the reserve. These thoughts should be part of the "international peace park" suggested in Part 3. The park has undergone no scientific study since 1964.

j. The Reserve de Dougia (59,400 ha) was created in 1961. It is accessible only by water from the Chari River. The reserve is bounded by the Chari River in the west and the shoreline of Lake Chad in the north. It is the only reserve directly in contact with the lake at reasonably high levels. While it acts as a sanctuary for mammals and birds, it is not known if it also supports fish breeding — a useful addition to the reserve. No recent work or information is available on Dougia. In the 1960s, elephants, hippopotami, waterbuck, Damalisk, lions, leopards, ostrich and even giraffe were present. The impacts of civil strife, drought, and poaching have led to the disappearance of lions, African buffalo, cheetah, and other species. The park has not been recently assessed.

k. Access to the park along the Chari River is hampered by poor roads. The response has been to dike the banks. It may be more prudent to create an all-weather road and allow flooding over the banks. In this area, flooding prevents environmental degradation by decreasing fire hazard, regenerating trees, increasing floodplain fishing, and restoring pasture.

2.3.5 Human Resources Background and Concerns

The lower Chari River is home to a large number of ethnic groups. The principle agricultural and agro-pastoral groups include the Kotoko, Baguirmi, Massa, and related groups (Sara, Hadjerai, etc.) Pastoral groups include Shuwa Arabs, Peul, and other transhumant Arab groups from the Kanem subbasin.

In the conventional basin, the Baguirmi live on the upper course of the right bank of the Chari River, where transplanted sorghum- and millet-based agriculture, fishing, and pastoralism are mixed. The zone is a transhumant corridor for populations from the Batha on their way to the Salamat. Kotoko semisedentary fisher agriculturalists and semisedentary Arabs

(Choa) live in its lower course. A variety of small agricultural groups distinguished by village and language live on the left bank. In the upper reaches cereals, tuber crops, and rice are grown. Population density is not high.

Populations traditionally faced certain resource constraints. The groundwater table varies from a few meters in the low lands to 45 m or 50 m over basement complex rocks in the Baguirmi region. Elsewhere the basement rock restricts water. Local water scarcity may provoke problems between transhumants and agriculturalists in the period before the grain is harvested. Alkaline soils unsuitable for agriculture are not uncommon, but seasonally inundated hydromorphic soils are characteristic. Economic diversification (i.e., cultivation of hydrophilic sorghums and millet, seasonal hunting and fishing, intensive stock rearing (Massa)) is the traditional response.

Since the 1970s Sahelian drought, the lower Chari River has become an increasingly important transhumant corridor at certain points of the year. Sedentary and nomadic groups who never encountered each other in wet years, have come into contact. The Oueled Rachid penetrate the deepest into this area in November through April, whereas the transhumant range of the Salamats and Khozzams is limited to the northern part of the Chari Diagnostic Basin near Ndjamena during the rainy season (Cabot et al., 1989). As agro-pastoralism has expanded into the area, the task of finding suitable pasture and (more importantly) water has become difficult. Conflict between the pastoral and agro-pastoral groups has ensued with the burning of bush and even farms—an unfortunate result of the competition for resources in the far south.

This competition became especially severe in 1984 to 1985 when Shuwa Arabs from the Chari River delta and Kreda and Kecherda from the Bahr-el-Ghazal descended towards Guelendeng and Bousso (Cabot et al., 1989). In 1984, large numbers of camel herders descended upon the region of Massenya for the first time in living memory. In 1982 to 1983, cattle herds concentrated along the Chari and Ba-Illa Rivers towards Bousso. These concentrations — the outcome of desperate survival strategies — resulted in intense pressure on pasture resources, created an ideal environment for the spread of animal disease, and provoked conflicts between herders and farmers over crop losses. Bush fires, which destroyed Sudanian woodlands species, were set to stimulate pasture regrowth or threaten other groups competing for resources.

In the lower delta, both nomads and farmer refugees have cleared land, carelessly exploited plant life and soils, and, in some cases, caused land tenure conflicts. For example, from Ngoura to Myota, the pastures are often degraded and discontinuous around the camps. The flat-bottomed cuvettes have been cleared for berbere. Land-clearing fires were observed from the air in July 1989. The trees on their slopes are often heavily grazed or have cut branches. The doum palms have been heavily cut for timber.

2.4 FLOODPLAINS OF THE LOGONE

2.4.1 Water Resources Background

Although the Logone River is a tributary of the Chari River, it is considered a major river in its own right in view of its specific characteristics. The river rises in the Adamacua Mountains in Cameroon at an altitude of about 1,200 m, and the area of the Logone Basin is estimated at 77,650 km² (see Figure 2.8). The Logone River starts at the confluence of the Vina and Mbera Rivers. About 25 km downstream of the confluence, the Soquel rapids are encountered. Below the rapids the character of the river changes: the gradient becomes flatter and the river flows through a narrow flood plain of alluvial soils until to its junction with Pende, below which the flood plain widens and Lai is reached.

The hydrological data indicate that the peak flood of the Logone River is extremely regular before it joins the Chari River above Ndjamena and that whatever the magnitude of flood in the upper catchment, there is little variation in the river's flow downstream. This reduction of peak flows is due to the natural attenuation through storage in the vast flood plains that occupy approximatiely 25,000 km². The range of maximum annual flows recorded in the Logone River at selected stations follows (MacDonald, 1973):

Station	Distance from the Lake (km)	Range of max. flow (m^3/s)
Lai	360	1,750-3,730
Bongor	410	1,740-2,630
Katoa	330	1,120-1,500
Logone Birni	200	850-980

This table indicates fairly conclusively where the major channel losses occur. Overspill to the Benue River via Mayo Kebbi occurs upstream of Bongor, but the largest amount of channel flow is lost downstream of Bongor through overspill to irrigate the Grand Yaeres.

The flood plains of Logone River can be divided into the following large areas (FAO, 1972):

- The Ba-Illi overspill area,
- the Tandjille Basin,
- the Mayo Kebbi overspill area (see Section 2.5).
- the Logomatia-Yeare-El Beid overspill area (Grand Yaeres).

About 20 km downstream of Lai, the Logone River overflows the right bank into the Sategui-Deressia plain. This overflow gives rise to the "Grand Courant," the origin of the Ba-Illi River which changes its name several times before discharging back into Logone River at Logone Gana, after a distance of about 410 km. In fact, the local population have dug canals to allow high water onto the plains. The Logone River begins to overflow its banks when the river gauge at Lai-Mission goes beyond 4.60 m (the altitude of "0" is 350.31 m above sea level). Overflows occur mostly from mid-August to mid-October. Up to the early 1970s, the flooding invariably took place with a duration of submergence sufficient to enable paddy cultivation. The droughts of the 1970s and 1980s made paddy cultivation very problematic. There was no overflow in several years (e.g., 1972, 1979, 1980, 1984, and 1985) and overflow of only very short duration in the remaining years.

The TENDJILE is the only important tributary of the lower Logone River that joins the river about 75 km below Gamboru. In Ere, there is an important overspill that eventually connects with the Mayo Kebbi system. Another left bank overspill occurs at Bongor, which also contributes to the Mayo Kebbi.

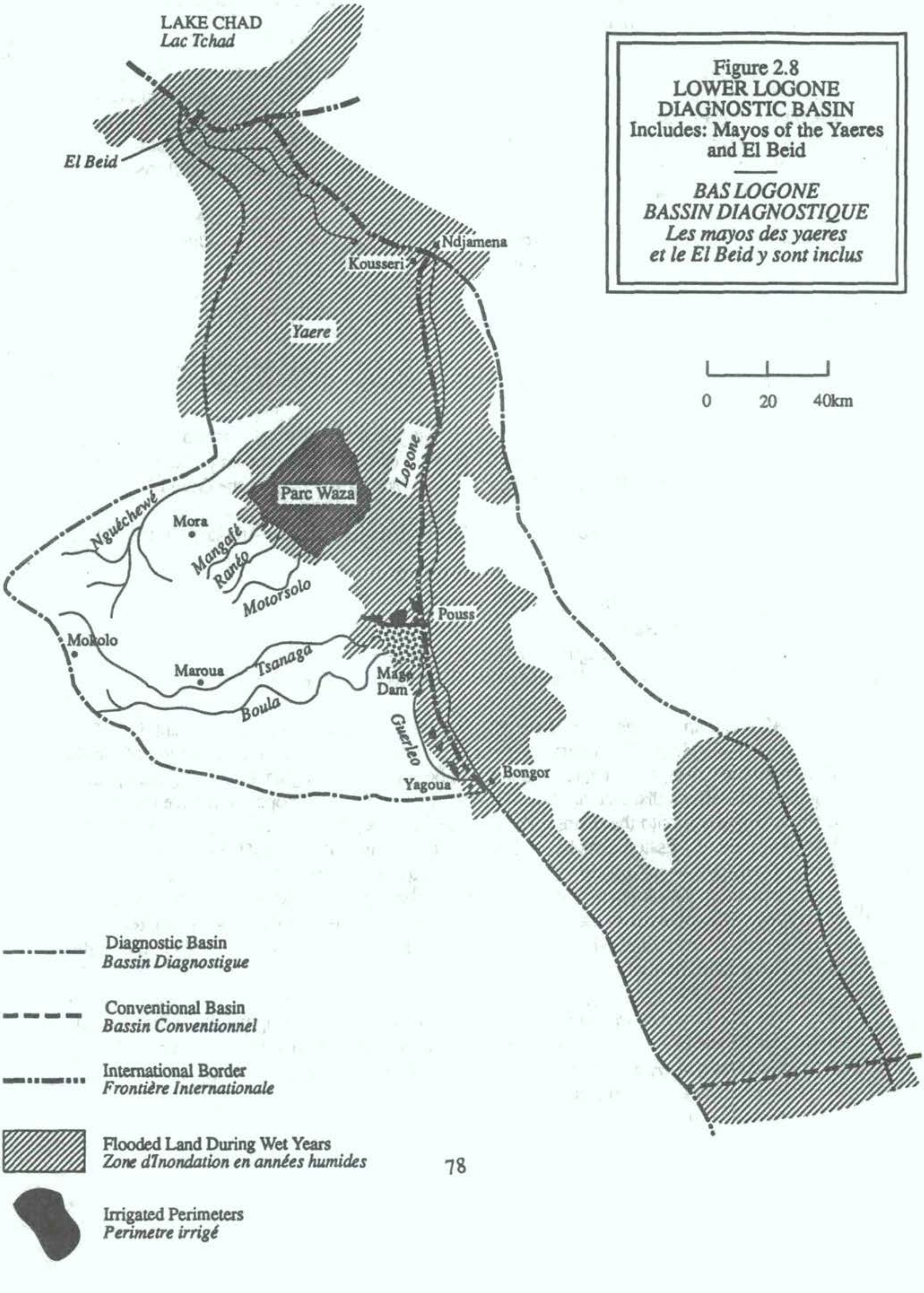


Figure 2.8
LOWER LOGONE
DIAGNOSTIC BASIN
Includes: Mayos of the Yaeres and El Beid

BAS LOGONE
BASSIN DIAGNOSTIQUE
Les mayos des yaeres et le El Beid y sont inclus

Immediately below Bongor, there is an important left bank effluent of Mayo Guerleou, which is one of the major sources of recharge to the Grand Yaeres. About 100 km downstream another left bank overspill combines to form the Logomatia, which eventually also supplies the Grand Yaeres.

The GRAND YAERES, an area of about 5,000 km² (see Figure 2.8), is the most productive of all the inundation areas in the Lake Chad Basin in terms of fisheries, livestock, and nonsystematic flood-retreat cropping. During the dry season, when grazing space is scarce elsewhere, the Grand Yaeres provide a most valuable alternative source of food and water for the animals. The ponds that remain after the water has receded are also important for fishing activities in the area.

The approximate water balance of Grand Yaeres for the median water conditions is given by GAC (1980):

Logone overspill
Rainfall
Drainage by El-Beid and other rivers
Evapotranspiration

For the relatively low water year of 1957/58, FAO (1972) estimated total evapotranspiration losses from the Grand Yaeres to be 4.30×10^9 m³. Other sources give an approximate figure of 5.00×10^9 m³, and current knowledge of the evapotranspiration processes in the area is very approximate. However it should be noted that a large share of the rainfall falls directly over the area of Grand Yaeres (almost three times higher than the Logone overspill).

There are no hydrological studies available on the nature and the extent of seasonal inundations in the Grand Yaeres. This is why more precise estimation of water flows, losses, and gains is not possible. It may be said, however, that during the hydrologically normal years, there are two inundation phases. The first one occurs during the period of heavy rains from August to September. The second, usually more intense than the first one, is caused by overspill from Logone River during September to December. In the dry years, these pulses may be separated by a month or two, and in the exceptionally dry years there may be no inundation whatsoever. Largest areal inundation has been estimated at 8,000 km². Typically, flooded land will be covered for a period of time with surface water about 0.7 m deep.

Hydrologically, the Grand Yaeres act as a large natural compensation reservoir, lowering and extending flood flow and generally providing more uniformly distributed inflow to Lake Chad. At the same time, the Yaeres' large-scale and shallow inundations result in major channel flow losses due to infiltration, evaporation, and evapotranspiration. The flood waters "irrigate" the pastures and recession agriculture fields, recharge the water table, and create habitat for fisheries reproduction and growth.

EL BEID River, locally known as the Ebeji, forms part of the border between Nigeria and the Cameroon. It drains the area of approximately 22,640 km². This stream flows most of the year, beginning in June or July and ending in the following May. Peak discharge occurs in November or December. The El Beid is by far the largest Nigerian river flowing into Lake Chad, but its water comes mostly from the Cameroon. Three main sources of water are: (1) direct runoff from the Mandara Mountains, (2) flood overspill from the Logone River into

Yaeres, and (3) relatively small overspills from the Serbewel River. The lower reach of the river has moved progressively to the west, resulting in a wide stretch of abandoned channels all following westerly courses. These channels break up in the north and enter the lake on the delta. Flow to the El Beid from the Logone River is estimated to begin when flows reach 1,500 m^3 at Bogor. Duration and size of flows contributed by the Logone River vary widely.

The most recent annual runoff data for the Gamboru station, near the outlet of El Beid River into Lake Chad, obtained directly from the Born State Water Board in Maidiguri, are as follows:

1968/69	570.21 x 10^6 m^3
1969/70	1,617.22 x 10^6 m^3
1970/71	2,556.52 x 10^6 m^3
1971/72	392.97 x 10^6 m^3
1972/73	4.44 x 10^6 m^3
1973/74	17.35 x 10^6 m^3
1974/75	300.79 x 10^6 m^3
1975/76	735.80 x 10^6 m^3
1976/77	641.70 x 10^6 m^3
1977/78	231.00 x 10^6 m^3
1978/79	773.47 x 10^6 m^3

2.4.2 Water Resources Concerns

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

b. The large-scale irrigation project furthest upstream is the Sategui-Deressia irrigation project in Chad, situated on the right hand of Logone in the large flood plain of the Sategui-Deressia River. The feasibility study completed in 1972 envisaged implementation of paddy cultivation projects of about 10,000 ha (Linoli and Maidengue, 1987). The work started in 1975 but it was interrupted by the civil strife in 1979. In 1985, the World Bank considered the possibility of relaunching the project. In 1986, a two-year program was initiated to put the structures built in the 1970s into operation. For the time being, the traditional farming in the area is adversely affected by the uncompleted and suspended development works.

c. The Maga Dam intercepts the Mayo Tsanaga and Mayo Boula (Figure 2.9). It is also fed by a canal from the Logone River. It has block runoff onto the yaeres, causing a permanent artificial drought (see below). Poor design and environmental impact analyses characterize this water project. For instance, a by-pass or overflow structure could have been incorporated into the design, which would have allowed downstream flooding, pasture irrigation,

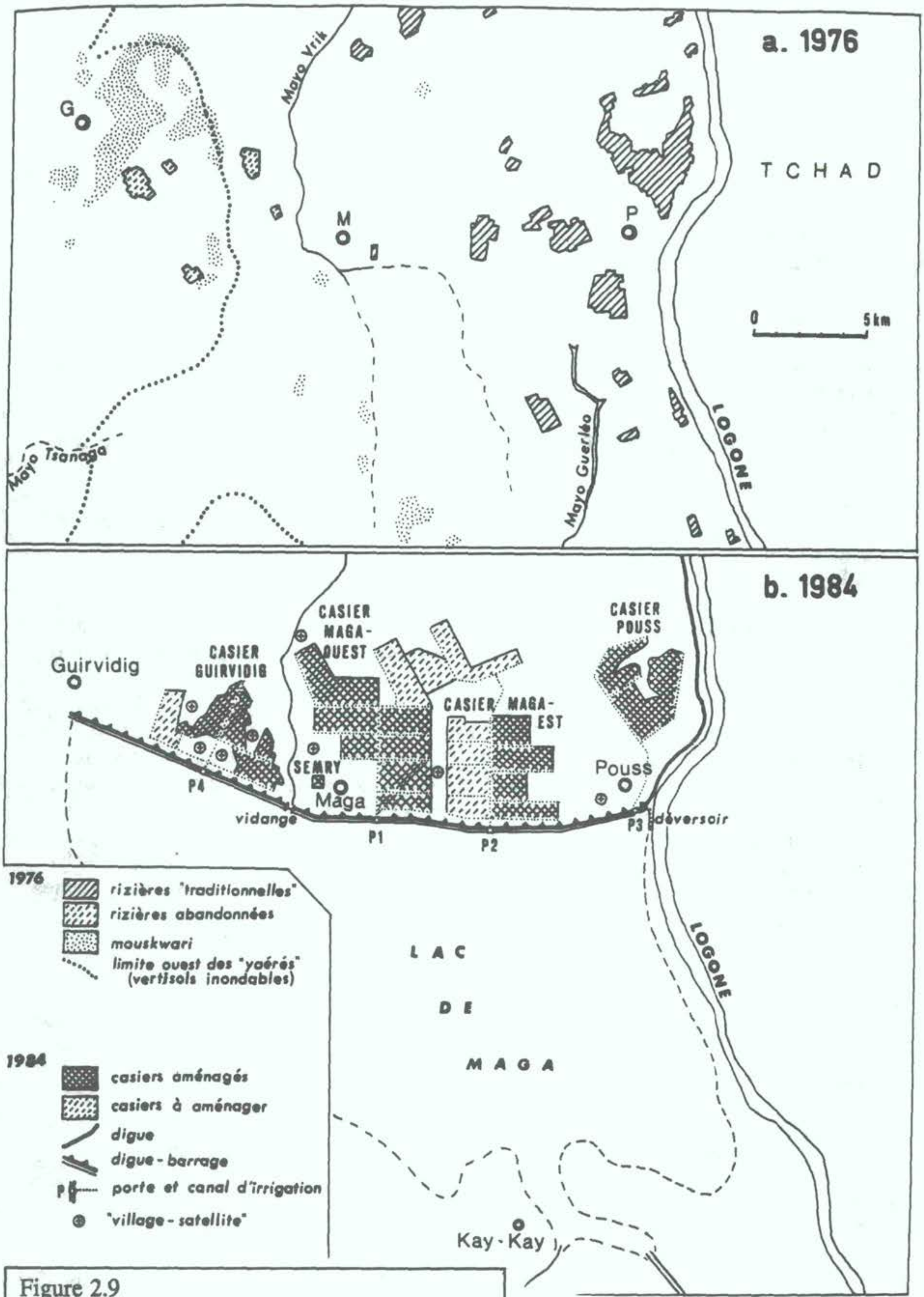


Figure 2.9
LAND AND WATER DEVELOPMENTS IN THE MAGA DAM AREA
LES DEVELOPPEMENTS DANS L'ENDROIT DE LA BARAGE DU MAGA

forest growth, wildlife support, and fisheries. The poor design hurt both the economies and conservation.

d. Flood diking along the banks of the Logone River are beneficial to farmers and harmful to pasture management, forest regeneration, and water table replenishment. They can increase flood peaking with unknown consequences downstream. Flood diking and its environmental consequences need review.

e. Upstream projects and an interbasin transfer from Zaire have been proposed. We could find no information on upstream dams in the Central African Republic. The Zaire project has been shelved as a result of cost/benefit analysis and is a low priority because of undocumented, possibly severe environmental damages.

f. A Serbewel/Chari/El Beid Rivers channel has been proposed. No details are available. Little is known about irrigation projects along the El Beid River.

g. Changes in groundwater levels from redistribution of the mayos and Logone River waters from diking, dams, and diversions has not been studied. Along with drought, such changes may significantly contribute to localized vegetation losses.

h. There appears to be no report on the cumulative impacts of water diversions in the headwaters of the mayos. The downstream consequences of diversions and storage requires review.

i. In Cameroon, a series of SEMRY irrigation projects rely on the Logone River flows . The pstream SEMRY I (see Fig. 2.10), with 5,300 ha under rice cultivation, originally included two plantings per year over the entire project area. Because of the high production costs, rice produced by SEMRY is about 60 percent more expensive than rice imported from Thailand. As a result, SEMRY management was forced to practice two plantings per year, alternating over one half of the project area only. In the 1985/86 campaign, about 3,900 ha were cultivated and the average water use was 18.0 m^3/ha. In 1986/87 corresponding figures were 4,800 ha and 19.4 m^3/ha.

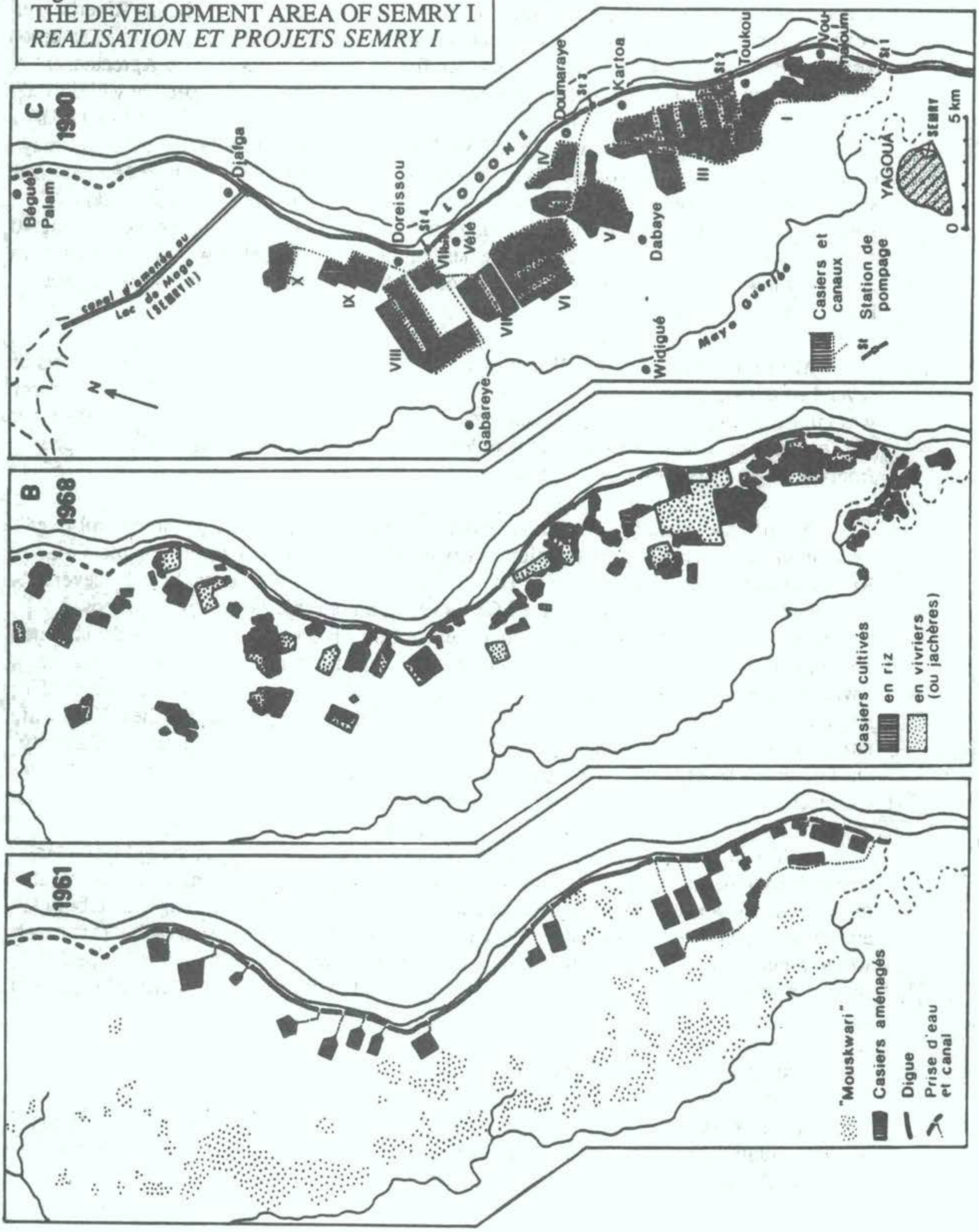
The SEMRY II project (Figure 2.9) with 6,000 ha is provided with the interseason equalization Maga reservoir (up to 600 x 10^6 m^3 capacity) which makes it possible to limit water withdrawals from the Logone River to a period of 75 days (November to January), long before the low-water season. The water balance of Maga reservoir in a median water year is the following:

Rainfall on the reservoir surface	240 x 10^6 m^3
Inflow from the Mandara mayos	210 x 10^6 m^3
Logone overspill	100 x 10^6 m^3
Evaporation and infiltration losses	150 x 10^6 m^3
Storage	400 x 10^6 m^3

In 1986/87 at SEMRY II, about 4,700 ha and 300 ha were brought under cultivation in the rainy and dry seasons, respectively. The water use was on the order of 15.0 m^3/ha. Evaporation losses from the shallow Maga reservoir covering an area of about 400 km^2 are significant, and the reservoir adversely impacts the water balance of Grand Yaeres (including

A. 1961 : casiers rizicoles des secteurs de Yagoua et Djafga.
B. 1968 : occupation des casiers rizicoles (Yagoua, Djafga)
C. 1980 : aménagements SEMRY I

Figure 2.10
THE DEVELOPMENT AREA OF SEMRY I
REALISATION ET PROJETS SEMRY I



the Waza National Park). Proposed fishery development in the Maga reservoir is an unproven mitigation measure.

During low water years, the amount of water needed by all of the above irrigation projects represents a considerable portion of the river flow. Because the Logone River serves as a border in its lower valley, an agreement was signed in 1970 between Chad and Cameroon for an equitable distribution of water withdrawn from the river (the Moundou Agreement). The agreement provided that each government undertake to limit their respective withdrawal of the Logone River water to 5 m^3/s in January, February, March, and April, and to 10 m^3/s from December to May. Still, when the SEMRY I project alone takes about 5 m^3/s, this may be about 25 percent of the Logone River flow in the intake profile (20 m^3/s has been recorded several times at the Bongor gauge in April or May). This is why in 1976 the Moundou Agreement was changed to allow each country to withdraw one-half of the flow exceeding 40 m^3/s. Irrespective of a rather weak enforcement of this rule, residual flow quite often happens to be very low, and the consequent reduction of fish has been noticed in the lower Logone River (Schrambach et al., 1987).

Most successful of all SEMRY projects is SEMRY III (Figure 2.11), which consists of several small-perimeter irrigation schemes organized around the existing villages (the project was implemented without any large-scale resettlements). The total project area is in the order of 1,200 ha, and annual water use in the order of 15 m^3/ha. Water for irrigation is pumped from the Logone and Serbewel Rivers.

To increase reliability of water supply to these irrigation projects and to control river flows in the lower Logone, construction of Koumban reservoir (5.0×10^9 m^3) on the Vina River and Gore reservoir (2.8×10^9 m^3) on the Pende River has been considered by several consultants. But as pointed out by the LCBC (1981), these projects have been proposed "without taking into account socioeconomic and political problems raised by the development of the Logone Basin." This concerns, above all, the region of Grand Yaeres, which is already adversely affected by the SEMRY I and II irrigation projects. To fully evaluate economic, social and environmental implications of the proposed development scheme, the UNDP will launch a new series of investigations. These studies should emphasize evaluation of already existing development projects and their cumulative impacts on Logone Basin pasture, fisheries, recessional farmers, forest growth, water tables, wildlife, and tourism.

j. The Gamboru and Ngala irrigation projects (total area 1,200 ha) are fed by water pumped from the El Beid River. The river, however, is unable to supply all irrigation requirements during low water years. The construction of a 10 km canal connecting the Serbewel and El Beid Rivers was proposed many years ago but as yet it has not been built. This canal would secure larger flow in El Beid from August to February. The Serbewel River peaks about 2 months earlier than the El Beid, but it is still at low flow during the critical months at El Beid of May and June.

2.4.3 Ecological Resources Background

The floodplains of the lower Logone River occupy about 32 percent of the river basin and fall within the conventional basin boundaries. The Logone River is the boundary between Chad and Cameroon. The degradation of its bed allows for side discharges and distributary emissions on both banks during the flood period. The "Chadian" discharge is known as the

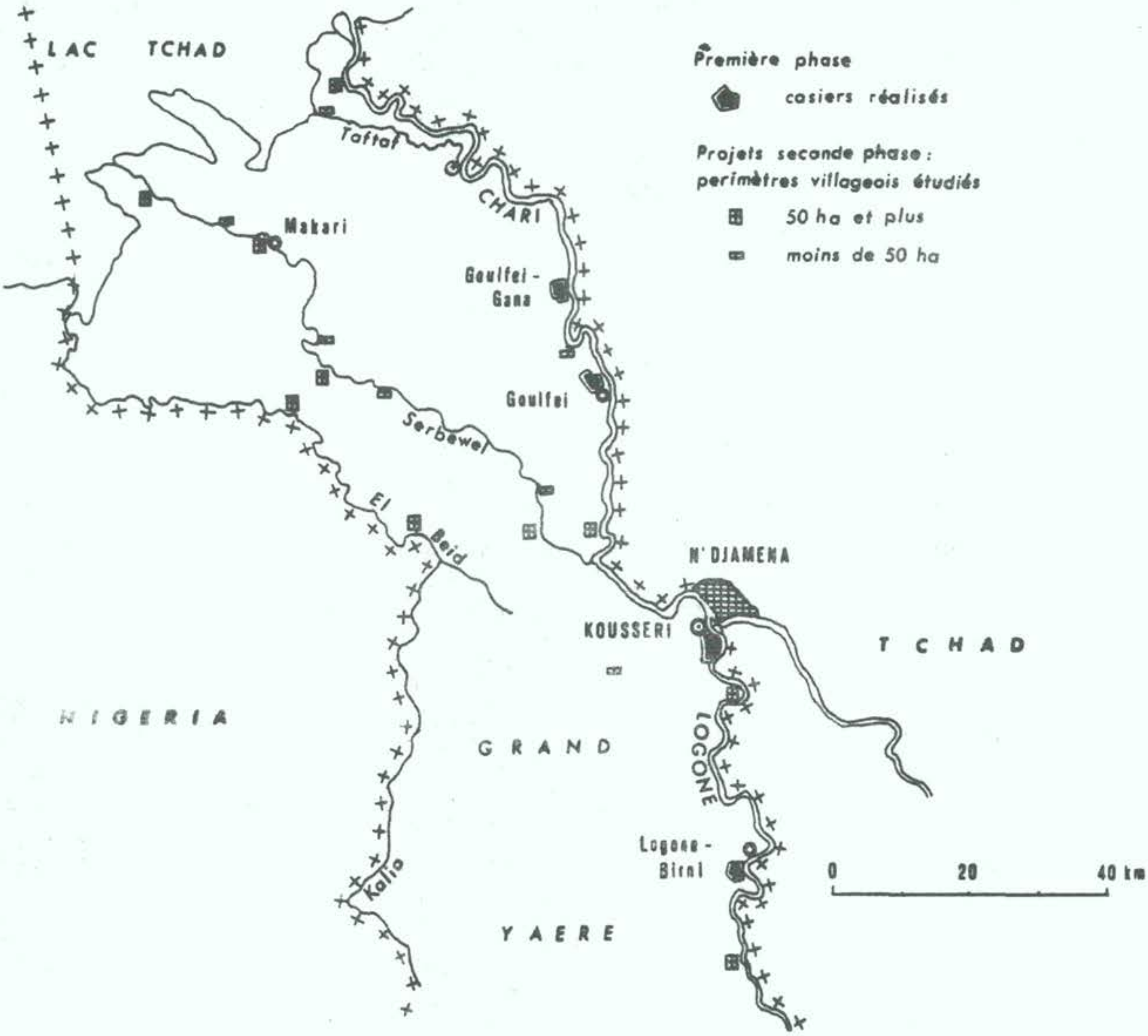


Figure 2.11
THE DEVELOPMENT AREA OF SEMRY III
REALISATION ET PROJETS SEMRY III

Grand Courant and includes the Ba-Illi overflow to the Chari River. In Cameroon, there are four major divisions: the Tandjille drainage; the drainages (mayos) from the Mandara Mountains; the Yaeres of the Logomatia, and the El Beid. This section will focus on the Yaeres and the El Beid River. The floodplains between the Logone and Chari Rivers are discussed under the Chari Diagnostic Basin because of their similar soils.

The Logone floodplains ("Yaeres") cover 8,000 km^2. They are very flat and are "irrigated" by the overflow of the Logone River floods, the mayos from the Mandara Mountains, and rainfall, which begins in mid-July. The flood waters of the mayos arrive first, followed by the overflow of the Logone River. In regular rainfall years, the inundation of the yaeres begins in September and retreats in December. This rhythm can provide a long, well-watered growing season in normal and wet years. But all sources of water are very variable. The areal extent, duration, and height of flooding determine the economics of the Yaeres — including fisheries, grazing, and agricultural productivity. In years with flooding above 1,500 m^3 at Bongor (and before the construction of dikes and dams), 850,000 T of clay/silt/mineral sediment are deposited on the Yaeres. This is its major source of "natural" fertilizer.

The floodplains have few trees. The shrub/grassland is interrupted only by marshes in depressions and villages at higher elevations. The flood levels (when there is a flood) vary between 0.7 and 1 m. The grasses of the Yaeres include *Eragrostis* sp., *Panicum*, *Setaria*, *Sorghastrum* sp. and *Hyparrhenia rufa*. The pockets of *Echinochloa* ("bourgu") are especially important to the pastoralist herds.

The soils (mostly vertisols and hydromorphic soils with calcium nodules and slumping) and extreme flatness are not particularly susceptible to erosion. There are only scattered alkaline soils and bands of sandy ferruginous leached soils. The drought years have changed plant species composition, not eliminated the grass and tree canopy. Wind and water remove topsoil only in isolated places where there are alkaline soils or on the slopes of the Mandara Mountains. The channel erosion of the Logone River and the channels of the Mayos could not be determined from the available literature and fieldwork.

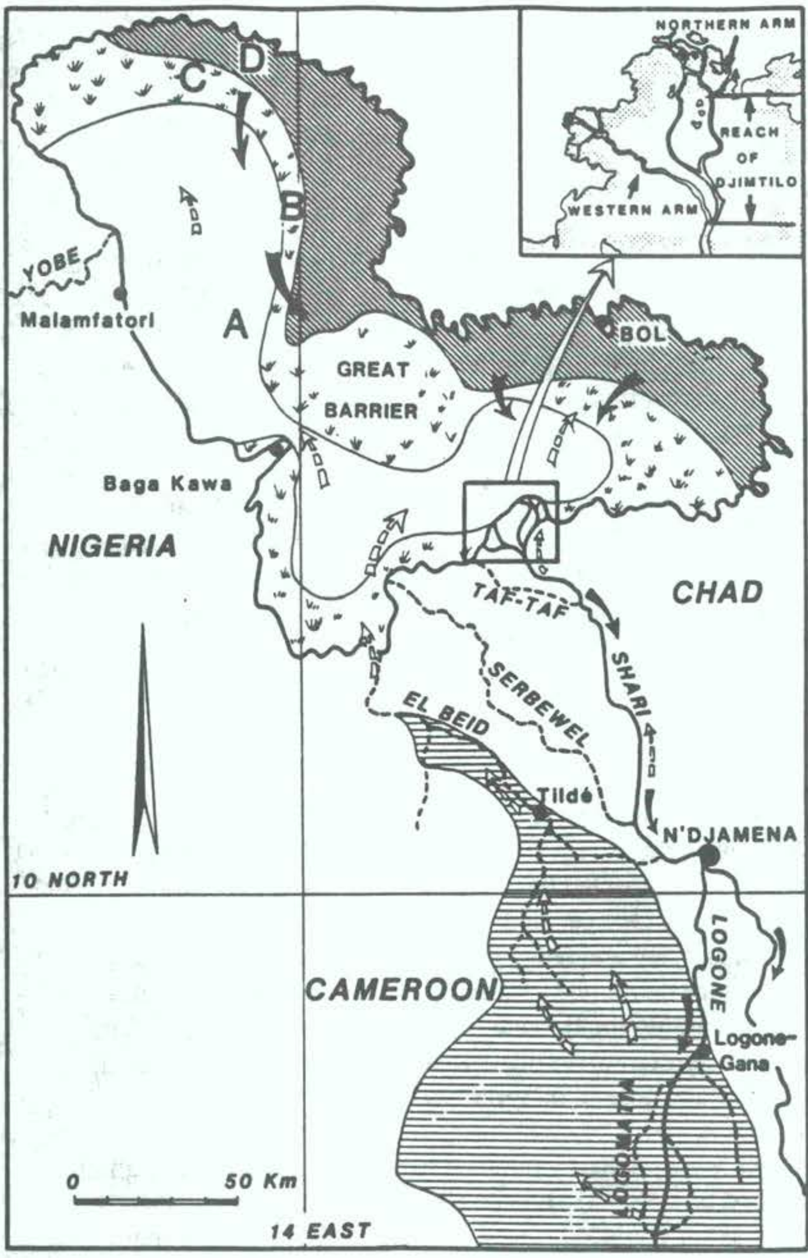
In general, population density is low. Human-caused erosion is local, with the exception of the stretch along the banks of the Logone River.

The diagnostic basin has flooded, sparsely wooded savannas on the vertisols, which forms "islands" on the sandy soils. There is a grass savanna on the gleyed hydromorphic soils. The leached red/brown soils support a shrub savanna with termite mounds or a wooded savanna with *Daniella* and *Burkea*. The shrub and wooded savannas and marsh/pond plant communities have been described in the section on Vegetative Resources.

The dry season ponds and the flooded Yaeres contain two different fish faunas: marsh/pond residents (transverse migrants) and lake/river (longitudinal) migrants. In wet years, a 2,000 m^2 pond can yield 8 T of fish. The flood is especially important to the dispersal of juveniles of about a dozen species crucial to fisheries production. *Alestes* sp., *Labeo* sp., and *Distichodus* sp. are typical of the migratory fish requiring the flood and floodplains to successfully grow and reproduce (Figure 2.12).

The flooded soils provide some of the best pasture in the basin. The pockets of bourgu and the marshes provide additional grazing. Herders come from Chad, Niger, Nigeria, and

Figure 2.12
FISH MIGRATIONS IN THE CHARI/LOGONE/LAKE BASINS
PECHES MIGRATOIRES DANS LES BASSINS DE LOGONE/CHARI/LAC



Arrows show the migration pattern of adults (black arrows) and juveniles (white arrows) of a typical migratory fish (*Alestes baremoze*).

Les fleches démontrent les migrations des adultes (flêches noires) et des jeunes (flêches blanches) d'une poisson migratoire representatif (*Alestes baremoze*).

Groups of migratory species at Daga Station (el Beid) for different phases of the flood.

Groupes d'especes migratoires observées à la station du Daga (el Beid) selon les differents stades d'inondation.

south Cameroon; 90 percent of cattle are from Cameroon. The Yaeres is crucial to Diamare and, to a lesser degree, neighboring departments.

The El Beid River floods from rainfall, Mandara mayos, and the Logone River when its flow is greater than 1,500 m^3/s at Bongor. The El Beid River acts as a drain for the Yaeres soils, disposing of heavy mineral salts after the first rains. During wet years of heavy flooding, the El Beid supports heavier fish, many juvenile cohorts and more species. In wet years, the El Beid is a second major area of fishing (along with the Logomatia) and is a major source of stock for the fishery in Lake Chad (Fig. 2.12).

The most striking lands within this diagnostic basin include Waza National Park (170,000 ha), the Kalamaloue Faunal Reserve (4,500 ha), part of Chad's Mandelia Faunal Reserve (138,000 ha), the canalization of the Logone River with dikes, the Maga Dam (30 km long), Chad's Bongor Rice development and the SEMRY rice projects, and the dams in the Mandara Mountains. Major urban centers include Kousseri, Makari, and Yagoua, Maroua, and Bongor.

2.4.4 Ecological Concerns

a. The Maga Dam has cut off the inundation from the Mandara Mountains and partially from the Logone River. About 900 km^2 of the yaeres is behind the dam (Figs. 2.8 and 2.9). About 1,500 km^2 of Waza National Park is impacted by the dam. The loss of inundation occurs even in years of good rainfall. Major changes in the vegetation are occurring: The *Vetivarria*, a major feed for elephants, is dying and being replaced by annuals. Dry season regrowth of bourgu and *Hyparhhenia* appears limited. Burning has begun to damage, rather than stimulate, regrowth. Trees are colonizing the floodplains, especially *Acacia seyal.* The lack of flooding has caused a drop in the grounwater table, causing the death of trees such as *Mitragyna inermis* and *Scelerocarya*, which depend on groundwater.

The impact of the dams and dikes is serious. More than half the flood plain vegetation of Waza National Park has disappeared (50,000 ha). It is believed that the carrying capacity of pastures outside the park has been greatly reduced. In other words, the waterworks have harmed both the wildlife (especially antelopes such as Kobes, Topi, and Roan) within the park and the livestock outside the park. In the 1970s, the area pastured 200,000 cattle. Recent counts have estimated only 100,000. In short, the Maga Dam has created a permanent downstream hydrological drought.

In addition, the "free" fertilization of the Yaeres by overflow and transported silt and minerals has stopped. This will result in long-term degradation of pasture land fertility. The grasslands are not so much overgrazed as undernourished and underirrigated because of the dam project. Herders switch to debranching trees for forage when confronted by poor grass production. The lack of good pasture and forage for certain species of wildlife forces them to wander outside the park where they are more easily poached or can contract bovine diseases such as rinderpest.

Engineering programs have contributed to the environmental degradation of this diagnostic basin. The rationale for these programs has underestimated the multipurpose economics of flooding. Reports justifying Maga Dam confused "water loss" by infiltration, evaporation, and evapotranspiration with "water supply" to productive pastures, land depression fisheries, recession agriculture, and groundwater table recharge (forest growth). No assessment of economic harms from the Maga Dam was carefully prepared before construction. Only "benefits" from irrigated agriculture, reservoir fisheries, and flood control were considered. The Yaeres were considered a "loss" of billions of cubic meters of water rather than a naturally fertilized and irrigated system of pasture, recession rice and bere-bere agriculture, fisheries and wildlife tourism. Ways of by-passing the Maga Dam and recreating artificial flooding are recommended in Part 3.

b. Besides the vegetation changes caused by Maga Dam, other management aspects of Waza National Park need consideration.

Waza has received "refugee" elephants from Chad's "evenements." It has become the safest sanctuary for elephants from both civil strife and poaching. Elephant migrations are international, going from northern Cameroon into the Lake Chad and Chari-Baguirmi Prefectures of Chad.

There is a need to develop an elephant policy to prevent or limit brushfires, to allow the *Acacia seyal* forest to grow, and to provide browse for the elephants. This is particularly important because the *Vitevaria* browse is dying out and the park is "overstocked" because of the refugee elephant herds. To reduce brushfires it is necessary to build a road into the *Acacia seyal* forests, which can also be used by tourists and park surveillance.

In addition, radios and helicopter surveillance would prevent poaching as well as help direct tourists to desired wildlife areas.

There is a need to map elephant movements and create safe corridors for elephant circulation into and out of the park and between Cameroon and Chad. This might include the expansion of the park to include the Mahe-Zinah-Tchede areas. An international peace park with Cameroon, Chad, and Nigeria is proposed in Part 3 to allow elephant movement, particularly during drought.

Waza, despite its size, is increasingly an "island" surrounded by roads, farms, and towns. During drought periods, the carrying capacity of the park falls and wildlife begins to move in search of water. There needs to be a drought management strategy for the park. This should include water development for dry years, such as new marsh depressions and small water-retention dikes; a safe-passage corridor to the Lagomatia; and a canal from the Maga reservoir by way of the Mayo Vrik.

The pond areas can also disperse grazing pressure in dry years and serve as tourist viewing locations.

Any possible environmental degradation caused by Baram village, which is within the park, could not be determined in the time allotted for this survey. If the village is a significant cause of environmental degradation, then a carefully planned relocation project should occur. This project must include an anthropologist who would fully consider the villagers needs and provide conflict resolution. It should try to include them in the economy of the park. Disgruntled villagers in other parts of West Africa have become poachers.

c. Land use changes may have significant effects on wood supplies, browse, and pastureland. The Maga reservoir itself occupies 35,000 ha. The dike prevents flooding on an additional 35,000 ha. SEMRY II occupies 50,000 ha. SEMRY III occupies 1,200 ha. Waza National Park covers 170,000 ha of the yaeres. Recession agriculture and towns, villages, and roads cover an unknown amount of hectares. UNDP (1979) estimates that current plans for irrigated agriculture will eliminate about 30,000 additional hectares of the Yaeres and Lai.

Deprived of their dry season grazing, transhumant herds rest longer in their rainy season pastures. This prolonged grazing has the most severe impacts on grassland regeneration outside the diagnostic basin. Within the diagnostic basin, it is not yet clear how much groundwater supply to woodland trees has been damaged by Maga Dam, the Pousse-Tekele dike, and some diversions from the Logone River. In general, a significant amount of land has been lost from potential forest, browse or grass-collecting; these losses have been further aggravated by drought-related groundwater drops.

With no secure land and water policies and rights, environmental degradation will be piecemeal and continuous. Herders will conflict with farmers and park rangers. Herders are not the cause but the victims of these land use changes. Entrepreneur wood gatherers, large-scale irrigation projects, and war have been the main causes of flood plain environmental degradation.

d. There have been losses of forest species and forest cover within the Logone Diagnostic Basin. Some forest losses are strictly from drought (e.g., *Khaya senegalensis*). In other cases, the lower rainfall combined with human activities (increased usage from drought emigrants, urban demand, need for alternative incomes, brushfires in dry periods, etc.) to cause problems in the woodland and shrub savanna. In Waza, for instance, lowered groundwater tables from both drought and dams have led to the death of *Anogeissus*, particularly the older trees that cannot respond quickly to changes in the level of the water table. In some cases, the species loss is due simply to overexploitation. For instance, the Ronier palms have been overcut far beyond a sustained-yield policy. The riparian forests along the Logone River have not been assessed but, while they appear unharmed by the drought, they may suffer from human overexploitation.

e. Mandelia Faunal Reserve is in poor condition. About ten elephants remain. Lions, buffalo, and cheetah have disappeared. The wildlife has been stressed by poaching and agricultural encroachment. There is serious discussion of moving the boundaries south and connecting the reserve more closely to Waza National Park (Part 3). The reserve was not visited by the survey team.

f. The Kalamaloue National Park is 4,500 ha adjacent to the Maltam-Kouserri road. Since national parks fall under the Ministry of Tourism, its major goal is tourism. There are no studies of its importance to natural history or as a habitat for various resident and migrant animals. The prehistoric ruins in the park have not been fully excavated. Kalamaloue could be a unique cultural/natural history tourist site. An updated report would help define the environmental resources and needs of the park.

The park has suffered from drought, herders, poaching, brushfires, and, perhaps, even from the three villages within it. It borders Chad and has suffered from the weapons and ammunition that spread throughout the area during the war. The park still supports elephants and could serve as one of the "habitat islands" used by migrating herds.

g. The environmental impact of the dikes has not been assessed. Alternatives such as floodway by-passes do not appear to have been considered.

h. The hillocks of the Yaeres have become very degraded by the need to concentrate livestock during the flood period and by the need for wood. The vegetation is essentially that of a humanized park, with *Acacia albida* and borassus palm, *Balanties*, *Zizyphus*, and annual grasses. Heavily used localities such as granaries, wells, markets, and village clusters need rehabilitation. This will be discussed in Part 3.

i. The borassus palm forests along the banks of the Logone River, which in 1975 supplied Ndjamena with construction wood, have disappeared. The resource is completely uncontrolled, and little protected reforestation is in place. The exploitation of borassus, which even includes female trees of inferior quality, prevents regeneration. As a result, local citizens are deprived of drought fallback foods and the improved nutrition that the fruit and seeds provide. The loss of borassus groves is an alarming symptom of deforestation that has nothing to do with climatic change.

The doum palms have also been exploited but appear to be crown sprouting and could eventually regenerate.

j. Mozogo-Gokoro Park (1,400 ha) is a unique forest relict in the Sudanian Zone of Africa in the Mandara Mountains. A forest reserve since 1932, the park is an important gauge to measure all sorts of environmental degradation. The forest should be actively studied by students in Cameroon universities, and should also serve as an important educational stop for tourists and consultants.

The park is surrounded by villages, and the contrast between agricultural fields and the forest is astounding. The villagers tend to avoid the park because of snakes. But the cutting of trees, the entrance of domestic animals, and the potential for runaway brushfires threatens the integrity of the park. There is only one park guard, who does not live adjacent to or in the park. The park animal life, though not the highlight of the park, suffered during the recent drought. Part 3 gives recommendations for protecting this unique relict forest.

2.4.5 Human Resources Background and Concerns

North of Sara, there is a zone of great ethnic diversity, with Marbai, Lele, Kim, Ham, and others often organized into autonomous village groups. Rice, red sorghum, pencil millet, and taro are common cultigens in the south. The Massa, who live north of these groups on both sides of the frontier between Cameroon and Chad, are involved in the rice perimeter developments of the past two decades. Still further north, on the borders of the Great Yaere between Pouss and Logone Birniis, is the province of the Mousgoum, whose people are related to the Massa. Seasonally, the Yaeres harbor Shuwa Arabs from the delta regions and Peul from Cameroon, Niger and Nigeria. Kotoko agro-fishers and Shuwa Arabs can be found near Ndjamena and Kousseri, but this entire area has become a zone of commercial horticultural production initiated by urban dwellers (Figure 2.13).

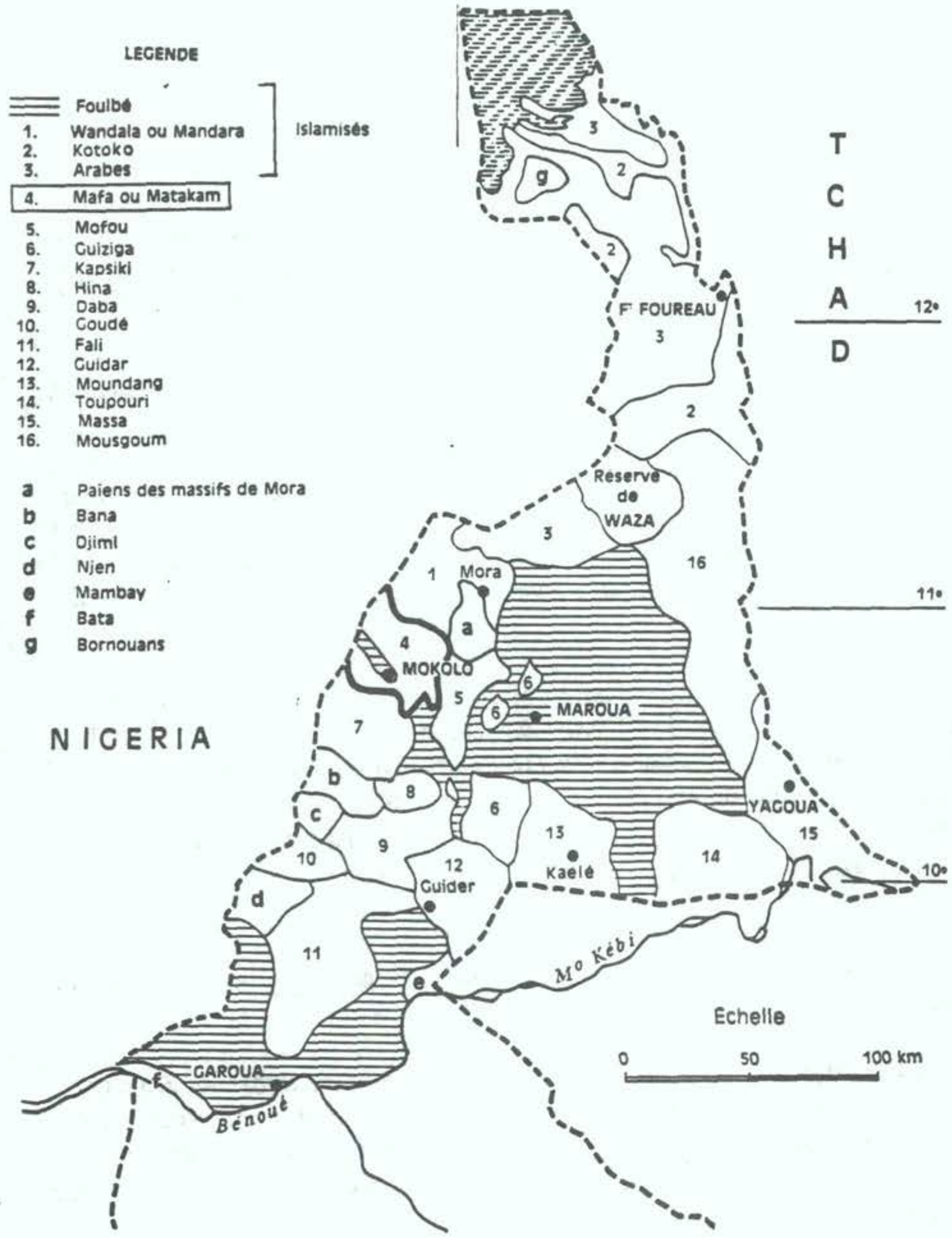
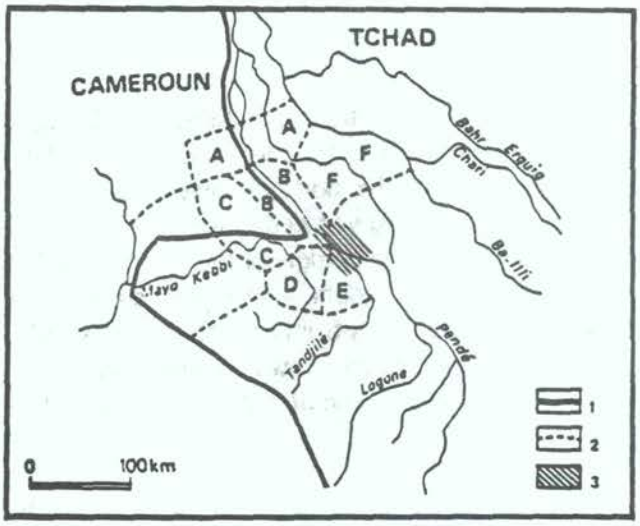


Figure 2.13
ETHNIC GROUPS OF THE LOWER LOGONE AND MAYO KEBBI
LES GROUPES SOCIO-CULTURELS LOGONE BAS ET MAYO KEBBI



1-Border between Cameroon and Chad
Frontiere entre Cameroun et Tchad
2-Ethnic Boundaries/*Frontieres Ethniques*
3-Kim territory/*Territoire Kim*

A-Mousgoum-Mouzouk Territory
B-Massa Territory
C-Toupouri Territory
D- Mousseye Territory
E-Marba Territory
F-Zone of Mousseye-Marba emigration
Zone d'emigration Mousseye-Marba

Diminished rainfall and surface water translates into a shrinking resource pool for these groups, loss of fishing and livestock income, loss of recession sorghum and millet lands, and increased reliance on commercial irrigated agriculture and trade.

Major investments in the SEMRY perimeters have displaced pre-existing economic activities, such as transplanted hydrophylic sorghum and millet production, and have diminished the pastoral potential of yaeres downstream. SEMRY has not provided durable economic compensation through rice production. One hundred sixty thousand tons of rice were sitting in the open air at SEMRY I in July of 1989 because of the 90 CFA franc price differential between Cameroonian- and Thai-produced rice. Maga reservoir is not subject to traditional fishing regimes of the rivers and has been brutally mined of its haleutic resources; the fishers lack a new management system for lack of funds to staff the fisheries center built by the Japanese.

The environmental problems confronted by the dozen or so major montagnard populations of the Mandara Mountains are essentially unchanged from those faced historically due to population pressure and shortages of water and land. While migration may solve the problem of population pressure, it compromises the maintenance of the water and soil control structures designed to conserve water and land. Movement to the piedmonts below the inselberges has entailed land tenure problems with the resident Peul aristocracy and villagers, set in motion profound changes in the vegetative communities, and provoked soil erosion and other problems associated with the alkaline soils of the region.

2.5 THE MAYO KEBBI DIAGNOSTIC BASIN

2.5.1. Water Resources

The diagnostic basin of the Mayo Kebbi includes only part of the total watershed. Part of the southern watershed is outside the conventional basin. In addition, the Mayo Kebbi flows into the Niger River basin at high water in the Logone River. This unique watershed divide is filled with a string of lakes, which, at times, can flow to the Logone River or flow towards the Niger River. This is a unique landscape feature in the Lake Chad Basin and a remarkable landscape feature for the planet (Figure 2.14).

The Mayo Kebbi, a right hand tributary of Benue River, drains the area of 21,360 km^2 located in Cameroon and Chad. It takes the overflow from the left bank of the Logone River near the Ere Bongor. There are two main lines of drainage: the Toubouris swamps and lakes in which water flows southward from Bongor, and the Loke, which flows westward from Ere. The main lakes of Toubouris depression are Fianga, Tikem, and N'Gara. Their surface varies considerably depending on the magnitude of Logone overspill. For example, the area of Lake Fianga is about 25 km^2 at a water level of 323 m (ORSTOM, 1967). Between Tikem and Fianga Lakes, water may flow in either direction. The Toubouris lakes give birth to Mayo Kebbi proper which flows in the east to west direction. At Mbourao, the river flows through a cascade of rapids, the highest of which is Chutes Gauthiot at 43 m. Further downstream, Mayo Kebbi transverses Treno and Lere Lakes and finally discharges into the Benue River.

Mean rainfall at Lake Fianga is 960 mm. High flows in Mayo Kebbi occur in July to October. The dry season lasts from November to March. The mean annual outflow from the Lake Chad Basin via Mayo Kebbi was estimated by FAO (1972) as 0.73 x 10^9 m^3/year — this

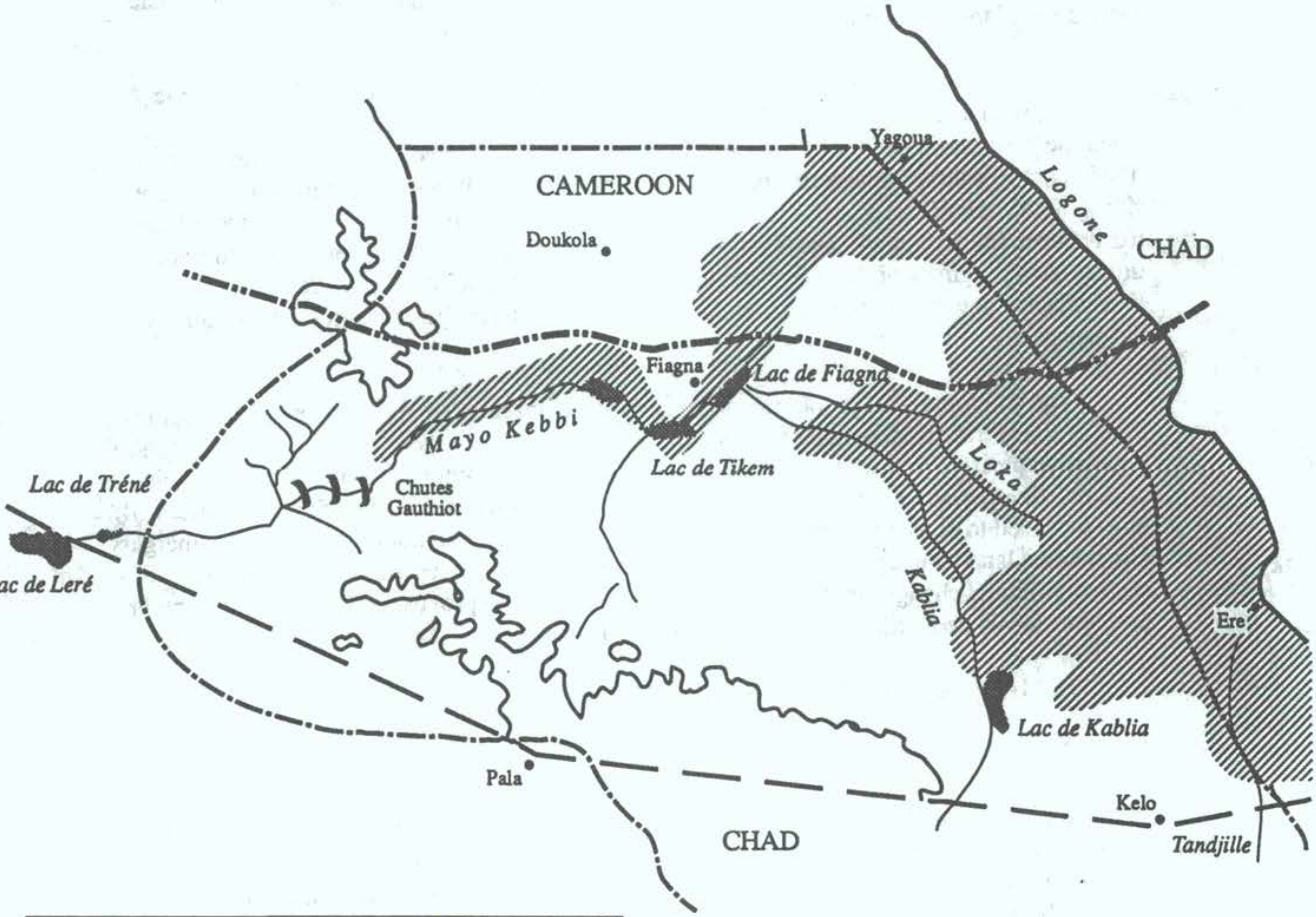


Figure 2.14
MAYO KEBBI DIAGNOSTIC BASIN

MAYO KEBBI BASSIN DIAGNOSTIQUE

Dams
Barrages
Conventional Basin
Bassin Conventionnel
International Border (Follows River Where Not Shown)
Frontière Internationale
Diagnostic Basin
Bassin Diagnostique
Flooded Land During Wet Years
Zone d'Inondation en années humides
400 meter elevation
400 meter elevation

amount is unreliable as it has no coefficient of variation, nor does it include the last two decades of data.

2.5.2 Water Resource Concerns

Within the framework of Logone River control plans, the construction of a dam and hydroelectric power plant at the Chutes Gauthiot was considered. A power plant with 27.8 MW-installed capacity was intended to meet the electricity requirements of Ndjamana and the neighboring small urban centers (total of about 80 x 10^6 kwh/year). To supplement insufficient natural flow of Mayo Kebbi, several options were examined: first, a diversion of about 800 m^3/year from the Logone River at Bongor during the flood period and, second, a more or less continuous diversion of Logone River flows, partially or totally eliminating flooding of the Grand Yaeres. Finally, the last option was construction of two large upstream storage reservoirs at Koumban on Vina River and Gore on Genda River. The Mayo Kebbi diversion for hydroelectric power generation would be just a part of the overall plan providing for a complete modification of the hydrological regime of Logone Basin.

Since all of the above options are expensive and would worsen the water budget of Lake Chad, the hydro-power development of Chutes Gauthiot is no longer considered appropriate.

2.5.3 Ecological Resources

The soils of the lakes are leached alkali soils in the bottomlands. The immediate slopes around the lakes are stony relict soils with ferruginous facies. Towards the Logone, the soils change to leached and weakly leached ferruginous soils, some areas with ironpan and concretions (Pala region).

The plant life on the stony relict soils is a reg-adapted "sudanian" wooded savanna with Combretacae and Burseracae dominants or an opened shrub savanna in which the trees are gradually replaced by *Acacia hockii*, *Albizia*, and *Dalbergia*. The vegetation of the tropical ferruginous soils is a complex mixture of shrub and wooded savannas. On the ironpan ferruginous soils, the shrub/wooded savanna near Pala contains *Isoberlinia* and *Monotes*.

There is a faunal reserve (Binder-Lere) at the far west end of the conventional basin. Little is known of this reserve. Roan and Bubale antelope live there. Lake Lere (just west of the conventional basin border) has a unique fauna with manatees and hippos and a combination of Niger River and Lake Chad Basin fish.

2.5.4 Ecological Concerns

On the ferruginous soils, the populations of trees have been increasingly disaggregated, and the older age classes have disappeared. It is increasingly difficult to tell one type of plant community from another. The Prefecture of Mayo Kebbi (including some areas outside the conventional basin) is the largest producer of firewood in Chad. The harvest is about 1,100,000 T (twice the harvest of any other prefecture). Marketing is not well-documented.

The impact of brush fires has been particularly severe over the last twelve years. The "paysage parc" seems to be intact. The clearest change has been the loss of *Isoberlinia doka* and replacement by *Monotes*.

The fallows are burned more often, preventing them regenerating soil and vegetation. The situation is most severe on cotton farms.

2.5.5 Human Resources Background

Massa, Touboucuri, Moundang, and a number of smaller groups people the Mayo Kebbi Diagnostic Basin (Fig. 2.13).

2.5.6 Human Resources Concerns

The problems associated with the Mayo Kebbi region are similar to those faced by the interfluvial delta populations and the Massa around Lake Maga. They include: (1) intensified population pressure on the haleutic resources of the lakes on the upstream portion of the Mayo Kebbi; (2) competition between refugee populations of large livestock and farmers because of lost pasture and transit routes along the rivers in the north; (3) overexploitation of selected ligneous species, especially rhun palm (*Borassus aethiopium*) to increase supplemental income; (4) cotton production without the application of adequate fertilizers, which may lead to long-term soil exhaustion; (5) high rates of waterborne illnesses.

2.6 THE BORNO DRAINAGES (Yedseram, Ngadda, Gubio)

2.6.1 Water Resources Background

For the most part, the diagnostic basin is a featureless plain, which slopes gently east and northeast towards Lake Chad. The only feature which breaks the monotony of the plain is a sandy Bama ridge extending from a point west of Maidiguri, past Maidiguri and Bama, for a distance of about 160 km. The ridge is probably an ancient shoreline of Lake Chad (Figure 2.15).

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

This diagnostic basin is totally within Nigeria. It includes only seasonal rivers. The most important are the Yedseram, the Gubio and the Ngadda.

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

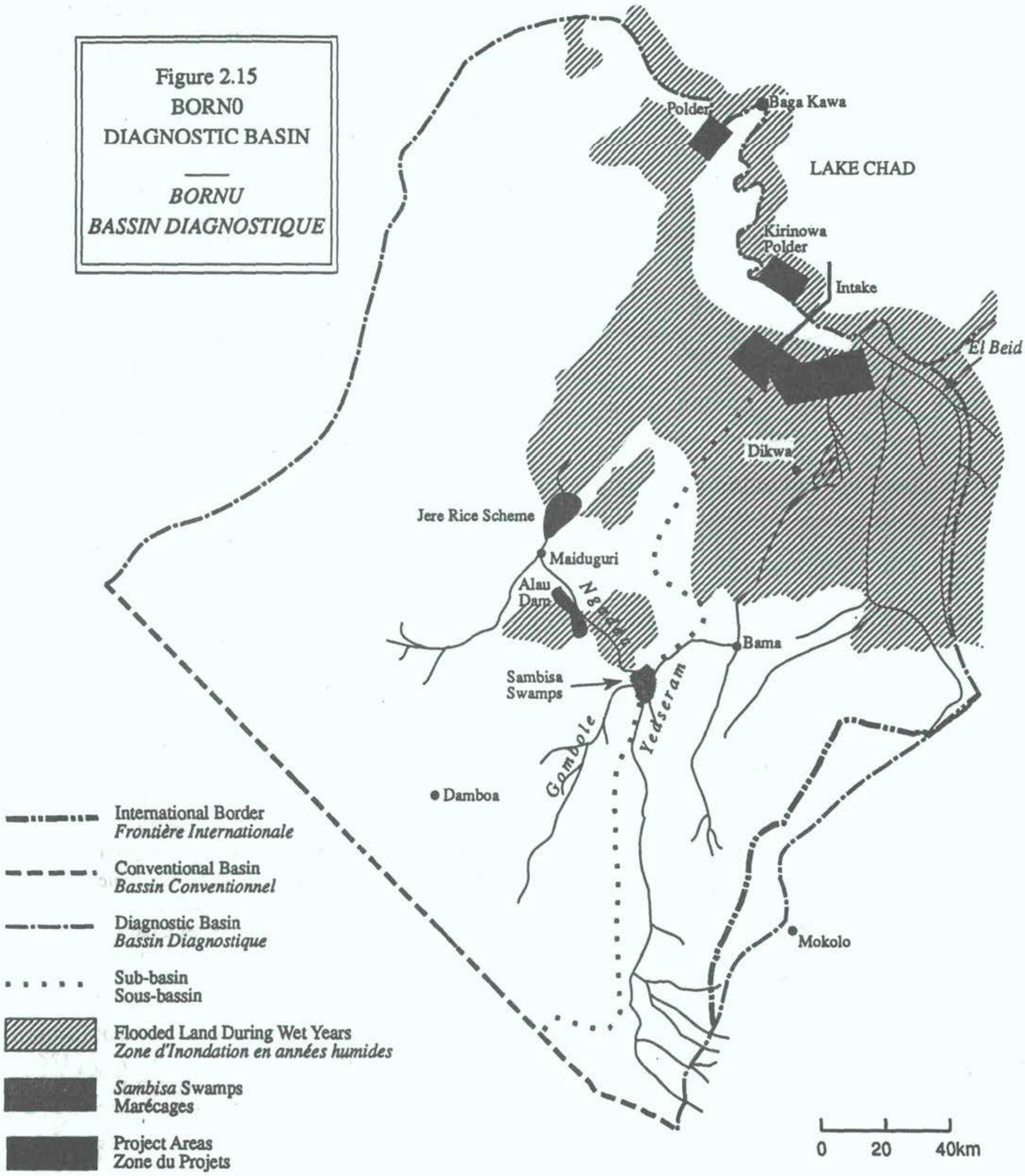


Figure 2.15
BORNO
DIAGNOSTIC BASIN
BORNU
BASSIN DIAGNOSTIQUE
Polder
Baga Kawa
LAKE CHAD
Kirinowa
Polder
Intake
El Beid
Dikwa
Jere Rice Scheme
Maiduguri
Alau
Dam
Ngadda
Bama
Sambisa
Swamps
Gombole
Yedseram
Damboa
Mokolo
International Border
Frontière Internationale
Conventional Basin
Bassin Conventionnel
Diagnostic Basin
Bassin Diagnostique
Sub-basin
Sous-bassin
Flooded Land During Wet Years
Zone d'Inondation en années humides
Sambisa Swamps
Marécages
Project Areas
Zone du Projets
0
20
40km

Below Yaza, recent quaternary lagoon deposits underlie the catchment (MacDonald, 1973). About 30 km west of Bama, south of the Gombole Forest Reserve, the Yedseram is joined by the Ngadda River. The rivers converge in a large Sambissa swamp covering about 130 km^2, through which the main water courses are ill-defined. Leaving the swamp, the Yedseram turns eastward and cuts through the Bama Ridge. Below Bama, the river follows an indistinct course through many lowland swamps where evapotranspiration losses are extremely high. North of Dikwa, the river breaks up into a series of braided channels which flow across the plain. Near Ngala the river channel again becomes more visible, crosses the Maidiguri-Gambaru road at Mbuli Bridge, and finally empties into Lake Chad about 20 km downstream.

Based on the information received from the Borno State Water Board, the discharge measurement stations are located now at the Uba, Muture, Ajer, Bama, and Mbuli Bridges. The annual volume of runoff from the Mandara Mountains in the upper catchment of Yedseram River ranges from 28 to 40 percent of the annual rainfall. In the Kuzzum profile (about 20 km downstream from the Uba Bridge), the annual volume of runoff was estimated in the wet years of 1965, 1966, and 1967 to be 306, 300, and 406 x 10^6 m^3, respectively (MacDonald, 1973). In the same years, the annual runoff recorded at the Mbuli Bridge was 94.3, 79.5, and 157 x 10^6 m^3 respectively. It is apparent that considerable losses occur directly from the river channel and over the flood plain, between the Kuzzum profile and the Mbuli Bridge. More recent annual runoff data for Mbuli Bridge, obtained from the Borno State Water Board, are (similar data from the 1980s are not yet computed):

1970/71	86.82 x 10^6 m^3
1971/72	73.45 x 10^6 m^3
1972/73	--------
1973/74	8.37 x 10^6 m^3
1974/75	45.04 x 10^6 m^3
1975/76	70.64 x 10^6 m^3
1976/77	3.60 x 10^6 m^3
1977/78	50.74 x 10^6 m^3
1978/79	125.51 x 10^6 m^3

The duration of flow at Mbuli Bridge in the 1970s was from two to three months (August to October).

The NGADDA River has a catchment area of 14,400 km^2 (FAO, 1972). From the Sambissa swamp it flows to the north and meets the Bama Ridge south of Konduga. There it fills the seasonal Lake Yare. From thereon it flows parallel to the ridge into Lake Alau, which can reach a size of 700 ha in years of high rainfall. From Lake Alau it flows to Maidiguri along the Maidiguri-Bama Road, until it eventually breaks through the extensive sand dunes at Maidiguri, and is dispersed in the low flow zone of the old Lake Chad bed. The Ngadda River does not, therefore, succeed in maintaining the definite course to the lake.

Between Ngadda and Komadougou-Yobe there is an area of about 27,000 km^2 around GUBIO, which has no distinct drainage pattern. The ground slope towards the lake is very small and surface water moves slowly toward shallow depressions from where it disappears by infiltration and evaporation.

As seen from the above, contribution of the seasonal rivers of Borno to Lake Chad (excluding El-Beid and Komodougu-Yobe which are discussed elsewhere), are negligible in comparison with the total lake inflow.

2.6.2 Water Resource Concerns

a. At the outlet of Lake Alau, a storage reservoir of 108 x 10^6 m^3 capacity is being built by the Chad Basin Development Authority. Most recent annual runoff data recorded at the dam profile, obtained from the Borno State Water Board, are as follows:

1975/76	284.29 x 10^6 m^3
1976/77	69.26 x 10^6 m^3
1977/78	253.16 x 10^6 m^3
1978/79	257.80 x 10^6 m^3
1979/80	146.01 x 10^6 m^3

The reservoir will stretch from the existing lake to Konduga, occupying about 6,000 ha. The reservoir will provide drinking water for Maidiguri and irrigation water for the Jere Bowl Project (8,000 ha), just north-east of Maidiguri. The project involves a substantial resettlement program. People will need to be displaced as a result of the reservoir construction and clearing of land for the irrigation scheme. The authors of this report are puzzled by the statement made by Haskoning, the firm invited to make the resettlement plans. The executive summary of the final report by Haskoning reads "the future reservoir threatens to destroy to a large extent the existing agricultural production of the Lake Alau area while increased agricultural production in Jere Bowl remains uncertain." This is very discouraging, especially as project implementation is seriously delayed due to the current economic problems of Nigeria. Under such circumstances, there is a risk that financial difficulties will adversely affect the budget of the resettlement program, which in similar cases is usually the first one to be cut.

b. Also under consideration is construction of a water transfer canal approximately 120 km long (about 7 m^3/s capacity) connecting the Alau reservoir with the Haval River inflowing Borno from the southern Gongola State. This would be an element of a large-scale scheme ultimately providing for water importation from the Niger Basin. Taking into account that the Borno groundwater resources are being rapidly exhausted, this idea does not come as a surprise. In the next 15 years, Borno is likely to face very serious water shortages in both urban and rural areas. The greatest pressure will be on areas of low per capita income and high population growth. Before opening a new source of supply, however, the efficiency of current water use in the Borno State should be carefully analyzed. Moreover, implementation of a large water transfer scheme will require an environmental and social impact assessment study to be carried out.

c. Special care must also be exercised in evaluation of geological conditions. In this respect, one of the intriguing and not fully understood phenomena in the area between Maidiguri and Lake Chad is development of many sinkholes of 0.5 to 30 m diameter and 300 to 600 m long fractures in the soft soils predominating in this area (Ostaficzuk and Pininska, 1987). Large numbers of new fractures have appeared in 1985 along the Konduga-Mafa Road, very near to the Alau Project. Once a long fracture or sinkhole is formed, it drains the surface water intensively as shown by a local network of gullies leading to them. These are quite disturbing phenomena, which may lead to all kinds of difficulties in the implementation of surface water projects (dam instabilities, uncontrolled water loss from storage reservoirs, etc.). There is a possibility that the formation of large fractures is caused by deep seated compactional and tectonic movements. It is also possible that groundwater pumping or destruction of recharge areas has caused subsidence or even triggered seismic movements. Existing seismic profiles of the area should be used as reference material for the interpretation of aerial photographs to determine if the sinkhole development and fracturing are confined to some specific zones or whether they are randomly distributed all over the area.

d. The seasonal rivers of Borno cannot also be used as a reliable source of irrigation water without providing them with storage facilities. There are, however, several questions concerning the feasibility of surface water storage in the area. As mentioned before, the geological conditions are difficult,and may lead to several problems (e.g., unexpected water losses from the reservoir). The year-to-year variability of markedly seasonal flow and water losses from evaporation from the reservoir are also important. The reservoirs under construction or under consideration have capacities considerably larger than the minimum annual runoff in the period of record. Downstream water rights must be assured.

e. Concerning municipal water supply, in 1976, only seven towns in Borno, with ta total population of about 370,000, have been served by the modern public water supply systems. Total volume of water supplied at that time was slightly less than 30,000 m^3/day (Ayoade, 1981). At present, Maidiguri is supplied with about 35,000 m^3/day of groundwater (mostly from the Continental Terminal aquifer). The percentage of city population served by private connections and public standpipes is 26 and 74 respectively. The population of the state capital is expected to grow from the current 350,000 to about 960,000 by the year 2005. Depending on the level of service, in 2005 the city will need from about 95,000 m^3/day (10 percent of population served by private connections) to 226,250 m^3/day (90 percent of population served by private connections). This implies that between now and the year 2005, the Maidiguri water supply must be able to handle daily three to eight times the quantity of water pumped and distributed to customers at the present time (Anyaeche, 1988).

The Chad Basin Development Authority is working hard to meet this challenge. Arrangements to upgrade the existing distribution system are in progress. Seventy-six percent of the capacity of Alau reservoir shall be allocated to Maidiguri municipal water supply 208,000 m^3/day and a water treatment plant capable of handling 67,000 m^3/day is under construction.

f. Precipitous borehole development and groundwater mining is occurring without adequate cost benefit analysis or mitigation of impact upon local groundwater users. For example, the water table is being drawn down three meters per year by boreholes sunk into the three aquifers. In 1981, tapping was on the order of 43.5 million m^3, while the possible yield from all three aquifers is calculated to be 41.7 million m^3 (Satter and John, 1985). Severe environmental degradation will continue without enforceable conjunctive use policies.

g. The El Beid River, after the inflowing Lake Chad, is the main source of water for the SCIP irrigation project. Different portions of its flood cycle, the El Beid River has high sodium and potassium concentrations. ORSTOM warned that these high concentrations in the southwestern corner of Lake Chad could cause severe soil damage and lower of crop yields. This water quality consideration was not included in the irrigation design of the SCIP.

h. The impacts of sewage disposal through septic tanks on groundwater in Maidiguri are not known but could be severe.

i. The 32 MW thermal electric generating plant at New Marte has been dysfunctional because of the inability to cool generators with Lake Chad water. A re-evaluation of the cooling system and method of disposing cooling system salts should be made. Salts from the cooling process (and El Beid River) waters could pose serious economic and environmental problems.

2.6.3 Ecological Resources

As in the Komadougou Diagnostic Basin, the land surfaces of the Borno drainages are formed from a combination of eolian and lake events. There are extensive eolian deposits; ancient and more recent shoreline and perilacustrine deposits of Lake Chad; recent alluvial deposits from the seasonal rivers that have formed plains of clays, diatomites, and salts; and old alluvial deposits with ferruginous soils.

The soils are all "juvenile" and form the upper horizons of deeper, hydromorphic, brown, and halomorphic soils and eolian sands. There are vertisols within the topographic depressions or vertisol/brown soil mixtures. The halomorphic soils are easily eroded.

The basin is basically in the Sahelian Zone and enters the Sahelo-Sudanian in periods with wet years or in areas with soils of higher water content. The extensively flooded zones and seasonal rivers create wetland habitats of great interest for fishing, rice cultivation, vegetable growing, dry-season pasture, and livestock watering. The northern part includes shrub steppes (*Acacia/Aristida*) grading into savanna woodland (*Combretum/Anogneissus/ Hypaarhennia*) to the south. The extensively flooded areas are virtual prairies of *Echinochloa stagnina* (bourgu) and *Hyparrhenia*. The riparian areas include *Acacia/Mitragyna* forests. The widespread "park savannas" with *Acacia albida* and baobab are human-made.

There is no map of the vegetation of the Borno drainages. The last available map is 20 years old (before the back-to-back droughts). A soil and grasses map was made in 1972. The Land Resources of Northeast Nigeria (ONDRI, 1972) remains the major, although outdated, source of information.

The diagnostic basin includes the Sambissa Game Reserve (518 km^2), the Chingurmi Game Reserve, and the Lake Chad Game Sanctuary. Sambissa is a major area for the conservation of elephants. It is the last stronghold of the ostrich in Nigeria and still supports lions, leopards, hyenas, and a variety of antelopes and giraffe. The Lake Chad Sanctuary has elephants, hippos, crowned cranes, and sitatunga (a special wetlands-adapted antelope). The Chingurmi Game Reserve, a more arid zone park adjacent to Cameroon's Waza National Park, is scheduled to become a national park.

There is concern because the population of black-crowned cranes, which has four major breeding and roosting sites within the basin. The dry season distribution of these cranes includes an extensive area about 40 km wide along the lake shore as well as Sambissa Game Reserve. The Baratura roosting site for the cranes also had the first flamingoes ever recorded in Nigeria. The status of these reserves is not well known, and many conflicts with water and agricultural developments exist.

There is no tse-tse or *Glossina* problem within the basin.

Major land and water uses within the basin are Maiduguri, the South Chad Irrigation Project, Yedseram Dam, other irrigation schemes, the game reserves, and the road/rail system.

2.6.4 Ecological Concerns

a. In general, both the large and small dams and irrigation systems have been built without provision for serious reforestation work or windbreaks, although in some cases farmers are compensated for the loss of economic trees (between about N 10 /tree). Thus SCIP is virtually bare of trees, which not only complicates the fuelwood problem, but also increases pressure on fuelwood resources in the Dikwa area, increases windspeed (thus depressing crop growth within and downwind of the project), and increases the risk of eolian soil erosion and sand deposition during dry periods.

b. Chaotic deforestation is a chronic problem. Domestic and industrial energy use from the fish-drying and bread-making industries of Maiduguri and other major towns contributes significantly to deforestation. Wood cutting has become a lucrative economic activity that is conducted without adequate management plans for naturally forested areas. Seasonal burning for land clearance is a serious problem that contributes to deforestation and air pollution; this is true in the Borno subbasin as well. It is not known whether burning is conducted to claim land, clear it, deprive others of its use, or to deinfest it. There is no controlled burning policy, but a ban on burning is being contemplated. In Mali and the Gambia, such bans have had effects opposite to those intended.

c. The Sambissa Game Refuge is an important wetland area that is in direct conflict with the South Chad Basin Authority project for the Kaberi Weir transfer canal; it will also suffer from the Yedseram Dam and Michiki Izge Irrigation project. There appears to be no dialogue between conservation and development authorities for the Borno drainages. The upstream projects could destroy this refuge, the last major area for the preservation of large mammal biological diversity in the Nigerian part of the Lake Chad Basin. Discussion of minimal instream flow and release scheduling is absolutely necessary.

d. The road to Diffa is now a series of tracks. These tracks are equivalent to heavy trampling by cattle resulting in the loss of vegetative cover, mobilization of top soils, and gulleying. A hardtop road would reduce erosion.

e. The elephant situation needs review and requires international aid. Elephant migration has been disrupted by large-scale farms, highways, and fast-growing towns, creating general confusion among the herds. Herds have split into small groups in order to find migration routes that are safe. The fragmentation of habitat and loss of migratory corridors will eventually doom the Borno elephants unless planning and protected links between habitats are established.

f. Within SCIP, gulleying and earth heaving are occurring on the embankments of irrigation canals made of vertisols. This is a common problem that should have been foreseen. Repair costs should be limited to areas where the fields will be reasonably used. Similarly, plant growth within the main intake to SCIP (mostly *Pistia*) causes a major loss of water from evapotranspiration and blocks tfishing boats and fishing. The situation needs review.

g. The Ministry of Animal and Forest Resources has started a shelter belt program with 55 km of shelter belt planted. The World Bank, through its Forestry II project, is funding shelter belts, seedling distribution, nurseries, *Acaia,* and fruit trees.

h. Rodent, locust, and quelea pests are major causes of production, natural plant biomass, and seed stock losses. Neem has suffered from a disease that reduced regeneration dramatically. The impacts of these pests could be reduced by coordinated efforts between the conventional basin nations. Nigeria has complained that quelea and neem disease came from Cameroon and Chad and could have been controlled with an early warning system or control measures in these counties. A recent rodent plague came, in part, from Niger.

i. Regeneration, vegetation cover, and crop yields has suffered from acute shortages of fertilizer within the diagnostic basin. An overview of supply routes and stability for the basin would be useful.

2.6.5 Human Resources Background

The Kanuri, practicing farming and sedentary animal husbandry, are the most important group demographically and politically in Borno (70 percent of the population). The second largest group are the Shuwa Arabs (about 8 percent of the population). They practice semi-nomadic agro-pastoralism and agriculture. Nomadic Fulani (Mbororo) make up about 5 percent of the population. Small groups, including Manga and Mobeur, live along the Niger/ Nigerian border. Groups related to the mountain peoples of the Mandara Mountains live along the Cameroon/Nigerian border.

2.6.6 Human Resources Concerns

a. In the Borno diagnostic basin, rural-urban migration and rural-urban wage gap differences have lead to labor shortages in the countryside. Rural labor shortages discourage investments in time-consuming activities to maintain and restore renewable natural resources. Isolation, population drain, and relative poverty go hand in hand in the more remote parts of Borno state.

b. There are only large trunk roads and no rural feeder roads (Onakomalya, 1986), resulting in localized deforestation along the main arterial routes for firewood sales and inequality of access to resources, technology, knowledge for resource management, agricultural extension, seed, fertilizer, etc., in the northern and eastern parts of the diagnostic basin.

c. Large-scale civil irrigation works have been constructed without adequate cost-benefit analysis of both foregone and derived economic and ecological benefits and without adequate site-specific technical analyses. For instance, the value of lost grazing, tourism, fadama production, and fisheries downstream from waterworks has never been analyzed. Due to design problems, neither SCIP nor the Baga polder projects have begun to amortize their colossal investments. Inability to use part of Borno's productive base in dry years because of design flaws associated with SCIP should be a major lesson transferable to other projects. It is exacerbated by the SCIP's management, which inhibits farmers from producing masakwa, the local term for the flood recession sorghum that is well suited to the area occupied by the SCIP project. Some officials admit that small-scale irrigation developments managed by local government areas in partnership with the Ministry of Agriculture have been de-emphasized for mainly political reasons, while large projects have received favor.

d. There has been a failure to develop energy alternatives appropriate to the rapidly evolving urban setting. The use of natural gas or kerosene cookers will not resolve the energy problem in the near future (especially in Maiduguri) unless a strongly coordinated effort is made to insure a constant supply of petroleum-based fuels, low prices, standardized parts for the stoves and tanks, replacement parts, new cookery education, and, possibly, a natural gas pipeline. Rural and village people will remain dependent on wood for many years. An extension program for fuel-efficient stoves and private woodlots is the only strategy in the rural areas.

e. Inequities in the temporal and geographical distribution of water from new storage dams to downstream users has depressed production and reduced the range of economic opportunities open to them.

f. There are several sources of degradation of grazing vegetation. Abusive commercial grazing on common grazing lands causes a depletion of the vegetative cover. The reduction in grazing areas is due to encroachment by farmers and by land clearance for large storage dams and irrigation projects. Meanwhile, conserved forage accounts for only about 24 percent of the dry season feed needs of livestock on Borno states.

g. The absence of environmental education in the schools creates an environment of neglect of resource issues. Available data is equivocal regarding the perceived threat and causes of environmental degradation (Rasheed, 1985).

h. Policy lacunae exist at all levels related to resource tenure and management. There is an absence of environmental law and environmental impact statements. Analysis of project design is not conducted by independent consultants. The monumental scale on which development projects are conceived and implemented in the Borno diagnostic basin considerably raises the possible costs of ill-conceived development which environmental impact analyses are designed to mitigate.

2.7 KOMODOUGOU-YOBE DIAGNOSTIC BASIN

2.7.1 Water Resources Background

This diagnostic basin of about 148,000 km^2 is divided into two distinct parts: an upland water collecting area situated in the Kano and Bauchi States and a lowland area of dispersal in the Borno State and in Niger (Figure 2.16). The upper part, upstream of Gashua, is the Hadejia-Jama'are Basin. East of Gashua, where the lower part begins, the system is known as the Yobe River. One hundred kilometers farther east of Gashua, it joins the Komadougou Gana River. The Komadougou-Yobe River (herein called the Yobe River) is a classical example of a tapering stream, losing a large part of its total annual flow by infiltration and evapotranspiration. The lowest 150 km of the river is an international boundary between Nigeria and Niger.

In the late 1960s, prospects of irrigation development motivated the government of Kano State to embark on several major irrigation projects in the Hadejia-Jama'are Basin. In

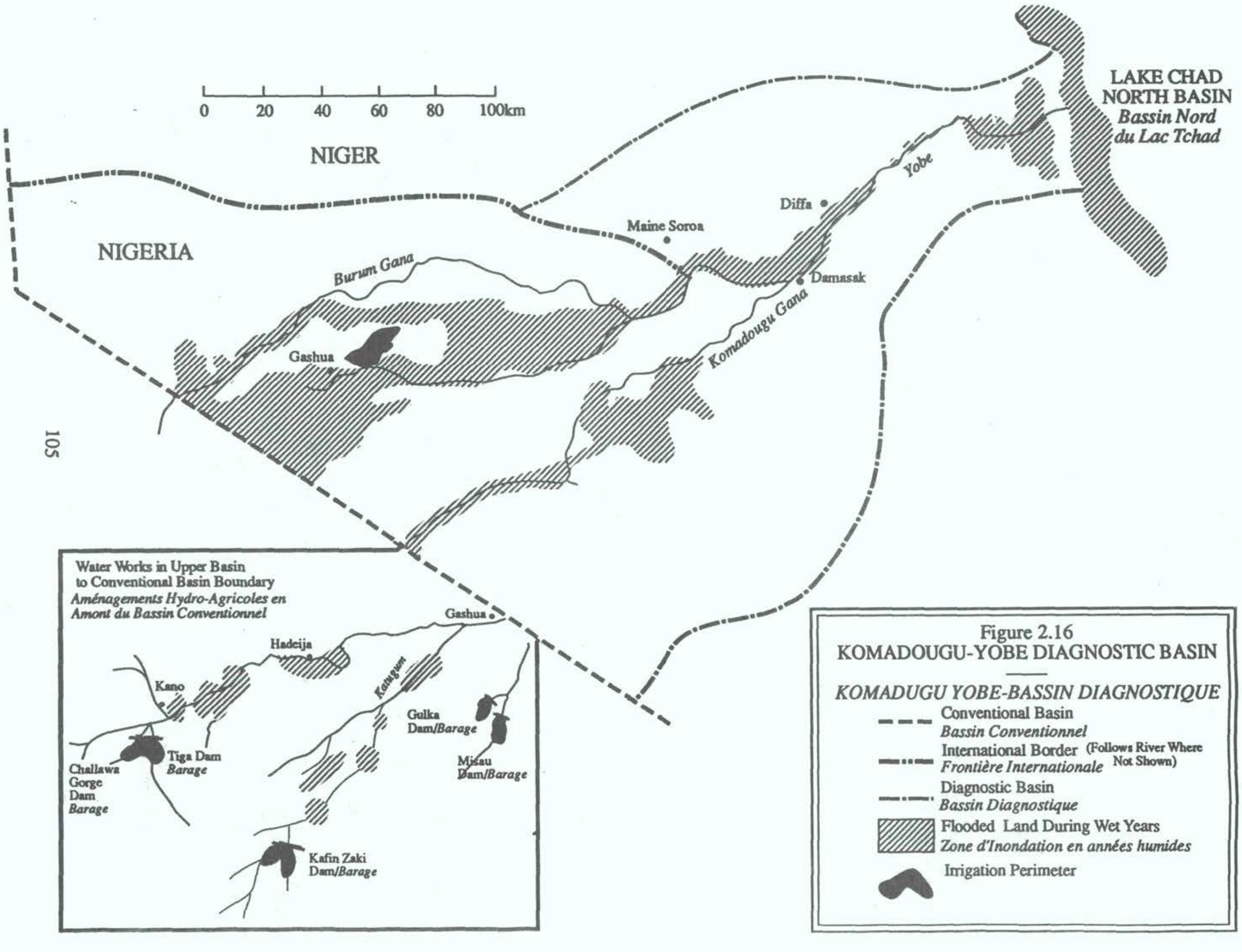


Figure 2.16
KOMADOUGU-YOBE DIAGNOSTIC BASIN

KOMADUGU YOBE-BASSIN DIAGNOSTIQUE

years 1970 to 1974, the Tiga Dam was built about 60 km south of Kano City on the Kano River, a tributary of the Hadejia River. This is the second largest earth fill dam in Nigeria, with a storage reservoir of 1,974 x 10^6 m^3 capacity (mean annual inflow 1,300 x 10^6 m^3). Tiga Reservoir is the cornerstone of several reservoir and irrigation projects being implemented in the basin area under the overall direction of the Hadejia-Jama'are River Basin Development Authority (established in 1976).

Because all irrigation projects in the basin are based on surface-water storage, two other large dams are under construction. The Challawa Gorge Dam on the Challawa River (a tributary of the Hadejia River, upstream from the Kano River) will provide a storage of 1,950 x 10 m^3 (mean annual inflow 1,060 x 10 m^3), and will occupy an area of about 100 km^2. The dam is about 40 percent complete and, according to the First Three-Year National Rolling Plan of Nigeria for years 1990 to 1992 (TYNRP), the expected completion date is 1992. The second is Kafin Zaki Dam, which is being built on the River Bunga, one of the tributaries of the Jama'are River. The reservoir will have a total capacity of 2,700 x 10 m^3. Less than 5 percent of the construction of the dam is completed, but access roads and construction camps are ready for continuation and expansion of work. According to TYNRP, the project completion date is 1995.

At present, Tiga Reservoir is a source of municipal water for the City of Kano, providing at the same time irrigation water for 16,000 ha of Kano Irrigation Project, Phase I (financed by Federal Government and British Overseas Development Agency). This phase of the project (bringing the total project area to 24,000 ha) will be completed by 1991. Another important irrigation scheme, located about 160 km downstream of Tiga, is the Hadejia Valley Project. Out of the 25,000 ha found suitable for dry season irrigated agriculture, an area of 12,500 ha has been taken up for development as Phase I of the project, based on irrigation water releases from the Tiga Reservoir. Construction of the project commenced in 1981 but, due to the unfavorable financial conditions, implementation of the project was suspended in 1984. Under the TYNRP, completion of Phase I is expected in 1989 (under the loan by a local banking consortium and Credit Lyonnais). The remaining 12,500 ha under, Phase II, is to be implemented after completion of the Challawa Gorge Dam.

2.7.2 Water Resource Concerns

a. In regard tyo the Hadejia Valley Project, it is important to note that downstream of Tiga Reservoir the Hadejia River crosses the boundary between two geological formations: the Basement Complex and the Lake Chad Formation. During the last ten years of Tiga's operation, at the juncture of the two rock formations, up to 70 percent of reservoir releases during the dry season disappeared from the river channel before reaching water intake of the Hadejia Valley Project.

The First Three-Year National Rolling Plan of the Hadejia-Jama'are River Basin Development Authority provides for the construction of several smaller irrigation projects in the years 1990 to 1992, for a total area of about 10,000 ha. Ultimately, it is planned to bring the total area under irrigated development in the Hadejia and Jama'are River Basins to 50,000 ha and 47,000 ha, respectively (Schultz, 1976).

Extensive river control and irrigation projects in the Hadejia-Jama'are Basin will alter the regime of Yobe River downstream of Gashua (Schultz, 1976). According to Schultz

(1976), the effect of upstream storage and long-term irrigation development (ultimately about 100,000 ha) on the annual flow at Gashua will be the following:

Year	No development	Maximimum development	Flow reduction
1964	2,280 x 10^6 m^3	1,570 x 10^6 m^3	32%
1965	1,520 x 10^6 m^3	800 x 10^6 m^3	47%
1966	1,630 x 10^6 m^3	920 x 10^6 m^3	44%
1967	1,210 x 10^6 m^3	500 x 10^6 m^3	59%
1968	1,130 x 10^6 m^3	420 x 10^6 m^3	63%
1969	1,490 x 10^6 m^3	780 x 10^6 m^3	48%
1970	1,560 x 10^6 m^3	950 x 10^6 m^3	40%
1971	1,350 x 10^6 m^3	640 x 10^6 m^3	53%
1972	780 x 10^6 m^3	70 x 10^6 m^3	91%
1973	590 x 10^6 m^3	0	100%
1974	1,560 x 10^6 m^3	650 x 10^6 m^3	58%

Flow reduction by 32 to 100 percent will substantially alter the hydrological regime of the river below Gashua. In a very dry year, such as 1973, there would be no flow at all in this stretch of the river. Recognizing the problem ten years ago, the consultants (Schultz, 1976) recommended a study to determine the possibilities of increasing flows at Gashua to normal levels. Such a study is of crucial importance because the Yobe River loses about 80 percent of its flow between Gashua and Yau, close to where the river enters Lake Chad. This is where the river passes through a narrow flow plain, which is marked by larger alluvial tracts on the inner bends of the river. Flooding of these tracts by overflow from the river and drainage from the sand dunes creates permanent marshlands, which are actively used for crop production by the local population.

At Bagara Station, which is typical of the international boundary area, the Komadogou-Yobe River flowed for about ten months (from July up until March or April of the following year) until the early 1970s. After the early 1970s, discharge decreased rapidly. During the dry season only disconnected pools remained in the main stream channel. In the 1970s flow was reduced on average to eight months (July thorugh February); during the 1980s, the average duration has been only six months (July through December). From the point of view of the local population, these are the most distressing changes. Drought and/or upstream storage have been implicated in the shortened flow regime (Andillo, 1989).

b. The mean annual contribution of Komadougou-Yobe Basin to Lake Chad has been evaluated by FAO (1972) as 450 x 10^6 m^3. In the critically dry years of 1973 and 1974, annual inflow to the Lake was 270.07 and 237.90 x 10^6 m^3 respectively (measured in the Yau profile). In the following years, based on the information obtained from the Borno State Water Board, flow varied between 200 and 400 x 10^6 m^3. In terms of Lake Chad as a whole, this contribution is almost negligible. It is, however, the only surface water ientering the northern pool of the lake. Moreover, it is important to the local population, which intensively uses the marshy pool at the river's mouth for crop production and fishing. These are sufficient reasons for maintaining Komadougou-Yobe River's inflows to Lake Chad at levels no less than those recorded in the past.

2.7.3 Ecological Resources

The part of the Komadougou-Yobe Diagnostic Basin within the conventional basin includes the Geidam plain, the Burum Gana plain and the Yobe flood plain, which form the "interior" delta of the basin. These floodplains were the crucial "natural irrigation" source. The Yobe River, which is well entrenched, then proceeds to Lake Chad.

Within the conventional basin, the present surface is generally flat, with dunes in some locales. Landforms include ancient alluvium from the period when the lake level was 320 m; the ancient sand barrier (cordon dunaire) from the lake's edge, the inundated areas along the river's channel, the areas with fadama depressions and heavier soils, areas with dunes that flood in the depressions (fayas), areas with dunes that do not flood; dunes with salts, fossil ergs and sandy plateaus (tropical red and red brown soils), and sediments from ancient lagoons and recent lake level changes along the shore.

The diagnostic basin falls within the Sahelian Zone with low rainfall years moving it closer to Sahelo-Saharan vegetation. The characteristic trees along the Komadougou are Tamarind and baobab; along the shoreline of Lake Chad are *Acacia nilotica*, *A. tortillis*, *Balanites*, *Zyziphus*, and *Salvadora*. In the depressions, doum or date palms grow. On the dunes, *Commiphora africana*, *A. senegalensis*, *Dalechampia scandens*, *A. albida*, and *Zyziphus mauritania*. There are scattered protected forests (forets classes), but their status could not be determined.

The alluvial plains support *Viteverria* grasslands on the spill floodplains; acacia woodlands in the seasonally flooded depressions; *Mitragyna/Mimosa* along the banks and bars of more active rivers, the *Oryza/Echinochloa* marshlands in ponds which contain free water for much of the year, and *Acacia albida* farmland on river terraces and point bars with sorghum and millet fields. *Calotropis* invades roadsides and the receding lakebed.

There are no game reserves or protected areas in the lower Yobe Basin. Upstream, on the border of the conventional basin, the Nguru wetlands have international importance as a wintering migratory area for Palearctic birds such as the ruff and wood sandpiper. It is a major conservation and development project in the basin (see below). The Buratura oasis is an important breeding and roosting site for black-crowned cranes. It was also the first location for flamingoes in Nigeria. There were, at one time, about 27 medium to large mammals in the diagnostic basin. The black rhinocerous, the cheeta, and the lion are now extinct in the area. No recent wildlife assessment was found. Dorcas gazelles are the only large mammal commonly reported. This diagnostic basin contains the Kouri breed of cattle (and crosses with Azawak and Bororo) unique to the Lake Chad Basin.

2.7.4 Ecological Concerns

Documents on specific environmental concerns in Nigeria are hard to find, if they exist. Nigeria appears more concerned with upstream development and has few, very simplified documents, on downstream consequences of new large-scale waterworks. It is difficult to find material on the Nigerian side of the border for the lower Komadougou-Yobe Diagnostic Basin. For this reason, we have concentrated on Niger.

Many of the environmental concerns in the tropical ferruginous soil areas are similar to those of the Northern Diagnostic Basin. Damasak has reported dune mobilization and widespread sand sheeting in the interdunal date orchards and the fadama and faya depressions within the lower Yobe. (The impacts on Lake Chad are addressed under the Lake Chad Diagnostic Basin.)

a. Upstream dams have altered the flow regime of the lower Yobe River and the major inflow to the northern pool of Lake Chad. Although no detailed study has separated the impacts of the drought from those of the dams, it is apparent that the groundwater table has lowered, causing streams, ponds, ox-bows and village wells to have less water for a shorter period during the year. The flow period of the Yobe River has changed from five to six months to three to four months per year. There are areas that are never flooded even in good rainfall/runoff years. Vegetation patterns, especially the *Vetiverria* grasslands, have undoubtably changed.

The fadamas, or lowlands and swamps, fed by Yobe River overspill, have been dry because of the drought and the lack of a floodpulse. When possible, farmers have irrigated fadama land with pumps and blocked side-channels of the Yobe River to prevent return flow.

The impacts on the Fulani pastoralists and vegetation have not been documented, but movement of the Fulani south is common knowledge.

b. The dams and drought have halted the Yobe River fishery and much of the recessional rice production. In addition, flood-depression fisheries have collapsed.

c. The dams and drought have been responsible for the loss of some rice cultivars. These genetically unique rice varieties should be searched for and preserved, if they still exist.

d. The Nguru Project is one of the few projects in the Lake Chad Basin that works on both conservation and development simultaneously. Its focus is an equitable partitioning of water resources. Conservation needs include limiting Fulani grazing, protecting wetlands and roosting areas for birds, limiting brush and thatch collection for transit camps, limiting fires set to stimulate pasture regrowth, firewood and construction overharvesting, illegal bird trapping and hunting, upstream diversion of water that supplies the wetlands, increasing pumping for irrigation and, of course, mitigating the impacts of the drought.

The Federal Republic of Nigeria has signed an agreement with ICBP and the Royal Society for the Protection of Birds. State governments and the Nigerian Conservation Foundation have joined the effort. The joint project includes an education program in the secondary school, as well as reforestation, joint land-use and development projects for villagers (and, ideally, pastoralists) that would protect the wetlands, train State Wildlife Departments, and monitor migratory birds. This project, like the project in the inner delta of the Niger in Mali, is based on local people, consensus building, education, and international aid inputs. It can act as a model for preventing environmental degradation and restoring already degraded habitats.

e. There has been intense degradation of wooded savanna caused by the droughts of 1968 to 1973 and 1983 to 1984. Exceptions include the wooded areas near the lake, along the Komadougou River, and the depressions (curvettes) of Maine-Soroa. Even before 1968, the quantity of livestock had an impact on regeneration of the wooded areas. The living trees and shrubs aged without young seedlings in the understory. The first drought killed many of these older trees, which could not increase root growth fast enough to meet evapotranspiration demands. The composition of herds changed after the 1973 drought, favoring goats and sheep. While a few locales started strong regeneration, the combination of browsers and the drought in 1983 halted the recovery of ligeous species, and the seedlings disappeared. In addition, by 1982, wood consumption in some departments (Diffa and Nguigmi but not Maine-Soroa) surpassed regeneration rates (firewood is collected 10 km from the town of Diffa).

Yet floodplain and rainfed farming has little influence on deforestation because of the difficulty of farming and the low population pressure. Fallow periods are still long enough to restore soil fertility. But the expansion of counter-seasonal farming with irrigation of large tracts of land may eventually change this situation, as it has in the Chari/Logone and Mayo Kebbi Diagnostic Basins.

The number of nurseries and seedlings distributed is impressive in the Niger side of the diagnostic basin, but evaluation of successful plantings is unavailable.

f. Pest control for quelea, rodents and locusts is a recurrent concern to both farmers and conservationists. Locust removal of vegetative canopy during drought periods encourages wind erosion, depresses seedling regeneration, and opens the soil to raindrop erosion. Rodent destruction of seedlings also hinders regeneration. The 1986 invasion of antelope rats (jer-oboa) was particularly acute in this basin.

g. Eolian deflation is localized and not widespread. It is still possible for immediate local attention to slow the impacts. Doum palm groves have been an effective preventative in interdunal depressions. Nevertheless, a sample of 110 depressions indicated that 20 percent of the farmers had noted problems with encroaching sand.

h. The gum arabic plantations were destroyed by the first wave of drought in the late 1970s. Favorable conditions for regeneration have shifted south. The browsing of seedlings by goats and a shift in rainfall isohytes has stifled the regeneration of *Acacia albida*. The use of doum for construction is under tight control by Eaux et Forets in Niger.

2.7.5 Human Resources Background

Kanuri and related groups dominate the upstream end of the Yobe River Basin with semisedentary and nomadic Peul herders. The downstream eastern end of the Yobe is home to the Mobeur sub-group of the Kanuri and related groups such as the Manga. The Mobeur settled in the valley over 300 years ago.

Before the current drought cycle, seasonal millet production, fishing, and animal husbandry made up the valley economy. Rice, grown in seasonal ponds, was introduced in the early 1950s. After 1970, as the importance of rice declined, vegetables were produced for export. Postflood sorghum was grown on the shores of Lake Chad, and a fairly complex system of dikes was built to protect polder-like fields from premature flooding. Wheat was traditionally grown in the Yobe valley and in the Yobe delta region. Thirty years ago, 6.5 T of fish were taken near the Yobe River delta, and 4.5 T were taken from the Yobe River during the fishing season (Anon., 1958).

Peul and Tubu (= Kreda or Gorane) pass through this diagnostic basin with their herds. Since the late 1970s, some Shuwa Arab groups in search of pasture have nfiltrated the diagnostic basin. They and their camels were observed in the Yobe Basin in July 1989 between Damasak and Diffa. The cause and extent of these migrations are not known.

The Niger part of the lower Komadougou Basin occupies the administrative regions of Diffa and Goure. According to the most recent information (from 1986), this area has a population of nearly 330,000 persons. About two-thirds of the population are agricultural peasants living in permanent settlements; the rest are nomadic herdsmen. The water needs of both population and livestock are satisfied by the phreatic and artesian aquifers. In 1979 there were 410 cemented wells and 37 boreholes in the area. During drought, the majority of the population moves south.

2.7.6 Human Resources Concerns

UPSTREAM

a. Upstream, the problems encountered are similar to those in the Borno River drainages.

b. Very little money has been invested in detailed research on the downstream, offstream, and groundwater impacts of upstream water projects. The timetable for effective implementation of sustained resource use strategies in the upper Yobe subbasin is slowed by the fact that the impacts of human use on the natural environment are not known, nor are there any models of intervention in systems of resource use and production.

DOWNSTREAM

a. Upstream damming, irrigation development, and the drought have negatively effected the downstream floodpulse on which the populations of the lower Komadougou Basin increasingly depend. Some 6,000 ha of irrigated land in the lower Yobe Basin on the Niger side of the border are at risk. Several hundred hectares in small irrigation developments on the Nigerian side of the border have been negatively impacted. The disruption of the Yobe floodpulse has led to the loss of an important regional, seasonal fisheries industry. Job switching has intensified the competition for irrigable agricultural land. The drought and water diversions have led to emigration. The entire department of Diffa in Niger has lost about 10,000 inhabitants since the early 1980s.

b. Increased irrigated cultivation tends to concentrate pests. Borers, caterpillars, locusts, crickets, quelea, and golden sparrows are already endemic. Increased use of pesticides, some of which are considered toxic in the United States, poses risks of pesticide loading in water and human illness.

c. The socioeconomic problems associated with medium-term drought and changes in pastoralist labor relations have become acute in the Sahelian Zone of this diagnostic basin. Prior to the 1960s, it is believed that labor shortages limited herd size and number. Given good rains and limited herds, no significant pasture degradation was reported. Since the 1960s, animal health programs, increased family size, improved human health and nutrition, and increased commercial opportunities have created a greater opportunity for more and larger herds in despite the onset of drought. In some cases, only urban traders can afford to run cattle, thus turning pastoralists from self-employed cattle herders to wage laborers and reducing their interest in long-term maintenance of pasture. (In some cases, the urban traders and herders are kin, thus reducing the alienation of wage-labor from resource maintenance). The alternative (i.e., cooperative pastoralist associations that manage resources) has yet to be established.

The rapidly changing pastoralist situation has highlighted the following socioeconomic problems:

— Pastoralist groups (even kin-based groups) lack secure pasture rights and have lost much of their drought reserve pasturelands to agriculture.

— There is government resistance to empowering pastoralist groups that want to decentralize control over land and water rights. Similarly, many urban commercial traders oppose pastoralist groups that would define pasture rights and prevent access to "national" pastureland.

— Despite the back-to-back droughts, many government officials still believe that settled livestock groups are better than flexible, mobile, and diversified transhumant groups.

— There is no water rights policy, nor is there a policy to close boreholes or wells to limit overstocking grazing areas.

— There has been no movement to assign irrigation water to pasture or browse plants as part of a transhumant cycle.

— There is no indication that a monetary savings policy would reduce herd size and replace the use of large herds as a savings account, investment asset, or insurance income.

— The transportation system for rapid offtake has not been a high national priority for government or international spending.

Until these formidable problems can be addressed, local overgrazing and overbrowsing, as well as social conflicts, will continue.

2.8 NORTHERN DIAGNOSTIC BASIN (includes Termit Sud, Bahr el Ghazal)

2.8.1 Water and Ecology Resources Background

Administratively, the northern "drainages" include parts of the Lake, Kanem, and Chari Baguirmi Prefectures of Chad and parts of the Nguigmi, Diffa, and Maine Goroa Prefectures of Niger. In Chad, the main urban centers are Bol, Mao, Ngouri, and Moussouro. In Niger, the major urban centers are Gore and Nguigmi.

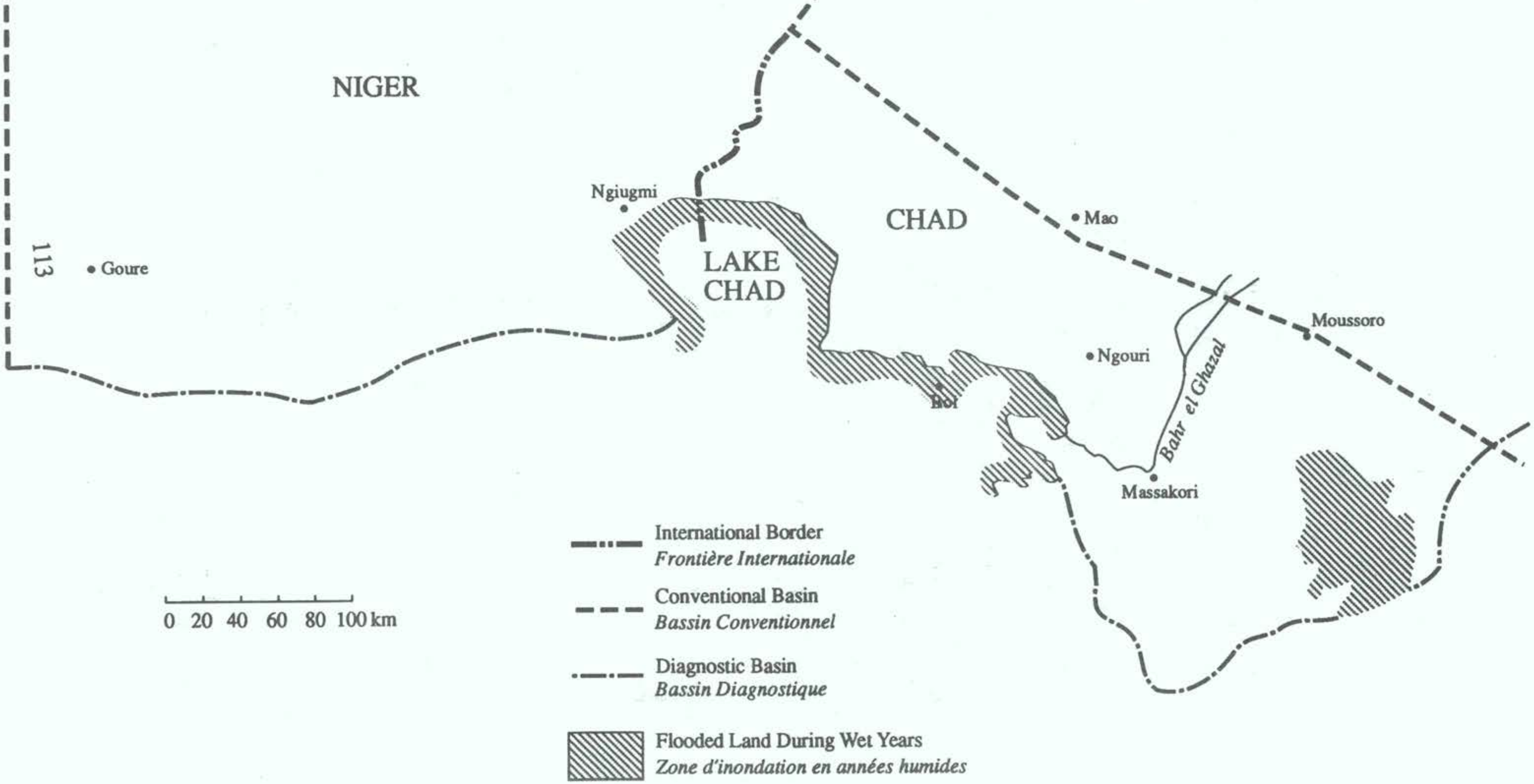
This diagnostic basin does not have any large drainages that normally flow into the Lake (Figure 2.17). It is the largest drainage area in the Lake Chad Basin, enclosing 807,360 km^2. For practical purposes, the area can be considered to provide no surface runoff to the lake. On the contrary, it has a distinct drainage pattern, flowing away from the lake along the Bahr el Ghazal trough towards the Bodele Depression.

The Termit Sud catchment, encompassing 738.850 km^2, provides almost no surface runoff to the lake. Sometimes, after exceptionally heavy rains, surface runoff occurs along a trough extending from the Termit Massif to Lake Chad at Nguigmi.

By far the largest area is covered by moving sands (low altitude plateau) and recent ergs. The Bahr el Ghazal and the depressions south of the Bahr are major exceptions. They

Figure 2.17
NORTHERN DIAGNOSIC BASIN

BASSIN DIAGNOSTIQUE SEPTENTRIONALE



have been formed from the lake deposits of an ancient Lake Chad. The other exception, on the western side of the lake, includes the ancient sand barrier of the lake, the Quaternary delta deposits from now dead rivers, and the alluvial deposits from the Quaternary period.

The soils follow the geomorphology closely. The slightly undulating, low altitude plateau contains siliceous sands, weakly ferruginous, red to red-brown in color, with no soil profile. The extreme northern part of the basin contains pockets of desert (eolian) soils. The delta deposits in the Bahr el Ghazal are covered by weakly ferralitic soils and ferruginous tropical soils on top of ferralitic soils. The depressions south of the Bahr and north of the Komadougou contain leached alkali soils. Circling the western side of the diagnostic basin, following the cordon dunaire, are hydromorphic mineral soils with gleys.

Because the most widespread soils (sandy tropical ferruginous soils of the French classification) are very susceptible to drought, the responses to human degradation are accelerated. The groundwater drops quickly, the surface becomes easily mobile, and sheetwash is more easily initiated in comparison to more southern soils.

It is important to remember that the northern diagnostic area includes regions in which wind erosion is normal. The movement of isohytes southward has "naturally" moved the limit of wind erosion southward. How far south the limit should be moved is unclear. Conservationists can only hope not to decelerate the southward drift by human actions.

BAHR EL GAHZAL

These flat and wide wadis have a clay or sandy clay texture sometimes mixed with nonnutritive eolian sand. Organic matter constitutes 4 to 5 percent of the upper horizons, and the pH about 8; there is no natron. The sweet water table is 1 to 1.5 m from the surface in the rainy season and 5 to 7 m in the dry season. There is an exceptional old-growth doum palm stand in the Cheddra wadis. In the Cheddra area, wadis have been turned into truck farms for Ndjamena. There are no date palms and few fruit trees, and mostly truck farms for Ndjamena.

There are three main types of vegetation of the northern drainages: (1) a shrubless *Panicum turgidum* grassland with a mixed herbaceous layer; (2) a shrub steppe of *Commiphora, Leptadenia,* and *Acacia raddianna* (shrubform) interspersed with *Arisitida* grasses; and (3) a shrub steppe, which at times reaches tree size with *Acacia senegal* and *A. laeta* as well as the other acacias, *Balanites* and *Arisitida/Scheonfeldia* grasses. The shrub limit has now moved south (see below). The woody plants have not been heavily used. They serve as firewood for nomads and provide extra income (from gum arabic) and browse for cows and sheep during the dry season and camels and goats year round.

With regard to livestock, over 25 kinds of pasture can be defined with varied mixes of browse and grasses. Some of the grasslands supported year-round grazing, at least until the cycle of drought began. These grasslands were never overgrazed, but were underwatered, causing southern movement of various pastoralist groups.

With back-to-back droughts, the vegetation changes have been spectacular. For instance, in Kanem Prefecture, the grass steppe with *Acacia tortillis* and *Balanites* extended as far north as 15°30' in the mid 1960s. By 1975, all the ligneous and perennial species had disappeared above the 15° parallel. In the State of Kanem, about 20,000 km^2 changed from a diverse grass steppe to a uniform annual grassland. By 1985, there was only enough grass for cattle up to the 14° parallel. In 1988 the CTFT mission reported a continuing loss of ligneous species, little regeneration of trees, replacement of both annual grasses and perennials by *Leptadenia pyrotechnia* in the nonligneous areas, inability of seeds to grow within the eolian layer now covering the pre-1960 soil profiles, and increasing exposed soil (which, in 1988, extended as far south as the 13° parallel). In short, the northern limit of the Sahel has moved south by about 100 km. Similar observations have been made in Niger.

The future movement of this very mobile Sahelo-Saharan line is impossible to predict. In discussions of "desertification," we must be humble. Medium-term drought cannot be technically fixed in this area of the Sahel.

The northern diagnostic basin supports goats, sheep, camels, cattle, and donkeys. Figure 2.2 gives some sense of the variation in pasture and grazing carrying capacity over a four year period. It does not include browse plants.

Although information on the fauna is scarce, early reports from the Nigerien part of the diagnostic basin and anecdotal information on the Chadian side tell a story of rapidly decreasing wildlife. Reports of ostrich, scimitar-horned oryx, addax, and Damas and Dorcas gazelle were common in the 1960s.

2.8.2 Water and Ecological Concerns

As donors and governments have learned, there is not much that can be done in the northern Sahel in the face of medium-term drought, except hope the rains will return. Below are concerns centered on this region. But, various discussions under the Komadougou-Yobe Basin are relevant to the southern part of this diagnostic basin.

a. In general, Saharan-type erosion does decrease toward the south but it is possible to locate pockets of active erosion caused by the combined impact of medium-term drought (the last twenty years) and human activity.

Symptoms of active erosion in this diagnostic basin include:

—rippled layers of white sands, and wind deflation depressions at the foot of trees on the plateau;

— active deposits of red, yellow, or white sand in the "quiet areas," high on the dunes protected from turbulent wind eddies;

— runnels, incised soils, and gullies on the lower parts of slopes;

— nebkhas, rebdous, and small blowouts from eolian deflation at the base of trees, shrubs, and doum palms within the depressions of silty clay soils.

According to recent observers, these symptoms of active erosion are not widespread within the diagnostic basin.

On the other hand, almost the entire basin now has a moveable top layer, excessively sandy for stablizing land to grow crops. This sandy layer has been deposited on top of the existing soil profile. The symptoms of soil degradation include:

— nebkhas, rebdous, or microdunes more or less covered with a grass layer;
— the reduction of fine particles in the top soils by deflation.

The topmost layer of soil is between 10 to 15 cm thick. Under the mobile layer, there is usually a fairly fixed bed of sand that contains the tap roots of the plants. The altered top layer contrasts with the normally grey-brown hue of the A-horizon and the brown-red hues of the B-horizon. These lower horizons have higher percentages of fine particles (clays, silts, and fine sands). The increased whiteness and loss of fines and humus can be traced to trampling and hoof-plowing by local livestock with subsequent eolian transport.

b. Cattle and livestock trampling, especially near human settlements and along passage tracks, are a major cause of top soil mobilization. The most severely damaged area in the diagnostic basin is around Mao. Trampling of vegetation and hoof-plowing commonly accelerate dune mobilization near villages above the 13° parallel, though it is not known how this effect compares to that for nonvillage dunes. In rangelands in the Manga grasslands of Niger, an increased number of dunes are activated, but they are of smaller stature than those near villages. The increase in dunes may have been initiated by grazing and made more severe by the droughts.

In Maine Soroa Prefecture (Niger), dune stabilization projects have revegetated dunes by eliminating grazing, building strong fencing, planting millet on blowouts and denuded slopes, leaving millet stalks, and planting trees at the foot of the slope. Sometimes, *Cenchrus biflorus* seeds have been scattered to initiate revegetation.

Various projects have been funded by the World Bank, EEC, and the French Coop. Other projects attempting to stabilize dunes with doum palm leaf-barriers and fencing began recently and results cannot yet be predicted.

The complete destabilization of dunes (their de-construction) has been suggested as a more viable solution to "stabilizing." No projects that attempted to disperse active dunes could be found within the basin.

c. The main concern for pastoralists within this diagnostic basin has been the lack of forage, which forces them to penetrate the Lake Chad shoreline for forage or to move south beyond the Komadougou (on the west side) and beyond even the Central African Republic border (on the east side).

Even without grazing, changes in species composition in the northern diagnostic basin would occur because of the drop in rainfall. In other words, transhumance sufferis from restrictions on mobility and flexibility, which, combined with drought, lead to localized overgrazing. There is little evidence for "global" overgrazing. Main restrictions on transhumance include international borders, cultivated land, watering areas, and assigned trekking routes. Many pastoralists now wander into unfamiliar territory, adding a random factor to overstocking particular locales.

In the Lake Chad area, the Kouri cattle are resistant to rinderpest, but suffer from parasites (e.g., trypanosomes) and blackleg in the marshlands. The clustering of cattle around the shoreline has led to localized overgrazing.

d. The expansion of livestock in the late 1960s hurt the regeneration potential of the vegetation by increasing browsing on seedlings and trampling. The two droughts further slowed regeneration. The change from cattle to goats and the southern movement camels also hurt seedling growth, as these livestock browse heavily. A major challenge is how to speed regeneration while faced with increased browsers and lower and more erratic rainfall. In fact, the overriding concern is the lack of balance between vegetative loss (which occurs quickly) and regeneration (which occurs slowly) in this diagnostic basin.

The long-term goal is accelerating regeneration of tree and browse species that survived the drought poor;y. By giving seedlings a headstart in nurseries, many local tree species will survive the current drought period. Species of interest near Bol include *Acacia nilotica*, *A. laeta*, *A. senegal* and *A. ortillis*, *Prosopis sp.*, *Neem*, and *Leptadenia*.

e. Locally, in areas with slopes, reduced canopy cover has led to increased sheetwash, rills, and runnels. Gulleying and occasional streambank erosion occurs rarely on the longer, steeper slopes; compared to other diagnostic basins, the problem is secondary to wind erosion.

f. In the long term, the southern movement of livestock and the death of certain plant species can lead to a loss of soil fertility and slowing of regeneration. There are few studies of this phenomena. The speed and degree of defertilization (loss of nitrogen and tilth from manure and of recycled minerals and nitrogen from trees) is unknown for the northern diagnostic basin.

g. There are no protected areas (faunal reserves or national parks) within the northern drainages of the conventional basin. The most important species requiring protecting are the endangered addax (unknown numbers) and Scimitar-horned oryx (perhaps 300). IUCN hopes to survey for addax, oryx and Sahelo-Saharan gazelles. Most of the promising habitat is outside the conventional basin but migrations must cross from Niger to Chad, through the conventional basin.

h. Data could not be found for wood consumption and regeneration. Regeneration has been slowed by lack of rain, lack of manure (pastoralists have moved south), and soil degradation.

i. The change from perennials and shrubs to annual grasses and dicots normally takes place during medium-term drought. The question of how livestock accelerate this change and push annuals to a *Leptadenia* and/or barren soil environment is not clear. Loss of perennials hurts fertility by decreasing underground biomass from roots and microbial/mychorrhizal communities. Perennials also hold soils more effectively during the dry season.

j. Deforestation is centered along public roads and sanded cuvettes near villages. Gum tree forests are scarce and degraded. A World Bank project hopes to reclassify remaining gum groves or forests in Niger, add gum trees to farm windbreaks, and find ways to insure that farmers have tree tenure (a long-term guarantee that the gum of trees they care for will be theirs).

k. The two main concerns for farmers in the Kanem (Bol) area and similar areas in Niger are (a) the sanding in of wadis and other depressions (fadamas) and (b) the re-activation of dunes. See discussion in Komadougou-Yobe section.

l. Bahr el Ghazal environmental concerns include:

(1) Sand sheeting and the need for windbreaks.

(2) Dunes were traditionally not fallowed.

Fertility was maintained by containgin livestock and using their manure. Now, with less livestock, the fallow cycle has been started: six years of cultivation and three of fallow. Less fertile fields are rotated, i.e., cow peas (one year), grain (two years), or the crop is spread by using unused fields. In short, farmers are actively maintaining the soil without international aid inputs. The only environmental change is in the spreading strategy — the clearing of new land on dune fields to compensate for lowered fertility.

(3) Wadi soils are fertile and rotation only indirectly maintains fertility (cowpeas are grown among the truck farm crops on half the field; then switched to the other half). But without livestock, there is increased need for continuous cropping and reduced fallowing.

(4) There is possible overexploitation of palms for shadoufs and construction wood in the last remaining natural stands in Cheddra and Rig Rig.

(5) Crop pests cause indirect environmental degradation. By reducing crops, they force farmers into other income-generating activities such as commercial woodcutting.

The interdunal depressions may contain lakes that support *Spirulina* (a harvested algae) or natron (a harvested salt) or more fertile soils that are used for cultivation or palm orchards.

2.8.3 Human Resources and Concerns

TERMIT SUD

The Termit Sud region is the home to pastoral populations including Tubu (= Gorane), Wo'daa'be Fulani, Shuwa Arabs, and other groups who practice a variety of transhumant production systems.

Isolation of herding groups from circuits of exchange inhibits their ability to destock in response to periodic instances of drought. Delayed destocking may result in overgrazing of diminished pasture resources, as well as inefficient economics.

Watering points do not always correspond to areas of pasture reserves, and modern boreholes create inequities in resource access becaise only wealthier herders can pay fees for their use. Further, as has been known since the early 1970s, boreholes become foci of environmental degradation through destruction of the vegetative cover and soil compacting.

The absence of an effective drought early warning system also limits the ability of the herders to migrate or destock in a timely manner.

Animal health infrastructure is deficient in the region, despite recent improvements in the cold chain. While herder knowledge of western medicine is relatively great, shortages of quality products limit use and the efficacy of prophylactics.

BAHR EL GHAZAL

This region is the cross roads for a variety of pastoral (Kreda, Daza, and Oueled Sliman), agro-pastoral (Kouri and Buduma), and agricultural (Kanembou and Haddad) groups (Figure 2.17). Dune and recession cultivation and short-cycle transhumance are characteristic of production systems around the lake and the Bahr el Ghazal area. The population density is highest near the lake, reaching about 7 p/km^2.

Isolation of herding groups from circuits of exchange inhibits their ability to destock in response to periodic instances of drought. Delayed destocking results in overgrazing of diminished pasture resources.

Farmers still lack access to intermediate pumping technologies that are necessary to increase their labor productivity in wadis with lowered water tables and, consequently, to reduce pressure on increasingly arid dunefields.

Under conditions of prolonged desertification, degradation of the vegetative cover has resulted from overcutting of tree branches, from clearing of wadi bottoms for gardening, from clustering of herders around boreholes where disputes tend to break out , and even from scorched earth tactics undertaken by one nomadic group against another which is deemed to be too close. Herders have attempted to expand the areas under their nominal control through this and other means (Cabot et al., 1989).

The prolonged desertification of the Sahelian Zone of Chad, as well as the acute climatological drought in the early 1970s and in 1984 to 85, aggravated relationships between refugee herders fleeing from either side of the Bahr and the Kanembu and Kanouri farmers occupying dune and wadi fields along the Bahr el Ghazal and south towards Massaguet (Cabot et al., 1989). Herders north of the Kanem have no refuge area in the south, as do short-cycle transhumants in the Chari Baguirmi area and long-cycle transhumants from Ouaddai.

Land tenure in the wadis, which benefits absentee pastoral land owners, is a constraint on investments in renewable resources (fruit, improved date palm, and shade trees). Absentee owners are unwilling to allow tenant residents to plant economically useful trees that confer tenure rights to occupants.

2.9 LAKE FITRI DIAGNOSTIC BASIN

2.9.1 Water and Ecological Resources Background

Only the western end of the Batha/Fitri depression is within the conventional basin (Figure 2.18). This includes Lake Fitri, which is sometimes considered a miniature version of Lake Chad. The Batha River and its tributaries form a closed basin with ephemeral wadis that run only during the rainy season (July to October). The runoff is extremely variable. Lake Fitri is 420 km^2, using the old calculations of a "median" year. It can double or triple in size during wet and very wet years (greatest recorded coverage is 1,300 km²) or completely dry up after consecutive dry years (1973 and 1984). For a surface of 800 km², inflow of about 1×10^9 m³ is needed to compensate for evaporation (about 3,000 mm per year), transpiration, and infiltration.

Following the rainfall, Lake Fitri's water level is extremely variable. The depth, during "normal" periods, is between 1.5 and 2 m. Lake Fitri volume (when not completely dry) varies between 0.7 to 2×10^9 m³. As in Lake Chad, the water contains few mineral salts.

The depression has complex soils because of the expansion and contraction of the lake and because of various dunal transgressions. Near Lake Fitri, the soils are gleyed, with hydromorphic clays or pseudo-gleys that support extensive wetlands. There are small pockets of alkaline soils. In the long term, flood and recession borders of the lake, brown subarid soils with widely spaced trees and shrubs or anthropogenic pseudosteppes form an irregular circle around Lake Fitri. Outside this circle, there is a "naga" soil/plant community of sandy soils overlaying old lake hydromorphic or alkaline halomorphic soils. In depressions, vertisols and alkaline halomorphic soils support an open canopy thorn forest. During wet and very wet years, the wetland vegetation moves into the Batha River's delta and into the southwestern interdunal depressions.

BIROE has been studying the Lake Fitri's bird fauna and has censused the area in 1984, 1986, 1987, and 1988. CEDRAT and BIEP have designed a rural development plan for Lake Fitri with financing from the Islamic Bank for Development. In 1988, IUCN proposed making Lake Fitri a "Biosphere Reserve." A document concerning both the conservation and rural development of Lake Fitri has been submitted to the Government of Chad for approval.

2.9.2 Water and Ecological Concerns

No specific information on Lake Fitri exists. We have not seen the IUCN, BIEP, or CEDRAT reports.

2.9.3 Human Resources Background

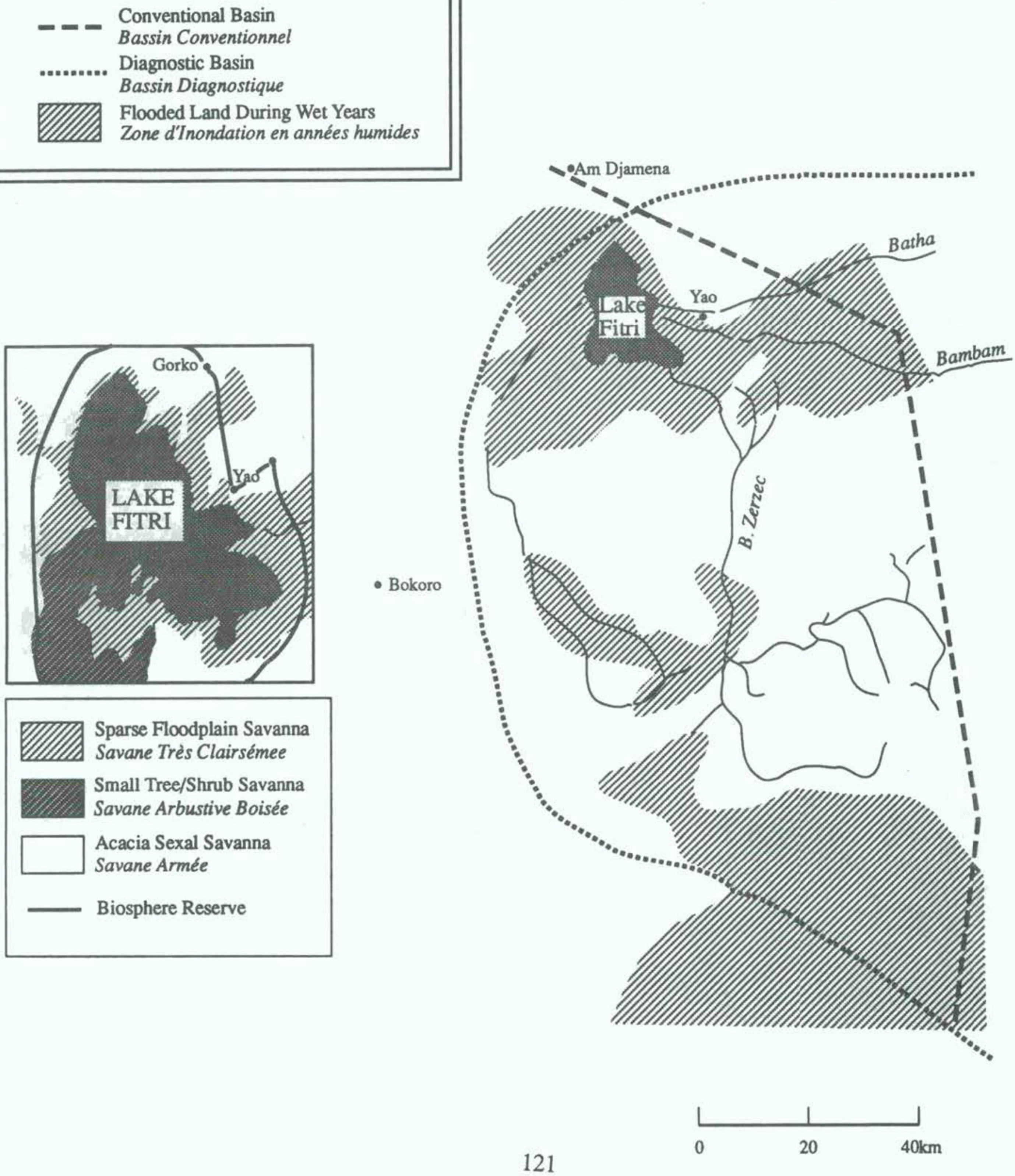
Lake Fitri and its environs are inhabited by the Bilala, an agro-pastoral people affiliated with the Kanembou. The area is seasonally visited by a number of Arab pastoral groups (Figure 2.18). Cultivation of berbere, kreb (*Panicum laetum*), and wild rices was among traditional agricultural activities of the zone. Millet is also grown on the dunes. Lake Fitri fisheries are also important to the traditional Bilala economy.

Lake Fitri is a particularly rich zone, with green pasture year round. Bourgoutieres in the hot dry season, recession pastures in the cold dry season, and dune pastures in the rainy season attract agro-pastoralists. In addition, the association of vertisols and dune soils makes for a diversified agricultural calendar involving transplanted recession sorghum, pencil millets, and kreb. In addition, fish (*Silurides* and *Pterocarpus*) are available.

Climatological drought has intensified competition for these resources among the indigenous populations. Short-cycle transhumant herders have moved to the southeast to-

Figure 2.18
LAKE FITRI/BATHA DIAGNOSTIC BASIN

LAC FITRI/BATHA BASSIN DIAGNOSTIQUE



wards the Salamat. New arrivals chased out of the north by drought (J.P. Monnier, personal communication) have entered the Lake Fitri area. The old rules of use, fixed by custom and habit, have been overturned. The Bilala agriculturalists have become very strict about the routes pastoralists may take through their territory. They have designated trekking routes, which animals must follow and designated locations where camps can be installed. For their part, herders have begun to charge for the transport and other services that used to be exchanged in kind.

PART 3: CONSERVATION AND DEVELOPMENT

3.1 PREAMBLE

There are two approaches to conservation and development in the Lake Chad Basin. The first focuses on the preservation of the basin's natural heritage, genetic resources, and tourism income in national parks and faunal reserves (Table 3.1). The second addresses activities that combine household food security, food production, and income generation — in short, economic development — with natural resource conservation (Table 3.2). Together, they form the two-pronged approach to fight degradation of the environment.

The proposed Action Plan shall aim to establish management activities that will protect the basin's natural capital (soils, water, and plant and animal life) in order to sustain equitably the needs of the rural and urban populace. In other words, for the Action Plan to be successful, it must promote the following projects and policies:

—prevent erosion of existing soils, stop erosion, improve soil fertility, infiltration, and water-holding capacity;

—improve water conservation, promote equitable water use, and prevent degradation of water quality;

—maintain vegetative cover, improve nutritive value of pasturelands, restore denuded landscapes, balance regeneration of wood biomass with offtake, create a sustained yield management for hardwoods;

—maintain or improve the protection and maintenance of biodiversity, collect and test cultivars for farmers and agroforestry; preserve unique ecosystems and species of special concern;

—reorganize human energies (productivity enhancement) so that individuals and/or communities have more time and income to participate in natural resource management activities;

—reorganize government and international assistance to assign high priority to the long-term conservation of natural resources in development projects.

When possible, we indicate which human activities and projects encourage the maintenance, rehabilitation, and restoration or the destruction and degradation of renewable natural resources. Certain activities, intentionally or unintentionally, act as <u>incentives</u> to protect and maintain natural resources, <u>disincentives,</u> which deter, warn, dissuade, or frighten citizens from destroying resources, or <u>perverse incentives,</u> which encourage destruction of natural resources.

Incentives, disincentives or perverse incentives exist at all levels as presidential edicts or national policies, regional water developments, international agreements, food-for-work programs, and basinwide conventions and through the presence of customs agents, forestry agents, police, and religious leadership. The team did not review all the legislation and administrative structures influencing natural resource access and use. Annex C lists projects and sponsors encountered in our three-week survey. A more complete review of projects, sponsors, laws, etc. and their importance to natural resources should be part of the Action Plan.

In Part 3, we articulate principles and values required for an effective Action Plan as well as specific tasks that should be further investigated for design and funding. Over 50 tasks and policy needs are identified. They each receive a paragraph or two. A "checklist" of priority projects and policy dialogs is summarized at the end of the chapter in Tables 3.1, 3.2, 3.3, and 3.4 (at end of this section).

3.2 BOUNDARIES

From the hydrological point of view, the boundaries of the conventional basin are not realistic. The Borno, the Komadougu, the Logone, the Chari, the Batha, and the Bahr el Ghazal Basins all extend beyond the boundaries of the conventional basin. An extended basin (Figure 3.1) has been suggested by the Heads of State. This extension should be implemented immediately. The boundaries should follow watershed boundaries, not arbitrary lines (e.g., the proposed extended basin cuts the Batha at its headwaters.)

On the other hand, the Benue drainage is not part of the Lake Chad Basin and should not be included. The proposed project to divert Logone water to the Benue damage economic production in three major diagnostic basins, including Lake Chad. This proposal has been shelved. The Mayo Kebbi/Niger River boundary should be renegotiated. (Perhaps Lake Lere should be added.)

3.3 WATERSHED MANAGEMENT AND HUMAN COMMUNITIES

3.3.1 Values and Knowledge

Popular and governmental recognition of natural resource management problems (sensibilisation) is critical to the adoption of technical and organizational solutions. Donors, school teachers, religious leaders, universities, the media, government officials at all levels, and even consultants need increased awareness of the environmental impacts of their policies, ethics, and projects.

3.3.1.1 Water Resources

Rainfall and runoff in the conventional basin will always be unpredictable and patchy. One or two years does not make a trend. Mean rainfall or channel flow are unreliable as the basis for development projects. The "worst" case or series of wet or dry years will always be a surprise (Sections 1.3 and 2.1.2).

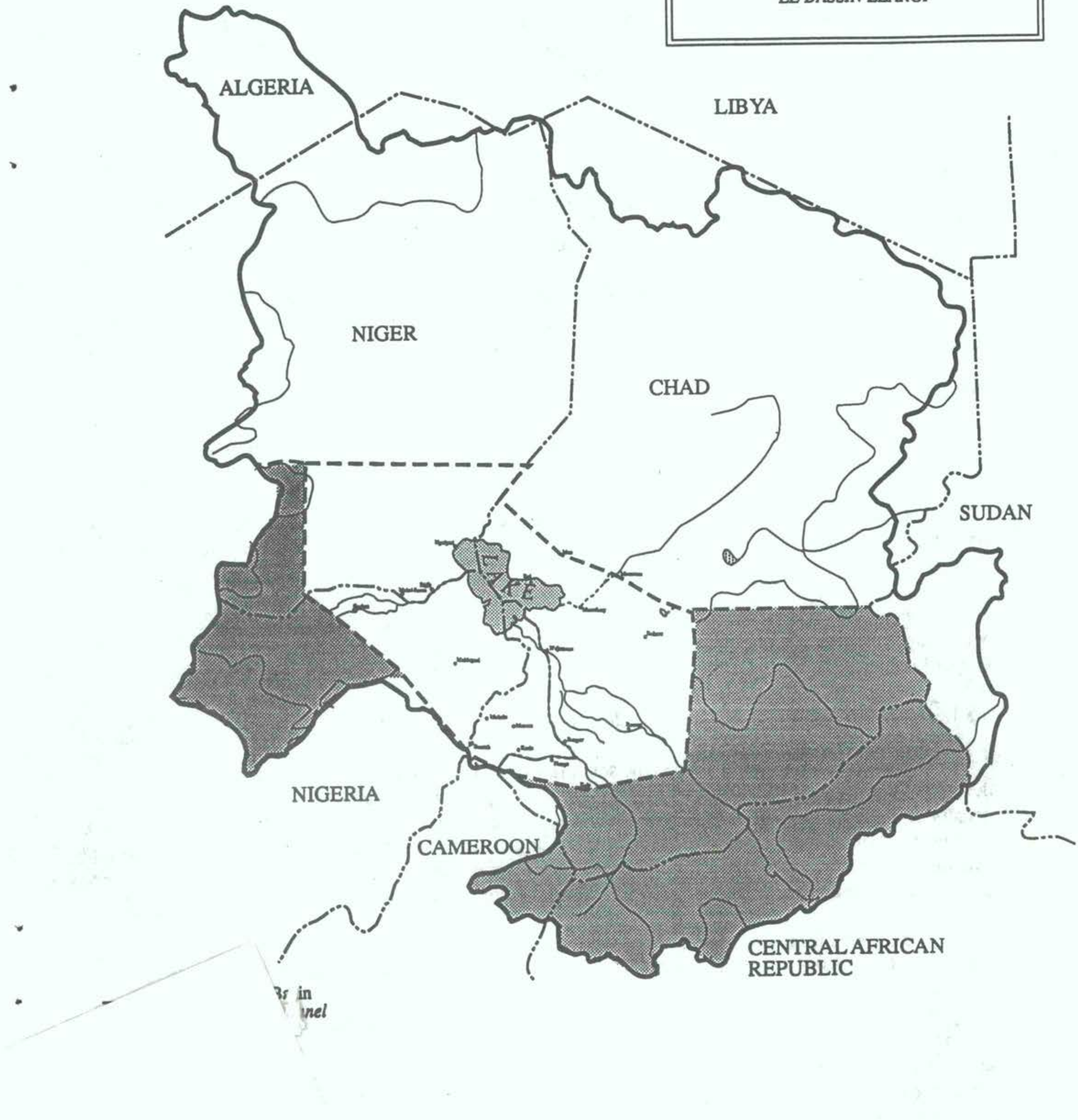
Water development policies and projects should not be fiats based on average years but should be flexible and tailored to type-years. This follows traditional adaptations to droughts and floods (Section 2.1.2).

The use of temperate zone "models" for water development is not applicable to the basin (Section 2.1.2).

Water allocation for crops subject to international price fluctuations should be considered a low priority. The "cotton crash" in Chad and the inability to sell Cameroonian rice illustrate how a capital-intensive project will not produce a stable, risk-avoidance economic base for a developing nation.

Figure 3.1
THE CONVENTIONAL AND
EXTENDED BASIN

LE BASSIN CONVENTIONNEL ET
LE BASSIN ELARGI



In the Chari, Logone, Borno, and Yobe diagnostic basins, the priority allocation of water for farmers should be floodwater and channel flow. Groundwater resources should be reserved for supplemental irrigation and emergency drought irrigation.

Upstream projects that deprive downstream farmers of floodwaters and channel flow will lead to social disputes, dislocations, and ultimately careless use of water and soil resources. Without secure downstream water allocations, upstream projects become perverse incentives.

3.3.1.2 Landforms and Soils

The type and severity of soil erosion are specific to each diagnostic basin. Global statements about the basin as a whole would be misleading. Even within each diagnostic basin, soil erosion problems may be very localized.

It is far cheaper to invest in preventative actions than it is to fund the remedies for land and soil degradation.

Management of land and soils is a decentralized process. It cannot be controlled by top-down policies (disincentives).

The management of land and soils is very localized. Soil types may change within tens of meters. Blanket soil and erosion-control policies may lead to discouraging failures.

The usefulness of soils changes according to rainfall type-year. Restricting farmers to small plots without considering soil needs by type-year may force a farmer into exploitive soil management.

There is widespread understanding and knowledge among farmers about proper soil management. There is great enthusiasm for projects that will help stabilize and improve soils. Proper funding and interventions on the local level are greatly appreciated, not resisted.

3.3.1.3 Animal-Based and Plant-Based Production Systems

International aid should focus on the small farmer rural economy — not large-scale developments. Even at its greatest potential, large-scale agriculture will employ only 4 percent of the farming population. Extension work, appropriate water conservation, fertilizer supplements, technologies, windbreaks, and browse and fruit tree nurseries, as well as new cultivars, require more support. Decentralized and widespread intervention offer a more effective and equitable combination of natural resources conservation and development.

Trained extension workers offering incentives are the most positive approach (incentive) in the Sahelo-Sudanian Zones for natural resources management (see Section 3.4).

Agricultural development has been isolated from "food self-sufficiency." For instance, in Cameroon, the international price of rice has dropped below national production costs. The national crop is without a market and is spoiling. In contrast to India, where the government can immediately purchase nonsalable grains for storage, the basin has no integrated famine prevention system.

Rangeland consultants should be encouraged to give up the idea that land has a single carrying capacity. All policies should accept and begin to work with type-year carrying capacities.

The major causes of rangeland degradation are social—not ecological. Settling pastoralists is not the best method to conserve pasturelands. In the Sahelian zones, mobility is crucial to livestock production.

Obligatory transhumant or obligatory sedentary livestock raising can be equally harmful to the environment. Again, in particular type-years it is important for a herder to move. In others, remaining may be the best grazing policy. Flexibility, choice of moving or staying, and a drought-adapted marketing system should be part of any new action plan within the basin.

3.3.2 RESEARCH AND MONITORING

3.3.2.1 Water Resource Research Monitoring

GROUNDWATER

The most important geohydrology research task within the conventional basin is achieving a better understanding of groundwater of the Chad Formation. Current overexploitation of groundwater needs to be identified and natural recharge areas need to be identified and protected.

More knowledge of the yields and areal extent of the deep aquifers is necessary, especially for drought-year urban supply. Simulation modelling may be needed for particular aquifers or basins.

Areas where groundwater quality limits irrigation agriculture need to be defined.

Piezometric networks need to be established for groundwater monitoring (level and head fluctuations). The computerized groundwater data system of ONHPV (Chad) needs to be extended throughout the conventional basin.

SURFACE WATER

The most important research task is defining water type-years for rainfall, channel flow, lake levels, and flooding. Research should include combinations of these hydro-indices if appropriate (e.g., Lake Chad may need all four). See Sections 2.1.2 and 3.3.2.2.

Type-year application to major diagnostic basins should be part of this research effort.

The highest priority hydrological index is for flood plain management in the Chari and Logone Diagnostic Basins. Flood height, duration, and areal extent are crucial to fishery management, especially recruitment levels of lake-to-river migrants.

A long-term research project should create an early warning system of anticipated floods and lake levels for the basin, perhaps relying on CAR rain gauges and remote sensing, using AGRHYMET's existing data. This early warning system would ultimately be the best management tool for the basin's fisheries, pastoralism, recession agriculture, transport, phreatic zone recharge, and forest growth resources in the southern diagnostic basins.

The system of rain gauges, coordination of rain data, and other weather variables needs basinwide review.

River gauge stations need review with the possibility of new gauges and better reporting of data, including the Chari and Logone headwater tributaries in the CAR. Lake Chad itself needs a larger series of monitoring stations to capture the dynamics of the two pool system, groundwater levels and movements, mid-lake rainfall, and evaporation rates.

A hydrological data bank and review of all sources of channel flow records are needed. The ultimate goal is a basinwide unified monitoring system for storage, discharge, solid transport, and water quality.

Legal research for codes and legislation is needed by the LCBC, which, at present, is ineffective in resolving water rights disputes.

3.3.2.2 Landform and Soils Research and Monitoring

The highest priority research is development of a comparative "watershed program" modelled after the USDA's Soil Conservation Service Program. The program would monitor and study protected vs. human-occupied watersheds for hillslope, channel, and eolian erosion and deposition. Susceptibility of various soil types to sheetwash, wind erosion, or gullying require site-specific information, which this program would provide. In addition, accelerated erosion vs. natural erosion could be compared by hydrometeorological type-year. Finally, the speed of fertility and tilth regeneration could be compared. We consider this a high priority and suggest that Mozogo National Park serve as one watershed area because of its intact vegetation and soils. Gambia has begun a similar watershed program with SCS.

The watershed monitoring and research program can be integrated with university programs (e.g., Universities of Maiduguri, Chad, and Naimey) and, most important, with extension training centers.

A research project on how fertilizer and special nutrient additions can revive run-down soils is needed. When wrongly applied, fertilizers can cause crop damage and "burn" soils rather than increase yields.

Dune reactivation has been studied around villages and rangelands. But the question of stabilizing vs. dispersing dunes has not been addressed.

A map of soil erosion, type, and severity does not exist for the basin. Nigerian reconnaissance maps need the most updating; the authors could not find a soils map of equivalent detail as those available for Cameroon, Chad, and Niger. This may be one reason for the inequitable distribution of land in the SCIP project.

No research on channel-form degradation or aggradation is known. No monitoring program on the impacts of dam storage and flood control diking on channel form are known. The authors could not find quantitative reports on erosion for the Mandara Mountain area.

There was no indication if, or how much, devegetation had accelerated channel or hillslope erosional processes.

3.3.2.3 Plant-Based and Animal-Based Systems

The resurrection of the fishery monitoring effort is the highest research priority. Since the Chadian war, there have been no surveys of fish production, fishery effort, marketing, species, size, location, and type-years. There is a crucial need to update the ORSTOM work and set policies for fishery management. Since the last surveys, the driest year of record for the yaeres fishery occurred, as well as the lowest lake levels. The monitoring of sales is a multinational project. Present yield estimates do not include the rivers that have been the major areas of fishing.

The second highest research priority is a project plan that analyzes the responses of different sectors of the economy during water-type years (e.g., Figure 2.3). Type-years shape the economics of the basin and, in certain years, cause normally independent sectors (fisheries and nomads) to strongly overlap. The ultimate goal is to plan projects and policies around a deeper understanding of type-year economics.

Long-term collaborative research to involve the rural population with new cultivars, new forms of village territory management, pasture use and water development, fishery cooperatives, and sustained yield management, etc., are needed more than ever. Fund these monitoring and research components as part of all rural development projects.

Long-term natural resource management will not occur without further research on land and water rights, juridicial duties and appeal procedures, and limits and liberties allowed officials, farmers, technicians, and other participants. The research goal would be a dialogue with LCBC member nations to encourage changing legislation, codes, and legal framework to encourage natural resources management.

There is no map of the areas of devegetation from all sources. Low altitude remote sensing might help remedy this situation. There is no vegetation map on a scale of 1: 500,000 for Cameroon, Niger, or Nigeria.

All drought-adapted and floodwater cultivars need to be collected and conserved. The genetic basis of crop production adapted to hydrometeorological type years is being lost. The basin nations do not have their own seed bank or in-situ culture program.

3.3.3 PROJECTS

The central lesson of development in West Africa over the last twenty years is simply that there are no quick fixes to natural resources degradation and maintenance. It is impossible to predict at what rate technology transfer, appropriate training, and implementation of good natural resource management will occur. The desire for quick results can be ultimately more damaging to natural resources management than no project at all. Patience, especially when new institutions and new webs of authority need to be created, is a necessity. Donors, citizenry, and national governments must think of "long-term" commitment in collaborations. "Long-term" may be from ten to fifteen years.

Another central lesson of the Sahel is that sectoral or single-purpose projects tend to fail or produce undesirable results. Projects need to be multipurpose and "packaged". Short-term benefits need to be balanced with long-term benefits. Organization of user groups (such as pastoralist groups) needs to be coupled with changes in local and national administration or legal codes. Labor sacrifices to ensure proper natural resource management, such as tree planting or conservation diking, require actions to insure tree tenure or land tenure. New cropping patterns require new extension training and marketing abilities. The highest priority projects for the basin are these "multiple-use" projects (Christophersen et al., 1989).

In general, the authors argue against funding further overviews. Too much information is recycled. The most difficult tasks are to avoid repeating descriptions that appear in numerous previous studies and to focus instead on the actual problems of environmental degradation. Future reports, it is hoped, will be specific to a diagnostic basin and its agr-, sylv-, pastoral, and fishing economic systems.

3.3.3.1 Water Resources Projects

Contrary to most "action plans," this diagnostic report recommends against any large-scale waterworks projects in the near future. We feel that a reassessment of existing projects and their impacts on the environment and economics is necessary (e.g., how much production and labor has been lost from reservoirs and downstream water loss). Project funding should go into this reassessment and restructuring before any new waterworks are designed. The major new priorities are the economics of downstream and floodplain users and the need to protect wetlands and flood plains as "multiple-use" areas for pasture and forestry reserves, fisheries, recession agriculture, and biological diversity.

In addition, water development projects with large recurrent costs have not increased employment nor proved economically viable in the conventional basin. Poor project design, high pumping costs, recurrent costs for ditch clearing, monocropping, pesticide and fertilizer subsidies, mechanical plowing and harvesting, maintenance costs in dry years when little or no income was generated, and unforeseen soil erosion problems have all turned "dreams" into marginal operations.

SURFACE WATER PROJECTS

1. Review and redesign all proposed and existing projects by water type-years and lake level type-years. What is a good policy in a wet year may be disastrous in a dry year or a series of dry years.

Use the water type-year to <u>limit diversions and seasons of diversions</u> of the perennial and seasonal rivers in the Lake Chad, Chari, Logone, Mayo Kebbi, Borno, Yedseram and Komadougu-Yobe Diagnostic Basins. Write release management schedules according to type-year for all storage dams.

Use the water type-years to establish month-by-month <u>guaranteed instream flows</u> in the Chari and Logone Diagnostic Basins to protect downstream pastoralists, recessional and phreatic zone dependent farmers, fisheries, and polders dependent on lake level. Apply the same or similar set of water type-years to the Komadugu Yobe Diagnostic Basin.

Use water priorities as the basis for judging project proposals. Livestock and fisheries require the highest priority because they produce foods for a large sector ot the population (e.g., Logone, Chari, Mayo Kebbi, Yobe, Borno). Safe drinking water is a high priority for human and livestock health.

Export crops such as cotton are lower priorities because of fluctuating market prices, high recurrent costs, and low labor requirement. Similarly, water allocations for the expansion of irrigated rice cultivation should be reconsidered. On the other hand, the integration of food storage and famine prevention with irrigated crops is of the highest priority.

The need to discuss of "water type-year" lake levels and their economic utility is more pressing than the desire to define an "optimal" Lake Chad (see research priorities).

Postpone initiation of any new large-scale dams or irrigation projects in the Chari, Logone, and Borno Diagnostic Basins until water type-years, flooding (height, duration, and areal extent), supplemental irrigation, market pricing, downstream, and recharge impacts are understood. Take into account the possible impact on "high use" priorities when any small-scale irrigation diversions (eg., SEMRY III) are considered.

2. Maintaining a year-round flow from controlled reservoir releases is a lower priority than creating the appropriate flood peak required for recession agriculture, fishery production, and pasture grass and tree growth.

CHARI/LOGONE SURFACE WATER PROJECTS

In future action plans that include waterworks proposals, assign the lowest priority to the use of the Chari and Logone Rivers for hydropower or navigation. Assign the highest priority to use of the Chari and Logone Rivers for "natural" irrigation of grazing lands, fish production, recession agriculture (rice and berebere), and forest growth.

3. Assess the economic impacts before any further dam or diversion project is designed that involves the whole southern lake shore (El Beid, Serbewel, backing up of the southern pool onto the yaeres, etc.) The 1,500 m^3/s flood at Bongor required for floodwaters to reach the El Beid drainage is purely speculative. Clearly delineate the economic consequences of lowering and shortening the flood peak. Global broadbrush studies (e.g., UNDP, 1979) do not address these questions, especially the consequences of different water type-years and their indirect impacts on production processes such as fish breeding.

The current computer models for the Chari and Logone Rivers are inadequate because they do not include flood area, depth and duration for the Yaeres, Ba Illi, Tandjille, Serbewel and El Beid Rivers. These are the crucial production areas for fish and livestock as well as recession rice and sorghum production. Revise the proposed computer model project to incorporate flood plain variables and economic consequences of various types of flood. The Mayos River without the Maga Dam or with a Maga Dam by-pass might be added to the model.

OTHER SURFACE WATER PROJECTS

4. The downstream Komadougu-Yobe River farmers and fishers have suffered both from the drought and from upstream diversions outside the conventional basin. (See Sections 2.6 and 2.7.) No further diversions or storage dams are warranted until the needs of the downstream users have been considered. This is an international problem affecting not only Niger and Nigerian citizens but also the whole basin since the Yobe River feeds the northern pool of Lake Chad. The LCBC could act as a negotiator for downstream users of both nations.

5. The authors believe that efforts to export water from the basin should be eliminated. In addition, imports from Zaire to Lake Chad should not be attempted at this time. Even feasibility studies are premature. All consideration should be postponed until the relation of flood variables to the economics of the yaere and El Beid and Serbewel Rivers.

WATERWORKS DESIGN, EVALUATION, AND MODIFICATION

Design all waterworks to create a floodpulse for downstream users (Mayo Kebbi, Yobe, and Borno Diagnostic Basins).

Minimize surface areas of all reservoirs in order to reduce evaporative losses.

Hydropower design is a low priority within the basin (Chari and Logone Diagnostic Basins).

Shape reservoir pool area for maximum fishing and dry season grazing.

As noted, the highest priority project is a review of the existing waterworks in Borno, Chari, Logone, Yobe, and Mayo Kebbi Diagnostic Basins. The project should specifically look at design features that limit flexibility, especially amplitude and duration of a downstream floodpulse.

6. Maga Dam (Logone Diagnostic Basin) has caused extensive environmental degradation (Section 2.4). The Maga Dam design should be reviewed to allow a by-pass channel or aqueduct to increase flooding on the yaeres and into Waza National Park. This is a high priority.

7. An environmental impact assessment of flood control diking along the Chari and Logone Rivers on all flood-dependent production systems (including forestry, grazing, and fisheries) is a high priority for the Chari and Logone Diagnostic Basins.

8. Review the design of the Tiga Dam (Kano State in Nigeria) release structure and other upstream release structures. The goal of the review project should be to redesign the dam structure and/or release scheduling to allow a large enough floodpulse to pass Gashua and supply water allocated to downstream users.

9. Water harvesting techniques are needed, especially in the Yobe and Northern diagnostic basins.

10. Small-scale irrigation from wells need support in Borno, Yobe, and Chari Diagnostic Basins and the Kanem wadis.

EARLY WARNING SYSTEM

11. Include the water type-year as part of an early warning system for the Chari and Logone Rivers based on gauges in the CAR or other headwaters. The purpose of the early warning systems would be to forecast from upstream rain and/or river gauges the arrival of floods, their height, and their duration. The early warning system would be a major economic and labor-saving benefit to recessional farmers.

GROUNDWATER RESOURCES

12. A combined research and development project for drinking water in urban areas is a high priority. Supply is presently erratic. Supply drinking water by groundwater if possible in order to reduce health risks and recurrent costs of treatment.

13. An important planning project is the definition of active management areas for groundwater basins threatened by overexploitation. The Groundwater Active Management Areas in Arizona and California (both areas rely on fossil groundwater) might serve as a model. The goal of this planning project would be a sustained yield pumping schedule to balance extraction and recharge. The Borno Diagnostic Basin may face the most severe problems.

14. Another high priority research and planning project is mapping downstream areas recharged by channel and surface flooding in the Chari, Logone, Yedseram, Borno, and Yobe Diagnostic Basins. Areas where surface water storage and diversions conflict with groundwater recharge should be delineated. The ultimate goal is conjunctive use management.

WATER QUALITY

At this point, no severe water quality problems have been defined. The impact of water quality of the El Beid River on SCIP irrigation needs careful attention. The possible pollution from major cities needs monitoring. The use of toxic pesticides that find their way to drinking water may be a localized problem. Irrigation with saline or highly mineralized water in the Lake Chad, Northern, Yobe, and Borno Diagnostic Basins also should be reviewed on a project-by-project basis.

3.3.3.2 Landforms and Soils

EROSION

15. Sand sheeting is the highest priority. In the northern diagnostic basins, sand sheeting is a common problem. All techniques to reduce wind speed and eolian transport are helpful. But which ones are most cost-efficient, socially acceptable, and effective are not known. Nor are these techniques being monitored, except anecdotally (see "experimental watershed" recommendation).

Similarly, in the Borno, Yobe, and Logone Diagnostic Basins, the filling of depressions with mobile sand has hurt food production levels. Include an erosion control feature in all development projects in these diagnostic basins, with special attention to fadama and faya areas.

16. The hardé soils (alkaline clays and clay loams) in the Logone, Mayo Kebbi, Mandara Mountain, and Chari Diagnostic Basins require special attention in all conservation or development projects. These degraded soils are difficult to rehabilitate. Experimental rehabilitation projects, especially near Ndjamena, are a high priority.

17. A review of hydrological and erosion problems of large-scale irrigation projects is a high priority (Chari, Logone, Borno, and Yobe Diagnostic Basins). Ditches at SCIP as well as wind erosion on land cleared for mechanical agriculture require erosion control interventions.

ROADS AND TRANSPORT

18. The roads from Maiduguri to Diffa/Damasak and the road from Chad through Cameroon to Nigeria are not surfaced. The unpaved roads are a major cause of wind and dust erosion as well as vegetative destruction when vehicles go off the road to find alternate tracks. Paving of these roads with proper drainage is an important goal. The project includes the Chari, Logone, Yobe, and Borno Diagnostic Basins.

19. The Northern Diagnostic Basin needs secondary roads to facilitate livestock offtake and reduce trekking erosion.

3.3.3.3 Plant-Based and Animal-Based Production Systems

FISHERY

20. The Chari and Logone Rivers' fishery resource is being wasted; up to 50 percent of the catch may be lost due to spoilage. In addition, to prevent spoilage, trees are cut for smoking fish. Smoking is a major "industrial" source of deforestation. The creation of a crushed ice and/or refrigerated transport cooperative should be reconsidered in terms of both economic and environmental damage averted. Even subsidized, this transport and storage would increase food self-sufficiency, reduce sickness, increase both wood and fish resource efficiency, create jobs, and perhaps fetch higher prices for the iced fish. The alternative salting program has a poor reputation because of oversalting in the past. But, the salting program may be revived with careful training and control.

As indicated above, the Lake Chad computer model should incorporate flood variables. These need to be related to fish survival, reproduction, species composition, weight gain, phytoplankton production, and location of nurseries.

LIVESTOCK

21. Of all sectoral projects, pastoralism requires the most elaborate "multipurpose" planning. Within the context of water type-year grazing policies (Section 2.1.2), design the action plan to promote protection and tenure rights of dry-year grazing preserves, the opening

and closing of wells or fencing, and subsidized pricing for quick offtake in bad years. The off-take "subsidy" is really an expenditure to prevent overgrazing. Without quick offtake, there will be future costs in rangeland rehabilitation (a low priority among national governments). Rangeland rehabilitation costs are always greater than the cost of preventing overgrazing. The Chari, Logone, Borno, Yobe, Northern and Lake Fitri diagnostic basins need the most attention.

In livestock degradation projects, address eolian erosion at boreholes and wells, market places, granaries, village-based farms in dune areas, trekking routes, and border crossings. In the southern diagnostic basins, crowding of agricultural users and livestock as well as "refugee" herders from civil strife will require a "conflict resolution" feature in all projects.

Provide as an incentive within some projects the use of supplemental irrigation to increase pasture production. Strategically placed within project design, irrigated pastures might help both the environment and the livestock by reducing walking, reducing interaction of herds, and automatically creating browse reserves.

In areas where reservoirs and irrigated perimeters have replaced by or conflict with grazing, the waterworks project needs to supply some of its water for irrigated pasture.

In other projects, agricultural return flows can be used for for irrigation in order to increas browse production and reshrubbing.

Another project "incentive" is coordinated entrance of livestock into agricultural fields. (Entrance into fields returns manure to fields while providing feed to the livestock).

Integrate calf and cow fattening with irrigation areas as another economic incentive.

22. There is a great need to increase the number of browse plants in nurseries and develop an action plan for planting (e.g., one *Acacia albida* per kilometer in appropriate soils). In exchange for "incentives," pastoralist user groups can plant and care for these perennials.

As indicated above, the Chari and Logone Rivrs computer model should incorporate flood variables with floodplain grass species, natural recharge of water table, growth of browse species, and water type-year productivity of the yaeres.

23. In the project design stage, a review of distances between natural and human-made watering points, productive biomass by water type-years, and borehole-closing is needed. Borehole-locking would occur only in water type-years that require lower stocking rates.

Because boreholes and wells tend to increase overgrazing in surrounding areas, they should be avoided if possible. Watering tanks (ponds) that fill with rains but seasonally dry out are preferred. In areas where tanks are impossible to construct, locked wells should be considered, although enforcement problems appear insurmountable without strong pastoralist association commitment.

24. Livestock health problems are severe in the Yobe, Northern, and Lake Chad basins. Tse-tse fly eradication and movement south has opened up permanent pastures to some groups. Support to CRA and the creation of pastoralist user groups is a high priority.

AGROFORESTRY

25. Part 2 shows that major deforestation in the Sahelo-Sudanian and the Sudanian Zones can be traced as much to urban demand and large-scale water projects as to drought. Large-scale irrigation and reservoir projects do not allow for regeneration. Cleared and flooded land is permanently removed from forest production. In the reforestation action plan, place major emphasis on urban usage and obligatory mitigation measures for all large-scale projects that permanently remove land from forest production. In urban areas, fuelwood substitutes, especially petroleum products in Nigeria, are necessary to lower the cutting pressure on forests. The Maiduguri gas pipeline should be reviewed in terms of fuelwood savings. An action plan for fuelwood substitution needs to be made—including standardizing appliances, assuring constant supply, and education and extension in new cooking methods. In all large-scale projects, some land and water should be set aside for tree irrigation and plantations.

26. Major users of fuelwood in the "industrial" sector include brickmakers, bakeries, and fish smokers. The World Bank appears interested in investigating fuel substitution or efficiency for these production systems. Fuel substitution is a high priority and will slow deforestation.

27. Windbreaks to slow or prevent eolian erosion are needed in areas with alkaline soils and large-scale agricultural clearing. The Borno and Lake Fitri Diagnostic Basins have particularly severe problems.

28. Reforestation is needed everywhere. During the survey, representatives of Borno, Northern, Logone, Mandara, Mayo Kebbi, and Chari diagnostic basins all expressed the need for more nurseries. With tree tenure, multipurpose trees for fruit, fuelwood, browse, construction, and medicine) become a form of savings, assets, and security for rural people.

29. An immediate project for hardwood plantations and regeneration is needed throughout the basin. *Borassus* palm protection and nursery growth is a high priority in the Chari, Logone, and Mayo Kebbi Diagnostic Basins.

AGRICULTURE

The destiny of most farmers (over 95 percent) is not tied to irrigated agriculture. The highest priority to counter environmental degradation is to reach this group of citizens. Shift donor and government funding to this clientele.

30. Soil conservation measures have been tried, tested, and proven in other Sahelian nations. They include contour and tied ridges, living hedges to define property lines, legume seedlings from nurseries, dune stabilization, intercropping, fertilizer applications to speed vegetative cover, etc. Information exchange and projects that take farmers to successful projects in other parts of the basin or other nations have proved very successful (Shaikh et al., 1988).

31. Many farmers desire to diversify agricultural crops, including fruit trees. The diversification of crops would lead to greater plant cover and, if legumes are included, in-

creased fertility. All rural development projects should help with nurseries and extension (Chari, Logone, Manadara, Mayo Kebbi, Yobe, and Borno Diagnostic Basins).

32. Large-scale waterworks have not included soil protection practices within their development design. Soil erosion is already evident in projects such as SCIP, and no windbreaks to minimize eolian erosion, improve water conservation and crop productivity are visible. Fund conservation measures in all parastatal projects.

As stated above, to maintain soil fertility, reduce the importance of cotton in crop rotations (Chari, Logone, and Mayo Kebbi Diagnostic Basins) in parastatal projects.

BIOLOGICAL DIVERSITY

33. An international "peace" park between Cameroon, Chad, and Nigeria is the highest priority. The parks in each nation (currently, Mandelia, Dougia, Waza, Kalamaloue, and Chuigurma) should have partially protected corridors between them to allow elephant and other large mammal movement. The international national park system would allow "habitat islands" to be linked up (the habitat archipelago concept) into a more effective overall protection system. It would act as a safety sanctuary in times of drought. The IUCN committee on elephants should be consulted for this project. The project would also create a tourist complex for the three nations involved.

34. Finance the conservation and development needs of Waza National Park (Section 2.4). Review Mandelia Game Reserve for boundaries and protection.

35. Fund and immediately protect the habitat of the black rhinoceros population. Fund a black-crowned crane survey.

36. The Sambissa swamp area is simultaneously proposed for protection and drainage by CBDA. There appears to be no communication between ministries. A high priority project is the reconciliation of the goals of these two ministries.

37. Search for possibly lost cultivars in the Chari/Logone diagnostic basin from flood-diking and other diversions and along the Komadougu Yobe from upstream dams should be funded. These cultivars are considered genetically unique and may be of great interest to future cultivar development. In addition, new date cultivars in Yobe and Northern Diagnostic Basins are greatly desired.

3.4 INSTITUTIONS AND ENVIRONMENTAL MANAGEMENT

Almost all policies and institutions required to prevent environmental degradation and encourage a development-with-conservation approach are similar throughout the basin. They will be addressed as "national" issues because the LCBC has no power over any national government to change its institutions or policies.

The team did not investigate the administrative structure of participating countries in detail. No specific recommendations for the action plan on a nation-by-nation basis have been included.

3.4.1 National Administrations and Environmental Management

38. All national governments within the basin must set impeccable examples of proper natural resources management for local administrators and citizens to follow. As the highest priority, revise the operations of the parastatals and make them examples of good natural resources management (Cameroon, Chad, and Nigeria).

39. The national governments can shape natural resources management within their boundaries by directing financing. As a high priority, invest in rural areas vs. urban areas to keep down the economically difficult provision of urban infrastructure. Investment can be directed towards sustainable natural resources management practices.

40. All participating nations have fragmented administration of natural resources management policies. The ministries are sectoral and rarely communicate. Seek donor funding for each nation to set up an interministerial review board, especially between agriculture, rural development, water development, forestry, wildlife, fishery, livestock and tourism departments. Each minister should be able to review and comment on other ministries' projects.

41. Cameroon, Chad, and Nigeria lacked coordination between ministries and administration of funding for a project to coordinate famine prevention, public works, water type-year economic and social scenarios, and labor mobility. These activities are a high priority. Dry-year public works projects should have a conservation component (e.g., reforestation, nurseries or road construction in eroded areas.) Action plans should contain features designed to relieve stress on environmentally vulnerable areas.

Each ministry needs to adopt and to understand the use of water type-years as the basis for planning projects and project design.

ENVIRONMENTAL EDUCATION

42. Fund and provide technical expertise to help all the Ministries of Education with a program of environmental education. An awareness of a) historical natural resources of the basin, including both flora and fauna; b) environmental problems; c) traditional mechanisms of coping with drought and environmental degradation; and d) knowledge of what can and must be done should be brought home to students at every academic level. Models for such programs exist in Kenya and in Mali and in the proposals of UNSD and the Institute du Sahel.

National publicity (various ministries) is an informal education approach. High priorities include the diffusion of information on improved wood-burning stoves to women in both urban and rural areas. Successful prototypes can be found in Burkina Faso, Mali, Niger, and Senegal. Such programs must emphasize the savings in women's time and energy from using such stoves. Other priorities include a "multipurpose" program on mother/child nutrition, family planning, and birth control.

TRAINING PRIORITIES

Training and extension programs are the crux of national participation in natural resources management. Without them, local natural resources management is without national direction or participation. Virtually all examples of successful natural resources management strategies seen across the Sahel come through sustained, intensive local extension programs with charismatic leadership.

The ministries and educational system responsible for training and extension now appear to have the crucial role. Their role has been enlarged by recent events. They need new knowledge of soils, water, wildlife and vegetation management as well as increased sensitivity to the cultural, social, and organizational lives of the populations they serve. In many cases, extension workers will need to learn additional languages.

From a quantitative perspective the needs for proper resource management training in the basin are summarized in Table 3.5.

TABLE 3.5
RESOURCE MANAGEMENT TRAINING

Category of Agent	Desired Qualifications	Hectares/ per Agent	Functions
Forestry, Wildlife, Fisheries Engineer	Ph.D., M.S.	35,000	planning, evaluation supervision, training of trainers
Forestry, Wildlife, Fisheries Technician	B.S.	10,000	site supervision, extension, training
Technical Assistant	H.S. + 1 year	5,000	execution, extension
Guards, Nurserymen Guides	on-the-job	20,000	execution

Promote a new kind of professionalism among cadres throughout the conventional basin. The guiding ethics for extension workers should be the long-term goal of developing sustainable, secure livelihoods for the majority of rural people through improved resource management.

43. Reorganization of technical training schools and priorities for technical training are the highest national priorities. Included in these is a change in the criteria for career advancement. Salaries need to be highest for rural civil servants working on long-term commitments ("hardship pay"), not urban civil servants. Separate salaries from fine and permit revenues. Consider providing bonuses for those working in particularly difficult areas.

44. Training in conflict resolution as well as technical interventions is required. Sectoral training schools need a curricula that integrates natural resource management goals. Interdisciplinary projects (such as the University of Maiduguri Arid Lands program) need support. Projects supported by national funds should integrate farmers or pastoralists into monitoring and research programs under the direction of trained personnel. Feedback between farmers and research workers is especially important in agronomic research on drought-resistant cultivars or flood-tolerant cultivars.

SPECIFIC NATIONAL TASKS

45. Each nation's ministry concerned with hydrology and geohydrology needs to develop a plan to balance recharge with annual use in order to prevent long-term depletion and short-term dropping of groundwater tables.

3.4.2 National Legislation, Codes, and Policies

RESOURCE TENURE REFORM

Basinwide, the most important legal and policy issue concerns the reform of land and resource tenure legislation to encourage local groups to invest in and take a more active role in the management of natural resources. Reforms should be based on the principles of local territory and common property management, legally enforceable definitions of "public domain" vs. private and village domains, reconciliation of usufruct vs. customary rights, special regulations for sylvopastoral areas, and methods of long-term national leasing of sylvopastoral lands in exchange for obligatory management and reforestation.

The legitimization of user groups (pastoralist or village groups) is part of this need to create a strong legal foundation for land use tenure. A procedure for processing claims to traditionally held land requires careful thought and assistance from experts on both customary and national law.

Conflict resolution between traditional and national legal claims is the most crucial aspect of long-term sustainable development and conservation. All projects should have sociologists, legally-trained extension workers, anthropologists, and workers trained in consensus building.

A NATIONAL CONSERVATION STRATEGY

To some extent, the plans to stop desertification have created the framework for a national conservation strategy. The policy and implementation need to be extended beyond arid areas.

A high priority step is a conventionwide agreement to require an environmental and economic impact statement for all major national development and conservation projects. Environmental and economic impact reports give citizens displaced by either waterworks or national parks as well as downstream users of water opportunities to review the consequences of national projects.

CODES

The team did not review in detail the national codes on forestry, land clearing, fishery, wildlife hunting, and fire control. A high priority project is to review these codes with assistance from the international community. This is occurring in Mali, Senegal and other Sahelian nations. Goals would be to change the enforcers of these codes into extension agents, minimize disincentives, and increase incentives.

The forestry codes need updating to establish cutting limits by diagnostic basin and specific species, write appeal procedures for contested tree tenure, and replace financial fines with "reforestation fines."

Water rights, especially those of flood plain and downstream users, need clearer definition. Appeal procedures in order to establish case law are also required.

NATIONAL GOVERNMENTS AND THE BUSINESS COMMUNITY

The business community plays a special role in balancing short-term financial gains vs. long-term sustainability. With the nationalization of all land, commercial ventures can reap benefits without taking responsibility for what has been left behind. A policy dialogue on "extraction fees" for fish, pasture, and forest resources is needed.

3.4.3 International Cooperation and Environmental Management

Besides political stability and general goodwill, the international community has three major interests in the Lake Chad Basin: compliance with international conventions, maintenance of the flow of goods which rely on the basin's natural resources, and the provision of an educational, aesthetic, and pleasurable outlet for its citizens ("tourism"). The immediate international concerns involve the four LCBC nations, but through donors and international alliances many more nations are involved.

DONORS

Many rural producers wish to conserve their soils, plant life, and water resources but lack the financial capital, savings, or insurance. Donors can be instrumental in "priming the pump" with obligatory conditions for natural resource management.

As stated in Part 1, donors have just begun to incorporate conservation strategies into development assistance. Important priority gaps in funding include: environmental monitoring, environmental education, natural resources management training, conflict resolution, policy dialogues on decentralizing natural resources management and changing land tenure rules, and regional coordination of common natural resource problems.

Donors involved with land tenure issues need to join dialogue with national governments on decentralizing control over natural resources.

BIOLOGICAL DIVERSITY

Besides the international park proposed, there are five international agreements concerning the conservation of biological diversity and natural resources: the African Convention for the Conservation and Management of Wildlife and Its Habitat; the African Convention on the Conservation of Nature and Natural resources; the Convention Concerning Protection of the World's Cultural and Natural Heritage; RAMSAR (for protection of internationally important wetlands); and CITES (Appendix III), which prohibits trade in endangered species.

It is important that all Heads of State sign these conventions and agreements within the conventional basin. Signature should be a requirement of IUCN projects in three of the basins

(Lake Fitri, Lake Lere, Nduru wetlands, and Waza National Park). This is a high priority, especially for RAMSAR, which will help protect the important lakes and wetlands of the basin.

LAKE CHAD BASIN COMMISSION

The Lake Chad Basin Commission is the most relevant international organization because it defines the conventional basin. The actions of the LCBC have fallen short of the Commission's mandate. Evidence of the Commission's presence is virtually invisible in the conventional basin apart from some scattered infrastructure. If the Heads of State give it the appropriate powers, the LCBC's role may become more important as competition between member states for resources becomes more acute. If the member states wish it to fulfill its mandate so as to avoid armed confrontation over water and land disputes, then the LCBC will need to be invested with more power to resolve conflicts than it now possesses. The Heads of States need to review the 1970s proposal for LCBC regulation of water supply and use.

Extend the conventional basin immediately by the LCBC heads of state. Begin active participation by the CAR. Without the CAR, Chari/Logone diagnostic water planning is of little value.

The LCBC should not attempt project implementation within national boundaries for which it lacks staff, logistical support, and authorization. These activities drain resources from its central mission of basinwide (international) planning, monitoring, evaluation, and conflict resolution.

The LCBC needs, at least, one fulltime person assigned to conflict resolution, identifying international disputes, areas of legal ambiguity, and potential conflicts and who can act as an informal liaison for the four basin nations. Adopted water type-year policies and definition of groundwater basins will reduce conflicts as described above.

Communications networking is the highest priority for the LCBC. Fund the LCBC to complete the microwave link between Ndjamena, Maiduguri, Diffa, adding a post in Maroua, and lobbying for the completion of the highway across northern Cameroon. The latter might be given some suitable name such as the "International Solidarity Highway/Route de Solidarite Internationale."

The microwave should be used with appropriate LCBC departments to coordinate information on movement of agricultural pests, bovine diseases, human epidemics, harmattan or tornado winds, cattle prices and supply, food shortage risks, famine relief needs, etc. (Figure 3.2).

Within the LCBC livestock sector create background documents on all international crossings and watering areas required by pastoralists, begin negotiation of pasture reserves for these traditional users, acquire portable radio contact with these groups in order to provide information of pasture quality, help organize binational conventions of pasture usage, provide informal conflict resolution teams to help with international disputes, etc.

Reinvigorate the LCBC with financing to update its library or coordinate its library with other institutions so that it has easy access to information on natural resources within the basin.

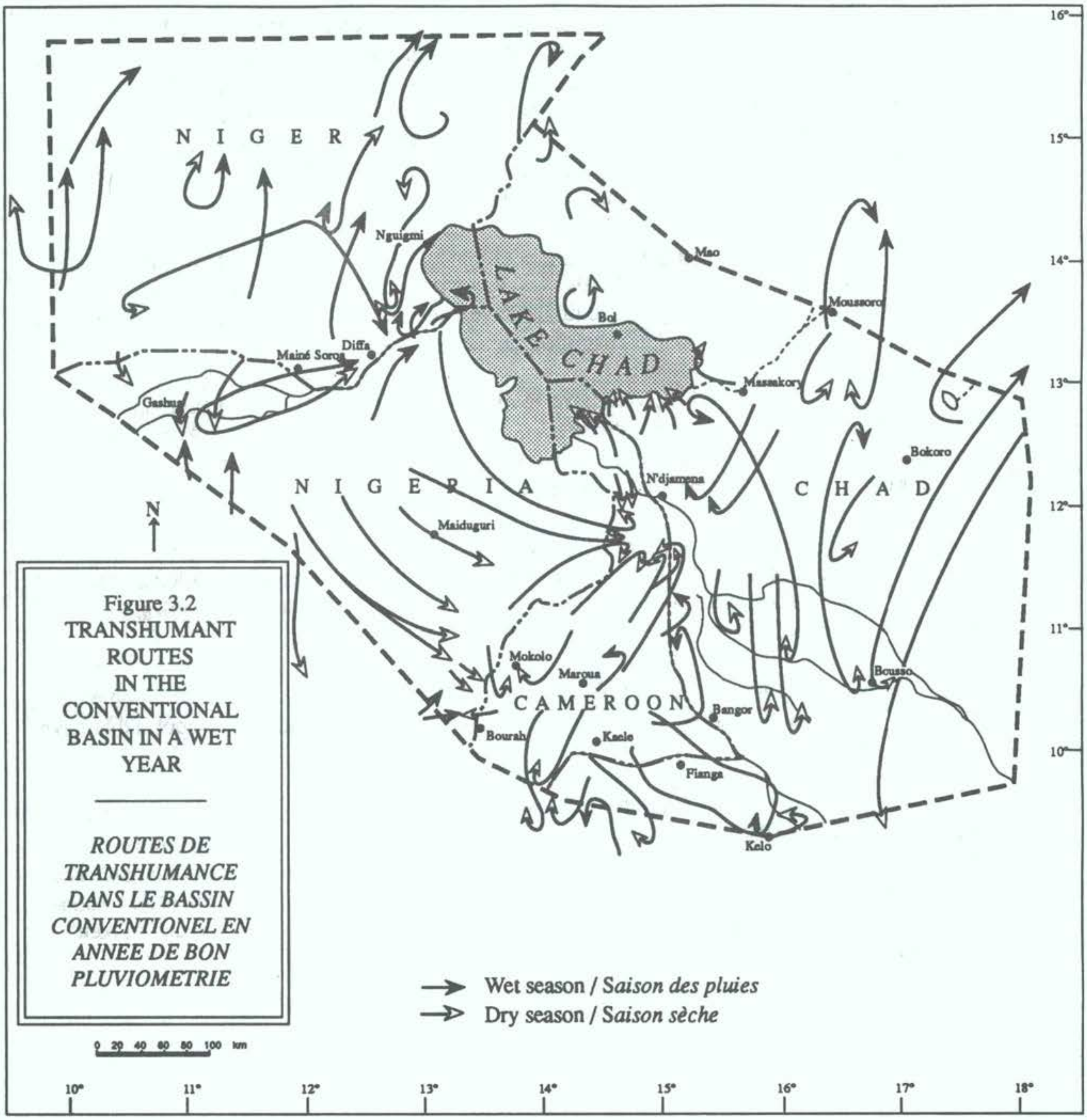


Figure 3.2
TRANSHUMANT ROUTES IN THE CONVENTIONAL BASIN IN A WET YEAR

ROUTES DE TRANSHUMANCE DANS LE BASSIN CONVENTIONEL EN ANNEE DE BON PLUVIOMETRIE

If the LCBC proves capable, it should become the depository for all hydrological monitoring described in earlier sections (e.g., lake level, groundwater, water quality, channel flow, rainfall, and atmospheric variables). The depository should include the whole basin, not just the conventional basin.

Continue funding the LCBC workshop projects and expand them to include major research organizations involved with natural resources management. These include: Institut de Recherche Agronomique, Maroua; Department of Geography, University of Yaounde, Yaounde; Centre de Recherche Appliquée, Ndjamena; Center for Arid Zone Studies, University of Maiduguri, Maiduguri; International Institute of Tropical Agriculture, Ibadan, Nigeria; Lake Chad Research Institute, Maiduguri; Institut Nigerien de Recherche Agronomique National, Niamey; ICRISAT Sahelian Center, Lamorde, Niger.

Environmental planning, monitoring, and assessment is the other high priority for the LCBC. Heads of State should give LCBC the right to perform environmental and economic impact assessments on any project that might have international consequences. This will avoid the self-promotional impact statements of organizations that want contracts.

The LCBC might be involved in the re-evaluations of large-scale irrigation and water storage projects described above with international (Lake Chad) implications. For instance, the Hadejia-Jama'are projects in the Komodougou Basin have significant impacts on the citizens of two nations and on the northern pool of Lake Chad.

The LCBC might review diagnostic basin or national plans for consistency with basinwide goals. If desired by the Heads of State, this could include the international parks and tourism for Cameroon, Chad, and Nigeria, as well as international fishery codes, to provide sustainable use of the rivers and lake resources.

The LCBC might be the central organization for monitoring changes in environmental degradation (e.g., soil erosion, loss of plant life, wildlife concerns, and water supply) that have basinwide implications.

In order to perform these tasks, the UNDP and other donors need to re-evaluate the LCBC and its capabilities. They will need to increase and retrain LCBC's staff, increase equipment, fund expatriate expertise, require performance sheets for further funding, etc. The projects that can be done more efficiently through direct binational aid should not the responsibility of the LCBC. Only those requiring international coordination should be undertaken under the auspices of the LCBC.

TABLE 3.1 RECOMMENDATIONS FOR THE PRESERVATION OF ECOSYSTEMS AND SPECIES DIVERSITY

Note: "*" means that the team felt the project was of the highest priority

Recommendations	Diagnostic Basins/Countriesß
*Internatinal "peace park" for Waza, Mandelia, Dougia, Dalamaloue, Chuigurma (see Part 3, No. 33).	Cameroon, Chad, Nigeria
*Fund conservation needs of Waza National Park (see Part 3, No. 34).	Logone
*Reconcile water rights for Sambissa swamp; continue funding of Nguru wetlands project (see Part 3, No. 36).	Borno
*Member states should sign CITES III, RAMSAR, the African Convention for the Conservation and Management of Wildlife and Its Habitat, the African Convention on the Conservation of Nature and Natural Resources, etc.	Cameroon, Chad, and Nigeria have not signed various agreements
Fund immediately habitat protection for the black rhinoceros (see Part 3, No. 35).	Chad, Nigeria (?)
Create Biosphere Reserve at Lake Fitri (seeSection 2.9).	Chad
Create Biosphere Reserve for Lake Lere.	Niger/Benue Basin
Protect crowned crane nesting areas (see Part 3, No. 35).	Lake Chad, Borno
Create sanctuary for water-dependent mammals (hippo, sitatunga, otter, etc.).	Lake Chad

TABLE 3.2 PARTIAL SUMMARY OF RECOMMENDED ACTIONS: PRIORITIES FOR CONSERVATION AND DEVELOPMENT

Note: "*" means that the team felt that the project was of highest priority

Recommendations	Diagnostic Basins/Countries
*Combine irrigated agriculture, food storage, and famine prevention programs.	All
*Reassess all large waterworks (dams, dikes, diversions), finance redesign of waterworks to accomodate downstream users, floodplain economics, and environmental protection (see Part 3, No. 6 (Maga Dam), No. 8 (Tiga Dam), No. 7 (Logone dikes), and No. 3 (Borno waterworks)).	Lake Chad, *Logone, *Mayo, *Chari, *Borno, *Yobe, El Beid, Serbewel, Yaeres
Write release management schedules by type-years for all storage dams (e.g., Tiga Dam); write quaranteed instream flow rules for all channels with significant dams, dikes, and diversions.	
*Combine development aid with conservation pracatices for small, rural farmers and pastoralists as long-term, multipurpose projects (see Part 3, No.s 21, 22, 23, and 24 for details of "pastoralist package" and No.s 27, 28, 30, and 31 for "agroforestry package"); incorporate water harvesting techniques in Yobe and Northern Diagnostic Basins; incorporate small-scale irrigations works in Borno, Yobe, Chari, El Beid, andKanem wadis.	All
*Fund and resurrect fisheries monitoring, cooperatives and fish spoilage control projects; work on fisheries regulations and trade rules.	Lake Chad, Chari, Longone, Serbewel, El Beid, Yobe
*Incorporate flood variables and fish management data into Lake Chad Basin computer model; include flood area, depth, and duration in computer model; establish hydrological indices for rainfall, channel flow, lake level, and floods for water type-year scenarios.	Chari, Logone, El Beid, Serbewel, Mayos
*Create active management areas for threatened basins with funding for monitoring, mapping recharge areas, establishing safe yields, and priority water rights.	Borno; groundwater re-charge areas: Chari, Logone, Yedseram, Yobe

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TABLE 3.2 PRIORITIES FOR CONSERVATION AND DEVELOPMENT *continued*

*Establish comparative watershed monitoring program to determine specific interventions for soil and vegetation rehabilitation actions; priorites: sand sheeting (fadama, faya areas), hardé soils.	Borno, Yobe, Logone, Mayo, Mandara Mts., Chari
*Review all large-scale agricultural projects; redesign management to incorporate grazing, water for tree regeneration, soil erosion control, windbreaks, and water conservation; revise operations for dry-year scenarios.	Chari, Logone, Borno, Lake Chad, Upper Komadougu
*Fund and provide technical expertise to Ministries of Education for a program in environmental education; include national publicity and diffusion of information.	All
*Reorganize technical schools, curricula, extension training, and salary schedules within Ministries to encourage rural, long-term natural resource extension work (see Part 3, No.s 43 and 44).	All
*Add browse species, native legumes, and fruit trees to nurseries; reforest windbreaks, shelterbelts, living fences, and gum arabic.	All
*Hardwood (Borassus palm) nurseries and regeneration project.	Chari, Logone, Mayo
Find and collect cultivars (especially floodplain cultivars) threatened with extinction.	*Yobe, Lake Chad, Logone, Chari, Mandara Mts.
Review groundwater quality and agricultural and human consumptive uses.	Borno
Establish a hydrological data bank.	All
Review urban water systems for water quality, reliability, and conservation action.	All
Study economic dislocation and competition within basin by water type-year scenarios.	All
Long-term project: Early Warning System.	Chari, Logone
Road paving to reduce erosion.	Cameroon, Chad, Nigeria Northern
Prefeasibility study for El Beid cross-canal.	Logone
Combine monitoring with remote sensing.	All

TABLE 3.3 POLICY RECOMMENDATIONS

Note: "*" means that the team felt that these policy issues were the highest priorities

Recommendations	Diagnostic Basins/Countries
Water Resources	
*Design and evaluate water resource projects by "water type-years" (Section 2.1.2).	All
*Give highest water allocation priority to floodplain economic activities (fisheries, pasture production, recesion agriculture, and forest regeneration); and groundwater recharge (see Part 3, No.s 3 - 10 and 20; Section 3.3.1.1); maintain or mimic floodpulse by schedules releases or free-flowing river.	Chari, *Logone, Mayos, *Borno, *Yobe, Fitri
Other priorities include supplemental and small-scale irrigation; use basinwide water priorities to judge project proposals; give lowest priority to navigation, hydropower, export crops, and year-round flow.	
*Change emphasis from new large water projects to redesign of existing waterworks and small-scale rurual d3evelopment; avoid projects with large recurrent costs; maximize labor-intensive projects and economic benefits of floodpulse.	Logone, Chari, Mayos, Yobe, Borno, Lake chad
If possible, reserve groundwater for dry type-years.	All
Implement legal codes to resolve water rights disputes and limit diversions from Lake Chad tributaries by type-years; secure downstream, polder, and floodplain water rights.	Logone, Yobe, Borno, Chari, Lake Chad
Human Resources	
*Give priority to long-term, "packaged" or multipurpose projects that combine sectors, secure land rights, and combine conservation of soils and water with economic development.	All
*Focus international aid on small, rural farmers.	All
*Give priority funding to training and extension workers in natural resources management.	All

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TABLE 3.3 POLICY RECOMMENDATIONS *continued*

*Start a policy dialog on reform and land resource tenure legislation to encourage local groups to invest in and take responsibility for natural resource management; legitimize user groups and provide conflict resolution between customary and national claims on resources.	All
Seek donor funding to bring ministries together in a review board of large national projects that impact many natural resources and producer gorups (see Part 3, No.s 40 and 41).	All
Work on national conservation strategies for each nation; review national strategies for conflicts between basin states.	All
<u>Ecological Resources</u>	
*Revise operationsof parastatals and make them impeccable examples of good natural resource management.	Cameroon, Chad, Nigeria
*Revise national codes on forestry, land clearing, fishery, land and tree tenure, user groups rights, grazing land regulations, wildlife, and fire with donor aid and expertise; hold basinwide workshops.	All
*Require donors and governments to incorporate conservation strategies in all development projects, including environmental and socioeconomic impact statements.	All
Start a policy dialog on extraction fees and environmental protection with the private business community.	All

TABLE 3.4 SUMMARY OF CONSERVATION AND DEVELOPMENT PROJECTS FOR THE LAKE CHAD BASIN COMMISSION

Note: "*" means that the team felt that these projects were of highest priority

Recommendations	Authority
*Extend Conventional Basin boundaries.	Heads of State
*Fund new position for conflict resolution and definition of basinwide potential sources of conflict.	Heads of State
*Make communications and networking LCBC"s highest priority; fund completion of microwave network, basinwide highways, library, and early warning system.	Donors, LCBC nations
Continue basinwide workshops on natural resource problems that impact all member nation states (livestock crossings, pest control, and fish trade).	Donors
Make environmental planning, monitoring, and assessment the other high priority; LCBC should review all projects with basinwide impacts; each diagnostic basin master plan should be reviewed by LCBC; only when there are no basinwide consequences should project design and environmental assessment be left to nations.	UN agencies, donors, LCBC nations

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ANNEX A: TERMS OF REFERENCE

The terms of reference for the Diagnostic Study were outlined by the United Nations Environment Programme as follows:

Under the supervision of the Deputy Assistant Executive Director of the Environment Programme and in cooperation with the consultants on desertification and national technical experts from the Lake Chad Basin countries, the consultants will prepare a French/English Diagnostic Study with the following objectives:

a) to define specific environmental problems and their impact, and to help the Lake Chad Basin Commission and Governments to provide on-going programs for the incorporation of environmental concerns into the management of water resources development, including water supply and sanitation;

b) to strengthen the awareness of the various governmental institutions involved in socio-economic development activities regarding their potential impact on the water environment within the lake basin, and the importance of their active participation in the adaptation and implementation of the Lake Chad Action Plan; and to encourage the donor countries for their influential contribution in this project;

c) to define specific environmental problems in the areas of the Lake Chad Basin exposed to desertification, and their impact on the economic development;

d) to review and analyze past, on-going, and planned activities for development in drought stricken areas on the one hand, and environment rehabilitation and protection, including natural resources use and conservation, on the other; and to identify possible gaps between the two; and

e) to prepare a list of specific priority activities and other measures needed to strengthen the desertification control, co-operation and co-ordination among countries concerned in order to carry out environmentally sound development programs when combating desertification.

ANNEX B
SELECTED LIST OF ONGOING PROJECTS IN THE CONVENTIONAL BASIN

Organization or Project	Location	Sector	Activities	Cost	Funding Sources	Beginning Date	Duration	Observations
1. Cameroon								
LCBC	Basinwide	multiple	10		member states	1964	ongoing	
Projet Centre Nord	Provinces of North & Extreme North	multiple	2,3,4		WB, Cam		terminated 1987	
SEMRY I & II	Province of Extreme North	agro-indust	1		CCCE, FAC Cameroon		ongoing	
SEMRY III	idem.	agro-indust	1		EDF, Cameroon		ongoing	
Mindif-Moulvoudaye	Province of North	multiple	2		Cameroon		reduced	
ONAREF	basinwide	environment	3		Cameroon		ongoing	outdated methods
CARE/ ONAREF	Mayo Savo & Tsanaga	environment	10,3	3.2m	CARE, Cameroon	1982	ongoing	monitor for innovations
Northern Wells	Extreme North P.	hydrology	6		CARE			
CRS		multiple	10		Catholic Church		ongoing	
INADES		human resources	5		CIDA, Cameroon	available		
Wells Development		hydrology	6,7		15 bilateral agencies		ongoing & terminated	evaluate
Waza-Logone	Waza	multiple	8		Netherlands	1990	beginning	monitor
IRA	North & Extreme North Provinces	research	5,8		Cameroon, France, USA, other donors		ongoing	
II. Chad								
Small-scale Irrigation	Kanem, Mayo Kebbi	agriculture ORT-Africaire	13	12.7m	USAID-CARE			
SODELAC	Lake	agriculture	1		BAD, FID	1967	ongoing	begin rehab in 1988
Bongor	Chari	agriculture	1		UNDP, WB			
Sategui-Deressia	Chari-Baguirmi	agriculture	1		UNDP, World Bank			perimeter rehab
Bongor Fisheries	Chari	fisheries	11		UNICEF			pilot project
Ngouri-Tarfey Project	Kanem	environment	15					
Italian Project	Kanem	multiple	1,2,3,4,6	97m	Italy			

Organization or Project	Location	Sector	Activities	Cost	Funding Sources	Beginning Date	Duration	Observations

II. Chad, *continued*

Organization or Project	Location	Sector	Activities	Cost	Funding Sources	Beginning Date	Duration	Observations
Water-use Planning LCBC				2.6m	UNDP			
Local Nurseries	Kanem, Mayo Kebbi	environment	3		BELACO, SECADEV, UNDP, FAO, FAC, EEC			
Improved Stoves	national	environment	17		Chad: CONAFA			
Chari-Baguimi IDP	Chari	rural development			FED			
Labo de Farcha	national	research	5,8		FAC			
CIRAT	national	research	5,8		FAC			

III. Niger

Organization or Project	Location	Sector	Activities	Cost	Funding Sources	Beginning Date	Duration	Observations
PADADO	Diffa	agriculture	3,6,8, 11,13	10m	ACDI	1989	5 years	Phase 2
Crop Protection	national	agriculture	1	42.1m	GTZ	1987	3years	institutional
Interim Forestry Project	national	environment	3	4.6m	Niger	1985	ongoing	plantations
Pilot Date Palm Project	Maine, Soroa	environment	8	0.7m	FAC	1986	4 years	
Nguigmi IDP	Nguigmi USAID-PAM	agriculture	10	3m	FENU-PNUP	1987	4 years	
Green Anchor	Adebour	environment	3	0.5m	ACDI	1988	2 years	
Rural Electri-fication	Nguigmi	energy	1	64.7m	Japan-ACDI	1989	1 year	
Provision of Potable Water	Maine, Soroa	hydrology	6	1.5m	FNI-FNE	1987	2 years	
Fourth Hydro Program	Diffa, Zinder	hydrology	6	16.8m	Denmark	1988	4 years	
Systematic Sampling of Wells and Boreholes	Diffa, Zinder	energy	8	0.03m	Kuwait	1989	3 years	
Development of Cuvettes	Maine, Soroa	agriculture	1	30.2m	CFCF	1987	2 years	remainder
Danish Project	Diffa, Maine	agriculture	?	2.1m	DANIDA	1988	4 years	
Improved Stoves	Maine,Diffa	environment	1	70m	CEAO	1988	1 year	
Road Protection	Maine	environment	15	0.21m	ACDI	1988	1 year	
Pastoral Village Wells	Hguigmi	hydrology	6	0.77m	ACDI	1986	3.5 years	
Wells Rehab Welldigger Training	Nguigmi	hydrology	5,6	0.87m	French Union of ILC	1988	2.5 years	

Organization or Project	Location	Sector	Activities	Cost	Funding Sources	Beginning Date	Duration	Observations
III. Niger, *continued*								
Micro-realizations	Niger Deparment	agriculture	13	0.73m	Japan	1984	ongoing	
North Diffa Rehab	Diffa	environment	2,3,6			1990		
Lake Chad Cuvettes	Nguigmi	agriculture .	12,6			1989		
Agric Dev and Desertification Control	department	agriculture, environment	2,3,13, 6,15			1990		
Natural Management of Gum Arabic	Maine	forestry	9,3			1990		
INRAN	department	research	5,8		multiple donors		ongoing	
IV. Nigeria								
CBDA	Borno	hydrology agriculture	1,4,7, 8,16		federal government	1978	ongoing	
SCIP	New Marte	agriculture	1		federal government	1979	ongoing	
BORADAP	Borno	agriculture	2		IDA			
Arid Zone Afforestation	northern states	forestry	3		IDA	completed		
Forestry Sector II	northern states	forestry	3,9		IDA			
Jama'are Nguru Wetlands Conservation	Yobe Basin	environment	12,17		Britain	1990		under study
Sambissa Swamp Park	Sambissa Swamp	environment	12,17					under study
Jama'are Yobe Small-scale Irrigaiton	river valleys	agriculture	13		federal government		ongoing	
Northern Arid Zone Dev. Proj.	northern states	rural development	10		EEC	1990		beginnings of grass roots development in Borno
LCRI	Borno	research	5,8		federal government		ongoing	underfunded

Note: Activity Codes

1. Large-scale irrigated production
2. Agro-pastoral production
3. Reforestation
4. Roads
5. Training and documentation
6. Wells
7. Dams
8. Research and Development
9. Agro-forestry
10. Diverse development activities
11. Fisheries
12. Wildlife
13. Small-scale irrigation
14. Pest control
15. Dune stabilization
16. Rural electrification
17. Conservation

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