# Chapter 9
# Desert Environments of Republic of Chad

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**Synopsis** This chapter presents an overview of the current status of desertification in Chad and outlines the measures being taken to arrest and reverse land degradation, revegetate bare land and raise household incomes. The outcomes of several successful projects are summarized.

**Key Points**

- Like most states of the African Sahel, Chad has suffered from the encroachment of the desert. Traditional herding practices and the need for firewood and wood for construction have exacerbated the problem. Lake Chad was one of the largest fresh bodies of water on the African continent and its disappearance will have a tremendous impact on the population surrounding it. The problem of Lake Chad is increasingly complex because of the international nature of the desertification. Lake Chad is a regional problem East African and North African member states of the African Union and UN must deal with it. A collaborative approach to combating the desertification of Lake Chad is needed to reverse the current trends.
- Land and terrestrial resources in Africa have unparalleled economic, social and environmental value. Traditionally, African societies are agrarian or pastoral, depending directly on subsistence farming to meet their daily needs. Commercial agriculture holds an equally important position, employing the largest share of the workforce in most countries, and contributing significantly to national economic growth, export earnings and foreign exchange. However, national and household dependency on agricultural output has been a significant factor in limited economic growth over the past three decades. Climatic instability

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has caused significant and frequent variability in production, and narrow crop diversity, and national and international market failures, have facilitated recurrent economic losses.

- Desertification, land degradation and drought have negative impact on the availability, quantity and quality of water resources that result in water scarcity. As desertification takes its toll, water crises are expected to continue raising ethnic and political tensions in drylands, contributing to conflicts where water resources straddle or delineate country borders. Water scarcity is the long-term imbalance between available water resources and demands. Increasing occurrences of water scarcity, whether natural or human-induced, serve to trigger and exacerbate the effects of desertification through direct long-term impacts on land and soil quality, soil structure, organic matter content and ultimately on soil moisture levels.
- The direct physical effects of land degradation include the drying up of freshwater resources, an increased frequency of drought and sand and dust storms, and a greater occurrence of flooding due to inadequate drainage or poor irrigation practices. Should this trend continue, it would bring about a sharp decline in soil nutrients, accelerating the loss of vegetation cover. This leads in turn to further land and water loss from pollution of surface and groundwater, siltation, salinization, and alkalization of soils. Poor and unsustainable land management techniques also worsen the situation. Over cultivation, overgrazing and deforestation put great strain on water resources by reducing fertile topsoil and vegetation cover, and lead to greater dependence on irrigated cropping. Observed effects include reduced flow in rivers that feed large lakes such as Lake Chad, leading to the alarmingly fast retreat of the shorelines of these natural reservoirs in Chad. With climate change, the situation is likely to get worse – less water and creeping desertification in the semi-arid terrain.
- Declining productivity and soil structure in the Sahelian zones of Chad is exacerbated by unpredictable rainfall and drought, resulting in extreme degradation and desertification. Chad is currently experiencing the greatest vulnerability to desertification, with 58 % of the area already classified as desert, and 30 % classified as highly or extremely vulnerable.
- Rapid population growth and policy pressures to increase production have forced the cultivation of greater and greater areas of land in all sub-regions, and the extension of cultivation and grazing to marginal areas. Combined with limited application of organic or inorganic fertilizers, reductions in fallow periods, restrictions on crop diversity, inappropriate irrigation, and an increasing use of herbicides and pesticides, this has resulted in the physical, chemical and biological degradation of vegetation and soil. Soil erosion and desertification rates are increasing as a result, and declines in productivity have been noted.

**Keywords** Dust storms • Wildlife • Biodiversity • Shelter belt • Oasis • Camels • Poverty • Ostriches • Lake Chad • Palms • Great Green Wall • Poverty • Armed conflict • Food insecurity • Ethnic tensions

## 1 Introduction

Located in north-central Africa, Chad stretches for about 1,800 km from its northern most point to its southern boundary. Except in the far northwest and south, where its borders converge, Chad's average width is about 800 km. Its area of 1,284,000 km$^2$ is roughly equal to the combined areas of Idaho, Wyoming, Utah, Nevada, and Arizona. Chad's neighbors include Libya to the north, Niger and Nigeria to the west, Sudan to the east, Central African Republic to the south, and Cameroon to the southwest (Fig. 9.1). Chad exhibits two striking geographical characteristics.


**Fig. 9.1** Map of Chad showing its location as a land-locked country located on the fringe of the Sahara desert

First, the country is landlocked. N'Djamena, the capital, is located more than 1,100 kilometers (km) inland from the Atlantic Ocean; Abéché, a major city in the east, lies 2,650 km from the Red Sea; and Faya Largeau, a much smaller but strategically important center in the north, is in the middle of the Sahara Desert, 1,550 km from the Mediterranean Sea. These vast distances from the sea have had a profound impact on Chad's historical and contemporary development. The second noteworthy characteristic is that the country borders on very different parts of the African continent: North Africa, with its Islamic culture and economic orientation toward the Mediterranean Basin; West Africa, with its diverse religions and cultures and its history of highly developed states and regional economies; Northeast Africa, oriented toward the Nile Valley and Red Sea region; and Central or Equatorial Africa, some of whose people have retained classical African religions while others have adopted Christianity, and whose economies were part of the great Zaire River system. Although much of Chad's distinctiveness comes from this diversity of influences, since independence the diversity has also been an obstacle to the creation of a national identity.

## 2 Geography, Climate and Land Use

### *2.1 General Geography*

Three climate regions make up the majority of the country – a desert in the north, an arid region in the center, and a tropical area in the south. Lake Chad is located on the western border and is an important source of water for Chad and surrounding countries. Although Chadian society is economically, socially, and culturally fragmented, the country's geography is unified by the Lake Chad Basin. Once a huge inland sea (the Pale-Chadian Sea) whose only remnant is shallow Lake Chad, this vast depression extends west into Nigeria and Niger. The larger, northern portion of the basin is bounded within Chad by the Tibesti Mountains in the northwest, the Ennedi Plateau in the northeast, the Ouaddaï Highlands in the east along the border with Sudan, the Guéra Massif in central Chad, and the Mandara Mountains along Chad's southwestern border with Cameroon. The smaller, southern part of the basin falls almost exclusively in Chad. It is delimited in the north by the Guéra Massif, in the south by highlands 250 km south of the border with Central African Republic, and in the southwest by the Mandara Mountains.

Lake Chad, located in the southwestern part of the basin at an altitude of 282 m above sea level (a.s.l.), surprisingly does not mark the basin's lowest point; instead, this is found in the Bodele and Djourab regions in the north-central and northeastern parts of the country, respectively. This oddity arises because the great stationary dunes (*ergs*) of the Kanem region create a dam, preventing lake waters from flowing to the basin's lowest point. At various times in the past, and as late as the 1870s, the Bahr el Ghazal Depression, which extends from the northeastern part of the lake

to the Djourab, acted as an overflow canal; since Independence in 1960, climatic conditions have made overflows impossible.

North and northeast of Lake Chad, the basin extends for more than 800 km, passing through regions characterized by great rolling dunes separated by very deep depressions. Although vegetation holds the dunes in place in the Kanem region, farther north they are bare and have a fluid, rippling character. From its low point in the Djourab, the basin then rises to the plateaus and peaks of the Tibesti Mountains in the north. The summit of this formation – as well as the highest point in the Sahara Desert – is Emi Koussi, a dormant volcano that reaches 3,414 m a.s.l. The basin's northeastern limit is the Ennedi Plateau, whose limestone bed rises in steps etched by erosion.

East of the lake, the basin rises gradually to the Ouaddaï Highlands, which mark Chad's eastern border and also divide the Chad and Nile watersheds. Southeast of Lake Chad, the regular contours of the terrain are broken by the Guéra Massif, which divides the basin into its northern and southern parts.

South of the lake lie the floodplains of the Chari and Logone rivers, much of which are inundated during the rainy season. Farther south, the basin floor slopes upward, forming a series of low sand and clay plateaus, called *koros*, which eventually climb to 615 m a.s.l. south of the Chadian border, the *koros* divide the Lake Chad Basin from the Ubangi-Zaire river system.

## *2.2 Rivers*

Chad's major rivers are the Chari and the Logone and their tributaries, which flow from the southeast into Lake Chad. Both river systems rise in the highlands of Central African Republic and Cameroon, regions that receive more than 1,250 millimeters (mm) of rainfall annually. Fed by rivers of Central African Republic, as well as by the Bahr Salamat, Bahr Aouk, and Bahr Sara rivers of southeastern Chad, the Chari River is about 1,200 km long. From its origins near the city of Sarh, the middle course of the Chari makes its way through swampy terrain; the lower Chari is joined by the Logone River near N'Djamena. The Chari's volume varies greatly, from 17 cubic meters per second (cusecs) during the dry season to 340 cusecs during the wettest part of the year.

The Logone River is formed by tributaries flowing from Cameroon and Central African Republic. Both shorter and smaller in volume than the Chari, it flows northeast for 960 km; its volume ranges from five to eighty-five cusecs. At N'Djamena the Logone empties into the Chari, and the combined rivers flow together for 30 km through a large delta and into Lake Chad. At the end of the rainy season in the Fall, the river overflows its banks and creates a huge floodplain in the delta.

The seventh largest lake in the world (and the fourth largest in Africa), Lake Chad is located in the *sahelian* zone, a region just south of the Sahara Desert. The Chari River contributes 95 % of Lake Chad's water, an average annual volume

of 40 billion cubic meters, 95 % of which is lost to evaporation. The size of the lake is determined by rains in the southern highlands bordering the basin and by temperatures in the Sahel. Fluctuations in both cause the lake to change dramatically in size, from 9,800 $km^2$ in the dry season to 25,500 $km^2$ at the end of the rainy season. Lake Chad also changes greatly in size from one year to another. In 1870 its maximum area was 28,000 $km^2$. The measurement dropped to 12,700 in 1908. In the 1940s and 1950s, the lake remained small, but it grew again to 26,000 $km^2$ in 1963. The droughts of the late 1960s, early 1970s, and mid-1980s caused Lake Chad to shrink once again (Coe and Foley 2001). The only other lakes of importance in Chad are Lake Fitri, in Batha Prefecture, and Lake Iro, in the marshy southeast.

### *2.3 Climate*

The Lake Chad Basin embraces a great range of tropical climates from north to south, although most of these climates tend to be dry. Apart from the far north, most regions are characterized by a cycle of alternating rainy and dry seasons. In any given year, the duration of each season is determined largely by the positions of two great air masses–a maritime mass over the Atlantic Ocean to the southwest and a much drier continental mass. During the rainy season, winds from the southwest push the moister maritime system north over the African continent where it meets and slips under the continental mass along a front called the ITCZ (intertropical convergence zone). At the height of the rainy season, the front may reach as far as Kanem Prefecture. By the middle of the dry season, the ITCZ moves south of Chad, taking the rain with it. This weather system contributes to the formation of three major regions of climate and vegetation.

## 3 The Saharan Desert System

### *3.1 Sahara Region*

The Saharan region covers roughly the northern third of the country, including Borkou-Ennedi-Tibesti Prefecture along with the northern parts of Kanem, Batha, and Biltine prefectures. Much of this area receives only traces of rain during the entire year; at Faya Largeau, for example, annual rainfall averages less than three centimeters. Scattered small oases and occasional wells provide water for a few date palms or small plots of millet and garden crops. In much of the north, the average daily maximum temperature is about 32 °C during January, the coolest month of the year, and about 45 °C during May, the hottest month. On occasion, strong winds from the northeast produce violent sandstorms. In northern Biltine Prefecture, a region called the Mortcha plays a major role in animal husbandry. Dry for 9 months

of the year, it receives 350 mm or more of rain, mostly during July and August. A carpet of green springs from the desert during this brief wet season, attracting herders from throughout the region who come to pasture their cattle and camels. Because very few wells and springs have water throughout the year, the herders leave with the end of the rains, turning over the land to the antelopes, gazelles, and ostriches that can survive with little surface water.

## *3.2 Sahelian Region*

The semiarid *sahelian* zone, or Sahel, forms a belt about 500 km wide that runs from Lac and Chari-Baguirmi prefectures eastward through Guéra, Ouaddaï, and northern Salamat prefectures to the Sudanese frontier. The climate in this transition zone between the desert and the southern *soudanian* zone is divided into a rainy season (from June to early September) and a dry period (from October to May). In the northern Sahel, thorny shrubs and *acacia* trees grow wild, while date palms, cereals, and garden crops are raised in scattered oases. Outside these settlements, nomads tend their flocks during the rainy season, moving southward as forage and surface water disappear with the onset of the dry part of the year. The central Sahel is characterized by drought-resistant grasses, shrubs and low trees. Rainfall is more abundant there than in the Saharan region. For example, N'Djamena records a maximum annual average rainfall of 580 mm, while Ouaddaï Prefecture receives just a bit less. During the hot season, in April and May, maximum temperatures frequently rise above 40 °C. In the southern part of the Sahel, rainfall is sufficient to permit crop production on unirrigated land, and millet and sorghum are grown. Agriculture is also common in the marshlands east of Lake Chad and near swamps or wells. Many farmers in the region combine subsistence agriculture with the raising of cattle, sheep, goats, and poultry.

## *3.3 Soudanian Region*

The humid *soudanian* zone includes the southern prefectures of Mayo-Kebbi, Tandjilé, Logone Occidental, Logone Oriental, Moyen-Chari, and southern Salamat. Between April and October, the rainy season brings between 750 and 1,250 mm of precipitation. Temperatures are high throughout the year. Daytime readings in Moundou, the major city in the southwest, range from 27 °C in the middle of the cool season in January to about 40 °C in the hot months of March, April, and May.

The *soudanian* region is predominantly savanna, or plains covered with a mixture of tropical or subtropical grasses and woodlands. The growth is lush during the rainy season but turns brown and dormant during the 5-month dry season between November and March. Over a large part of the region, however, natural vegetation has yielded to cropland.

## 4 Environmental Protection

With two national parks, five game reserves, and one Wetland of International Importance, 9 % of Chad's natural areas are protected. The chief environmental problem is increasing desertification after a decade marked by below-normal rainfall and periodic droughts. Warring factions in Chad have damaged the environment and hampered the efforts of the government to address environmental problems for 25 years. Locust swarms periodically cause crop damage. The availability of fresh water is also a major problem. Safe drinking water is available to 31 % of urban dwellers and 26 % of the rural population. About 82 % of the nation's renewable water resources are used for farming activity.

Elephant herds were reported greatly decimated in the 1970s. As of the 2000, endangered species in Chad included the black rhinoceros, Dallon's gerbil, and African wild ass. The Sahara oryx, also called the scimitar-horned orynx, is extinct in the wild. Of 134 species of mammals in Chad, 14 are threatened with extinction. Three bird species out of 370 are also threatened. One reptile out of five and five plant species out of 1,600 are in danger of extinction. In 1986 approximately 83 % of the active population were farmers or herders. This sector of the economy accounted for almost half of GDP. With the exception of cotton, some small-scale sugar production, and a portion of the peanut crop, Chad's agriculture consisted of subsistence food production. The types of crops that were grown and the locations of herds were determined by considerable variations in Chad's climate.

## 5 Land Use

As with most Third World countries, control of the land determines agricultural practices. There are three basic types of land tenure in Chad. The first is collective ownership by villages of croplands in their environs. In principle, such lands belong to a village collectively under the management of the village chief or the traditional *chef des terres* (chief of the lands). Individual farmers hold inalienable and transmittable use rights to village lands, so long as they, their heirs, or recognized representatives cultivate the land. Outsiders can farm village lands only with the authorization of the village chief or *chef des terres*. Renting village farmlands is possible in some local areas but is not traditional practice. Private ownership is the second type of tenure, applied traditionally to the small plots cultivated in wadis or oases. Wells belong to individuals or groups with rights to the land. Ownership of fruit trees and date palms in the oases is often separate from ownership of the land; those farmers who plant and care for trees own them. State ownership is the third type, primarily for large enterprises such as irrigation projects. Under the management of parastatal or government employees, farmers enter into contractual arrangements, including paying fees, for the use of state lands and the benefits of improved farming methods.

The *soudanian* zone comprises those areas with an average annual rainfall of 800 mm or more. This region, which accounts for about 10 % of the total land area, contains the nation's most fertile croplands. Settled agricultural communities growing a wide variety of food crops are its main features. Fishing is important in the rivers, and families raise goats, chickens, and, in some cases, oxen for plowing. In 1983 about 72 % of all land under cultivation in Chad was in the *soudanian* region.

The central zone, the *sahelian* region, comprises the area with average annual rainfall of between 350 and 800 mm. The minimum rainfall needed for the hardiest of Chad's varieties of millet, called *berebere*, is 350 mm. The western area of the zone is dominated by the Chari and Logone rivers, which flow north from their sources in southern Chad and neighboring countries. The courses of these rivers, joining at N'Djamena to flow on to Lake Chad, create an ecological subregion. Fishing is important for the peoples along the rivers and along the shores of Lake Chad. Flood recession cropping is practiced along the edges of the riverbeds and lakeshore, areas that have held the most promise for irrigation in the zone. International donor attention focused on this potential beginning in the mid-1960s. Particular attention has been paid to the traditional construction of polders along the shores of Lake Chad. Land reclaimed by the use of such methods is extremely fertile. Chad's only wheat crop is cultivated in these polders.

In the rest of the *sahelian* region, the hardier varieties of millet, along with peanuts and dry beans, are grown. Crop yields are far lower than they are in the south or near rivers and lakes. Farmers take every advantage of seasonal flooding to grow recession crops before the waters dry away, a practice particularly popular around Lake Fitri. The *sahelian* region is ideal for pasturage. Herding includes large cattle herds for commercial sale, and goats, sheep, donkeys, and some horses are common in all villages.

The Saharan zone encompasses roughly the northern one-third of Chad. Except for some dates and legumes grown in the scattered oases, the area is not productive. Annual rainfall averages less than 350 mm, and the land is sparsely populated by nomadic tribes. Many of Chad's camel herds are found in the region, but there are few cattle or horses.

## 6 Agriculture

Production systems in the Saharan region are characterized by an agro-forestry system that centers on the *wadis* and palms. Date palm cultivation, irrigated subsistence farming, sedentary rearing of small ruminants and nomadic camel rearing are all practised.

**Fig. 9.2** Local livestock owners of livestock practice transhumance to chase the seasonal availability of forage and water

## *6.1 Sahelian Region*

Production systems in the Sahelian region are a combination of diversified systems dominated by pastoral agro-forestry. Agricultural practices range from traditional irrigated subsistence farming to a more viable extensive farming of oilseeds and legumes. Although vegetation in the south includes trees and forests, the north is more steppe-like. Forests are exploited essentially for ligneous products for domestic energy needs and economically profitable ligneous sub-products, in particular gum arabic. Animal rearing is transhumant (Fig. 9.2).

## *6.2 Sudano Region*

Production systems in the Sudano region are very diversified. Vegetation consists of dry dense forests and savannah. These lands are used for cattle-rearing and cereal, oilseed, tuber, legume and cotton production.

Chad's subsistence farmers practice traditional slash-and-burn agriculture in tandem with crop rotation, which is typical throughout much of Africa. Sorghum is the most important food crop, followed by millet and *berebere*. Less prevalent grains are corn, rice, and wheat. Other secondary crops include peanuts, sesame, legumes, and tubers, as well as a variety of garden vegetables.

Crop rotation in the *soudanian* zone traditionally begins with sorghum or millet in the first year. Mixed crops of sorghum and/or millet, with peanuts, legumes, or tubers, are then cultivated for approximately 3 years. Farmers then return the land to fallow for periods up to 15 years, turning to different fields for the next cycle. Preparation of a field begins with cutting heavy brush and unwanted low trees or branches that are then laid on the ground. Collectively owned lands are parceled out during the dry season, and the fields are burned just before the onset of the first rains, usually around March. Farmers work most intensively during the rains between May and October, planting, weeding and protecting the crops from birds and animals. Harvesting begins in September and October with the early varieties of sorghum. The main harvest occurs in November and December. Farmers harvest crops of rice and *berebere*, grown along receding water courses, as late as February.

The cropping cycle for most of the *sahelian* zone is similar, although the variety of crops planted is more limited because of dryness. In the polders of Lake Chad, farmers grow a wide range of crops; two harvests per year for corn, sorghum, and legumes are possible from February or March to September. Rice ripens in February, and wheat ripens in May.

Detailed and reliable statistical information on Chad's agriculture was scarce in the late 1980s; most researchers viewed available statistics only as indicators of general trends. The one region for which figures were kept was the *soudanian* zone through survey coverage by officials of the National Office of Rural Development (Office National de Développement Rural–ONDR), who monitored cotton production. These officials also gathered information on food production, but this effort was not carried out systematically. Survey coverage of the *sahelian* zone was first hampered, then prevented, by civil conflict from the mid 1970s to the early 1980s.

Moreover, figures from international and regional organizations often conflicted or differed in formulation. For example, total area devoted to food production was difficult to estimate because sources combined the area of fields in production with those lying fallow to give a total for arable lands. The arable land figure has shown a gradual increase since 1961. Estimated then at 2.9 million hectares (Mha), it rose to almost 3.2 Mha in 1984. In 1983 there were about 1.2 Mha in food production and in 1984 slightly more than 900,000 ha. Therefore, perhaps a third of Chad's farmlands were in production in a given year, with the balance lying fallow.

## 7 Desertification in Chad: Causes and Consequences

Land degradation and dwindling water resources are caused by over-exploitation of natural resources to satisfy daily food and energy requirements, as well as climate change. Food production systems based on unsustainable practices and the removal of wood for fuel are among the issues that must be addressed. A lack of arable land due to desertification, coupled with limited access to water and healthcare, has had devastating effects on malnutrition rates in the region. Food insecurity is a major problem.

## 8 Demography and Population Movements

The impact of climate degradation on Chad's ecosystems is accentuated by the pressure exerted on the environment by Chad's strong demographic growth (2.5 % per year). Migratory movements that occur under the combined effects of war and drought have, moreover, profoundly modified the socio-economic equilibrium. The social structure of herder-farmers has been disturbed The presence and sometimes settlement of rearer-herders in certain areas has brought about tensions with farmers Encouraging rearer-herders to shift to farming activities has not been achieved without social problems as new agricultural lands need to be found for these people.

## 9 Desert Encroachment Problems

Like most states of the African Sahel, Chad has suffered from the encroachment of the desert. Today, the phenomenon of desertification affects the entire country of Chad. However, the most affected areas are located between 12° and 22° north latitude, covering an area of 1,091,420 $km^2$ approximately 85 % of the country.

Traditional herding practices and the need for firewood and wood for construction have exacerbated the problem. In the early 1980s, the country possessed between 13.5 and 16 Mha of forest and woodlands, representing a decline of almost 14 % from the early 1960s. To what extent this decline was caused by climatic changes and to what extent by herding and cutting practices was unknown. Regulation was difficult because some people traditionally made their living selling wood and charcoal for fuel and wood for construction to people in the urban center. Although the government attempted to limit wood brought into the capital, the attempts have not been well managed, and unrestricted cutting of woodlands remains a problem.

## 10 Combating Desertification and Controlling Desert Encroachment

These twin problems are inextricably linked in Chad in the same way that they are seen in many of the case studies in this book. The original thinking about desertification was that it represented as "a process of drying which turns previously productive areas into areas classically defined as desert or wasteland". Later, the concept morphed into something more general like "degradation of formerly productive land through a combination of human-induced and climatic factors" (see Chap. 1). 'Fighting the desert' is a recurring theme in many of the case studies presented here.

*National Program of Action to Combat Desertification (PAN/LCD).* The Program of Action defines a framework of measures to assist people and local organizations in securing a sustainable improvement in dryland management. It identifies factors contributing to desertification and concrete measures to combat it and mitigate the effects of drought. It is to incorporate long-term strategies to combat desertification and be integrated with national policies on sustainable development.

One of the most pressing issues for Chad is the rate of desertification due to deforestation, inappropriate farming techniques and crop selection. In fact, the country is experiencing environmental problems. The main ones are:

- Encroachment of sands into oases and croplands
- Lack of soil protection and regeneration and an absence of an agency to coordinate water and soil conservation;
- Inadequate nature conservation measures and the failure to implement existing regulation

## 11 Political and Strategic Considerations

Because of political instability and subsequent clashes, which have occurred at the same time as periods of drought, Chad has been unable to implement a real strategy to combat desertification to the extent of other Sahelian countries. Although activities have been undertaken within the general framework of combating desertification, they tended to be aimed at improving the environment (the green belt of N'djamena) or promoting agricultural production (*Acacia albida, Karité*) or forest production (*Acacia senegal*). In all cases, these projects were instigated by the forestry service, or under its auspices, and their objectives were essentially sectoral.

Furthermore, these actions were too limited in terms of both their time frames and the affected land areas to have any significant impact on the desertification process. In a significant number of cases, they did not achieve their sectoral objectives. Because of this, it became apparent that, if Chad was to be successful in fighting desertification, there was a need to implement a rational and consistent strategy; drawing on accumulated experience and a more objective analysis of the situation It was determined that this strategy should be inspired by the regional structure outlined in the Nouakchott strategy (CILSS 1994), and should be translated at the national level by a General Plan to Combat Desertification (*Plan directeur de lutte contre la désertification*, or PDLCD). The PDLCD would need to analyze the process of desertification, define directions in line with development options, put forward a strategy and, finally, propose an action program. In brief, it would guide actions, in view of proposing solutions better adapted to the specific problems of desertification in Chad.

Desertification control is a major component of Chad's national environmental protection. The national action plan to combat desertification (PDLCD) has the following strategic orientation:

- Transferring natural resource management responsibilities to rural communities
- Awareness raising and information, training and extension work;
- Promoting environment-friendly;
- Protecting and regenerating environmental resources;
- Improving production systems;
- Establishing an institutional framework (see below).

The Chadian government elaborated and adopted the PDLCD in 1989. The strategic orientations of the PDLCD hinge on the following four major axes:

- Transferring responsibilities for the management of natural resources to the rural community: this must be translated at the judicial level, notably as concerns tax laws, by a thorough reform of government's hitherto centralized approach. The sectoral session of 1994 thus announced that rural communities would be involved in the management of natural resources, in particular through a 'decentralization of responsibilities' within the framework of village land management.
- Promoting public awareness by disseminating information and provision of training as the principal means of involving the population.
- Promoting use of production systems that do not consume natural resources. This involves choosing appropriate, cost-efficient regions in which to operate the careful selection of resources, while monitoring natural resources and increasing public understanding of them.
- Establishing an organizational structure that promotes inter-sectorality and the integration of rural/environment development and is centered on adapting existing structures and projects rather than on introducing specific environmental structures.

## 12 Case Studies of Projects Designed to Arrest and Reverse Desertification

### *12.1 Case Study: Combating Sand Encroachment in Kanem*

The area covered by this study, the Kanem, covers 115,000 $km^2$ and has a population of 280,000 people. As have other Sahara and Sahel regions, the natural environments of Kanem has suffered degradation in the past few decades, due to the prolonged drought periods that have ruthlessly affected the country since the 1960s, and continue to affect it.

Sand encroachment in Kanem is the most spectacular of the causes of desertification in the region. Currently, sand encroachment affects 64 % of the land and threatens the livelihood of 14 % of the population of Chad. Primarily caused by

human activities, other natural factors, such as drought, compound its effects. The considerable scale of the phenomenon is such that the means mobilized by the population have not proven sufficient to protect the region's important infrastructures (inhabited villages, farmed and grazing areas, wells). It has largely been due to government mobilization and the assistance of NGOs that a number of villages (such as Tarfey, Rig-Rig and Barra) and certain *wadis* (Miou, Barkadroussou, Moto) have been saved from being engulfed by sand. The successful actions implemented by the pilot Kanem Agro-Forestry Pastoral Development Project can be used as a model for future interventions against sand encroachment in arid and semi-arid zones. The principal causes are the following: persistent drought, overgrazing, cattle tramping, deforestation and relentless tree logging (evaluated at 250,000 tonnes in 1988), and farming on sand dunes (rendering the dune surface vulnerable to the erosive effects of the wind). In fact, 219 villages, 324 *wadis* and numerous boreholes and grazing areas are increasingly becoming so threatened by sand encroachment as to be potentially life threatening for the local population in Kanem.

The strategy used to fight desertification in Kanem hinges on the following four imperatives:

- The protection of threatened sites and the regeneration of ecological resources
- The improvement of production systems
- The reinforcement of institutional capacities
- The development of a national scheme of land planning

It is within the framework of this combat strategy that the agro-forestry pastoral development project in operation in Kanem from 1993 to 1998 contributed to saving certain villages, *wadis*, schools and clinics from the catastrophe of sand encroachment. Both structural and biological methods were used to halt sand encroachment.

## *12.2 Structural Methods of Inhibiting Sand Encroachment*

### 12.2.1 Brush Fences

Fencing consists of setting up a barrier (using date palms, *Leptadenia* branches, thorny twigs and millet thatch) between the source of the sand and the threatened area. As sand accumulates along this barrier, it forms an artificial dune, which itself acts as a further obstacle. The fence is placed 200–300 m from the site to be protected, orientated perpendicular to the dominant wind direction.

The following characteristics are required for the success of this approach:

The fence must have a certain permeability, to prevent the wind from destroying it. The only criteria used is the quantity of material used: an average of 20–25 palms or 4–6 branches of *Leptadenia* is used per meter;

- Taking into account sand distribution along the fence according to wind flux, the ideal height of the fence is between 1.5 and 1.8 m;

- Resistance: the greater the height of the fence, the lower its resistance. In building the fence, a trench at least 30 cm deep is needed to firmly sink the supporting elements of the fence. Similarly, these fence elements should be firmly tied together between at two or more levels along the length of the fence to increase its resistance.

This fencing technique has been shown to be very effective in Kanem, especially as the wind is unidirectional (NE–SW). If the opposite is the case, a network of different meshes would be required. As the fence will eventually be engulfed by sand, its height will need to be increased once the sand has reached within 10–15 cm of the top of the fence.

### 12.2.2 Hedges

After stabilizing sand by mechanical means, it is essential to fix the dunes definitively by promoting vegetation growth. The final aim is to recreate the ecosystem as it existed in the past, which means to conquer land degradation and shifting sands by covering them with as dense a vegetation as possible.

The choice of forest species and local and exotic grasses for biological fixation depends on the capacities of the species to adapt to this environment (its aridity and soil structure). The best adapted local species are *Acacia spp, Balanites aegyptiaca, Leptadenia pyrotechnica, Ziziphus mauritiana* and *Panicum turgidum*. Exotic species that are also well adapted include *Prosopis chilensis, Prosopis juliflora, Parkinsonia aculeata* and *Cajanus cajan*.

Taking into consideration the intensity of sand encroachment in Kanem, biological fixation of shifting dunes is technically only possible with planted species grown in nurseries. The production of plants relies on, among other things, harvesting seeds, choosing an appropriate site and training nursery growers. Work should begin in January each year and terminate in August. Plants grown in the nurseries should be healthy and vigorous, with a height of 50–80 cm. They should be planted out in mid-July, or as soon as soil humidity reaches a depth of 30–40 cm, at a density of 400 plants per hectare — to minimize the cost of the operation and to limit competition between plants, thus favoring natural regeneration.

## *12.3 Involving the Local Population*

The results over the course of the six-year experiment were very encouraging. The method of intervention (using a participatory approach) was based on a contractual agreement between local people and project organizers. The nature of the relationship, the reciprocal engagement and the working methods were written up into a standard contract defining the terms of agreement between the two parties. Agreement to the terms of the contract reflected the two parties shared responsibility. Any community wishing to subscribe to a contract to combat sand encroachment must first organize itself into a united group, which becomes the principal actor in

the project. As a result of numerous public-awareness campaigns in recent years, women often find themselves as frontline players in terms of their contribution to agricultural production activities and to the rehabilitation of deforested areas in outlying villages (establishing plant nurseries, constructing fences, planting and maintaining trees, etc.).

## *12.4 Socio-economic Impacts of the Kanem Project*

As well as the immediate ecological and technical impacts achieved by the agro-forestry pastoral development project in Kanem (19 villages have been stabilized, 42 *wadis* have been protected by constructing brush fences, planting live fences and setting up windbreaks, and vegetation has been successfully introduced on 71.5 ha of bare land and moving dunes), the socio-economic impacts of the project have been encouraging. Among these impacts are the recuperation of agricultural and pasturelands in villages and *wadis* that were otherwise abandoned to sand dunes and which are now being farmed. Small mammal (hares and other rodents) long since disappeared from the landscape are returning to these regions.

The development project has then contributed significantly to the local economy. The seasonal rural exodus towards large urban centres such as N'djamena, Moundou and Sarh, or neighbouring countries (Saudi Arabia, Sudan, and Libya) has diminished significantly as local people have become increasingly involved in constructing fences and rehabilitating dunes. Actions to combat sand encroachment are often instigated in Kanem either in response to a state of urgency (e.g. in Tarfey) or through short-term projects with often very limited funds. In the absence of a global program integrating the whole of the ecosystem, these actions have generally been localized one-off projects with limited goals, essentially aimed at combating the encroaching dune fronts. Future studies should be orientated towards elaborating (replication and scaling-up) as part of the PDLCD and combat sand encroachment and integrating a national scheme of land planning and development projects at the regional level, based on a systematic approach and careful analysis of the economic feasibility of projects. The participation of local populations through the provision of incentive measures and the involvement of local authorities is essential to the success of these projects (see also Box 9.1).

**Box 9.1: Wind Erosion Control in Bokoro**

Wind erosion is a problem and each year seedlings are abraded and arable land is lost to encroachment by sand. The creation of boscages — barriers made up of hedging and trees — using species that are resistant to or adapted to drought conditions and aridity is a potential and feasible action for local farmers to take.

(continued)

**Box 9.1** (continued)

In an effort to control such damage the following treatments were applied:

1. Simple scarification followed by direct sowing of sorghum (the staple crop).
2. Earthen ridging was constructed, with seeds sown on the ridges.
3. Earthen ridging was constructed, with seeds sown in the furrows.

The crop planted was a local variety of sorghum: 'Kourtofan'. The seeds were sown in rows 60 cm apart, with one seed every 40 cm in plots that were protected by windbreak hedges comprised of nursery-raised seedlings about 20 months old and 1 m high that were planted in rows at regular 1-m intervals around the perimeter. Crop yields in protected fields were higher and survival of sorghum seedlings was enhanced. It took several years for the hedges to become fully effective. Barriers made up of hedging and trees — using species that are resistant to or adapted to drought conditions and aridity is a potential and feasible action for local farmers to take to protect the crop seedling from the encroaching sand and from being scorched by hot sand particles. It is possible to restore degraded land, even severely degraded land, by employing inexpensive and accessible methods.

**Box 9.2: Summary of Ennedi Project in Northern Chad**

In the Ennedi region, of northern Chad there was a Swiss government-supported project to protect the oases from desert encroachment. The global objective of the program is the improvement, perpetuation and wider resonance of local activities aimed at combating desertification, and the development of relations and consultation between the relevant actors and the National Office for the Struggle against Desertification, in order to consolidate and strengthen the measures. The initial results of this support are encouraging. They demonstrate the awareness of the local players and their commitment to the need to combat desertification:

– More than 14,000 m of palisades woven with palms have been constructed along the wind corridors.
– The soil contaminated by sand has been reclaimed and put to good use by the owners. Some 150 date seedlings have been planted on the soil freed from the sand dunes.
– The protection and regeneration of vegetation have allowed the ground water to be recharged.

The international donor and NGO community in conjunction with the Chadian government, are addressing the effects of climate change with programs aimed at better management of dwindling water resources and at holding back the spread of desertified land by planting trees in one of the driest and hottest countries on earth.

The Chadian Environment agency inaugurated a national data collection center in 2001 to compile statistics on desertification in the country. The center, a unit of the Agency for Domestic Energy and the Environment, has ended its pilot phase and it was intended for monitoring a 200 km radius around the capital N'djamena.

Lake Chad was one of the largest fresh bodies of water on the African continent and its disappearance will have a tremendous impact on the population surrounding it. The problem of Lake Chad is increasingly complex because of the international nature of the desertification (Coe and Foley 2001). Lake Chad is a regional problem East African and North African member states of the African Union and the UN must deal with it. A collaborative approach to combating the desertification of Lake Chad is needed to reverse the current trends. Projects centered on Lake Chad's desertification reversal highlights an important aspect of the climate change issue. The treatment of symptoms will not solve the larger problem of global climate change. It will take the efforts of people thousands of kms away in a combined effort to combat the global climate change. The improvement of the global condition will make it easier to accomplish the difficult task of desertification reversal but some of the initiatives already in effect (Boxes 9.1, 9.2, 9.3 and 9.4) can do much to arrest and reverse desertification.

**Box 9.3: Great Green Wall to Stop Sahel Desertification**

The wall envisioned by 11 African countries on the southern border of the Sahara, and their international partners, is aimed at limiting the desertification of the Sahel zone. The building of this pan-African Great Green Wall (GGW) was approved by an international summit in Bonn. The GGW, as conceived by the 11 countries located along the southern border of the Sahara, and their international partners, is aimed at limiting the desertification of the Sahel zone. It will also be a catalyst for a multifaceted international economic and environmental program. The Sahel zone *sens lat*. is the transition between the Sahara in the north and the African savannas in the south, and includes parts of Burkina Faso, Chad, Djibouti, Eritrea, Ethiopia, Mali, Mauritania, Niger, Nigeria, Senegal and Sudan. The GGW initiative initially involved the planting of a 15 km-wide forest belt across the continent, with a band of vegetation as continuous as possible, but rerouted if necessary to skirt around obstacles such as streams, rocky areas and mountains – or to link inhabited areas. Its aim is to ensure the planting and integrated development of economically interesting drought-tolerant plant species, water retention ponds, agricultural production systems and other income-generating activities, as well as basic social infrastructures.

**Box 9.4: Reforestation Using *Acacia albida***

Reforestation using *Acacia albida* (syn. *Faidherbia albida*), a fast-growing leguminous savanna tree, has been proposed to combat desertification in the Sahel. The tree provides valuable livestock fodder, hardwood, and enhances soil fertility. An initial 3-year (1976–1979) rural development project focussed on the establishment of *A.albida* plantations in southwest Chad. The final goal was an ecologically-oriented integrated land management program (Kirmse and Norton 1984). A community-based planting program of *Acacia albida* to enhance local livelihoods and for desertification control was carried out in southwest Chad.

## 13 Conclusions

Chad has demonstrated how the approach embodied in a participatory process was able to contribute to the formation and training of village committees who help organize their communities to fight bushfires and riverbank erosion and get involved in forest management. It helped communities create partnerships with technical service organizations who were able to provide land users with materials they needed for their development projects such as seedling production. It had positive outcomes for women's empowerment. These successes depended on a variety of different contextually appropriate communication tools ranging from video, to traditional musicians to theatre, to community meetings etc. A major achievement is the fact that when the results were shared with national coordinating bodies for the CCD, national committees of the PDLCD as well as NGOs who sponsor projects fighting desertification, those present were convinced to adopt and expand the experience as a useful tool for implementing the aims of the national action plans in combating desertification.

Some policies and regulations have already put in place and to have them fully implemented as part of a long-term national policy that will cover all the areas concerned is a continuing challenge. But there are measures that the government can take now:

- Educate people about the construction of Green belts
- Channel rivers manually to strategic locations
- Ensure that the areas severely affected by land degradation have enough water supply
- Ensure that the people of those areas have a proper diet and their diet is not affected by desertification-induced crop failure
- Channel a river to Lake Chad to act as major water source
- Plant more trees to enhance local transpiration

- Advise farmers and educate them about proper ways to grow crops including crop rotation
- Teach about the consequences of over grazing and risks of using primitive farming techniques
- Make better use of leguminous plants (intercropping) which will fix nitrogen making the soil more fertile and less subjected to desertification
- Promote the use of Solar Ovens and subsidize their purchase as a way to reduce pressure on fuel wood harvesting. Alternative fuel sources, such as gas and biogas, have been introduced in Chad and other countries, along with energy saving stoves and solar-powered cookers.

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