Natural Disasters and Desertification

A Beja nomad village in Kassala state. Climate change and desertification threaten the livelihoods of millions of Sudanese living on the edge of the dry Sahel belt.

Natural disasters and desertification

3.1 Introduction and assessment activities

Introduction

Natural disasters in the contrasting forms of drought and flooding have historically occurred frequently in Sudan, and have contributed significantly to population displacement and the underdevelopment of the country. A silent and even greater disaster is the ongoing process of desertification, driven by climate change, drought, and the impact of human activities.

In Sudan, desertification is clearly linked to conflict, as there are strong indications that the hardship caused to pastoralist societies by desertification is one of the underlying causes of the current war in Darfur.

Given the severity of the impact of such events and processes, there is a clear and urgent need for improved climate analysis, disaster prediction and risk reduction for Sudan in general, and for Darfur in particular. The current and forecast impact of desertification, especially, is poorly understood, and major efforts are required to investigate, anticipate and correct this phenomenon.

This chapter discusses the key linkages between natural disasters, desertification and the environment, as well as options for mitigating both the risk of disasters occurring and their impact when they do occur.

Assessment activities

UNEP's work on climate change and natural disasters in Sudan was part of the larger investigation of the agricultural, forestry and water resource sectors; fieldwork details are accordingly provided in Chapters 8, 9 and 10 respectively.

Though relatively little background literature can be found on flooding in Sudan, a significant body of documentation is available on drought. In addition, a detailed and authoritative project on climate in Sudan was completed in 2003 with the assistance of the UN Framework Convention on Climate Change (UNFCCC) [3.1]. The final reports from this project provide much of the technical basis for the country-specific climate change work presented in this chapter.

Rainfall in the Sahel commonly falls in short torrential bursts, resulting in extensive but short-lived flooding

Even though 2006 was a relatively 'good' year, this small dam in Western Darfur dried up completely. Rain only falls during four months of the year, so surface reserves do not last through the dry season

3.2 Water shortages

Sudan suffers from a chronic shortage of freshwater overall. In addition, water distribution is extremely unequal, with major regional, seasonal and annual variations. Underlying this variability is a creeping trend towards generally drier conditions.

Annual climate variability and drought

Insufficient and highly variable annual precipitation is a defining feature of the climate of most of Sudan. A variability analysis of rainfall records from 1961 to 1990 in Northern and Southern Kordofan found that annual precipitation ranged from 350 to 850 mm, with an average annual variation of 65 percent in the northern parts of Northern Kordofan and 15 percent in the southern parts of Southern Kordofan [3.1].

Annual variability and relative scarcity of rainfall – in the north of Sudan in particular – have a dominant effect on agriculture and food security, and are strongly linked to displacement and related conflicts. Drought events also change the environment, as dry spells kill otherwise long-lived trees and result in a general reduction of the vegetation cover, leaving land more vulnerable to overgrazing and erosion.

Together with other countries in the Sahel belt, Sudan has suffered a number of long and devastating droughts in the past decades. All regions have been affected, but the worst impacts have been felt in the central and northern states, particularly in Northern Kordofan, Northern state, Northern and Western Darfur, and Red Sea and White Nile states. The most severe drought occurred in 1980-1984, and was accompanied by widespread displacement and localized famine. Localized and less severe droughts (affecting between one and five states) were also recorded in 1967-1973, 1987, 1989, 1990, 1991, 1993 and 2000 [3.1].

Isolated drought years generally have little permanent effect on the environment. In the case of central Sudan, however, the eighteen recorded years of drought within the last half-century are certain to have had a major influence on the vegetation profile and soil conditions seen in 2006.

Recent research has indicated that the most likely cause of these historical droughts was a medium-term (years) change in ocean temperature, rather than local factors such as overgrazing [3.2]. Therefore, the potential for such droughts to occur again remains.

Long-term regional rainfall reduction

In addition to and separately from the variation in precipitation noted above, there is mounting evidence of long-term regional climate change in several parts of the country. This is witnessed by a very irregular but marked decline in rainfall, for which the clearest indications are again found in Kordofan and Darfur states.

Table 4 below summarizes the long-term trends noted, as indicated by thirty-year moving averages of annual precipitation for three locations in Darfur.

Precipitation records have been kept in Darfur since 1917. However, there are still only three continuously monitored stations for an area of over 0.8 million km^2. The data below shows an overall trend of declining rainfall, with the most marked decrease on the northern edge of the Sahel in Northern Darfur. Since records began, the ten-year moving average for El Fasher has declined from 300 mm per annum to approximately 200 mm, while the last time rainfall exceeded 400 mm was in 1953 [3.3].

The scale of historical climate change as recorded in Northern Darfur is almost unprecedented: the reduction in rainfall has turned millions of hectares of already marginal semi-desert grazing land into desert. The impact of climate change is considered to be directly related to the conflict in the region, as desertification has added significantly to the stress on the livelihoods of pastoralist societies, forcing them to move south to find pasture.

A more detailed discussion of linkages between climate change and conflict in Darfur is provided in Chapter 4.

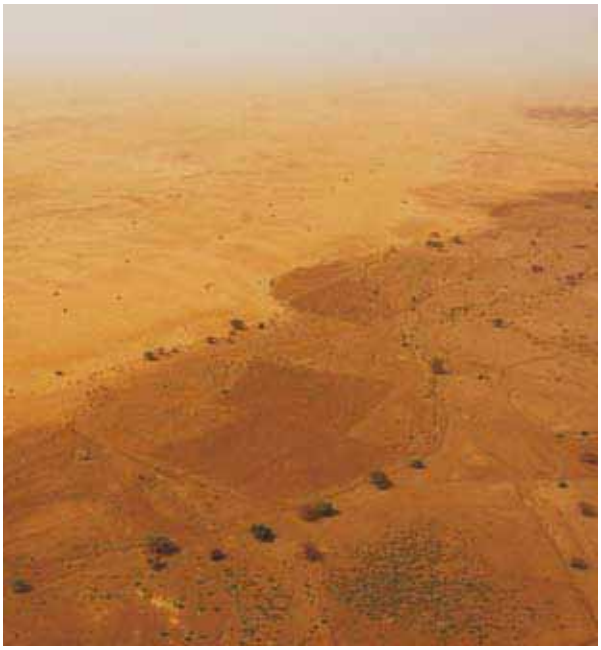
The foundations of an abandoned village on the steep hills of the northern limits of the Jebel Marra plateau, Northern Darfur. Evidence of abandonment of rural land can be found all along the northern edge of the Sahel

Climate change model predictions provide grim warnings for dryland Sudan

The Sudan climate change study conducted in 2003 provides a solid technical basis for discussion. Moreover, a range of very recent regional studies, as well as a number of additional assessments of the potential impacts of climate change, indicate good agreement with earlier work. Following is a concise summary of this work, to set the context for the findings of UNEP's assessment.

Table 4. Long-term rainfall reduction in Darfur

Rain gauge location	Average annual rainfall (mm) 1946 - 1975	Average annual rainfall (mm) 1976 - 2005	Reduction (-)	Percentage
El Fasher, Northern Darfur	272.36	178.90	- 93.46	- 34 %
Nyala, Southern Darfur	448.71	376.50	- 72.21	- 16 %
El Geneina, Western Darfur	564.20	427.70	- 136.50	- 24 %



There is generally no clear edge to the desert, but in this case in Northern Darfur, the boundary between the overgrazed sandy rangeland and the threatened rain-fed agricultural zone is quite marked

The 2003 study selected Northern and Southern Kordofan for detailed analysis; all the results presented thus relate to those areas only. A 'baseline climate' was determined using rainfall and temperature data from 1961 to 1990. A range of global warming scenarios were then modelled to predict changes in temperature and rainfall from the baseline to the years 2030 and 2060.

The climate model results indicated a 0.5 to 1.5°C rise in the average annual temperature and an approximate five percent drop in rainfall, though results varied across the study area. These findings were then used to project the scale of potential changes in crop yields for sorghum, millet and gum arabic.

The final results are alarming: the crop models show a major and potentially disastrous decline in crop production for Northern Kordofan and lesser but significant drops further south. For example, the modelled sorghum production in the region of El Obeid is predicted to drop by 70 percent, from 495 kg/hectare to 150 kg/hectare.

These dramatic findings are due principally to the fact that the region is situated on the fringes of the Sahara desert and on the northern limit of viability for rain-fed crop production, where even small increases in temperature and minor reductions in precipitation could tip the balance towards desert-like conditions.

Other climate models covering all of Africa generally predict similar problems, although there are some major differences in predicted annual rainfall [3.4, 3.5]. One model, which focused on changes in the growing season, predicted that in the Sahel belt, growing seasons would reduce and the percentage of failed harvests would increase [3.6]. The scale of the change varies from region to region, but in Darfur it is predicted to be in the order of 5 to 20 percent from 2000 levels by 2020.

Summary: history and modelling combine for a downward forecast

Historical data, anecdotal field reports and modelling all point to the same general trend. Overall, rainfall is becoming increasingly scarce and/or unreliable in Sudan's Sahel belt, and this trend is likely to continue. On this basis alone, large tracts of the Sahel will be severely impacted by declining food productivity over the next generation and beyond.

Settlements like Malka in Northern Darfur are already on the margins of survival; a small reduction in rainfall could suffice to render large parts of the semi-arid desert fringe unviable. Land degradation is clearly visible as large swathes of bare red subsoil

3.3 Desertification: Sudan's greatest environmental problem

Desertification, as defined in the UN Convention to Combat Desertification, is the degradation of land in arid, semi-arid and dry sub-humid areas caused by climatic change and human activities.

In northern Sudan, there is high awareness of the issue of desertification within the academic community, and historical evidence of a number of attempts to quantify and/or limit the extent of the problem since at least the 1950s [3.7]. As early as 1953, a landmark study discussed several of the sources of the problem (such as overgrazing), as well as its implications (long-term damage and reductions in productivity) [3.8].

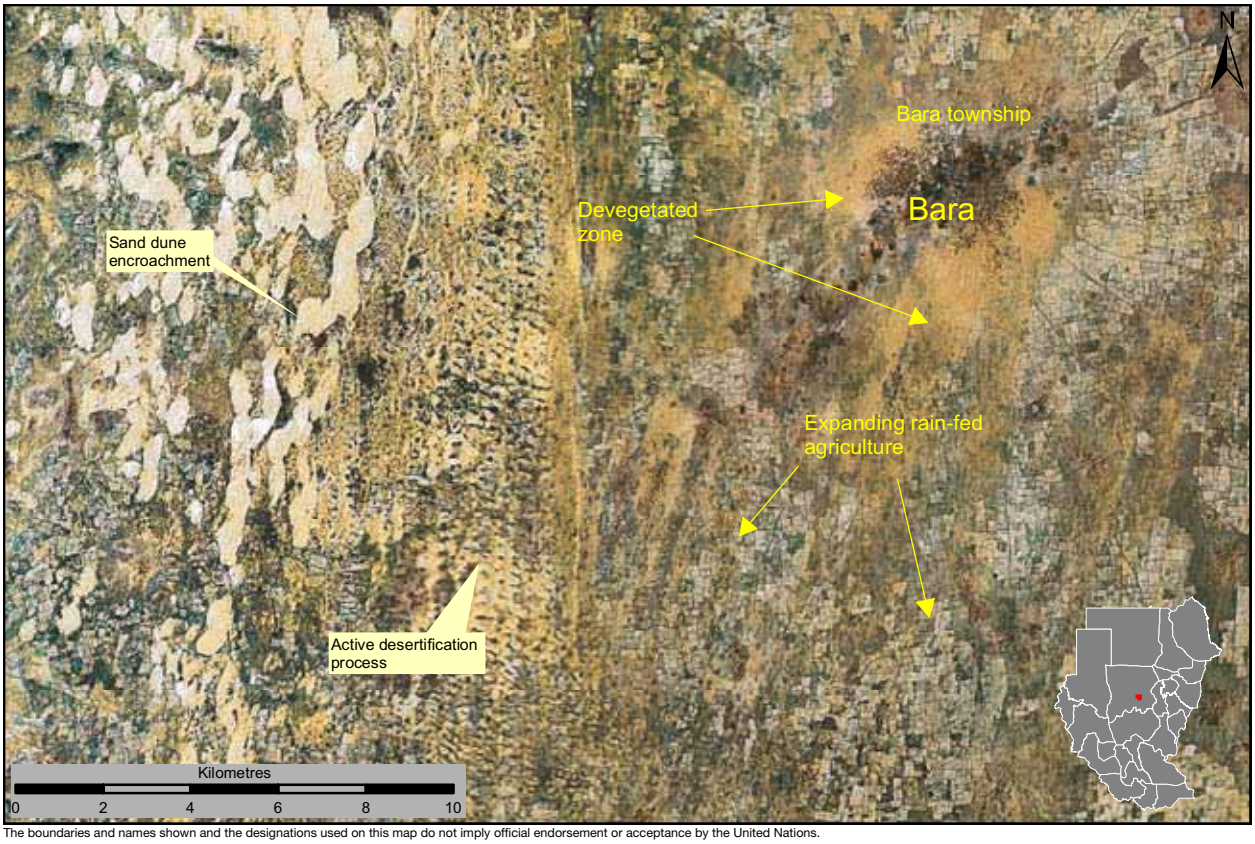
UNEP considers that three compounding desertification processes are underway in Sudan, which are relatively difficult to distinguish, separate and quantify on the ground:

1. Climate-based conversion of land types from semi-desert to desert. The scale and duration of the reduction in rainfall noted above is sufficient to have changed the natural environment, irrespective of human influence. This type of change occurs as a regional process, where less drought-resistant vegetation gradually dies off or fails to reproduce, resulting in a lower-density mix of different species. In a shift as rapid as that observed in Northern Darfur and Northern Kordofan, this is manifest first and foremost in the widespread death of trees during drought events, which are not followed by recovery. This has been the case for *Acacia senegal*, the tree that produces gum arabic (see Case Study 8.2), for example. The limited figures available indicate a southward shift in desert climate of approximately 100 km over 40 years [3.7].

2. Degradation of existing desert environments, including *wadi*s and oases. At least 29 percent of Sudan is already true desert. Within this large area, however, are hundreds of smaller wetter regions

Fuelwood vendors in Red Sea state. Deforestation is a major cause of land degradation in desert environments. Tree cover is concentrated in seasonal wadis, where it helps retain soil that would otherwise be swept away by wind and flash floods

Figure 3.1 Desertification in Bara district, Northern Kordofan



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

These date palms are submerged by shifting sands. Farmers have attempted to hold back the sands by building walls around the trees, but these will eventually be submerged as well

resulting from localized rainfall catchments, rivers and groundwater flows. Virtually all such areas inspected by UNEP were found to be moderately to severely degraded, principally due to deforestation, overgrazing and erosion.

3. Conversion of land types from semi-desert to desert by human action. Over-exploitation of semi-desert environments through deforestation, overgrazing and cultivation results in habitat conversion to desert, even though rainfall may still be sufficient to support semi-desert vegetation. In Sudan, a particular problem has been the conversion of dry and fragile rangelands into traditional and mechanized cropland. A detailed analysis of these processes is provided in Chapter 8.

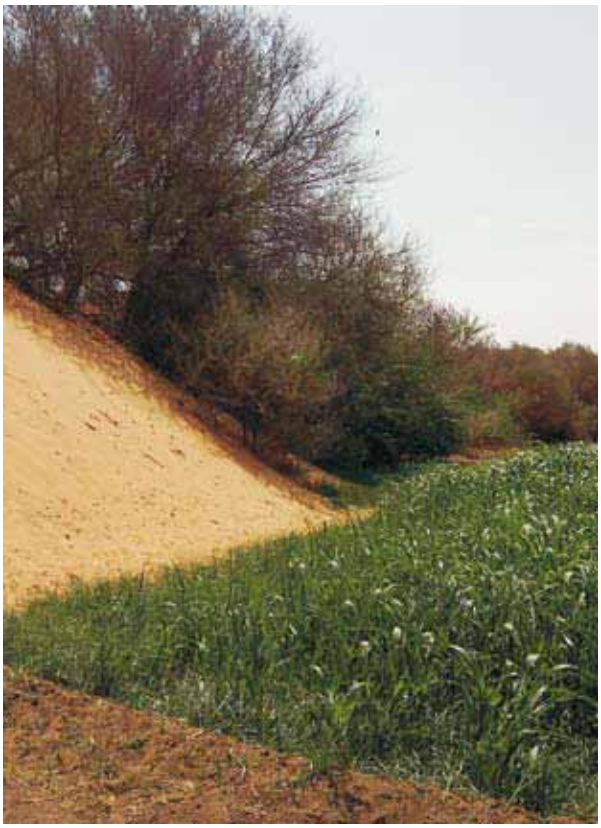
Regional differences in soil types and topography also play a part in this complex three-pronged process. The soil in the north and west of Sudan, for instance, is sandy and prone to water and wind erosion, while the south and east have more resistant clay soil. In addition, mountain ranges such as the Jebel Marra plateau form high rainfall watersheds in otherwise arid areas.

To summarize, there is sufficient disseminated evidence to support the following findings:

- Moderate to severe land degradation is ongoing in the desert and semi-arid regions that cover the northern half of Sudan;
- A 50 to 200 km southward shift of the boundary between desert and semi-desert has occurred since rainfall and vegetation records began in the 1930s. This shift, however, has not been well quantified and is based largely on anecdotal evidence and small-scale studies;
- The desert and semi-desert boundaries are expected to continue to shift southwards due to declining precipitation/reliability of precipitation;
- Most of the remaining semi-arid and low rainfall savannah on sand, representing approximately 25 percent of Sudan's agricultural land, is at considerable risk of further desertification, to the extent that food production in these regions will at minimum plateau, and more likely continue to drop significantly (i.e. up to 20 percent or more); and
- Modelled predictions of a future 70 percent drop in food production in Northern Kordofan have actually already taken place on a smaller scale and on a short-term and local basis, due to reduced rainfall and ongoing land degradation and abandonment. This trend is expected to worsen with time and the predicted result is that in the absence of major changes in agricultural patterns, food insecurity will only increase in these regions.

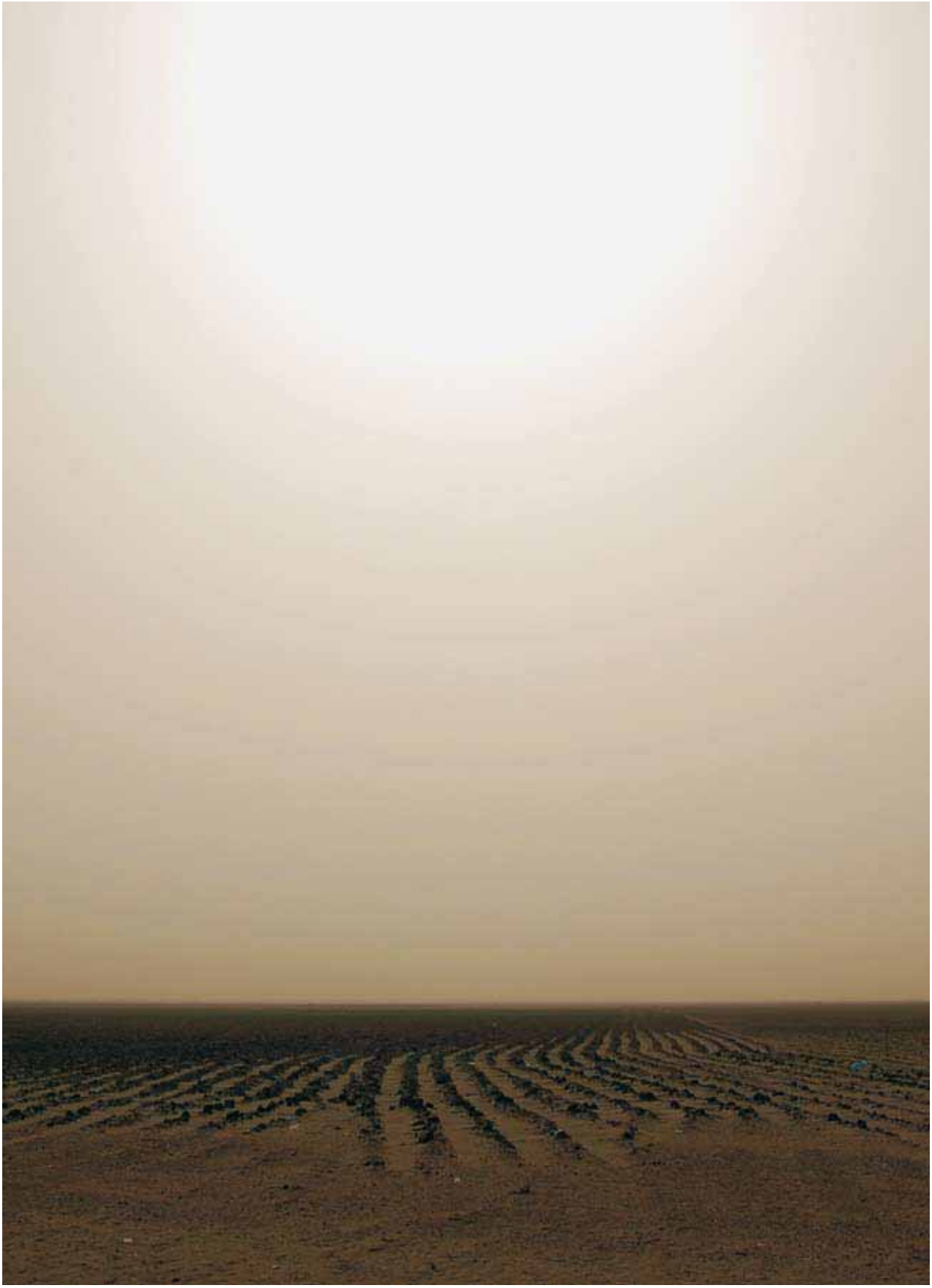
The area at greatest risk is the Sahel belt, as shown in Figure 2.5. It includes the conflict-affected parts of Darfur, the previously drought-stricken parts of Northern Kordofan and Khartoum states, and conflict- and drought-stricken Kassala state.

Much of the evidence for the above findings is piecemeal, anecdotal and/or based on site-specific data. The limited numerical data available does validate the anecdotal findings, but further solid and comprehensive analysis is clearly needed.



A thin tree belt prevents a dune from overwhelming irrigated fields in Northern state

The fields' survival is threatened by uncontrolled cutting in the nearby protective tree belt



This abandoned field within a collapsed irrigation scheme in Khartoum state previously supported low density rangeland. It is now barren and its remaining topsoil is being blown away

3.4 Water damage

Flooding

Despite serious water shortages, floods are common in Sudan. The two predominant types of floods are localized floods caused by exceptionally heavy rains and run-off (flash floods), and widespread floods caused by overflow of the Nile and its tributaries.

Severe flash floods were recorded in 1962-1965, 1978-1979, 1988, 1994, 1998, 1999 [3.1] and 2006. This last flood was directly observed by UNEP in the field. Though generally short in duration, these events can cause major damage to villages and urban and agricultural areas located in catchment and drainage zones.

Nile floods usually originate from heavy rainfall in the (now largely deforested) catchment areas of the Ethiopian mountains, which causes unpredictable surges in the flow of the Blue Nile. The sequence of severe Nile floods – which were recorded in 1878, 1946, 1988, 1994, 1998 and 2006 – clearly shows that the frequency of flooding has increased dramatically over the last twenty years.

Riverbank erosion

Riverbank erosion is a natural phenomenon in Sudan that can, in extreme cases, be characterized as a local disaster due to its social and environmental impacts. This problem is most acute on the main Nile downstream from Khartoum, where peak wet season flows and river channel changes result in very rapid removal of land from riverside terraces.

On the main Nile in Northern state. One of the causes of riverbank erosion is the increased frequency of sand dune migration into the Nile, as the rapid influx of sand alters the riverflow, resulting in downstream erosion as well as sediment deposition

The destruction witnessed by UNEP field teams is impressive. For example, an estimated 17 percent of Ganati (1,420 ha), 25 percent of El Zouma (200 ha) and 30 percent of El Ghaba (1,215 ha) cooperative societies in Northern state have been swept away in flood peaks [3.9]. Moreover, bank erosion leads to sedimentation problems elsewhere.

Flash flooding 20 km north of Khartoum, September 2006

The submerged Sunut Forest wetland in the metropolitan Khartoum area, August 2006. The flooding of the Nile is an annual natural event

Farmers in Northern state watch as the date palms on which their livelihoods depend are washed away by riverbank erosion

3.5 Disaster risk reduction and the mitigation of desertification

The potential to predict and limit impacts

The past thirty years have seen major developments in the field of disaster prediction and risk reduction. It is now generally recognized that while the natural phenomena causing disasters are in most cases beyond human control, the vulnerability (of affected communities) is generally a result of human activity. This is particularly clear in Sudan.

Drought. The vulnerability to drought is partly related to social and development factors such as the tendency to maximize herd sizes rather than herd quality, and the lack of secure water resources such as deep boreholes which can be relied upon during short-term droughts.

Completely degraded rangeland in Northern Darfur. This area immediately outside a large IDP camp has been subject to a combination of long-term overgrazing and fodder gathering, with topsoil largely removed and virtually no remnant vegetation or seed stock

As a result of overgrazing, the thin topsoil of this rangeland near El Geneina in Western Darfur is being eroded by wind and water

Desertification. While climate-related desertification cannot be easily addressed, desertification due to human activity can be limited through appropriate land use planning and regulation, to avoid over-exploitation of fragile semi-desert regions.

Flooding. The increase in Blue Nile flooding is considered to result partly from deforestation and overgrazing in the Ethiopian highlands. Besides, the impact of floods in Khartoum state is generally highest in the slums and IDP camps located in low-lying areas previously left unoccupied as they are known by locals to be flood-prone.

Riverbank erosion. While adjustments in river morphology are a natural phenomenon, human action in altering stream discharge and sediment loads has played a significant role in accelerating the process. The main impacts include watershed degradation from deforestation, overgrazing and poor farming practices that increase stream turbidity, and the effects of dams on the Blue Nile and Atbara rivers. The removal of riverbank vegetation through fires or grazing further aggravates the problem, as it weakens the banks' ability to withstand the erosive power of flood peaks. In this context, UNEP anticipates that pulsed water released from the new Merowe dam will become a major cause of downstream riverbank erosion on the main Nile (see Case Study 10.1).

Action required in addition to more studies and plans

Reducing the vulnerability of communities to natural disasters is the core principle of disaster risk reduction. Environmental protection is one component of an integrated response to the issue. For Sudan, this translates into the need for practical risk-reduction measures, such as better rangeland management to create a buffer capacity to deal with periodic droughts, or catchment protection to mitigate flood risk.

There are already numerous policies, strategy papers and small-scale projects aimed at tackling drought and desertification in Sudan [3.7], and similar work is commencing on flood risk reduction. These positive early steps should be supported with substantial follow-up actions.

3.6 Conclusions and recommendations

Conclusion

Conflict, displacement and food insecurity are three of the most pressing issues facing Sudan, and the main reasons for the current international humanitarian aid effort. Natural and partly man-made disasters such as drought, desertification and floods are major contributing causes to these problems.

For the Government of Sudan, tackling these issues will require a major investment in improving natural resources management, as well as the elaboration of new policies for the sustainable use of natural resources. Investment by the international community is also warranted as part of the shift from humanitarian relief to sustainable development assistance.

The role of vegetation in controlling desertification is exemplified in this photograph of degraded rangeland in Khartoum state. The clump of grass has been grazed but its roots still retain the underlying soil, while surrounding soil has been removed by wind erosion

Riverbank erosion removed the supports of this irrigation pump intake system within months of its installation, and threatens to destroy it completely. Without mitigatory measures, the site is not suitable for such a project

Background to the recommendations

Rather than establish major investment programmes focused solely on natural disasters and desertification, it is recommended that these issues be integrated into development and food security programmes at the national level. Accordingly, many recommendations relevant to this topic are spread throughout specific sector chapters, including agriculture, forestry, water resources and environmental governance (Chapters 8, 9, 10 and 13 respectively). In this chapter, recommendations are limited to data collection, analysis and coordination.

Because the areas of disaster risk reduction, desertification and adaptation to climate change in Sudan could benefit greatly from better data, robust analysis and improved data accessibility, investing in science is a main theme for these recommendations. A second theme is awareness-raising, as alarming findings such as those expressed in climate change work to date should be validated and widely communicated to promote a national response to these challenges.

Finally, international assistance should play a strong role in the fields of climate change adaptation and disaster risk reduction, as these are global issues for which extensive expertise and financial resources are available to help countries like Sudan.

Recommendations for the Government of National Unity

R3.1 Invest in national weather and drought forecasting services, including in measures to increase data collection and existing data accessibility, and provide improved early warning of drought episodes. This work should tie into existing international early warning and forecasting programmes, such as the US-based Famine Early Warning System.

CA: GI; PB: GONU MAF; UNP: UNEP; CE: 3M; DU: 5 years, ongoing

R3.2 Undertake a major study to truly quantify desertification in Sudan. This should include a combination of fieldwork and remote sensing on both local and national scales.

CA: GI; PB: GONU MAF; UNP: UNEP; CE: 0.5M; DU: 2 years

R3.3 Validate and disseminate climate change findings together with desertification findings. The results of the two studies should be used as the benchmark for land use planning in the dryland states of Sudan.

CA: AS; PB: GONU MAF; UNP: UNEP; CE: 0.5M; DU: 2 years