



# Sudan

## Post-Conflict Environmental Assessment

United Nations Environment Programme



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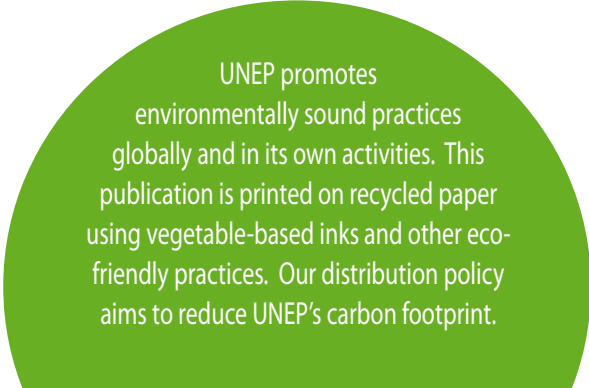
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## Foreword

The peace deal signed in Nairobi by the Sudanese government and the Sudan People's Liberation Movement on 9 January 2005 put an end to more than two decades of civil war in the country. The United Nations family in Nairobi is proud to have played a lead role in the conclusion of the peace process by hosting an exceptional meeting of the United Nations Security Council in November 2004, which facilitated negotiations that led to a Comprehensive Peace Agreement being reached in early 2005.

For most of Sudan, it is now time to focus on recovery, reconstruction and development. In this context, the Government of National Unity and the Government of Southern Sudan requested UNEP to conduct an environmental assessment of the country in order to evaluate the state of Sudan's environment and identify the key environmental challenges ahead. This report presents the findings of the fieldwork, analysis and extensive consultations that were carried out between December 2005 and March 2007, and contains:

- an overview of the environment of Sudan and the assessment process;
- analysis and recommendations for the major cross-cutting issues of climate change, desertification, conflict, and population displacement; and
- analysis and recommendations for key environmental issues in nine different sectors (urban/health, industry, agriculture, forestry, water, wildlife, marine environment, law and foreign aid).

Sudan will not benefit fully from the tangible dividends of peace as long as conflict rages on in Darfur. Despite the signing of a peace agreement in May 2006, violence and insecurity continue to prevail in the region. The United Nations, through its Secretary-General, has designated the resolution of the crisis in Darfur as a main priority, and it is hoped that the findings and recommendations presented in this UNEP report will contribute to this goal.

Indeed, UNEP's investigation has shown clearly that peace and people's livelihoods in Darfur as well as in the rest of Sudan are inextricably linked to the environmental challenge. Just as environmental degradation can contribute to the triggering and



perpetuation of conflict, the sustainable management of natural resources can provide the basis for long-term stability, sustainable livelihoods, and development. It is now critical that both national and local leadership prioritize environmental awareness and opportunities for the sustainable management of natural resources in Sudan.

We wish to sincerely thank the Governments of Sweden and the United Kingdom for their generous financial support, which enabled UNEP to carry out this assessment, organize two environmental workshops for national delegates in Sudan in 2006, and publish this report.

In addition, this assessment would not have been possible without the support of our colleagues in the UN Sudan Country Team, including those in sister agencies such as UNDP, UNICEF, FAO, UNHCR, WFP and OCHA. The Ministries of Environment of the Government of National Unity and the Government of Southern Sudan were also active partners in the assessment process, providing both information and support. We hope that UNEP can remain a long-term partner of the Sudanese authorities and people as they address the environmental challenges ahead.

Achim Steiner  
United Nations Under-Secretary-General  
Executive Director  
of the United Nations Environment Programme



## Executive summary

### Introduction

In January 2005, the Sudanese Government and the Sudan People's Liberation Army signed a Comprehensive Peace Agreement, putting an end to twenty-two years of continuous civil war. With peace and a fast-growing economy fueled by its emerging oil industry, most of the country can now focus on recovery and development.

Sudan, however, faces a number of challenges. Among these are critical environmental issues, including land degradation, deforestation and the impacts of climate change, that threaten the Sudanese people's prospects for long-term peace, food security and sustainable development. In addition, complex but clear linkages exist between environmental problems and the ongoing conflict in Darfur, as well as other historical and current conflicts in Sudan.

### Post-conflict environmental assessment

With a view to gaining a comprehensive understanding of the current state of the environment in

Sudan and catalysing action to address the country's key environmental problems, the Government of National Unity (GONU) and Government of Southern Sudan (GOSS) requested the United Nations Environment Programme (UNEP) to conduct a post-conflict environmental assessment of Sudan. The goal of the UNEP assessment was accordingly to develop a solid technical basis for medium-term corrective action in the field of environmental protection and sustainable development.

### Assessment process

The post-conflict environmental assessment process for Sudan began in late 2005. Following an initial appraisal and scoping study, fieldwork was carried out between January and August 2006. Different teams of experts spent a total of approximately 150 days in the field, on ten separate field missions, each lasting one to four weeks. Consultation with local and international stakeholders formed a large and continuous part of UNEP's assessment work, with the total number of interviewees estimated to be over two thousand. Parties consulted include representatives of federal, state and local governments, NGOs, academic and research institutions, international agencies, community leaders, farmers, pastoralists, foresters and businesspeople.



*The UNEP team on mission in Northern state. Different teams of experts spent 150 days in the field, on ten separate field missions, each lasting one to four weeks*



Figure E.1 General map of Sudan





*The UNEP team interviews a group of local men in Umm al Jawasir, in Northern state. Community hearings and consultations were a critical component of UNEP's assessment work*

The assessment team was comprised of a core UNEP team and a large number of national and international partners who collaborated in a range of roles. These partnerships were crucial to the project's success, as they enabled the fieldwork, ensured that the study matched local issues and needs, and contributed to national endorsement of the assessment's outcomes. UNEP also worked closely with the Government of National Unity and the Government of Southern Sudan, and specific efforts were made to align UNEP activities with a government initiative known as the National Plan for Environmental Management.

## Summary of the findings

The assessment identified a number of critical environmental issues that are closely linked to the country's social and political challenges.

### **Strong linkages between environment and conflict: a key issue in the Darfur crisis**

The linkages between conflict and environment in Sudan are twofold. On one hand, the country's long history of conflict has had significant impacts on its environment. Indirect impacts such as population displacement, lack of governance, conflict-related resource exploitation and under-

investment in sustainable development have been the most severe consequences to date.

On the other hand, environmental issues have been and continue to be contributing causes of conflict. Competition over oil and gas reserves, Nile waters and timber, as well as land use issues related to agricultural land, are important causative factors in the instigation and perpetuation of conflict in Sudan. Confrontations over rangeland and rain-fed agricultural land in the drier parts of the country are a particularly striking manifestation of the connection between natural resource scarcity and violent conflict. In all cases, however, environmental factors are intertwined with a range of other social, political and economic issues.

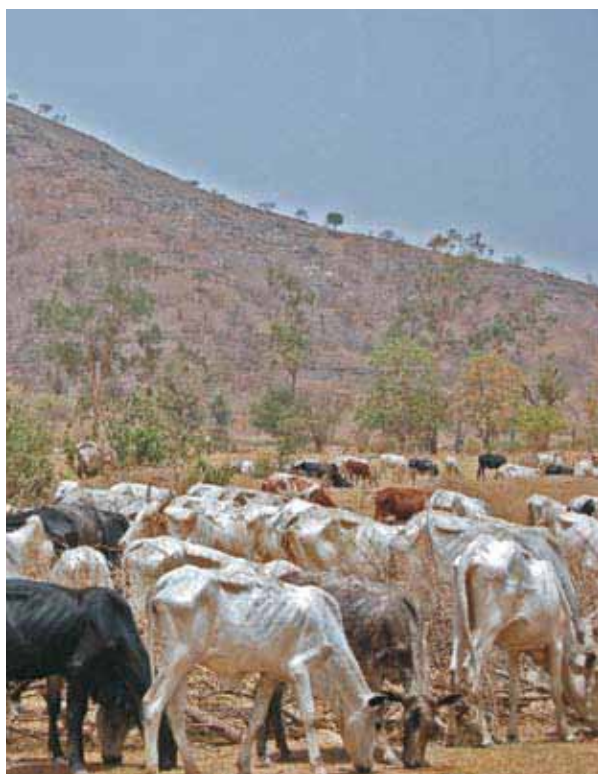
UNEP's analysis indicates that there is a very strong link between land degradation, desertification and conflict in Darfur. Northern Darfur – where exponential population growth and related environmental stress have created the conditions for conflicts to be triggered and sustained by political, tribal or ethnic differences – can be considered a tragic example of the social breakdown that can result from ecological collapse. Long-term peace in the region will not be possible unless these underlying and closely linked environmental and livelihood issues are resolved.



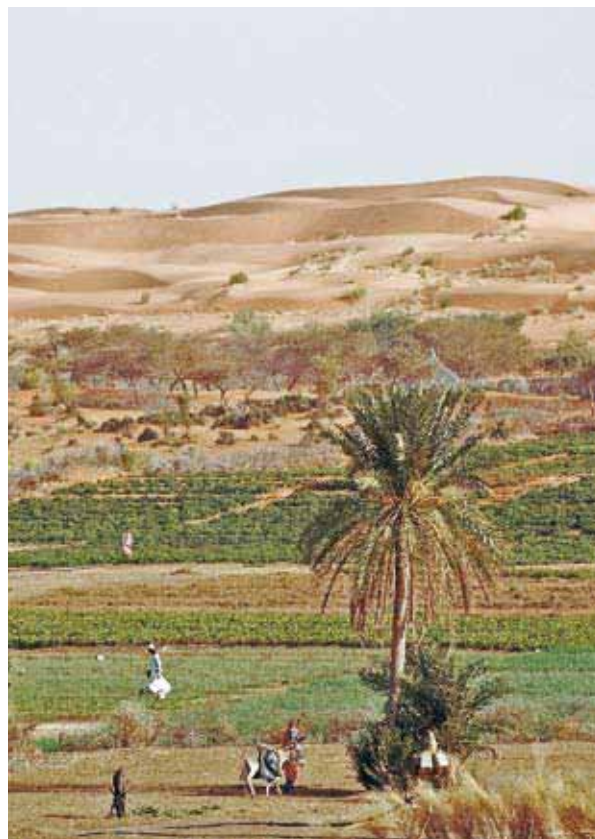
### Population displacement: significant environmental impacts

With over five million internally displaced persons (IDPs) and international refugees, Sudan has the largest population of displaced persons in the world today. In Darfur, internal displacement has occurred at an unprecedented rate since 2003, with some 2.4 million people affected. This massive population displacement has been accompanied by significant human suffering and environmental damage. Areas around the larger camps – particularly in Darfur – are severely degraded, and the lack of controls and solutions has led to human rights abuses, conflicts over resources and food insecurity. Although this is not a new phenomenon, the scale of displacement and the particular vulnerability of the dry northern Sudanese environment may make this the most significant case of its type worldwide.

In addition, the large-scale return of southern Sudanese to their homeland following the cessation of the civil war is likely to result in a further wave of environmental degradation in some of the more fragile return areas.



*Cattle in poor condition on overgrazed land near El Geneina, Western Darfur. Intense competition over declining natural resources is a contributing cause of the ongoing conflict in the region*



*Desertification and the associated loss of agricultural land are not an inevitable and unstoppable process. Good management practices can sustain agriculture even in seemingly arid and hostile environments, as in this dune belt in Northern Kordofan*

### Desertification and regional climate change: contributing to poverty and conflict

An estimated 50 to 200 km southward shift of the boundary between semi-desert and desert has occurred since rainfall and vegetation records were first held in the 1930s. This boundary is expected to continue to move southwards due to declining precipitation. The remaining semi-desert and low rainfall savannah on sand, which represent some 25 percent of Sudan's agricultural land, are at considerable risk of further desertification. This is forecast to lead to a significant drop (approximately 20 percent) in food production. In addition, there is mounting evidence that the decline in precipitation due to regional climate change has been a significant stress factor on pastoralist societies – particularly in Darfur and Kordofan – and has thereby contributed to conflict.



### **Natural disasters: increasing vulnerability and impacts**

Sudan has suffered a number of long and devastating droughts in the past decades, which have undermined food security and are strongly linked to human displacement and related conflicts. The vulnerability to drought is exacerbated by the tendency to maximize livestock herd sizes rather than quality, and by the lack of secure water sources such as deep boreholes that can be relied on during short dry spells.

Despite serious water shortages, floods are also common in Sudan. The most devastating occur on the Blue Nile, as a result of deforestation and overgrazing in the river's upper catchment. One of the main impacts of watershed degradation and associated flooding is severe riverbank erosion in the narrow but fertile Nile riverine strip.

### **Agriculture: severe land degradation due to demographic pressure and poorly managed development**

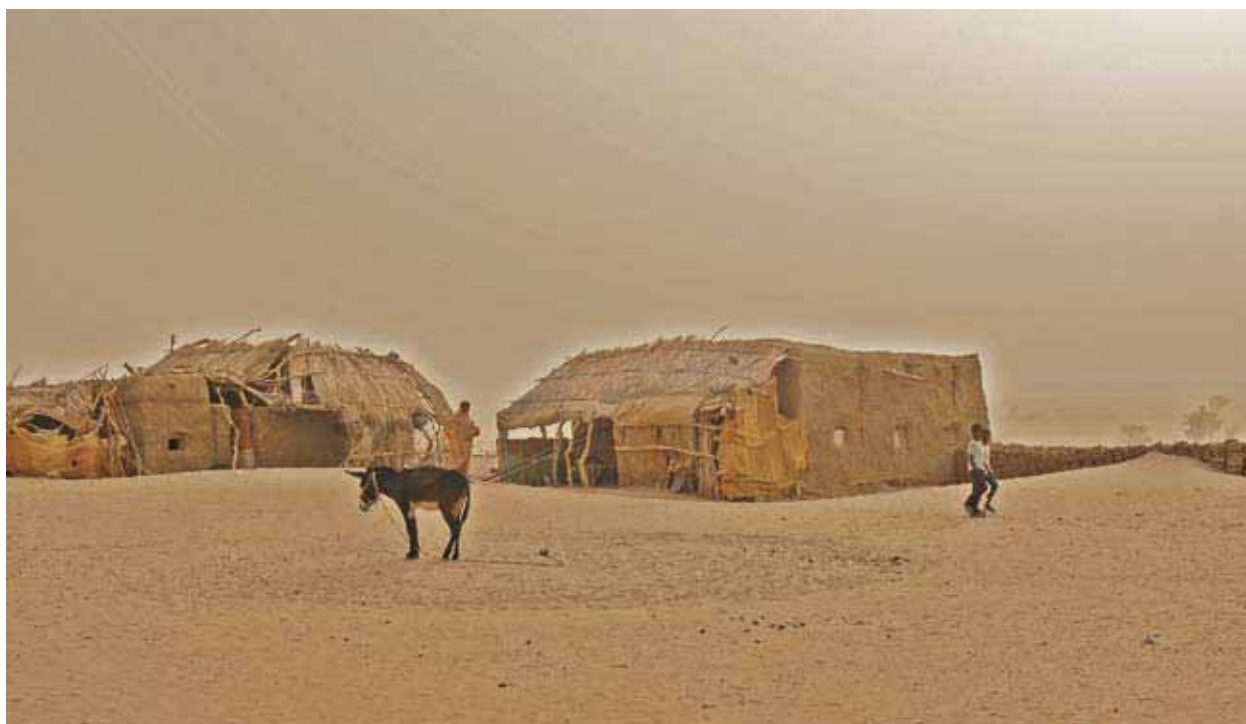
Agriculture, which is the largest economic sector in Sudan, is at the heart of some of the country's most serious and chronic environmental problems, including land degradation in its various forms, riverbank

erosion, invasive species, pesticide mismanagement in the large irrigation schemes, and water pollution. Disorganized and poorly managed mechanized rain-fed agriculture, which covers an estimated area of 6.5 million hectares, has been particularly destructive, leading to large-scale forest clearance, loss of wildlife and severe land degradation.

In addition, an explosive growth in livestock numbers – from 28.6 million in 1961 to 134.6 million in 2004 – has resulted in widespread degradation of the rangelands. Inadequate rural land tenure, finally, is an underlying cause of many environmental problems and a major obstacle to sustainable land use, as farmers have little incentive to invest in and protect natural resources.

### **Forestry: a deforestation crisis in the drier regions, risks and opportunities in the south**

Deforestation in Sudan is estimated to be occurring at a rate of over 0.84 percent per annum at the national level, and 1.87 percent per annum in UNEP case study areas. It is driven principally by energy needs and agricultural clearance. Between 1990 and 2005, the country lost 11.6 percent of its forest cover, or approximately 8,835,000



*The most serious and common natural disaster facing the population of Sudan is drought. Rural communities such as this village in Khartoum state have faced waves of drought since the 1970s, which have exacerbated rural poverty and precipitated large-scale displacement to the northern cities*



*Abandoned degraded agricultural land in a former irrigation scheme near Tandelti in Northern Kordofan*

hectares. At the regional level, two-thirds of the forests in north, central and eastern Sudan disappeared between 1972 and 2001. In Darfur, a third of the forest cover was lost between 1973 and 2006. Southern Sudan is estimated to have lost 40 percent of its forests since independence and deforestation is ongoing, particularly around major towns. Extrapolation of deforestation rates indicate that forest cover could reduce by over 10 percent per decade. In areas under extreme pressure, UNEP estimates that total loss could occur within the next 10 years.

These negative trends demonstrate that this valuable resource upon which the rural population and a large part of the urban population depend completely for energy is seriously threatened. The growing use of fuelwood for brick-making in all parts of Sudan is an additional cause for concern. In Darfur, for instance, brick-making provides a livelihood for many IDP camp residents, but also contributes to severe localized deforestation. If it were properly managed, however, the forestry sector could represent a significant opportunity for economic development and sustainable north-south trade.



*A mango orchard in Juba, Central Equatoria. The combination of higher rainfall and lower population and development pressure results in Sudan's remaining forest cover being concentrated in the southern half of the country*





*The rusting wreckage of the Jonglei canal excavator lies in the unfinished main channel. This failed venture illustrates the risks associated with developing large-scale projects in socially and environmentally sensitive areas without local support*

### **Dams and water projects: major impacts and conflict linkages**

UNEP considers the principal and most important environmental issue in the water resource sector in Sudan to be the ongoing or planned construction of over twenty large dams. While its electrical output is expected to bring major benefits to the country, the Merowe dam epitomizes environmental and social concerns over the country's ambitious dam-building programme. Although it is the first dam project in Sudan to have included an environmental impact assessment, the process did not meet international standards, and would have benefited from more transparency and public consultation. Major environmental problems associated with the Merowe dam include silt loss for flood recession agriculture, dam sedimentation and severe riverbank erosion due to intensive flow release within short time periods.

In addition, the active storage capacity of all of Sudan's existing dam reservoirs (with the exception of Jebel Aulia) is seriously affected by sediment deposition. Dams have also caused major degradation of downstream habitats,

particularly of the maya wetlands on the Blue Nile and of the riparian *dom* palm forests in the lower Atbara river.

The infamous Jonglei canal engineering mega-project, which started in the 1970s, was closely linked to the start of the north-south civil war. As it was not completed, its anticipated major impacts on the Sudd wetlands never came to pass. The unfinished canal bed, which does not connect to any major water bodies or watercourses, now acts only as a giant ditch and embankment hindering wildlife migrations. Nevertheless, lessons learnt from this project should be carefully studied and applied to existing efforts in peacebuilding between north and south, especially as economic motivations for the project still exist, including from international partners.

### **Urban issues and environmental health: rapid and chaotic urbanization and chronic waste and sanitation issues**

Uncontrolled sprawl, chronic solid waste management problems and the lack of wastewater treatment are the leading environmental problems

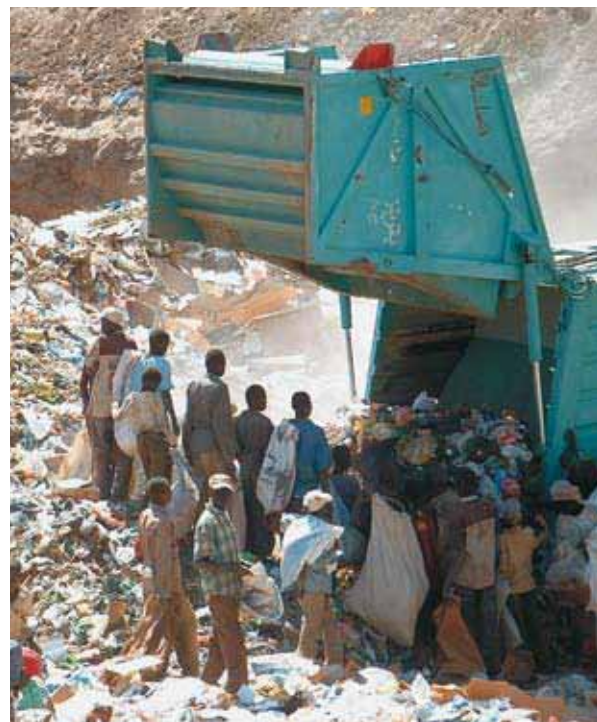


facing Sudan's urban centres. The explosive growth of the capital Khartoum continues relentlessly, with 64 percent of the country's urban population residing in the area. The larger towns of Southern Sudan are also experiencing very rapid growth fueled by the return of formerly displaced persons, estimated at 300,000 by end of 2006. In Darfur, the majority of the two million displaced are found on the fringes of urban centres, whose size in some cases has increased by over 200 percent in the last three years.

Sewage treatment is grossly inadequate in all of Sudan's cities, and solid waste management practices throughout the country are uniformly poor. In the majority of cases, garbage of all types accumulates close to its point of origin and is periodically burnt. These shortcomings in environmental sanitation are directly reflected in the elevated incidence of waterborne diseases, which make up 80 percent of reported diseases in the country.



*The release of industrial effluent from older factories lacking wastewater treatment facilities is an issue of particular concern*



*Waste pickers at the main Khartoum landfill site. Waste management is problematic throughout Sudan.*

#### **Industrial pollution: a growing problem and a key issue for the emerging oil industry**

Environmental governance of industry was virtually non-existent until 2000, and the effects of this are clearly visible today. While the situation has improved over the last few years, UNEP has found that major challenges remain in the areas of project development and impact assessment, improving the operation of older and government-managed facilities, and influencing the policies and management approach at the higher levels of government.

Due to the relatively limited industrial development in Sudan to date, environmental damage has so far been moderate, but the situation could worsen rapidly as the country embarks on an oil-financed development boom. The release of effluent from factories and the disposal of produced water associated with crude oil extraction are issues of particular concern, as industrial wastewater treatment facilities are lacking even in Khartoum. Industrial effluent is typically released into the domestic sewage system, where there is one.



*The all-women State Environment Council Secretariat in Gedaref state. The CPA and Interim Constitution devolve extensive responsibility to state governments in the area of environmental governance. State-level structures, however, remain under-funded and in need of substantial investment*

Other issues include air emissions, and hazardous and solid waste disposal. While UNEP observed generally substandard environmental performance at most industrial sites, there were exceptional cases of responsible environmental stewardship at selected oil, sugar and cement facilities visited.

**Wildlife and protected areas: depleted biodiversity with some internationally significant areas and wildlife populations remaining**

The past few decades have witnessed a major assault on wildlife and their habitats. In northern and central Sudan, the greatest damage has been inflicted by habitat destruction and fragmentation from farming and deforestation. Larger wildlife have essentially disappeared and are now mostly confined to core protected areas and remote desert regions. In the south, uncontrolled and unsustainable hunting has decimated wildlife populations and caused the local eradication of many of the larger species, such as elephant, rhino, buffalo, giraffe, eland and zebra. Nonetheless, Sudan's remaining wildlife populations, including very large herds of white-eared kob and tiang antelope, are internationally significant.

Approximately fifty sites throughout Sudan – covering 10 and 15 percent of the areas of the north and south respectively – are listed as

having some form of legal protection. In practice, however, the level of protection afforded to these areas has ranged from slight to negligible, and several exist only on paper today. Many of these important areas are located in regions affected by conflict and have hence suffered from a long-term absence of the rule of law. With three exceptions (Dinder, Sanganeb and Dongonab Bay National Parks), the data on wildlife and protected areas is currently insufficient to allow for the development of adequate management plans.

**Marine environment: a largely intact ecosystem under threat**

UNEP found the Sudanese marine and coastal environment to be in relatively good condition overall. Its coral reefs are the best preserved ecosystems in the country. However, the economic and shipping boom focused on Port Sudan and the oil export facilities may rapidly change the environmental situation for the worse. Steady degradation is ongoing in the developed strip from Port Sudan to Suakin, and the symptoms of overgrazing and land degradation are as omnipresent on the coast as elsewhere in dryland Sudan. Mangrove stands, for example, are currently under severe pressure along the entire coastline. Pollution from land-based sources and the risk of oil spills are further issues of concern.



### **Environmental governance: historically weak, now at a crossroads**

By granting the Government of Southern Sudan and the states extensive and explicit responsibility in the area of environment and natural resources management, the CPA and new Interim Constitutions have significantly changed the framework for environmental governance in Sudan and helped create the conditions for reform.

At the national level, the country faces many challenges to meet its international obligations, as set out in the treaties and conventions it has signed over the last thirty years. Although the technical skill and level of knowledge in the environmental sector are high and some legislation is already in place, regulatory authorities have critical structural problems, and are under-resourced.

In Southern Sudan, environmental governance is in its infancy, but the early signs are positive. High-level political and cross-sector support is visible, and UNEP considers the new structures to be relatively suited to the task.

### **Environment and international aid: reduced environmental impact of relief operations and improved UN response to environmental issues necessary**

The environmental assessment of the international aid programme in Sudan raised a number of issues that need to be resolved to avoid inadvertently doing harm through the provision of aid, and to improve the effectiveness of aid expenditure in the environmental sector. UNEP's analysis indicates that while most aid projects in Sudan do not cause significant harm to the environment, a few clearly do and the overall diffused impact of the programme is very significant.

One major and highly complex issue is the environmental impact of the provision of food and other emergency aid to some 15 percent of the population, and the projected impact of the various options for shifting back from aid dependence to autonomous and sustainable livelihoods. Indeed, the country is presently caught in a vicious circle of food aid dependence, agricultural underdevelopment and environmental degradation. Under current



*The coral reefs of the Red Sea coast are the best preserved ecosystems of Sudan*

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circumstances, if aid were reduced to encourage a return to agriculture, the result in some areas would be food insecurity and an intensification of land degradation, leading to the high likelihood of failure and secondary displacement.

The integration of environmental considerations into the current UN programme in Sudan needs to be significantly improved. In addition, the environment-related expenditure that does occur – while acknowledged and welcome – suffers from a range of management problems that reduce its effectiveness. Priorities for the UN and its partners in this field are improved coordination and environmental mainstreaming to ensure that international assistance ‘does no harm’ to Sudan’s environment, and ‘builds back better’

## Recommendations

1. **Invest in environmental management to support lasting peace in Darfur, and to avoid local conflict over natural resources elsewhere in Sudan.** Because environmental degradation and resource scarcity are among the root causes of the current conflict in Darfur, practical measures to alleviate such problems should be considered vital tools for conflict prevention and peacebuilding. Climate change adaptation measures and ecologically sustainable rural development are needed in Darfur and elsewhere to cope with changing environmental conditions and to avoid clashes over declining natural resources.



*A group of southern Sudanese travels down the White Nile aboard a ferry, returning to the homeland after years of displacement due to the civil war. A massive return process is currently underway for the four million people displaced during the conflict*



*A food aid delivery awaits distribution at Port Sudan. Fifteen percent of Sudan's population depends on international food aid for survival*

2. **Build capacity at all levels of government and improve legislation to ensure that reconstruction and economic development do not intensify environmental pressures and threaten the livelihoods of present and future generations.** The new governance context provides a rare opportunity to truly embed the principles of sustainable development and best practices in environmental management into the governance architecture in Sudan.
3. **National and regional government should assume increasing responsibility for investment in the environment and sustainable development.** The injection of oil revenue has greatly improved the financial resources of both the Government of National Unity and the Government of Southern Sudan, enabling them to translate reform into action.
4. **All UN relief and development projects in Sudan should integrate environmental considerations in order to improve the effectiveness of the UN country programme.** Better coordination and environmental

mainstreaming are necessary to ensure that international assistance 'does no harm' to Sudan's environment.

### **The way forward and the UNEP Sudan country programme**

This report's 85 detailed recommendations include individual cost and time estimates, and nominate responsible parties for implementation. While they envisage a central and coordinating role for the environment ministries of GONU and GOSS, the wholehearted support and participation of many other government ministries and authorities, as well as several UN agencies, are also needed. The total cost of the recommendations is USD 120 million with expenditure spread over five years. UNEP considers that the majority should be financed by GONU and GOSS, with the balance provided by the international community.

For its part, UNEP plans to establish a Sudan country programme for the period of at least 2007-2009, and stands ready to assist the Government of Sudan and international partners in the implementation of these recommendations.

# Introduction

*Farmers in the Tokar delta, in Red Sea state. The rich silt deposited annually in the Tokar delta historically supported intensive agriculture in the region, including an export cotton industry. From 1993 to 2005, the conflict between Sudan and Eritrea forced the local population off the land, leading some 50,000 hectares to become overgrown with a dense thicket of the invasive mesquite tree. The land is now gradually being cleared and converted back to agriculture.*





# Introduction

## 1.1 Background

In January 2005, after more than two decades of devastating civil war, the Sudanese central government in Khartoum and the Sudan People's Liberation Army in the south signed a historic Comprehensive Peace Agreement. This landmark achievement – which was followed by the adoption of an Interim Constitution – brought peace to most of the country for the first time in a generation.

Now, thanks to the rapid development of its oil industry, Sudan is one of the fastest-growing economies in Africa. Direct investment and international aid are starting to flow into the country on a large scale, and some parts of Sudan are undergoing brisk development.

As it focuses on recovery and development, however, the country faces a number of key challenges. Chief among them are several critical environmental issues – such as land degradation, deforestation and the impacts of climate change – that threaten Sudan's prospects for long-term peace, food security and sustainable development.

Recent tensions in north-south border regions have highlighted several environmental issues that constitute potential flashpoints for renewed conflict, including the environmental impacts of the oil industry and the management of the country's water resources.

In Darfur, where violence and insecurity continue to prevail despite the signing of a peace agreement in May 2006, complex but clear linkages exist between environmental problems and the ongoing conflict. Indeed, climate change, land degradation and the resulting competition over scarce natural resources are among the root causes as well as the consequences of the violence and grave humanitarian situation in the region.

Natural resource management and rehabilitation, therefore, are not only fundamental prerequisites to peacebuilding in Darfur and the rest of Sudan – they must become a national priority if the country is to achieve long-term social stability and prosperity.

With a view to obtaining a comprehensive understanding of the current state of the environment in Sudan, and catalysing action to address the country's key environmental problems, the Government of National Unity (GONU) and Government of Southern Sudan (GOSS) requested the United Nations Environment Programme (UNEP) to conduct a post-conflict environmental assessment of Sudan. The present report is the principal product of the resulting national-scale assessment project, managed by UNEP over the period November 2005 to January 2007.

## 1.2 Objectives

### Goal and objectives

The goal of the UNEP post-conflict environmental assessment for Sudan was to develop a solid technical basis for medium-term (1-5 years) corrective action in the field of environmental protection and sustainable development. This goal was expanded into five objectives:

1. Provide neutral and objective information on the most critical environmental problems facing the country, and on the potential risks to human health, livelihoods and ecosystem services;
2. Recommend strategic priorities for sustainable resource management and identify the actors, timelines and costs necessary for implementation;
3. Facilitate the development of national environmental policy and strengthen the capacity for national environmental governance;
4. Raise awareness and catalyse financial support for environmental projects by national authorities, UN actors, NGOs and donors; and
5. Integrate environmental issues into the recovery and reconstruction process.

This report aims to present the post-conflict environmental issues for Sudan in a single concise document accessible to a wide audience of non-experts. A number of detailed studies were prepared in parallel to provide the technical basis for this PCEA report. Access to the technical report series and further information on Sudan's environment can be obtained from the UNEP Sudan website at <http://sudanreport.unep.ch>.



## Links to the UN country team in Sudan and international UN processes

This report is designed to fit within the United Nations country- and global-level frameworks for Sudan. At the country level, this study aims to assist the UN family to integrate or ‘mainstream’ environmental issues into the UN programme for Sudan, according to the framework provided by the UN Country Team Forum, the annual UN Sudan Work Plan process, and the Sudan National and Darfur Joint Assessment Missions.

At the global level, this report is designed to link with ongoing UN reform processes, which focus on issues such as aid effectiveness, improved coordination and better integration of cross-cutting issues like the environment.

A new and developing theme at the global level – addressed by such high-level bodies as the High-level Panel on System-wide Coherence in the Areas of Development, Humanitarian Assistance and the Environment – is the recognition that environmental degradation has become a major contributor to food insecurity, conflict and vulnerability to natural disasters. It could be argued that this is evident in Sudan today.

### 1.3 Assessment scope

The geographical scope of UNEP’s survey extended to all states of the Republic of Sudan, the coastline, and to territorial seas.

The assessment’s technical scope was developed in two stages – an initial broad scan was followed by a targeted study focused on identified key themes. The final twelve themes, as reflected in the chapters of this report were: natural disasters and desertification; conflict and peacebuilding; population displacement; urban environment and environmental health; industry; agriculture; forest resources; freshwater resources; wildlife and protected area management; marine environments and resources; environmental governance and awareness; and international aid.

To ensure linkages to some of the major humanitarian and governance issues the UN and partners are attempting to address in Sudan,

UNEP’s assessment work also included the following six cross-cutting topics:

1. Capacity-building: to build national capacity during the process by maximizing the use of government counterparts and technical experts;
2. Engagement with local partners: to link the UNEP process with existing and new local initiatives for environmental assessment and management;
3. Livelihoods and food security: to explicitly link the observed environmental issues with their impact on the poor, particularly on the rural poor;
4. Gender: to link environmental issues and impacts with gender, as issues such as water and firewood scarcity have a disproportionately negative impact on women;
5. Peacebuilding: to analyse the linkages between conflict and environment in order to assist ongoing conflict prevention and resolution efforts; and
6. Aid effectiveness: to critically assess the success of what has been attempted so far in this sector and design a more effective response to the environmental issues identified.

### 1.4 Methodology

#### Assessment process

The post-conflict environmental assessment process for Sudan commenced in earnest in late 2005. The major components of this process were:

- an initial appraisal and scoping study;
- consultation;
- desk studies;
- fieldwork;
- remote sensing;
- analysis; and
- development of the recommendations and reporting.

The fieldwork and consultation process are described in more detail below.

## Fieldwork

UNEP's fieldwork was carried out between January and August 2006. Different teams of experts spent a total of approximately 150 days in the field, on ten separate field missions, each lasting one to four weeks. The states covered and the timing of each mission are set out below, while the locations visited and field trip routes are shown in Figure 1.1.

Table 1. UNEP field missions in Sudan

Timing	States visited
February 2006	Northern and Red Sea states, and the coastline
March 2006	Northern and Southern Kordofan
March 2006	Institutional assessment in Juba
April 2006	Khartoum, Kassala, Gedaref, El Gezira, White Nile, and Blue Nile states
May 2006	Central Equatoria (Bahr el Jabal) and Jonglei states
May 2006	Institutional assessment in Khartoum
June 2006	Northern, Western and Southern Darfur
July 2006	Lakes, Northern and Western Bahr el Ghazal, and Upper Nile states
July 2006	Central Equatoria (Bahr el Jabal) state and the town of Yei
August 2006	Northern state

The total distance travelled was in the order of 12,000 km. The average fieldwork day included three to five stakeholder meetings of varying formality; the total number of interviewees is estimated to have been over two thousand.

## Constraints and acknowledged gaps in assessment coverage

The two major constraints encountered in the course of the assessment were security risks posed by ongoing military action and fieldwork logistics in Southern Sudan and Darfur. Lesser but nonetheless significant limitations included minefields and the lack of environmental data due to extended periods of conflict.

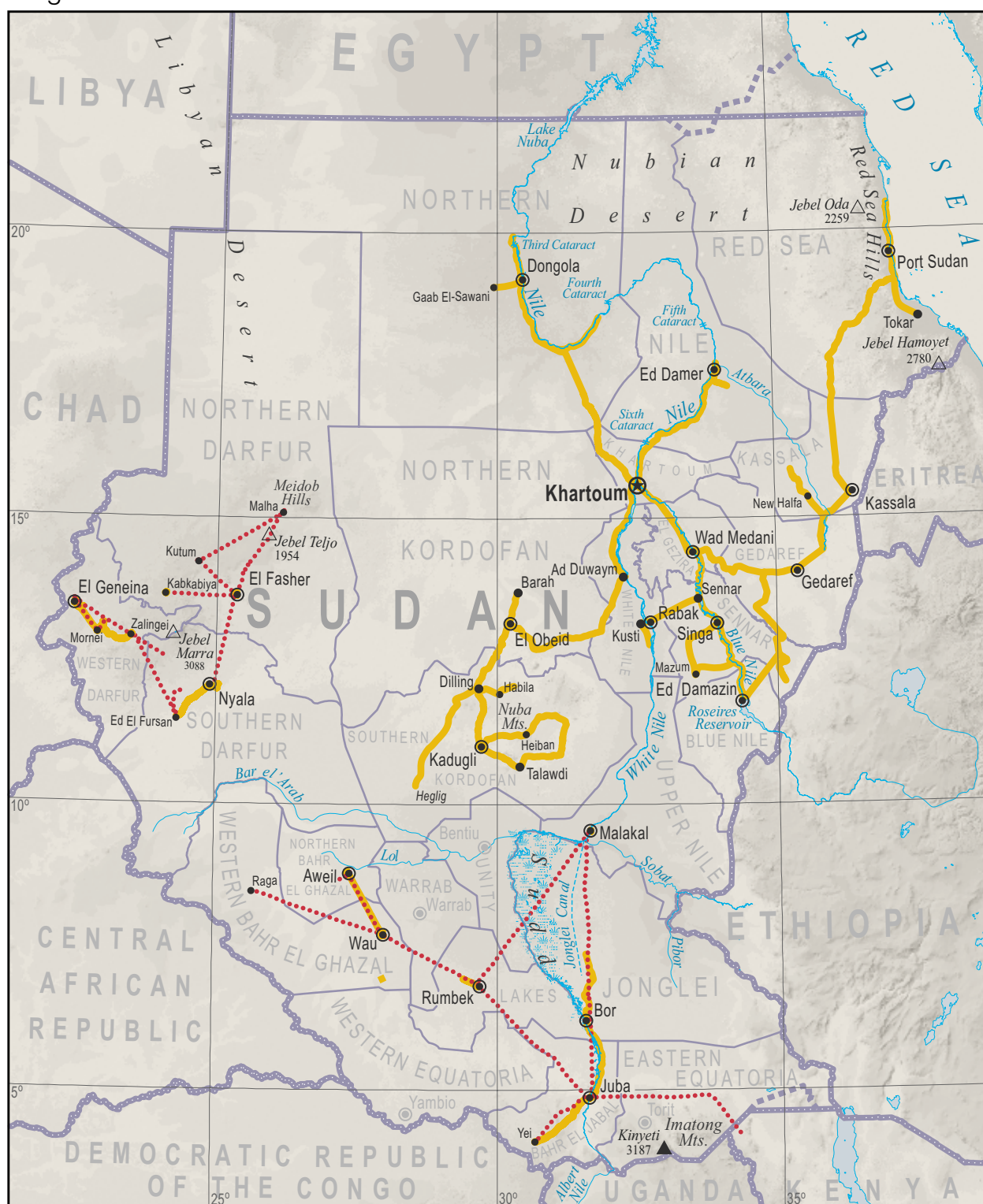
UNEP considers the technical and geographical scope of the fieldwork to be adequate for the purposes of this assessment. Given the size of Sudan, however, and the security and other constraints detailed above, it was not possible to survey all regions thoroughly. The following areas received only limited coverage:



*In the relatively undeveloped areas of Southern Sudan and Darfur, distances are great and roads are poor. In the wet season, mud and flooded stream crossings preclude road travel and restrict aircraft landings in many locations*



Figure 1.1 UNEP fieldwork routes



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

## Field Missions

- ..... Travel by air  
 ——— Travel by road

UNEP/DEWA/GRID~Europe 2006

Sources:

SIM (Sudan Interagency Mapping); FAO; vmaplv0, gns, NIMA; srtn30v2, NASA; void-filled seamless srtn data, International Centre for Tropical Agriculture (CIAT), available from the CGIAR-CSI srtn 90m database; various maps and atlases: UN Cartographic Section.

- Abyei, Unity state and Upper Nile (oilfields in particular);
- Eastern Equatoria (particularly the Imatong ranges and the dry plains in the far east);
- Western Equatoria (the tropical rainforest in particular);
- the Jebel Marra plateau in Darfur;
- the far south of Southern Darfur, west of Western Bahr el Ghazal; and
- the Eastern Front region on the border of Kassala and Red Sea state.



*UN helicopters were the only viable method of transportation in many parts of Darfur and Southern Sudan*

### UNEP link to national institutions and processes

In order to maximize local engagement in the assessment process and its outcomes, UNEP worked closely with the Government of National Unity (GONU) and the Government of Southern Sudan (GOSS) throughout 2006. Specific efforts were made to align UNEP activities with a government initiative known as the National Plan for Environmental Management (NPEM).

In practical terms, UNEP provided technical and financial support for two major environmental workshops in 2006, one held in Khartoum in July and the other in Juba in November. At these events, technical papers were presented and national delegates discussed and debated regional and national environmental issues.

The draft report consultation process also allowed for UNEP material to be integrated into NPEM documents as they were being developed.



*Stakeholders consultation meetings were organized in early 2007 by the Ministry of Environment and Physical Development in Khartoum to discuss and review the draft UNEP post-conflict environmental assessment report*

### GONU and GOSS report review and endorsement

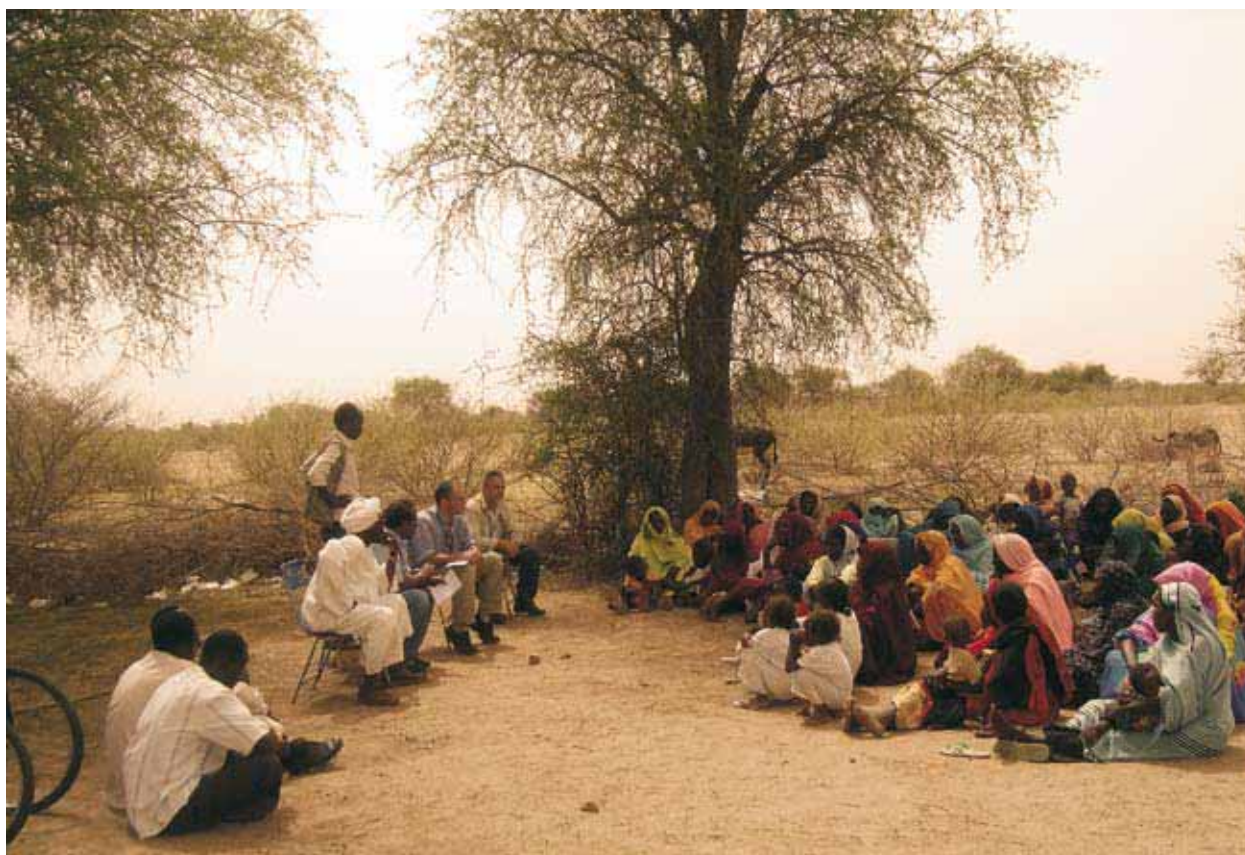
UNEP engaged the Government of National Unity and the Government of Southern Sudan in a formal process of draft document review. While it incorporates the agreed solutions and wording from that process, this final report is, however, first and foremost an independent UNEP report, with endorsement from the GONU and GOSS.



## 1.5 Assessment team and consultations

The assessment team was comprised of a core UNEP team and a large number of national and international partners who contributed in a range of roles. The full list of contributors is presented in Appendix III and summarized below:

- UNEP Post-Conflict Branch (core team including seconded individual consultants);
- UNEP Regional Office for Africa and UNEP GRID;
- other UN agencies, including UNOPS, UNDP, WFP, FAO, UNHCR, UNICEF, OCHA, and DSS;
- UN Mission in Sudan;
- African Union Mission in Sudan;
- USAID and the European Commission;
- Government of National Unity Ministry of Environment and Physical Development,
- including the Secretariat of the Higher Council for Environment and Natural Resources;
- Government of National Unity Ministries of Agriculture and Forestry; of Energy and Mining; and of Irrigation and Water Resources;
- Government of National Unity Remote Sensing Authority and Forests National Corporation;
- Government of Southern Sudan Ministry of Environment, Wildlife Conservation and Tourism;
- Government of Southern Sudan Ministry of Agriculture and Forestry;
- Sudanese Environmental Conservation Society;
- Boma Wildlife Training Centre;
- Kagelu Forestry Training Centre;
- World Agroforestry Centre (ICRAF);
- Rift Valley Institute; and
- Nile Basin Initiative.



*Consultation with local stakeholders formed a large and continuous part of UNEP's assessment work, as here in the small village of Mireir, Southern Darfur*



*The UNEP team discusses a local agricultural project with men from the village of Um Belut, Southern Darfur*

These partnerships were absolutely crucial to the project's success, as they facilitated the fieldwork, ensured that the study matched local issues and needs, and contributed to national endorsement of the assessment's outcomes.

## Consultations

Consultation with local and international stakeholders formed a large and continuous part of UNEP's assessment work. The list of parties consulted, which is provided in Appendix III, included representatives of federal, state and local governments, non-governmental agencies, academic institutions, international agencies, local residents, agriculturists, pastoralists, foresters and business people.

Key partners in the process were the two counterpart ministries for UNEP, the Government of National Unity's Ministry of Environment and Physical Development, located in Khartoum, and the Government of Southern Sudan's Ministry of Environment, Wildlife Conservation and Tourism, located in Juba. These counterparts accompanied UNEP staff on several of the field missions and provided the main link to other branches of their respective governments.

## 1.6 Report structure

This report has four main sections:

1. An introduction providing the details of the assessment process;
2. A 'country context' chapter offering general background information on Sudan;
3. Twelve thematic assessment chapters, each in a common format:
  - introduction and assessment activities;
  - overview of the sector or theme;
  - overview of the environmental impacts and issues related to the theme;
  - discussion of the individual impacts and issues; and
  - theme-specific conclusions and detailed recommendations;
4. A conclusion presenting a summary of findings and recommendations, and a discussion of the general way forward.

The twelve thematic chapters are grouped and sequenced according to the type of issue under discussion, as follows:



### Cross-cutting issues

- Chapter 3 - Natural disasters and desertification;
- Chapter 4 - Conflict and environment;
- Chapter 5 - Population displacement;

### Sectoral issues

- Chapter 6 - Urban environment and environmental health;
- Chapter 7 - Industry;
- Chapter 8 - Agriculture;
- Chapter 9 - Forest resources;
- Chapter 10 - Freshwater resources;
- Chapter 11 - Wildlife and protected area management;
- Chapter 12 - Marine environments and resources;

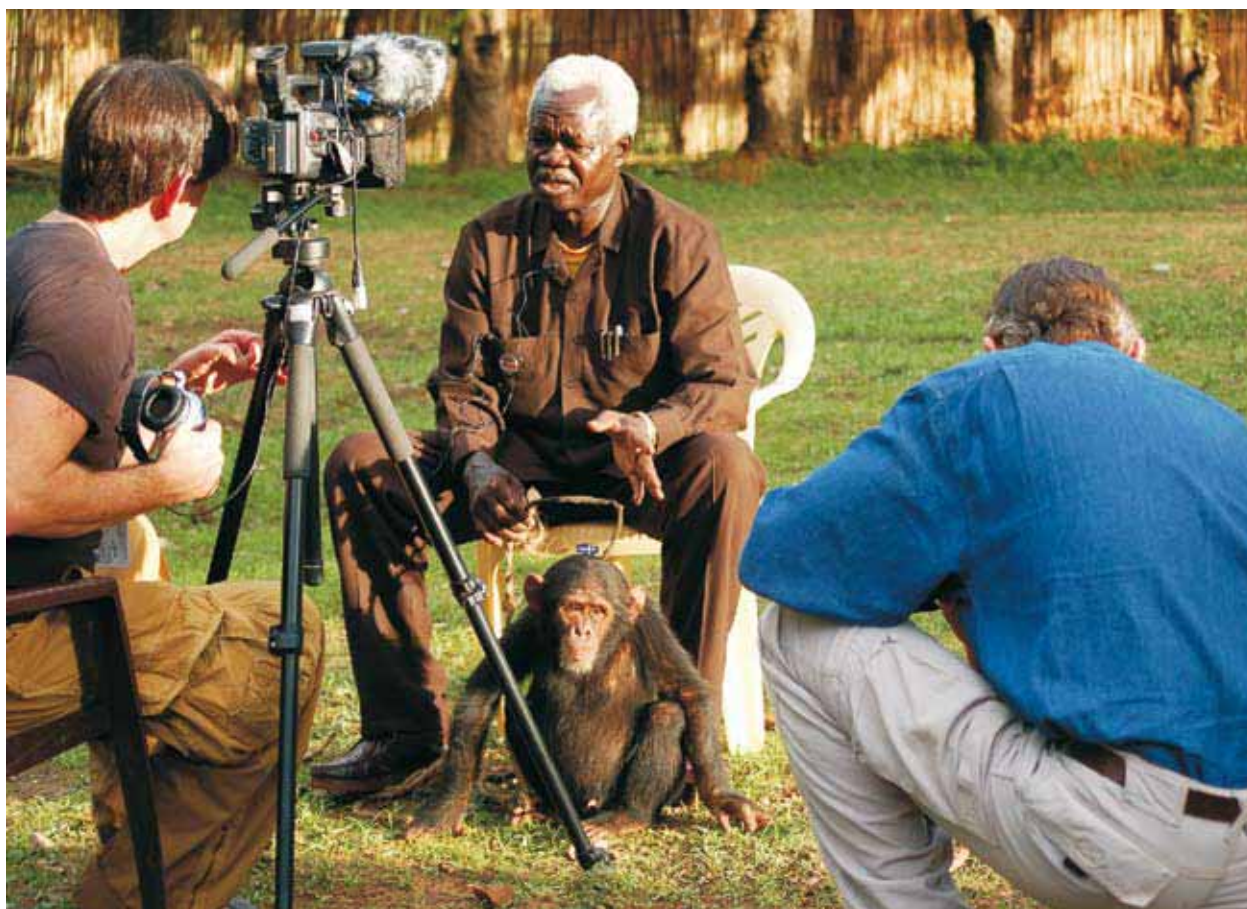
### Institutional response to the issues

- Chapter 13 - Environmental governance and awareness;
- Chapter 14 - International aid.

### Recommendation format

In each thematic chapter, recommendations are provided in the following standard format:

- **Numbering:** All recommendations are numbered to aid collation and tracking;
- **Description:** A one- to four-line description of the recommendation, including a note on the scope applicable to the stated cost, if appropriate;
- **Category (CA):** One of seven categories of response the recommendation pertains to, as set out below;
- **Primary beneficiary (PB):** The party considered by UNEP to be the main target or recipient of the project's benefits. Note that in many cases, projects have a large number of direct and indirect beneficiaries, and that many of the benefits will derive



*The post-conflict assessment process also included photography and filming: over 35 hours of footage and 5,000 photographs were taken*

from subsequent work done by the primary beneficiary. This is particularly the case in governance or capacity-building projects directed at a specific government sector;

- **United Nations partner (UNP):** The UN agency considered by UNEP to be most suitable to be the primary partner to the beneficiary in the implementation of the project. In the absence of a clear nominee, UNEP remains the default (although a default role is not preferred for a number of reasons). The partner role may range from monitoring only to full involvement through the provision of advice, services and equipment;
- **Cost estimate (CE):** The estimated cost for all parties combined (beneficiary and partners) to implement the recommendation. Note that many governance recommendations will result in laws, policies and plans that will have a major economic impact. This follow-on cost is not included in the estimate. All costs are in USD million, in divisions of USD 100,000; and

- **Duration (DU):** The estimated time required for completion of the project from scoping to close-out. Recommendations are given in the range of one to five years.

The recommendations have been divided into seven categories of response to align with UN and donor agency structures and strategies for assistance to Sudan, as follows:

1. **Governance and rule of law (GROL)** covers the areas of policy development, planning and legislation. In some case, this entails the reform of existing structures, policies, plans and laws;
2. **Technical assistance (TA)** covers the provision of expert advice and technical services, with the objective of addressing an immediate need;
3. **Capacity-building (CB)** covers all topics where the main objective is to improve the ability of the beneficiary to fulfill its mandate, through activities such as mentoring, training and providing equipment and support services. Capacity-building logically follows technical assistance;



*A UNEP expert interviews Chadian refugees in Um Shalaya camp, in Western Darfur*





*A UNEP expert documenting the mission*

4. **Government investment (GI)** covers a range of subjects for which UNEP considered that all the factors needed to resolve the issue were generally already in place, except for sufficient funding by the host government. This category thus applied mainly to areas where local technical and human capacity were rated as relatively high and solutions were already devised, but lack of funding prevented the responsible party from fulfilling its mandate.
5. **Awareness-raising (AR)** covers all topics where the main objective is to expose a wide audience to the concepts and issues of environment and sustainable development (focusing on those specific to Sudan). This includes activities such as environmental education, stakeholder briefings, media releases and document distribution.
6. **Assessment (AS)** covers all forms of proposed follow-up assessments and related studies warranted by UNEP. This includes specific studies on subjects and regions that UNEP was not able to include adequately in the scope of this national report due to cost, time and document size constraints.
7. **Practical action (PA):** the majority of the above categories of recommendations focus on building human resources and generating outputs in the form of legislation, policies, plans and other documents. UNEP believes that a certain percentage of projects in the environmental sector should also include or consist of practical action, in order to provide and promote the visible and concrete benefits of good environmental governance and awareness. Such practical projects could include tree-planting, waste clean-up and sustainable building construction. This report strongly emphasizes demonstration projects to catalyse positive change on a larger scale.

# Country Context

*School children in the Mandela camp  
for internally displaced persons,  
in Khartoum state. The combined  
effects of conflict and food insecurity  
have caused over five million  
Sudanese to be displaced  
into camps and urban fringes.*







## Country context

### 2.1 Introduction

#### Introduction to the national context

The Republic of Sudan is the largest country in Africa. Its highly diverse landscape ranges from desert to tropical forest, and its abundant natural resources include oil, timber, extensive agricultural land, and marine and inland fisheries. The country is also culturally diverse, as it bridges the Islamic culture of North Africa with the largely Christian south, and comprises hundreds of distinct tribal and ethnic groups.

Unfortunately, Sudan has long been plagued by civil war and regional conflict. In the fifty years since achieving independence, the country as a whole has been at peace for only eleven years (1972-1983). While a historic peace agreement was reached for Southern Sudan in 2005, conflict rages on in Darfur. Adding to the burden of war, Sudan has experienced several severe droughts in the past thirty years, and food production in many regions has dropped at the same time as the population has increased.

The combined impacts of conflict and food insecurity have caused over five million Sudanese to be both internally and internationally displaced into camps and urban fringes, and over five million to receive international food aid [2.1, 2.2].

#### Introduction to the international context

The international community currently provides Sudan with over USD 2 billion per annum in aid, through humanitarian crisis response programmes, recovery and development programmes, and peacekeeping operations. This major investment is delivered through a number of organizations, including the Sudanese Government, donor country governments, the UN family of agencies and the World Bank, bilateral agencies, and national and international non-governmental organizations [2.1, 2.2].

The objectives of this vast and complex programme of assistance are threefold: 1) to prevent, contain and

resolve conflict, 2) to save human lives and reduce suffering, and 3) to assist sustainable development. In practical terms, this translates into the achievement and maintenance of peace agreements, and positive numerical indicators in poverty reduction and sustainable development as provided by the UN Millennium Development Goals.

### 2.2 Society

#### Population

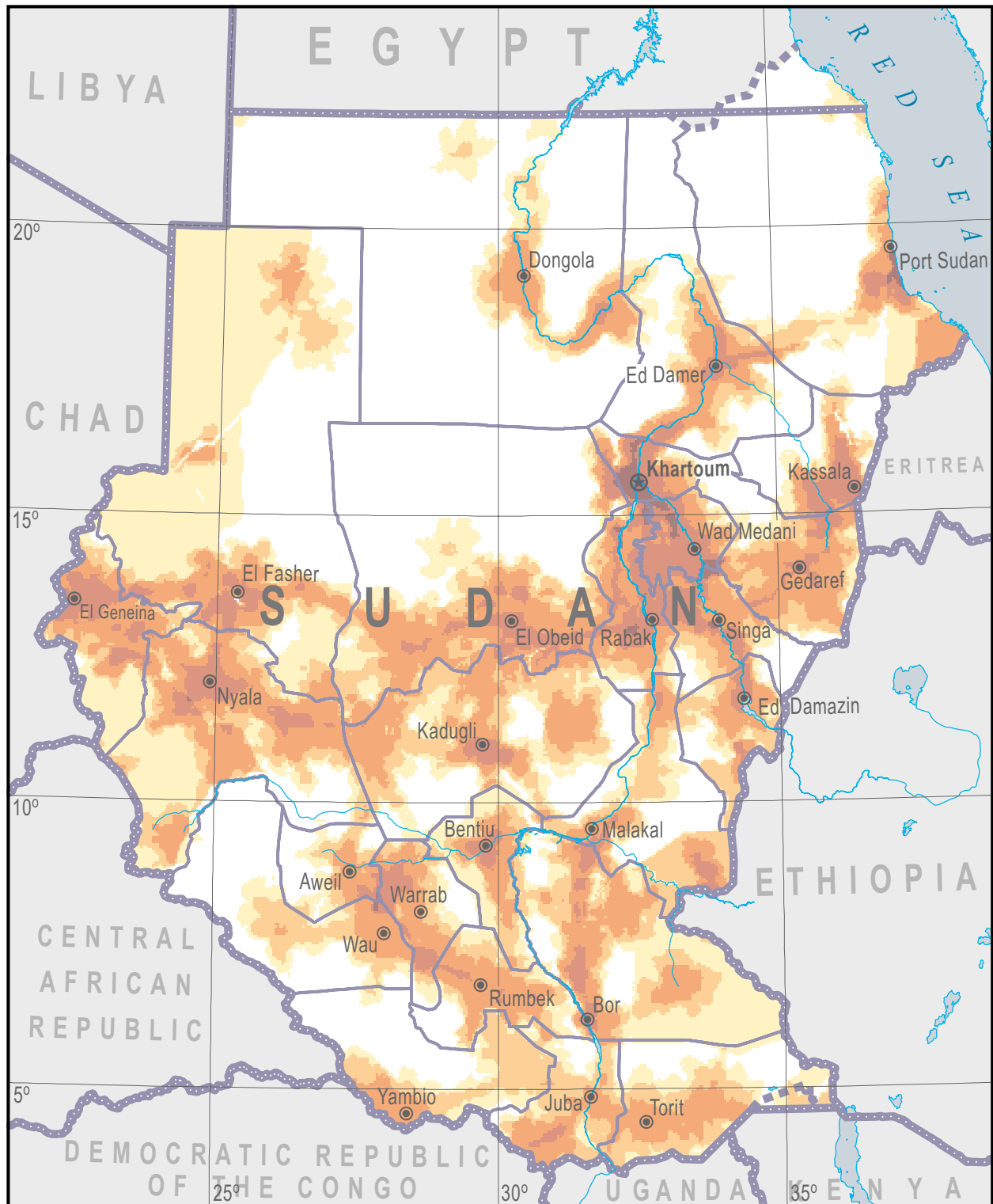
A detailed national census has never been carried out for all of Sudan; all population figures must therefore be regarded as broad estimates that are rapidly made obsolete by a swelling population with a growth rate estimated to exceed 2.6 percent [2.1, 2.3, 2.4, 2.5, 2.6]. In addition, all detailed data collection to date has excluded Southern Sudan, whose population is broadly estimated at 7-10 million [2.1, 2.7]. Taking these limitations into account, the population of Sudan in 2006 could be estimated to be between 35 and 40 million, with approximately 70 percent living in rural areas, and the other 30 percent living in the capital Khartoum and the country's six other largest cities: Port Sudan, Kassala, Omdurman, El Obeid, Wad Medani, Gedaref and Juba [2.8].



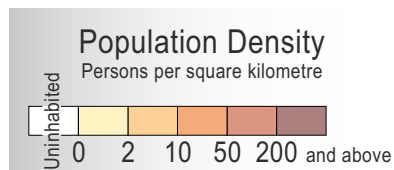
*Farmers in Mornei, Western Darfur. The majority of Sudanese live in rural areas and depend on agriculture for their livelihood*



Figure 2.1 Sudan population density



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



UNEP/DEWA/GRID~Europe 2006

Sources:  
SIM (Sudan Interagency Mapping);  
Africa population database 2000, UNEP/GRID-Sioux Falls and CIESIN;  
vmaplv0, NIMA; UN Cartographic Section.

## Development status

Sudan is rated as a least developed country by UNCTAD, and this is reflected in the most recent Millennium Development Goals Report, Human Development Report and related figures for the country.

It should be noted that these national and regional figures mask very wide regional variations, as wealth and development are concentrated in urban areas and northern states.



*Gum arabic farmer from the Jawama'a tribe in El Darota, Northern Kordofan*

Table 2. Development context for Sudan

Indicators	Value	Year
Population size (million)	37	2006
Population growth rate (%)	2.6	1998-2003
Life expectancy at birth (years)	56.5	2004
GDP per capita (USD)	640	2005
Prevalence of HIV/AIDS in adult population (age 15-49) (%)	1.6	2003
Contraceptive prevalence (women age 14-49)	7	2004
Population with access to improved water supply (%)	70	2004
Population with access to improved sanitation (%)	34	2004
Population undernourished (%)	26	2000
Percentage of malnourished children under five (%)	27	2003
Infant mortality rate (per 1,000 live births)	62	2004
Children immunized against measles (%)	50	2000
Gross enrolment rate in primary education (%)	59.6	2004
Youth literacy rate (age 15-24) (%)	60.9	2004
Ratio of girls to boys in primary education (%)	88	2000
Under five mortality rate (per 1,000 live births)	90	2005
Birth attended by skilled health staff (%)	57	2004
Maternal mortality rate (per 100,000 live births)	590	2000
Fixed lines and mobile telephone subscribers (per 1,000)	69	2003

Table 3. Key socio-economic indicators for Southern Sudan

Indicators	Value	Year
Population size (million)	7,514	2003
Refugees or internally displaced persons (million)	4.8	2002
Population growth rate (%)	2.9	2001
Life expectancy at birth (years)	42	2001
GNP per capita (USD)	< 90	2002
Percentage of population earning less than one USD a day (%)	> 90	2000
Prevalence of HIV/AIDS in adult population age 15-49 (%)	2.6	2001
Population without access to drinking water (%)	73	2001
Adult literacy rate (%)	24	2001
Net enrolment ratio in primary education (%)	20	2000
Ratio of girls to boys in primary education (%)	36	2000
Under five mortality rate (per 1,000 live births)	250	2001
Maternal mortality rate (per 100,000 live births)	1,700	2000





*Dinka tribe children in the town of Bor, Jonglei state*

### Ethnicity and religion

Sudan comprises hundreds of ethnic and tribal divisions and language groups, with two major distinct cultures: Arab and Black African. Arab populations generally live in the northern states, which cover most of Sudan's territory and include most of the country's largest urban centres. The Black African culture has its heartland in the south but extends north into Blue Nile state, the Nuba mountains region, and the three Darfur states. In addition, several million internally displaced people, mainly from the south, have relocated to the cities and agricultural regions in the north and centre of the country.



*Beja tribesman in Gadamayai, Red Sea state*

Most of the estimated 25-30 million Sudanese living in the northern regions are Arabic-speaking Muslims, though traditional, non-Arabic mother tongues are also widely used. Among these are several distinct tribal groups: the Kababish of Northern Kordofan, a camel-raising people; the Ja'alin and Shaigiyya groups of settled tribes along the rivers; the semi-nomadic Baggara of Kordofan and Darfur; the Hamitic Beja in the Red Sea area and the Nubians of the northern Nile areas, some of whom have been resettled on the Atbara river; as well as the Negroid Nuba of Southern Kordofan, the Fur in the western reaches of the country, and the Funj in southern Blue Nile state [2.12].

The southern states, with a population of around 7-10 million, are home to many tribal groups and many more languages than are used in the north. Though some practice indigenous traditional beliefs, southern Sudanese are largely Christian. The Dinka – whose population is estimated at more than one million – is the largest of the many Black African tribes. Along with the Shilluk and the Nuer, they are 'Nilotic' tribes. The Azande are 'Bantus'; the Moro and the Madi, who live in the west, are 'Sudanic', while the Acholi and Otuho, who live in the extreme south, are 'Nilo-hamites'.

## History

Sudanese civilization dates back to at least 3000 BC [2.12]. It long concentrated along the northern reaches of the Nile river, the area that came to be known as Nubia. The region's three principal kingdoms were converted to Coptic Christianity by missionaries in the 6<sup>th</sup> century AD. These Black Christian kingdoms coexisted with their Muslim Arab neighbours in Egypt for centuries, until the influx of Arab immigrants brought about their collapse in the 13<sup>th</sup> to 15<sup>th</sup> centuries. Sudan was then partly converted to Islam.

By 1874, Egypt had conquered all of Sudan and encouraged British interference in the region. This aroused Muslim opposition and led to the revolt of the Mahdi, who captured Khartoum in 1885 and established a Muslim theocracy that lasted until 1898, when their forces were defeated by the British in the Battle of Omdurman. The country was then run jointly as the Anglo-Egyptian Sudan, a 'condominium' in which the British were the dominant partner. When Egypt became a British protectorate in 1914, Sudan was taken under British rule until it achieved independence in 1956 [2.12].

The recent history of Sudan has been marked by turmoil, with several periods of conflict and a series of natural disasters leading to massive population displacement. Civil strife began with the Torit mutiny in 1955 and intensified until 1962, by which time the south was effectively at war with the north. This situation lasted until 1972. A fragile peace then prevailed for eleven years, but from 1983, the war was more or less continuous until January 2005, when it was officially ended by the signing of a Comprehensive Peace Agreement (CPA) between the Sudanese Government based in Khartoum and the Sudan People's Liberation Movement (SPLM) and allies in the south.

Low-level conflict, which had been ongoing in Darfur for a generation, developed into a new regional civil war in 2003. The war continues today, despite the signing of the Darfur Peace Agreement in 2006. Low-level conflict also took place in eastern Sudan from the 1990s, though a provisional peace agreement was concluded in October 2006.

A detailed account of historical and current conflicts in Sudan is provided in Chapter 4.

## 2.3 Governance and economy

### Governance structure

In accordance with the provisions of the 2005 peace agreement, Sudan is now ruled by a central government, the Government of National Unity (GONU), headed by the President, Omar Hassan Ahmed El Bashir, and the First Vice-President, Salva Kiir Mayardit. The First Vice-President is also the leader of the SPLM and the President of the new Government of Southern Sudan (GOSS), which has substantial regional autonomy. This structure will stay in effect until 2011, at which time Southern Sudan may choose through a referendum either to remain an autonomous region or to become independent.

Sudan is divided into twenty-five states. Each has its own state government and a measure of executive and legislative authority. The GOSS administers ten states. Two states, Blue Nile and Southern Kordofan, as well as part of a third state (the Abyei region), are geographically part of the north, but have historical, tribal and ethnic links to the south [2.12]. A compromise was reached for these three areas in the peace agreement. The nation's capital Khartoum is subject to a special regime that differs from the rest of the north: as the peace accord states that Khartoum 'shall be a symbol of national unity and reflect the diversity of Sudan', it is administered by an eight-member cabinet composed of four members from the National Congress Party (NCP), two members of the Sudan People's Liberation Movement (SPLM) and two from other northern parties. While Sharia (Islamic law) continues to be the legal system in the north, non-Muslims – mainly Southerners – are exempt from it.

The governance system in Sudan has been severely affected by the four decades of instability the country has undergone. Developing governance and the rule of law is accordingly one of the major challenges set out in the UN and Partners Work Plan for 2007 [2.1].


A detailed discussion of Sudan's governance structures is provided in Chapter 13.



Figure 2.2 Sudan political map



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

 Three Areas

UNEP/DEWA/GRID-Europe 2006

Kilometres  
0 100 200 300 400 500  
Lambert Azimuthal Equal-Area Projection

Sources:  
SIM; vmaplv0, NIMA; various maps; UN Cartographic Section.

## Economy

Despite relatively abundant natural resources, Sudan is currently a very poor country due to underdevelopment, conflict and political instability. In 2004, the gross domestic product per person was estimated at USD 740 (using Purchasing Power Parity figures), as compared to USD 3,806 and USD 1,248 for neighbouring Egypt and Kenya respectively.

While the production and export of oil are growing significantly in importance, Sudan's primary resources are agricultural. Sorghum is the country's principal food crop, and livestock, cotton, sesame, peanuts and gum arabic are its major agricultural exports. Sudan, however, remains a net importer of food and a major recipient of food aid.

Industrial development, which consists of agricultural processing and various light industries located in Khartoum North, is limited in Sudan. The country is reputed to have great mineral resources but the real extent of these is unknown.

Extensive petroleum exploration began in the mid-1970s and export began in 1999. Sudan's current production is approximately 500,000 barrels per day, and it is expected that the oil industry will soon rival agriculture in importance.

While Sudan remains poor overall, an 11.8 percent growth of the GDP is forecast for 2007 [2.3] and parts of the country have recently started



*Spate irrigation crops in the Tokar delta, Red Sea state. Agriculture is the largest economic sector in Sudan*



*A sandstorm in Khartoum in May 2006. Sand and dust storms are common throughout northern and central Sudan*

to experience rapid development. The present oil-financed economic and construction boom is focused on Khartoum, Port Sudan and a limited number of mega-projects such as the Merowe dam. Most of the major projects are managed and partly financed by foreign investors and multinational firms, including Middle Eastern and Asian companies.

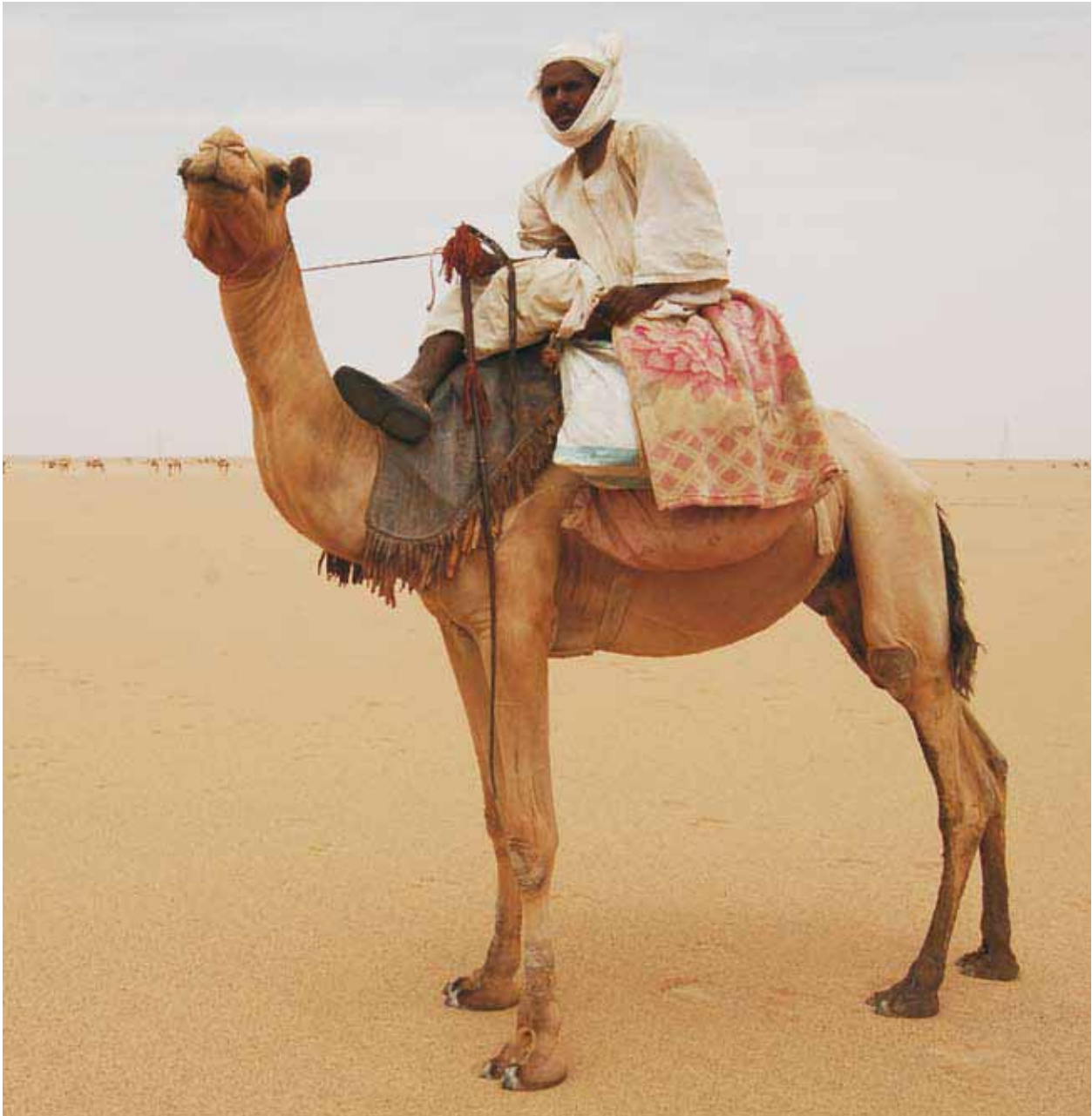
Sudan's industrial sector, including its oil industry, is discussed in more detail in Chapter 7.

## 2.4 Climate

Average monthly temperatures in Sudan vary between 26°C and 36°C. The hottest areas, where temperatures regularly exceed 40°C, are found in the northern part of the country.

The dominant characteristic of Sudan's climate is a very wide geographical variation in rainfall [2.15]. In the north, annual precipitation ranges from close to zero near the border with Egypt, to approximately 200 mm around the capital, Khartoum. Sand and dust storms that can cover vast regions and last for days at a time are a defining feature of this low rainfall belt.





*A camel herder in Northern state. The northernmost third of Sudan has a desert climate*

In central Sudan, a division of seasons can be observed:

- winter or dry season (December-February);
- advancing monsoon season (March-May); and
- retreating monsoon season (October-November).

Just south of Khartoum, annual precipitation rarely exceeds 700 mm. In addition, precipitation

is relatively erratic, with a combination of short- and long-term droughts, and periods of heavy rainfall.

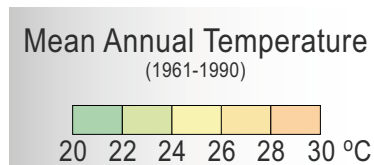
The extreme south-west is almost equatorial: the dry season is very short and falls in between two peak rainy seasons, and annual precipitation can exceed 1,600 mm.

The issue of climatic variability and its link to environmental problems is covered in more detail in Chapter 3.

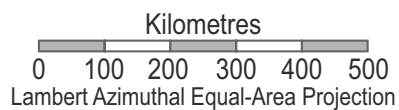
Figure 2.3 Sudan average annual temperature



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



UNEP/DEWA/GRID~Europe 2006

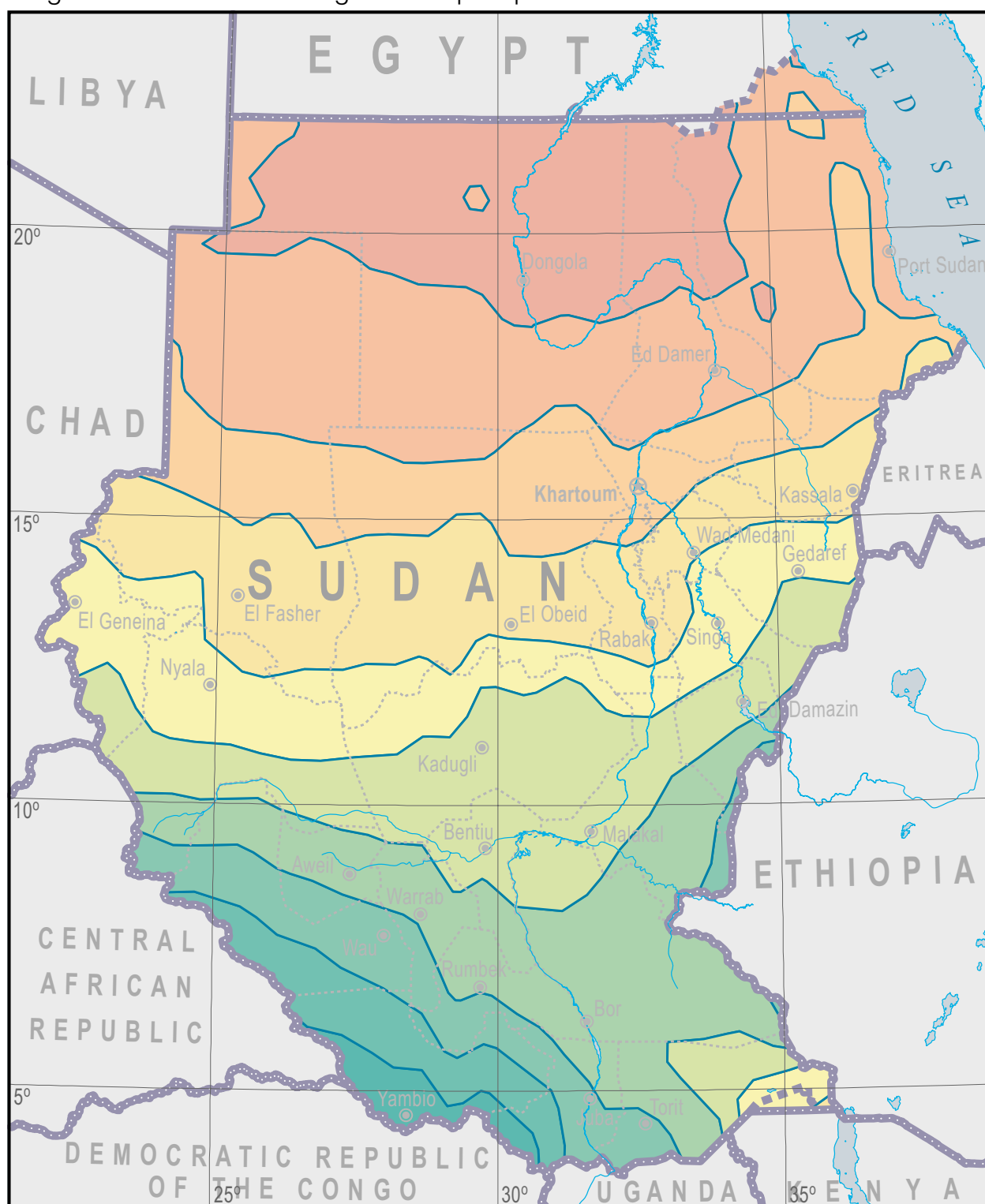


Sources:

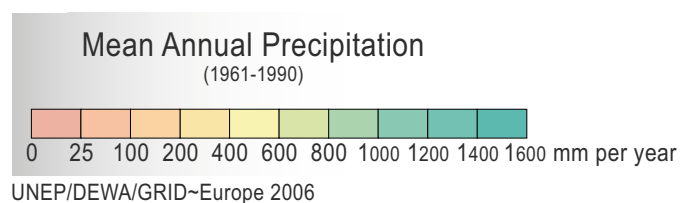
IPCC and CRU; SIM (Sudan Interagency Mapping); vmaplrv0, NIMA;  
UN Cartographic Section.



Figure 2.4 Sudan average annual precipitation



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



Kilometres  
0 100 200 300 400 500  
Lambert Azimuthal Equal-Area Projection

Sources:  
IPCC and CRU/SIM (Sudan Interagency Mapping);  
vmaplv0, NIMA; UN Cartographic Section.

## 2.5 Geography and vegetation zones

### A large and geographically diverse country

With an area of 2.5 million km<sup>2</sup>, Sudan is the largest country in Africa. Its territory crosses over 18 degrees of latitude, which results in an extremely diverse environment ranging from arid desert in the north to tropical forests in the south. Sudan is bordered by ten countries: Egypt, Eritrea, Ethiopia, Kenya, Uganda, the Democratic Republic of Congo, the Central African Republic, Chad and Libya.

The majority of Sudan is very flat, with extensive plains in an altitude range of 300 to 600 m above sea level. Isolated mountain ranges are found across the country, including the Red Sea hills in the far north-east, the Jebel Marra plateau in the west, the Nuba mountains in the centre, and the Imatong mountains in the south-east. The average elevation of these mountains is 1,000 m above sea level, but the highest point is Mount Kinyeti in the Imatong range, which reaches 3,187 m.

The dominant river system in Sudan is the Nile, whose basin extends over 77 percent of the country. The river's two main tributaries, the Blue and White Nile, flow into Sudan from Ethiopia and Uganda respectively, and meet in Khartoum before flowing north into Egypt. In an otherwise arid terrain, the Nile plays a crucial role in the country's various ecosystems. Sudan also has over 750 km of coastline and territorial waters in the Red Sea, which include an archipelago of small islands.

Twenty-nine percent of Sudan's total area is classified as desert, 19 percent as semi-desert, 27 percent as low rainfall savannah, 14 percent as high rainfall savannah, 10 percent as flood region (swamps and areas affected by floods) and less than one percent as true mountain vegetation [2.15]. Note that the precise figures in each class are highly dependent upon the classification system and date; the above are based on recent FAO figures.

### Different regions and associated environmental issues

Due to its geographic and climatic diversity, environmental issues affecting Sudan differ radically

across the country. To provide context for the issues under discussion in the following chapters, the most ecologically significant regions and geographic features of Sudan are briefly described below. From an environmental perspective, the most important regions and features are:

1. territorial seas;
2. the coastline and islands;
3. northern, central and south-eastern arid regions, including mountain ranges;
4. the central semi-arid region known as the Sahel belt;
5. the Marra plateau;
6. the Nuba mountains;
7. wetlands;
8. the southern clay plains;
9. savannah of various types based on rainfall and soil profile;
10. subtropical lowlands and the plateau in the extreme south of Sudan; and
11. the Imatong, Dongotona, Acholi and Jebel Gumbiri mountain ranges.

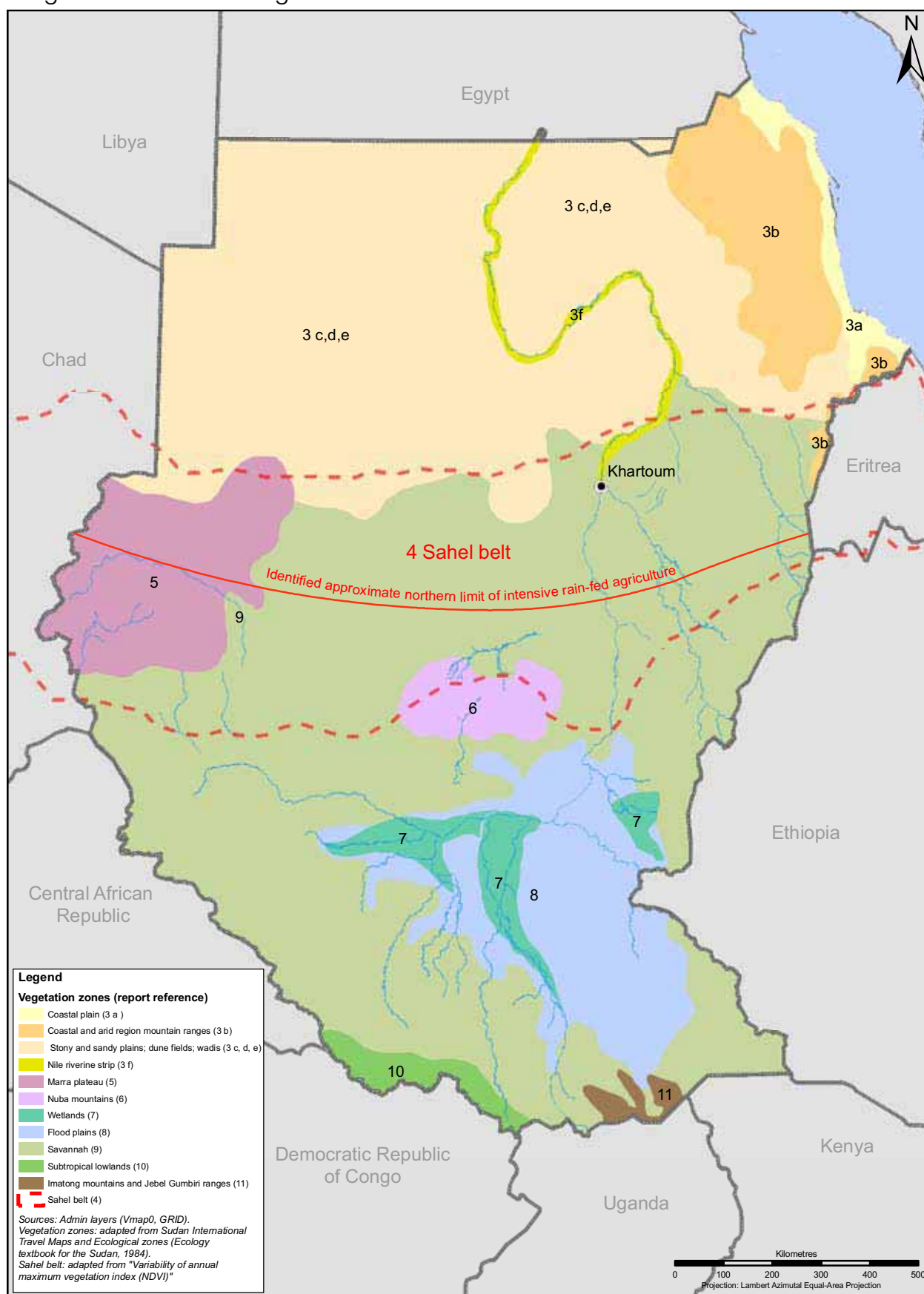
It should be noted that many different versions of ecological, soil, vegetation and livelihood zoning for Sudan are in circulation, for a range of purposes [2.15, 2.16, 2.17, 2.18]. The zones listed above and discussed in more detail below are a simplified blend of these classifications, with a focus on major variations between ecosystems.



*Sandstorm in Northern Darfur*



Figure 2.5 Sudan regional environments



## 1. Territorial seas

The Sudanese Red Sea is famous for its attractive and mostly pristine habitats, and particularly for its coral reefs. The Red Sea is home to a variety of pelagic fish including tuna, but the overall fish density is relatively low due to limited nutrient input. Sudan's territorial waters host important populations of seabirds and turtles, as well as mammals like dugong, dolphins and whales.

Sudan is a member of the Regional Organization for the Conservation of the Environment of the Red Sea and the Gulf of Aden (PERSGA).

## 2. Coastline and islands

The coastline of Sudan on the Red Sea is approximately 750 km long, not including all the embayments and inlets. Numerous islands are scattered along the coast, the majority of which have no water or vegetation. The dominant coastal forms are silty beaches, rocky headlands and salt marshes. Fringing coral reefs are very common and water clarity is high due to the lack of sedimentation.

Average precipitation in the coastal areas is extremely low, ranging from 36 mm per year at Halaib to 164 mm per year at Suakin, so



*A Manta ray in Sanganeb Marine National Park*

that the desert extends all the way to the tide mark. The only exception is the Tokar delta, which receives substantial run-off from seasonal streams originating in the Ethiopian and Eritrean highlands. The islands and most of the coastline are relatively undisturbed and host important feeding and nesting sites for a variety of seabirds.



*Barren headland with fringing reef 100 km north of Port Sudan*





© RED SEA ENTERPRISES, PORT SUDAN

*The coral reefs fringing the Sudanese coastline and islands are generally in excellent condition*



*A salt marsh 40 km south of Port Sudan. Offshore, seagrass beds support various marine life*



### 3. Northern and south-eastern arid regions

The majority of Sudan can be classified as arid land, with approximately 29 percent classified as true desert (less than 90 mm of rain per year). Four of the northern states are located within the Sahara desert and its margins. A small area in the extreme south-east of the country (the Toposa region) is also semi-arid.

The common features of the northern deserts are extreme temperatures, very low rainfall and, as a result, sparse vegetation. Within this pattern, variations are due to nuances in precipitation, geology, topography, and isolated riverine regions. Important sub-regions within the northern deserts include:

**a. The coastal plain.** This gently sloping plain, which is some 56 km wide in the south near Tokar and approximately 24 km wide near the Egyptian border, is intersected by spurs of the adjacent mountain ranges and *wadis* (intermittently flowing rivers). A notable feature is the Tokar delta, which has sufficient groundwater and seasonal flooding to support intensive agriculture.



*The coastal plain 10 km south of Suakin*

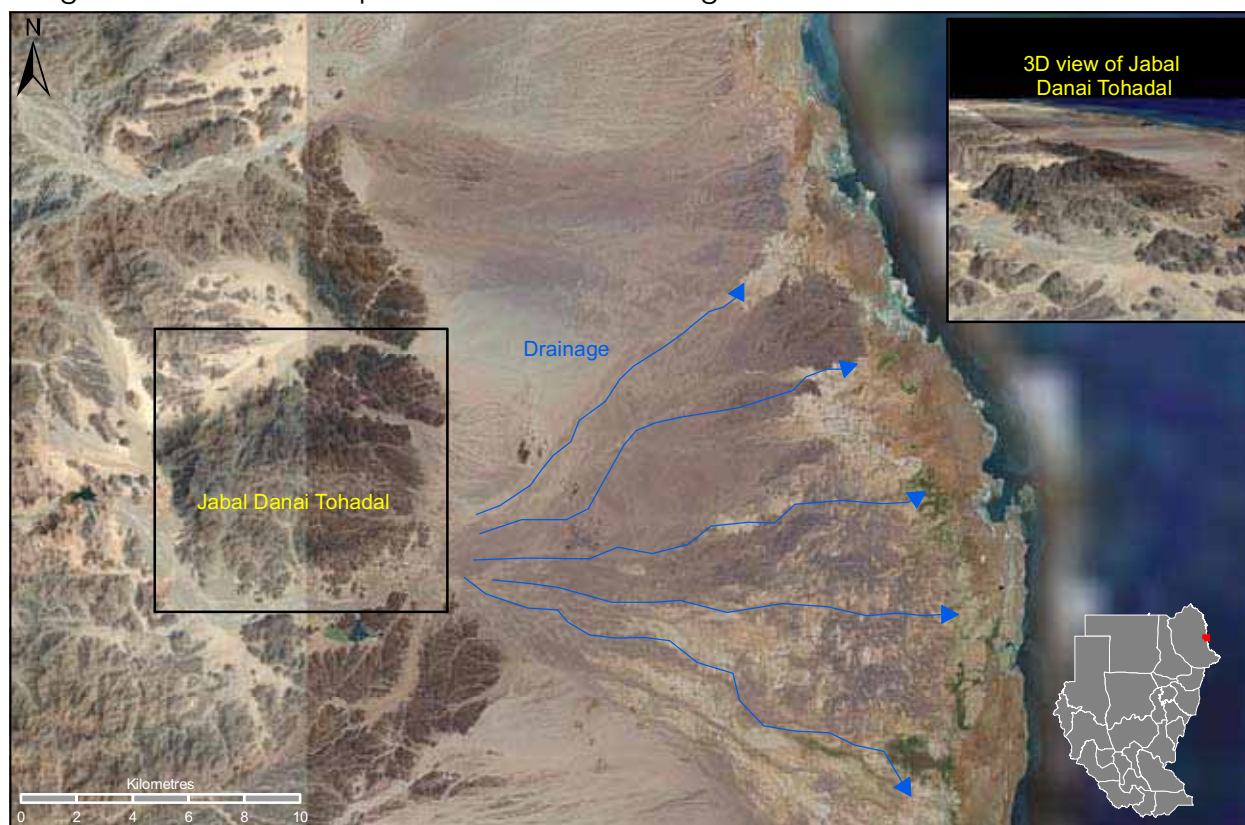
**b. Coastal and arid region mountain ranges.** The coastal mountain range runs virtually uninterrupted along the entire coastline, with peak elevations generally in the order of 1,100 m. Mountains also extend along the Eritrean and Ethiopian borders, where they form the western edge of the Ethiopian plateau. The coastal and other hyper-arid regional mountain environments are characterized by very thin or absent soil cover and negligible vegetation, except in alluvial valleys and isolated oases.



*Coastal Jebel*



Figure 2.6 Coastal plain and mountain range



**c. Stony and sandy plains.** The majority of deserts in Sudan are stony and sandy plains, which represent areas of wind erosion. In the most extreme cases, soil cover is completely absent over large areas.

**d. Dune fields.** Sand dunes occur across most of the Sahara and Sudanese deserts, although their types and density vary significantly from region to region. The largest dune fields are found in the north-west, in Northern state. Dunes can be mobile or immobile/fixed; the former present major threats to agricultural land in arid regions.



*Stony plain 60 km north of Port Sudan*



*Mobile dune in Northern state*



**e. *Wadis*.** *Wadis* or *khors* (generally dry seasonal watercourses) are ecological hotspots within desert and semi-desert environments. Drainage and infiltration from seasonal rainfall events concentrate beneath the dry stream beds, and support trees and short-lived grasses, in addition to higher densities of the more drought-resistant shrub species.

**f. The Nile riverine strip.** The waters of the Nile have sustained civilizations in the arid regions of Egypt and Sudan since the development of agriculture over 10,000 years ago. The annual wet season flow surge results in regular flooding and sediment deposition on a narrow strip along nearly the entire length of the Nile, in an otherwise very arid environment. The width of the cultivated and heavily developed strip has been expanded by irrigation schemes, but outside of these areas, it is generally no more than two kilometres wide.

With the exception of the Nile riverine strip and the coastal plain, the desert regions of Sudan are relatively undeveloped, as the land can only support low-intensity pastoralism and isolated oasis communities.

#### 4. The central semi-arid region: the Sahel belt

The Sahel, which extends from Senegal eastward to Sudan, forms a narrow transitional band between the arid Sahara to the north and the humid savannah to the south. With eight to eleven dry months per year, it has an approximate annual precipitation of 300-600 mm. As the bulk of agriculture in Sudan is practised within and to the south of the Sahel belt, most of the original landscape has been altered: the majority of central Sudan, where rain-fed and irrigated agriculture predominate, is now covered by flat and open fields with limited tree cover.

In its natural state, the Sahel belt is characterized by baobab and acacia trees, and sparse grass cover. Since the late 20th century, it has been subjected to desertification and soil erosion caused by natural climate change, as well as overgrazing and farming. The countries of the Sahel zone also suffered devastating droughts and famine in the early 1970s, and again in the 1980s. Apart from long-term droughts, the Sahel is prone to highly variable rainfall, with associated problems for livestock- and crop-rearing.



*Nile riverine agriculture, Northern state. A narrow strip of irrigated land on either side of the main Nile in the desert regions supports up to three crops a year*



Figure 2.7 Nile riverine strip

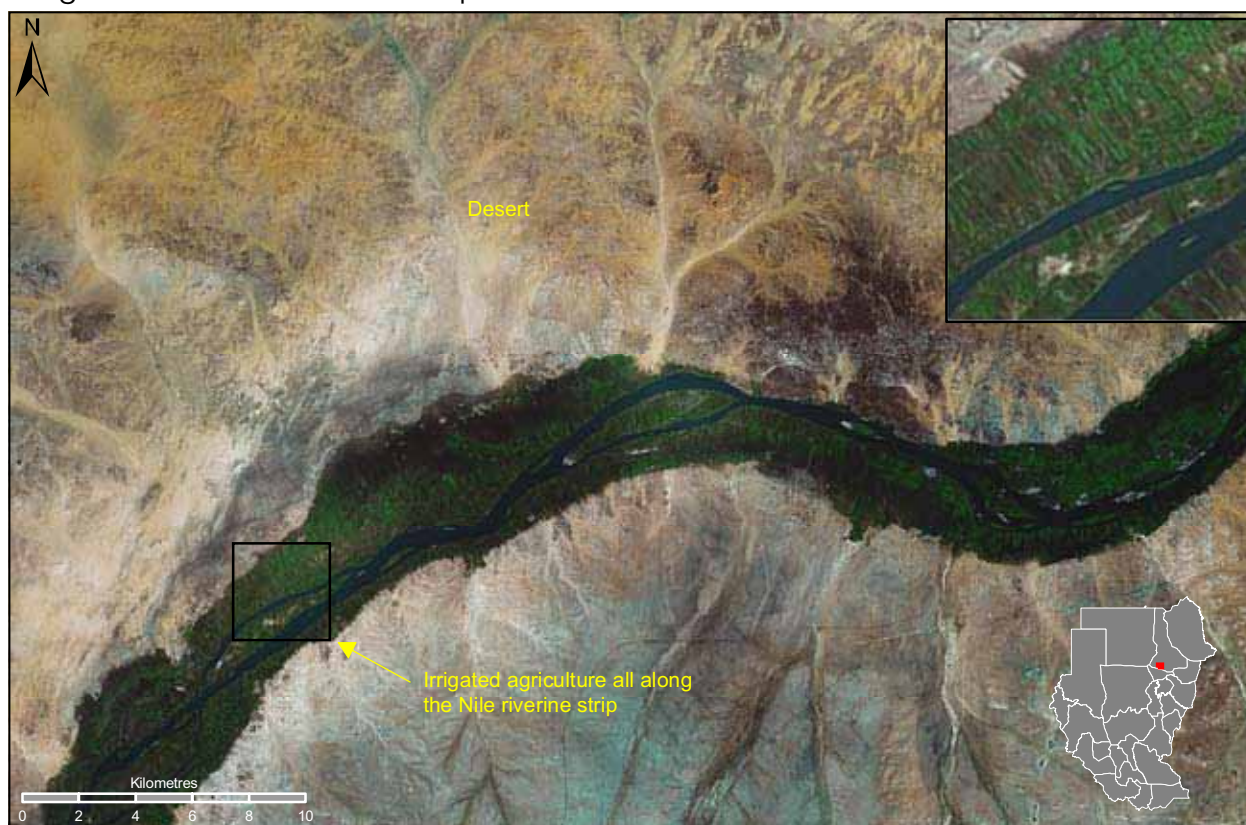
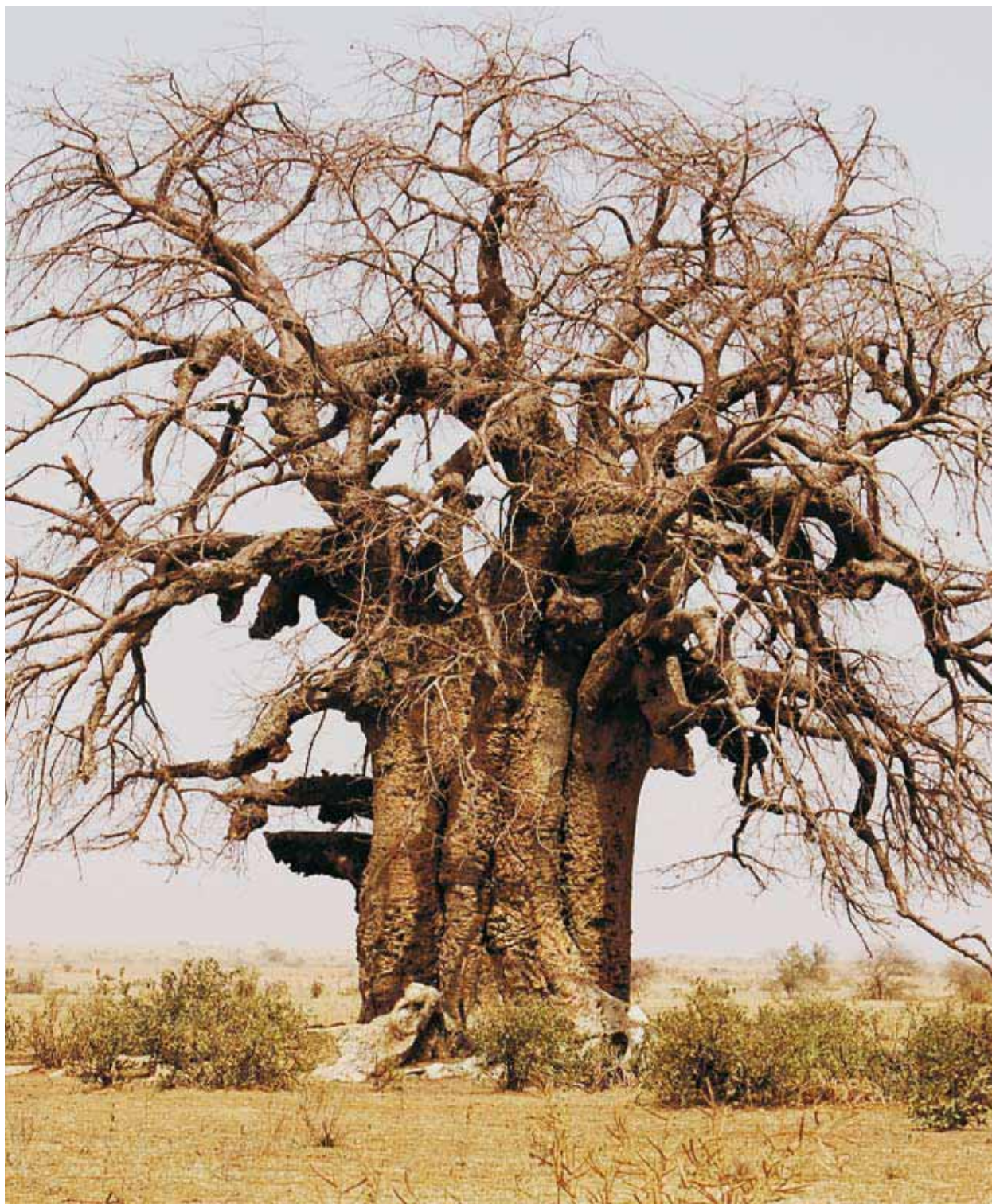


Figure 2.8 Sahel belt and Gezira irrigation scheme







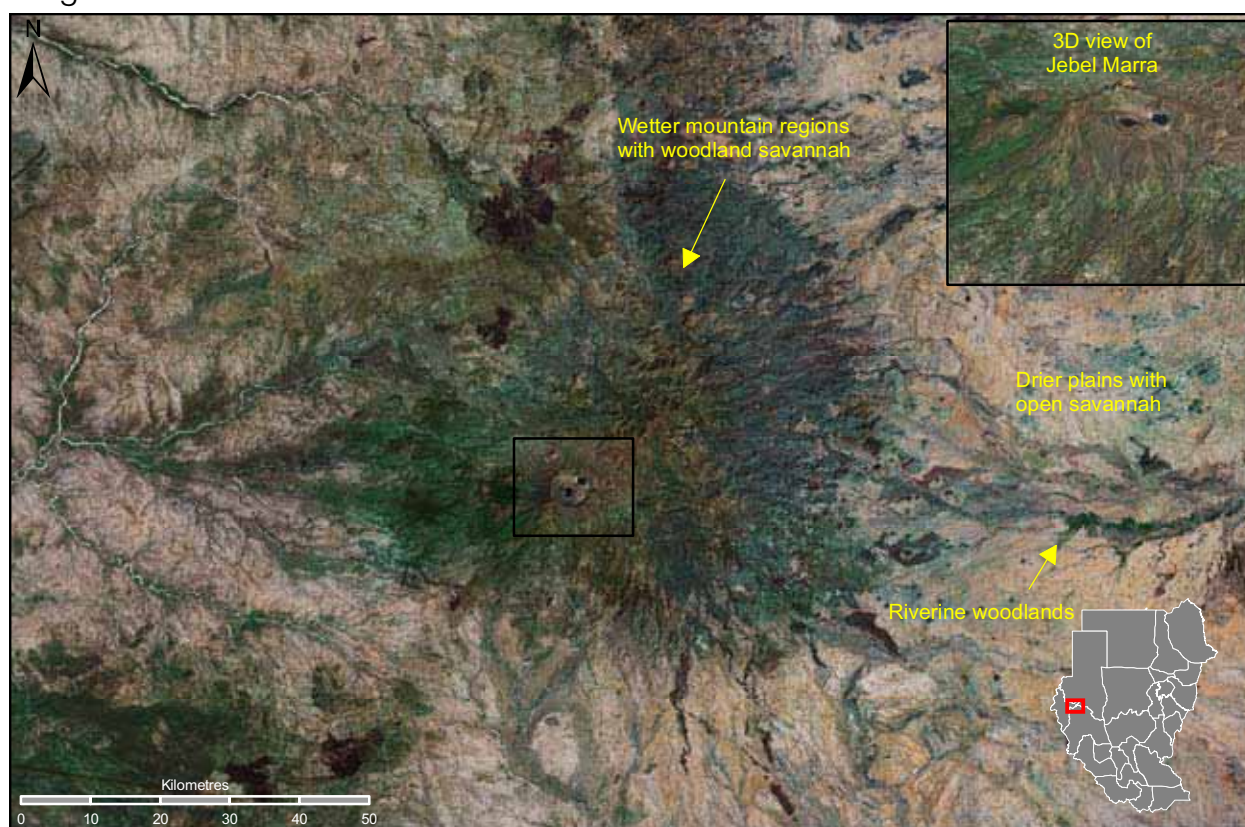
*A baobab tree in the Sahel during the dry season, Northern Kordofan*

Accurately mapping and defining the Sahel in Sudan is problematic due to the limited records available and the changing climate. Accordingly, UNEP has used three different indicators for the Sahel belt and the associated limits of rain-fed agriculture:

- historical rainfall records converted to annual average contours for 300-600 mm;
- the approximate northern limit of intensive rain-fed agriculture as indicated by UNEP



Figure 2.9 Jebel Marra and Sahel belt



*Bushland and wadi on the southern limit of the Sahel, Southern Darfur*

analysis of Landsat images dating from 2000 to 2005 (note that scattered rain-fed agriculture and pastoralism occur well north of this line); and

- a measure of annual rainfall and associated vegetation variability recorded by satellite images (analysis by the Vulnerability Analysis and Mapping Unit, WFP-Khartoum), using an annual change rate of 15 percent or more for the period 1982-2003 [2.11].

### 5. The Marra plateau

The Marra plateau is a rugged volcanic range that occupies approximately 80,000 km<sup>2</sup> in central Darfur, with an average altitude of 1,500 m and a maximum elevation of 3,088 m at Jebel Marra. The higher and more southerly parts of the plateau have a wetter microclimate (over 600 mm of rain per year) than the surrounding area, which is relatively arid with erratic rainfall. The plateau originally had extensive woodlands, which have been partly removed for agricultural development.

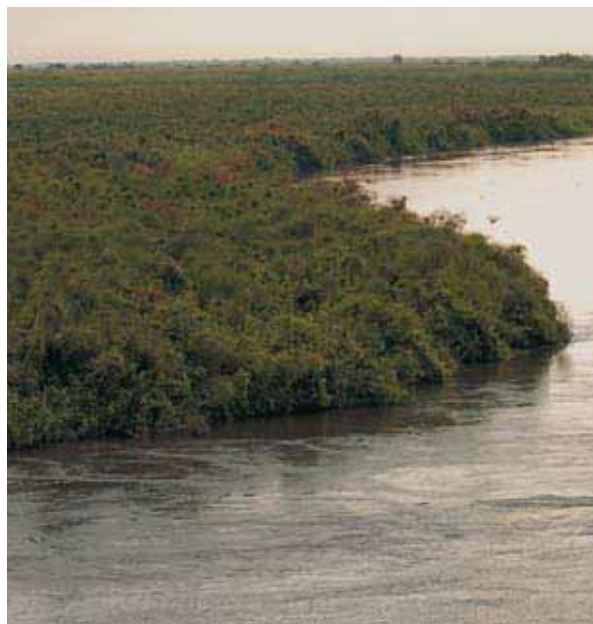


## 6. The Nuba mountains

The Nuba mountains are a set of widely spaced small mountains located in the state of Southern Kordofan. Their average altitude is 900 m with a maximum elevation of 1,326 m at Jebel Heiban. They are relatively steep-sided, with extensive hinterlands and a wetter microclimate that results in higher-density forest coverage than the surrounding savannah.

## 7. Wetlands

Permanent wetlands make up approximately five percent of the area of Southern Sudan, while a much greater area, both north and south, is seasonally flooded. The largest wetlands and flood plains are all linked to the Nile tributaries that traverse the southern plains. The largest wetland is the Sudd, which is formed by the White Nile in very flat topography between the towns of Bor and Malakal. Covering more than 30,000 km<sup>2</sup>, the Sudd comprises multiple channels, lakes and swamps, with a maze of thick emergent aquatic vegetation.



*Fringing swamps on the White Nile, Jonglei state*

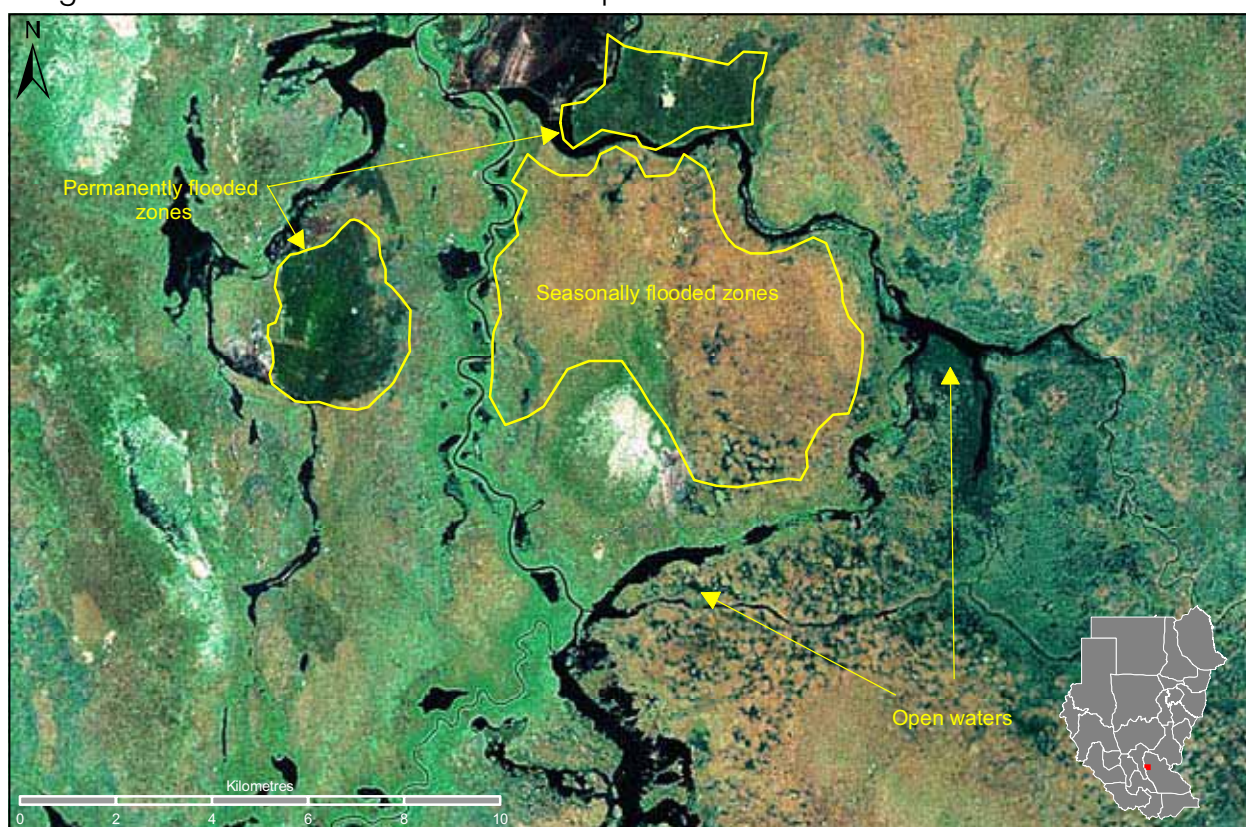
In the south, the wetlands are essentially undeveloped and represent a safe haven for wildlife, including migratory birds.



*Villages perched on steep hillsides in the Nuba mountains, Southern Kordofan*



Figure 2.10 Sudd wetland and flood plains



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



*Mongalla gazelles grazing in the tall grass of the clay plains in Padak district, Jonglei state*

### 8. Flood plains

Much of central and south Sudan is covered by sediment deposited in the Nile basin and known locally as 'black cotton' soil. Due to its high clay content, the soil in these areas retains water in the wet season to form very soft and virtually impassable shallow flood plains. In the dry season, the water disappears from all but a few swamps, waterholes and tributaries, and the clay shrinks

and cracks. These areas are relatively fertile but difficult to cultivate.

The geographic border between flood plains and the drier Sahel belt is somewhat arbitrary in the clay soil regions, as even the dry areas flood easily during high rainfall events. The boundary between flood plains and wetlands is also often arbitrary, as many parts of Southern Sudan consist of a network of seasonally variable wetlands interlacing multiple small flood plains.



*White-backed vultures resting on the new grass of the seasonally flooded 'toic' in Padak district*



## 9. Savannah

Large areas of central and south Sudan are considered to be savannah, classified as low-density woodland, mixed scrub and grassland. Within this broad class, the density and proportions of the three vegetation types vary significantly according to regional climates, soil types, topography and the influence of deliberate seasonal burning, which tends to favour the development of grasslands.

## 10. Subtropical lowlands

The extreme south and south-west of Sudan can be classified as subtropical. This is reflected in the vegetation, which changes relatively abruptly from savannah to semi-tropical forest in the region south and south-west of Juba.

The land bordering the Democratic Republic of Congo in the south-west rises to form a continuous low range known as the Ironstone hills. These hills also form the boundary between the Nile and Congo watersheds. The region supports intensive agriculture and some forestry, but is otherwise undeveloped.



*High rainfall woodland savannah in Bor district, Jonglei state*

## 11. The Imatong, Dongotona, Acholi and Jebel Gumbiri mountain ranges

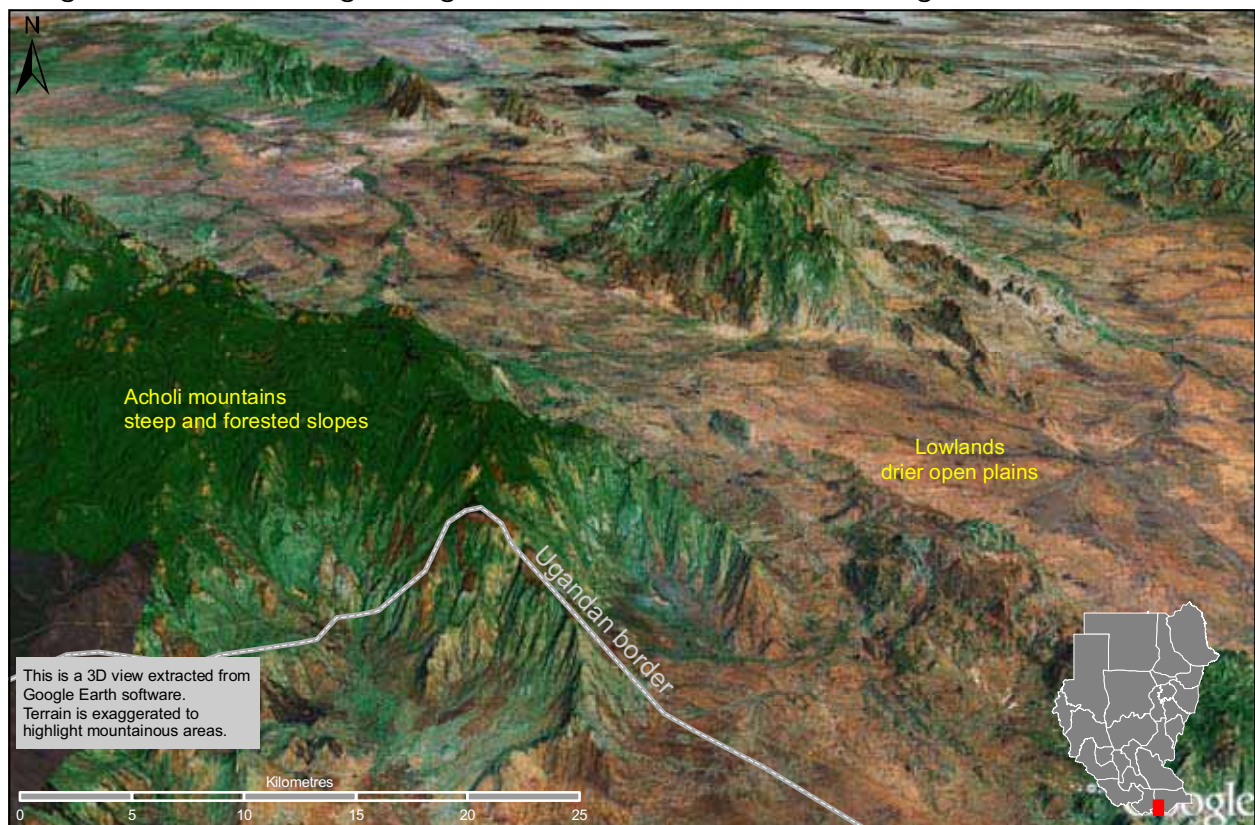
The Imatong, Dongotona and Acholi mountain ranges flank the White Nile in the extreme south of Southern Sudan. Their average altitude is 900 m, with a peak elevation of 3,187 m at Mount Kinyeti, which is the highest point in Sudan. They are characterized by steep slopes and high rainfall, resulting in dense forest and high-yield agriculture. The Jebel Gumbiri mountains, further west, support extensive teak plantations.



*High rainfall woodland savannah with a small seasonal wetland in Wau district, Western Bahr el Ghazal*



Figure 2.11 Imatong, Dongotona and Acholi mountain ranges



*Subtropical vegetation and red ironstone soil in Yei district, Central Equatoria*

# 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<sup>2</sup>. 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 %



### 3 NATURAL DISASTERS AND DESERTIFICATION



*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 swaths 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].

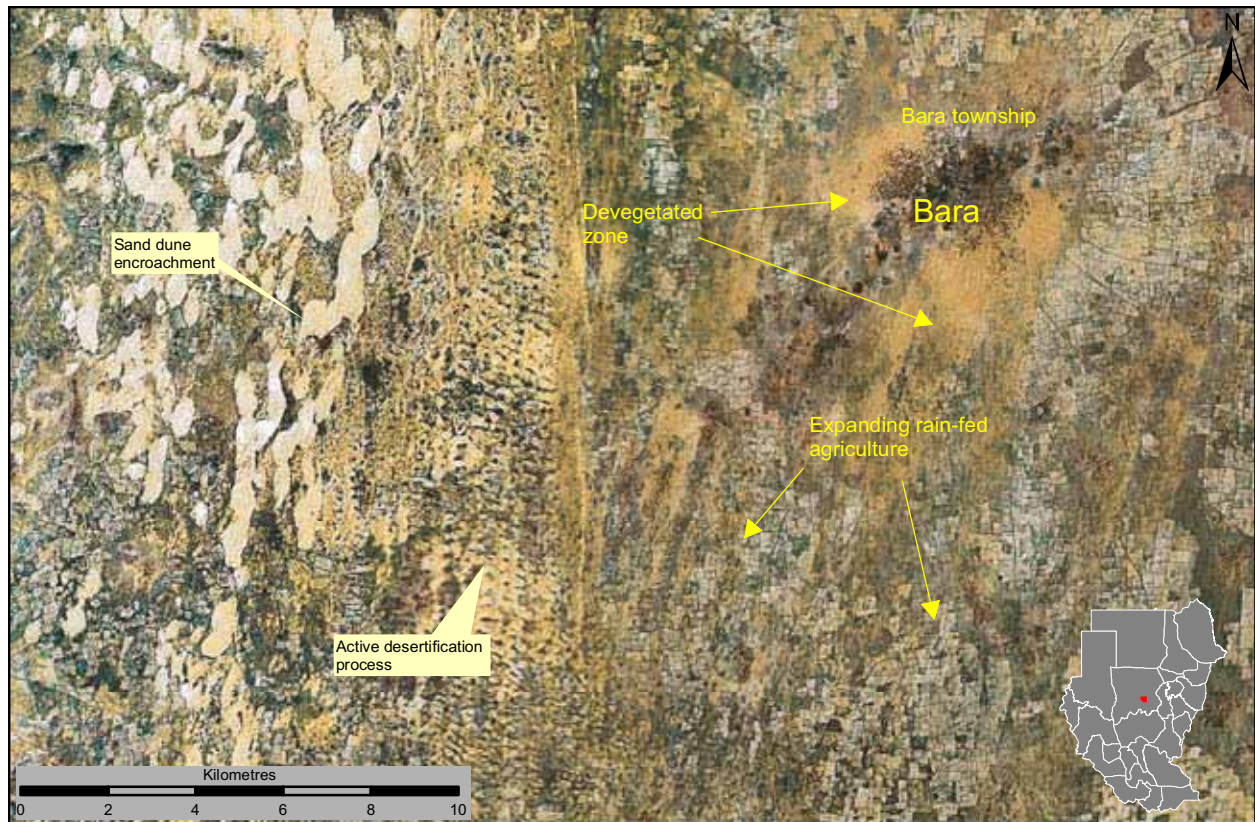
**2. Degradation of existing desert environments, including *wadis* and oases.** At least 29 percent of Sudan is already true desert. Within this large area, however, are hundreds of smaller wetter regions



*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



*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*



### 3 NATURAL DISASTERS AND DESERTIFICATION



*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

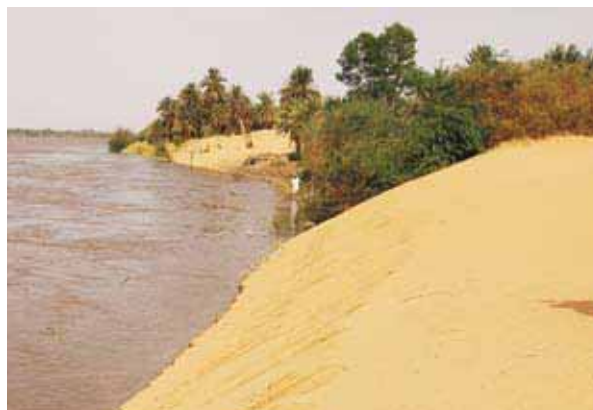
Despite serious water shortages, floods are common in Sudan. The two predominant types of floods are localized floods caused by exceptionally heavy rains and run-off (flash floods), and widespread floods caused by overflow of the Nile and its tributaries.

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



*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*

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.

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

# Conflict and the Environment

*The African Union Mission in Sudan (AMIS) military escort for UNEP fieldwork near El Geneina, Western Darfur. Intense competition over declining natural resources is one of the underlying causes of the ongoing conflict.*







## Conflict and the Environment

### 4.1 Introduction and assessment activities

#### Introduction

Sudan has been wracked by civil war and regional strife for most of the past fifty years, and at the time of finalizing this report, in June 2007, a major conflict rages on in Darfur. At the same time, Sudan suffers from a number of severe environmental problems, both within and outside current and historical conflict-affected areas. UNEP's assessment has found that the connections between conflict and environment in Sudan are both complex and pervasive: while many of the conflicts have been initiated partly by tension over the use of shared natural resources, those same resources have often been damaged by conflict.

This chapter is divided into three main sections:

1. **a conflict overview**, presenting a summary of the history of recent conflicts in Sudan;
2. **an overview of the role of natural resources** in the instigation and continuation of historical and current conflicts, listing the major resources of concern and focusing specifically on conflicts involving rangelands and rain-fed agricultural land; and
3. **a brief environmental impact assessment of the various conflicts**, evaluating the direct and indirect impacts of conflict on Sudan's environment.

Chronic environmental problems are covered in other chapters, though it should be noted that at the local level, the boundary between chronic and conflict-related environmental issues is often unclear.

#### Assessment activities

The assessment of conflict-related issues was an integral part of fieldwork throughout the country. In addition, UNEP carried out a number of specific activities, including:

- walkover inspections of destroyed military equipment in Juba, Bor and Padak, in Southern Sudan;



*Visible remnants of war: abandoned armoured vehicles in Juba, Jonglei state, Southern Sudan*



- viewing of unexploded ordnance (UXO) and mined areas (where walkovers were not possible) in Juba, Yei, Malakal and the Nuba mountains;
- walkover inspections of burnt and destroyed villages and forests east of El Geneina in Western Darfur, and low flyovers in other conflict-affected parts of Darfur;
- viewing of weaponry held by various armed parties throughout Sudan;
- interviews with de-mining and military experts within Sudan; and
- interviews with conflict-affected communities in Darfur, Southern Kordofan and Southern Sudan.

These activities were considered sufficient to obtain an overview of the direct impacts of conflict and related issues for most of Sudan, though UNEP was not able to carry out sufficient fieldwork in Darfur to allow for a full analysis. Moreover, UNEP chose not to investigate in detail the social and political aspects of conflicts in Sudan, focusing instead on their environmental dimension.

### 4.2 Overview of conflicts in Sudan

#### A complex mosaic

Conflicts have directly affected over 60 percent of the country for the last 50 years, and hence greatly influenced its development [4.1, 4.2]. Understanding Sudan's complex mosaic of conflicts is an essential first step in establishing the linkages between conflict and environment in the region. This section accordingly provides a brief summary of the chronology and geography of the various confrontations, together with a short account of the tactics and weaponry used. A thorough review of social and political factors might be taken into consideration in a comprehensive conflict analysis, but is outside the scope of this environmental assessment.

#### Tribal and small-scale conflicts

Tribal and small-scale conflicts fought only with small arms have occurred continuously throughout the history of Sudan [4.3]. No part of

the country has been exempt from such clashes, but they have been concentrated in the south, west and east of the country for the last thirty years. Their causes are generally poorly recorded, but include disputes over cattle theft, access to water and grazing, and local politics [4.3]. Many – though not all – of the large-scale conflicts in Sudan have a connection to tribal friction.

#### The major conflicts

The majority of large-scale conflicts in Sudan have been long-term (five years or more) confrontations between forces aligned with the central Sudanese government based in Khartoum and an array of anti-government forces. The government side has comprised conventional army and air forces, and allied local militias. The opposition has consisted of local militias which – in the case of the Sudan People's Liberation Army (SPLA) in Southern Sudan – evolved into a united resistance army with a parallel governance and administration structure (the Sudan People's Liberation Movement or SPLM).

Major conflicts have at times extended over as much as 60 percent of the territory of Sudan, principally in the ten southern states, but also in the west (all three Darfur states), the centre (Blue Nile and Southern Kordofan states), the east (Kassala state) and the north-east (Red Sea state). In total, over 15 million people have been directly affected, not including the approximately six million people currently still impacted in Darfur. Total conflict-related casualties are unknown, but estimated by a range of sources to be in the range of two to three million [4.4].

Although the government forces' weaponry has included tanks and heavy artillery, most military confrontations have been fought mainly with light weapons such as AK47 assault rifles. The opposition forces' armament has been generally light, with a small number of tanks and other heavy weapons. Only government forces have had airpower.

Landmines have been used widely in most major conflicts. Minefields have been abandoned without marking or extraction and are mostly unmapped. As a result, Sudan now suffers from a severe landmine legacy which continues to cause civilian casualties. It should be noted that there are no reports of extensive use of landmines in the ongoing war in Darfur.

Figure 4.1 Conflicts in Sudan: 1957–2006







*A destroyed village and badly eroded land seen from the air in Northern Darfur*

There is no firm field or documented evidence of any unconventional weapons (chemical, nuclear or biological) ever being held or used in Sudan. Some local communities reported that drinking water wells had been poisoned in Darfur, but in the absence of detail and opportunity for inspection, UNEP did not investigate this issue further.

The history and current status of each of the major conflict areas is briefly described below. The geographical extent of the various conflicts as interpreted by UNEP is shown in Figure 4.1.

### **Darfur**

Fighting in Darfur has occurred intermittently for at least thirty years. Until 2003, it was mostly

confined to a series of partly connected tribal and local conflicts [4.5]. In early 2003, these hostilities escalated into a full-scale military confrontation in all three Darfur states, which also frequently spills into neighbouring Chad and the Central African Republic.

The ongoing Darfur conflict is characterized by a 'scorched earth' campaign carried out by militias over large areas, resulting in a significant number of civilian deaths, the widespread destruction of villages and forests, and the displacement of victims into camps for protection, food and water. Over two million people are currently displaced, and casualties are estimated by a range of sources to be between 200,000 and 500,000 [4.6].



*A downed fighter-bomber near Padak, Jonglei state*

## **Southern Sudan**

In the fifty years since Sudan's independence, the south has experienced only eleven years of peace. During most of the civil war, the central Sudanese government held a number of major towns and launched air attacks and dry-season ground offensives into the surrounding countryside. The opposition forces, the Sudan People's Liberation Army (SPLA) and their allies, fought guerrilla actions, besieged towns and conducted ground offensives in both wet and dry seasons. Most of the countryside, however, saw little or no military activity. Frontlines with prolonged, active fighting were confined to northern-central border regions and besieged towns. The fiercest fighting took place in the 1990s, with frontlines changing constantly and several towns being taken many times.

The conflict extended to areas in central Sudan, such as Abyei district, Blue Nile and the Nuba mountains in Southern Kordofan. Known as the 'Three Areas', these regions retain a high level of political uncertainty today. Small-scale conflict due to the Ugandan militia the Lord's Resistance Army (LRA) has also occurred intermittently in the far south even after the signing of the Comprehensive Peace Agreement in January

2005, and some instability persists in other border regions, particularly in Upper Nile.

## **Nuba mountains**

The Nuba mountains were a SPLA stronghold in the 1990s. The SPLA held the forested regions and steeper terrain, while the open ground and surrounding plains were largely occupied by government forces. The area saw extensive fighting and aerial bombardment [4.7].

## **Kassala state - Eastern front**

The region bordering Eritrea in Kassala state was a stronghold of the Beja people, who were allied with the SPLA. Conflict flared up in the 1990s, but a separate peace agreement between the central government and eastern forces – known as the Eastern Sudan Peace Agreement – was concluded in October 2006.

## **Red Sea state - Eritrean conflict**

The Tokar region in Red Sea state was affected by low-level conflict between Sudan and Eritrea and local allied groups for twelve years, beginning in 1992. Hostilities ceased completely only with the signing of the CPA in early 2005.

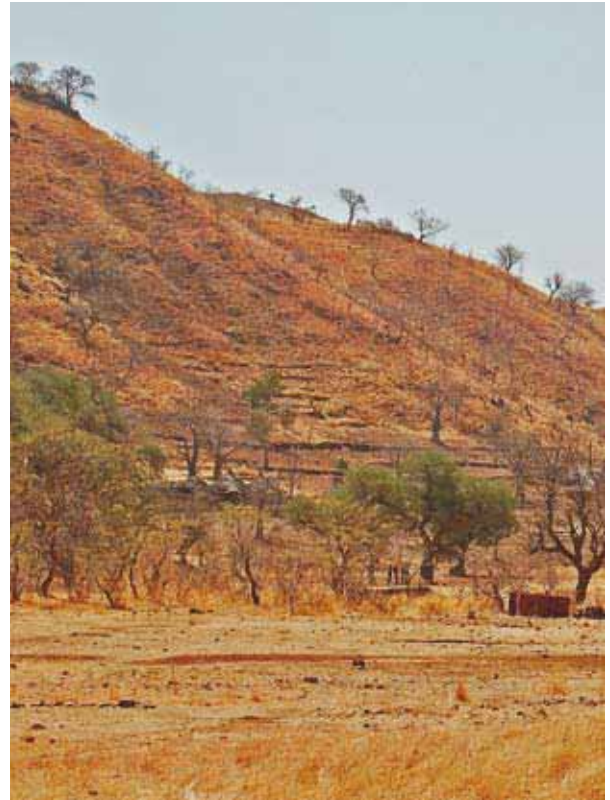


### The ongoing LRA conflict

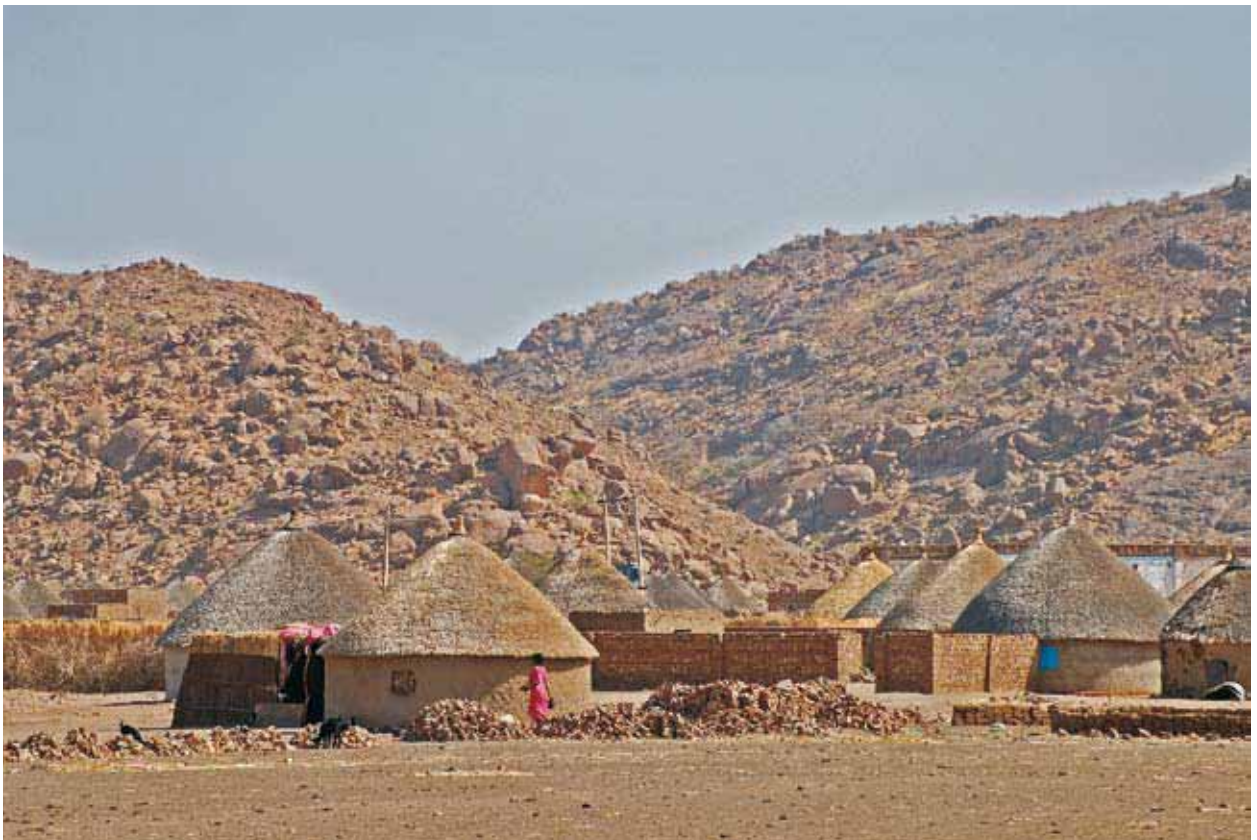
Traditionally based in northern Uganda, directly south of the Sudan's Eastern Equatoria state, the Lord's Resistance Army (LRA) has fought against the Ugandan armed forces for over twenty years. In 2005 and 2006, the conflict spread to Southern Sudan and the Democratic Republic of Congo. As of June 2007, a ceasefire is in effect but peace negotiations have stalled and sporadic conflict is ongoing.

### 4.3 Analysis of the role of natural resources as a contributing cause of conflict in Sudan

It is acknowledged that there are many factors that contribute to conflict in Sudan that have little or no link to the environment or natural resources. These include political, religious, ethnic, tribal and clan divisions, economic factors, land tenure deficiencies and historical feuds. In addition, where environment and natural resource management issues are important, they are generally **contributing** factors only, not the sole cause for tension.



*The Nuba mountains were the scene of sustained fighting in the 1990s*



*The conflict on the Eastern front was fought in the barren hills of Kassala state, near Ethiopia*

As noted previously, 'non-environmental' factors have been excluded from detailed examination in this assessment to allow for a tighter focus on the environmental dimensions of conflict. Also excluded is any analysis of the subsequent behaviour of the conflicting parties, except where it is directly relevant to the environment, as is the case for the targeted destruction of natural resources.

### Four natural resources closely linked to conflict in Sudan

In Sudan, four categories of natural resources are particularly linked to conflict as contributing causes:

1. oil and gas reserves;
2. Nile waters;
3. hardwood timber; and
4. rangeland and rain-fed agricultural land (and associated water points).

Potential conflicts over oil, Nile waters and hardwood timber are national-scale issues. Tensions over rangeland and rain-fed agricultural land are primarily local, but have the potential to escalate and exacerbate other sources of conflict to the extent of becoming national-scale issues, as is presently the case in Darfur.

The linkages between these resources/land uses and conflict are discussed below; the fourth category is examined in more detail in a separate section, as it has strong ties to the ongoing conflict in Darfur.

Note that groundwater (on a regional scale), wildlife, freshwater fisheries and all types of marine resources are excluded from this list of important contributing causes, as there is no evidence that they have been major factors in instigating conflict in Sudan to date.

### Competition over oil and gas reserves

Though the major north-south conflict started well before oil was discovered in central Sudan, competition for ownership and shares in the benefits of the country's oil and gas reserves was a driving force for the conflict and remains a source of political tension today [4.4]. This is, however, considered to be primarily an economic, political and social issue, and is hence not addressed in detail in this report.

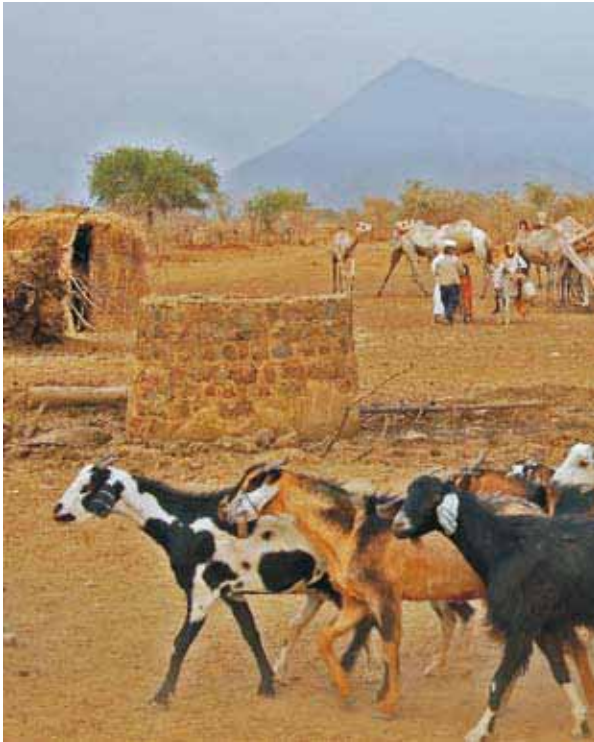
Of more relevance to UNEP, in this context, are the environmental impacts of the oil industry and their potential to catalyse conflict in the future. Consultations in central and south Sudan revealed widespread and intense dissatisfaction with the oil industry's environmental performance, coupled with the above-mentioned general concerns about ownership and benefit-sharing. In summary, the population in the vicinity of the oilfields said they felt subjected to all of the downsides of the presence of the oil industry (including its environmental impacts) without receiving a share in the benefits. Experience from other countries, such as Nigeria, shows that the root causes for this type of resentment must be addressed in order to avoid long-term instability and conflict at the local level. Part of the solution is to improve the environmental performance of the industry.

The environmental aspects of this issue are covered in a more detailed assessment of the oil industry in Chapter 7.



*Camels graze in a destroyed village in Western Darfur. The trees have been cut for fuelwood and to provide the animals with fodder. Fighting over grazing land has been ongoing in Darfur since 1920 at least*





*Water is the most precious natural resource in the drier regions. Goats, cattle and camels all use this crowded water point in Southern Kordofan*

### **Conflict over water rights and benefits from the Nile**

Competition for the benefits accrued from the use of surface water was also an important contributing factor of the civil war, as illustrated by the Jonglei canal project (see Case Study 10.2), which was a cause as well as a victim of the conflict that flared up in Southern Sudan in 1983. The significance of this issue has not declined over time and tensions over attempts to re-start the project are still high.

However, a number of institutional safeguards are likely to prevent a re-instigation of conflict over water rights alone at the state and federal level. First, as a high profile and easily identifiable issue, it receives significant attention from GONU and GOSS leadership, as well as international assistance in the form of programmes like the Nile Basin Initiative. Second, major projects such as new dams or canals require both large investments and long periods of time, and this development process (in its modern form at least) has a range of built-in safeguards to identify and mitigate the risk of conflict. Water issues are covered in more detail in Chapter 10.

### **Timber and the war economy**

While there is no indication that timber has been a major contributing cause of the instigation of conflict in Sudan, there is clear evidence that revenue from hardwood timber sales helped sustain the north-south civil war. Timber became part of the war economy, and there are now signs that this process is being repeated with charcoal in Darfur. Overall however, the timber-conflict linkage in Sudan is considered to be mainly an environmental impact issue (rather than a conflict catalyst). This is discussed in more detail in the next section, and in Chapter 9.

### **Local conflicts over rangeland and rain-fed agricultural land**

Local clashes over rangeland and rain-fed agricultural land have occurred throughout Sudan's recorded history. In the absence of demographic and environmental change, such conflicts would generally be considered a social, political or economic issue and not warrant an assessment purely on environmental grounds. However, environmental issues like desertification, land degradation and climate change are becoming major factors in these conflicts. This topic is addressed in more detail in the following section.



*Low quality degraded rangeland in Northern Darfur. To survive in these regions, pastoralists must travel across agricultural areas to find water and fodder for their herds, which commonly leads to conflict*



#### 4.4 Environmental linkages to local conflicts over rangeland and rain-fed agricultural land

##### Introduction and limits to the observed linkages

It is important to note that while environmental problems affect rangeland and rain-fed agricultural land across virtually all of Sudan, they are clearly and strongly linked to conflict in a minority of cases and regions only. These linkages do exist, but their significance and geographic scale should not be exaggerated.

That said, there is substantial evidence of a strong link between the recent occurrence of local conflict and environmental degradation of rangeland and rain-fed agricultural land in the drier parts of Sudan.

##### The actors of conflict at the local level: three major competing and conflicting groups

The rural ethnic and livelihood structures of Sudan are so complex and area-specific that any summary of the issue of resource competition on a national scale is by definition a gross simplification. For instance, traditional pastoralist and agricultural societies in Sudan are not always clearly separated: in many areas, societies (families, clans and even whole tribes) practice a mixture of crop-growing and animal-rearing. Nonetheless, there are some relatively clear boundaries – defined as much by livelihoods as by any other factor – between different tribes, clans and ethnic groups.

For the purposes of this discussion, UNEP has classified the hundreds of distinct rural social units present in the current and historical conflict regions into three major groups, based on livelihood strategies:



*Unexploded ordnance partially buried in a pit outside Juba, Jonglei state*





*This mined road in Jonglei state has not been used by vehicles for a decade, but locals still walk along it to collect firewood and access farm plots*

1. predominantly sedentary crop-rearing societies/tribes;
2. predominantly nomadic (transhumant) livestock-rearing societies/tribes; and
3. owners of and workers on mechanized agricultural schemes.

All three groups depend on rainfall for their livelihood. The other major rural group is comprised of farmers using river and groundwater for irrigation. To date, however, irrigated agriculture has not been a major factor in local conflicts in Sudan.

Most of the recorded local conflicts are within and between the first two groups: pastoralists and agriculturalists fighting over access to land and water. The third group, the mechanized farming lobby, is generally not directly involved in conflict, but has played a very strong role in precipitating it in some states, through

uncontrolled land take from the other two groups. In the Nuba mountains and in Blue Nile state, combatants reported that the expansion of mechanized agricultural schemes onto their land had precipitated the fighting, which had then escalated and coalesced with the major north-south political conflict [4.7, 4.8, 4.9].

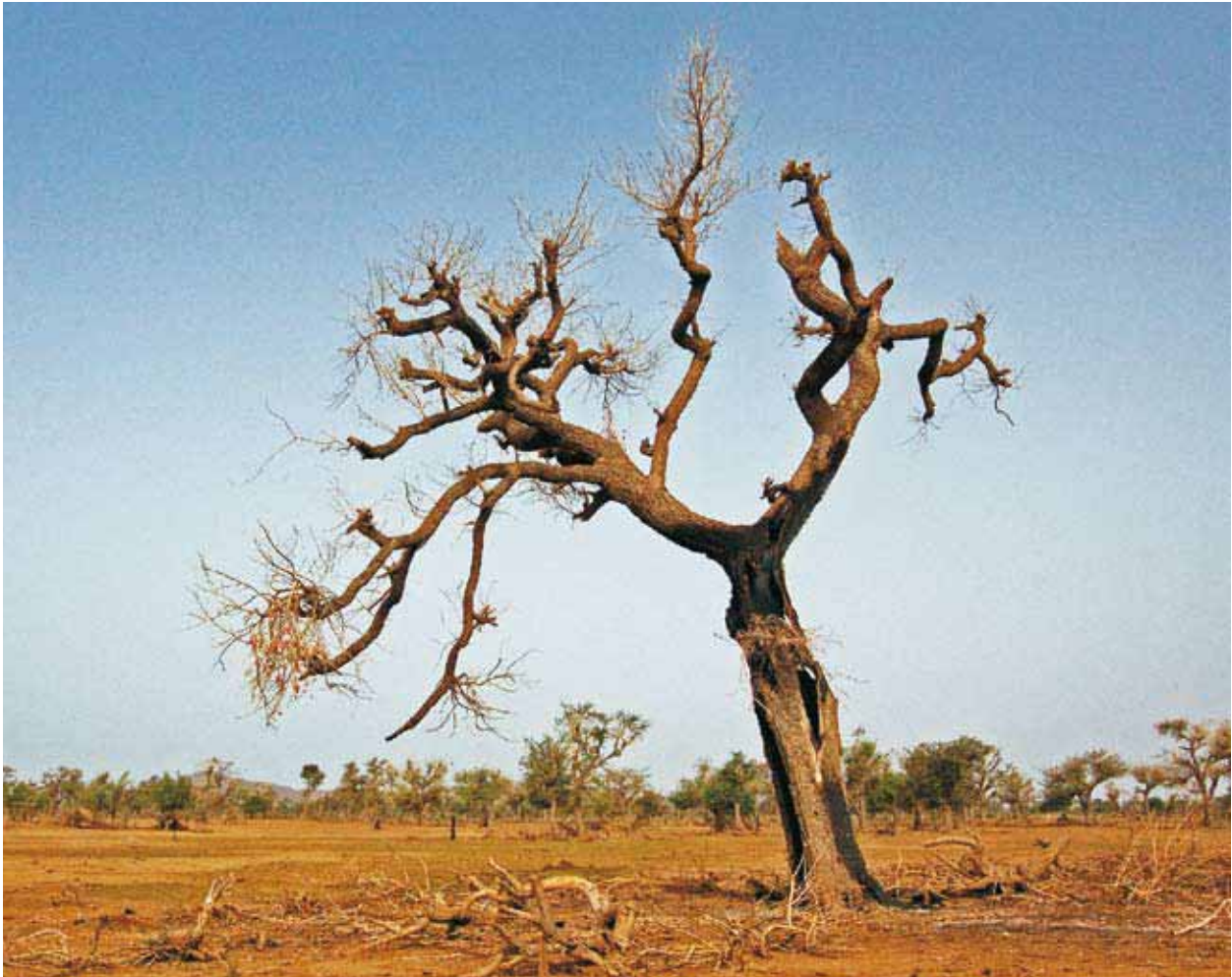
### **The historical background: a tradition of local conflict and resolution**

Violent conflict resulting partly from competition over agricultural and grazing land is a worldwide and age-old phenomenon. In Sudan – and particularly in Darfur and Kordofan – there is an extensive history of local clashes associated with this issue [4.3, 4.5, 4.10, 4.11]. A 2003 study on the causes of conflict in Darfur from 1930 to 2000, for example, indicates that competition for pastoral land and water has been a driving force behind the majority of local confrontations for the last 70 years (see Table 5).

Table 5. Causes of local conflicts in Darfur from 1930 to 2000 [4.3, 4.5]

No.	Tribal groups involved	Year	Main cause of conflict
1	Kababish, Kawahla, Berti and Medoub	1932	Grazing and water rights
2	Kababish, Medoub and Zyadiya	1957	Grazing and water rights
3	Rezeigat, Baggara and Maalia	1968	Local politics of administration
4	Rezeigat, Baggara and Dinka	1975	Grazing and water rights
5	Beni Helba, Zyadiya and Mahriya	1976	Grazing and water rights
6	Northern Rezeigat (Abbala) and Dago	1976	Grazing and water rights
7	N Rezeigat (Abbala) and Bargo	1978	Grazing and water rights
8	N Rezeigat and Gimir	1978	Grazing and water rights
9	N Rezeigat and Fur	1980	Grazing and water rights
10	N Rezeigat (Abbala) and Bargo	1980	Grazing and water rights
11	Taaisha and Salamat	1980	Local politics of administration
12	Kababish, Berti and Ziyadiya	1981	Grazing and water rights
13	Rezeigat, Baggara and Dinka	1981	Grazing and water rights
14	N Rezeigat and Beni Helba	1982	Grazing and water rights
15	Kababish, Kawahla, Berti and Medoub	1982	Grazing and water rights
16	Rezeigat and Mysseriya	1983	Grazing and water rights
17	Kababish, Berti and Medoub	1984	Grazing and water rights
18	Rezeigat and Mysseriya	1984	Grazing and water rights
19	Gimir and Fallata (Fulani)	1987	Administrative boundaries
20	Kababish, Kawahla, Berti and Medoub	1987	Grazing and water rights
21	Fur and Bidayat	1989	Armed robberies
22	Arab and Fur	1989	Grazing, cross-boundary politics
23	Zaghawa and Gimir	1990	Administrative boundaries
24	Zaghawa and Gimir	1990	Administrative boundaries
25	Taaisha and Gimir	1990	Land
26	Bargo and Rezeigat	1990	Grazing and water rights
27	Zaghawa and Maalia	1991	Land
28	Zaghawa and Marareit	1991	Grazing and water rights
29	Zaghawa and Beni Hussein	1991	Grazing and water rights
30	Zaghawa, Mima and Birgid	1991	Grazing and water rights
31	Zaghawa and Birgid	1991	Grazing and water rights
32	Zaghawa and Birgid	1991	Grazing and water rights
33	Fur and Turgum	1991	Land
34	Zaghawa and Arab	1994	Grazing and water rights
35	Zaghawa Sudan and Zaghawa Chad	1994	Power and politics
36	Masalit and Arab	1996	Grazing, administration
37	Zaghawa and Rezeigat	1997	Local politics
38	Kababish Arabs and Midoub	1997	Grazing and water rights
39	Masalit and Arab	1996	Grazing, administration
40	Zaghawa and Gimir	1999	Grazing, administration
41	Fur and Arab	2000	Grazing, politics, armed robberies





*The scorched earth tactics used by militias in Darfur include cutting and burning trees in a haphazard manner*

Until 1970, there is also a well-documented history of local resolution for such conflicts, through established mediation and dispute resolution mechanisms. Since then, however, legal reforms have essentially destroyed many of these traditional structures and processes, and failed to provide a viable substitute. In addition, the last thirty years have seen an influx of small arms into the region, with the unfortunate result that local conflicts today are both much more violent and more difficult to contain and mediate.

### **Theories of natural resource scarcity and application to local conflict in Sudan**

Academic research and the discourse on the role of natural resource scarcity as a driver of conflict have developed significantly over the last decade [4.12, 4.13, 4.14, 4.15]. In light of the ongoing Darfur crisis, Sudan is a prime example of the

importance, complexity and political sensitivity of this topic. The following analysis borrows heavily from the language and concepts used by leading researchers in this field.

As a basis for discussion, the environmentally significant factors that contribute to conflict related to rangeland and rain-fed agricultural land have been divided into four groups:

- supply: factors affecting the available resources;
- demand: factors affecting the demand for resources;
- land use: changes affecting the way remaining resources are shared; and
- institutional and development factors.

While all the purely environmental factors are 'supply' issues, they have to be put into the context of 'demand' and 'institution-specific' factors.



*During the major north-south conflict, the town of Wau in Western Bahr el Ghazal was a centre for the logging and regional export of teak. The trade was effectively halted by the closing of the rail link; only a small-scale local teak trade subsists today*

### Supply – an unreliable and dwindling resource

The noted environmental issues affecting agriculture in Sudan all result in a dwindling supply of natural resources:

- **Desertification, soil erosion and soil exhaustion** (depletion of nutrients and compaction) lower agricultural productivity and, in the worst cases, take land out of use for the long term. This has been well documented but poorly quantified in Sudan (see Chapters 3 and 8);
- **Deforestation**, particularly in the drylands, has resulted in a near permanent loss of resources including seasonal forage for pastoralists and natural fertilizer/soil recovery services for farmers. Deforestation rates in the areas studied by UNEP average 1.87 percent per annum (see Chapters 8 and 9);
- **Historical climate change** has reduced productivity in some areas due to a decline in rainfall. A major and long-term drop in precipitation (30 percent over 80 years) has been recorded in Northern Darfur, for example. The implications of such a decline on dry rangeland quality are obvious (see Chapter 3); and
- **Forecast climate change** is expected to further reduce productivity due to declining rainfall and increased variability, particularly in the Sahel belt. A drop in productivity of up to 70 percent is forecast for the most vulnerable areas (see Chapter 3).

### Ever increasing demands on resources

The demand for natural resources in Sudan is uniformly increasing, due to the following factors:



- **Human population growth** is the underlying driver of increased demand for natural resources. Sudan has an overall growth rate of over 2.6 percent per annum, masking much higher localized rates. In central Darfur, for example, government statistics indicate a regional population (linear) growth rate of 12 percent per annum, from 3 persons/km<sup>2</sup> in 1956 to 18 persons/km<sup>2</sup> in 2003 [4.16]. These growth rates are indicative of large-scale in-migration, in this case mainly from the north and possibly due to environmental factors such as desertification; and
- **Livestock population and growth rates;** government officials and academics have tracked the population increase of livestock since the 1960s. In northern and central Sudan alone, it is estimated to have increased by over 400 percent between 1961 and 2004 (see Chapter 8) [4.17].

### Land use changes – a dwindling share of resources for pastoralists

The horizontal expansion of agriculture into areas that were previously either rangeland or forest has been a well recognized trend for the last four decades. The northwards expansion of rain-fed agriculture into marginal areas historically only used for grazing has been particularly damaging. Three examples from the recent UNEP-ICRAF [4.18] study of land use changes illustrate a major reduction in rangeland areas due to expanding agriculture (see Chapters 8 and 9):

- In Ed Damazin, Blue Nile state, agricultural land (mainly mechanized), increased from 42 to 77 percent between 1972 and 1999, while rangeland effectively disappeared, dropping from 8.3 to 0.1 percent;
- In the El Obeid region of Northern Kordofan, rain-fed agricultural land increased by 57.6 percent between 1973 and 1999, while rangeland decreased by 33.8 percent and wooded pasture by 27 percent; and
- In the Um Chelluta region of Southern Darfur, rain-fed agricultural land increased by 138 percent between 1973 and 2000, while rangeland and closed woodland decreased by 56 and 32 percent respectively.

In addition to the loss of grazing land, agricultural expansion has also blocked livestock migratory routes between many of the widely separated dry and wet season pastures, and between the herds and daily watering points. A further complication is that sedentary farmers are increasingly raising their own livestock, and are hence less willing to give grazing rights to nomads in transit [4.19] (see Chapter 8 for a more detailed discussion of these issues).

### Institutional factors – failing to rectify the issues

Agricultural institutions and environmental governance in Sudan are discussed in detail in Chapters 8 and 13 respectively. In summary, the rural environment has been impacted by a combination of ill-fated reform and development programmes, as well as legal reforms and failures in environmental governance. One key issue is the difficulty of developing and applying a practical, just and stable system of rural land tenure in an ethnically complex society of intermingled sedentary farmers and transhumants/nomads. This has not been achieved in Sudan so far.

### A lack of development and livelihood options

Outside of the main urban areas, Sudan remains very poor and underdeveloped. Rural populations consequently have very few options to solve these agricultural crises, as solutions like agricultural development, improvements in pasture and stock quality, and using working capital to cover short-term needs and alternative employment are simply not available [4.19].

### The net result – disappearing livelihoods for dryland pastoralist societies

The clear trend that emerges when these various elements are pieced together is that of a **significant long-term increase in livestock density on rangelands that are reducing in total area, accessibility and quality**. In environmental terms, the observed net result is overgrazing and land degradation. In social terms, the reported consequence for pastoralist societies is an effectively permanent loss of livelihoods and entrenched poverty.

Pastoralist societies in Sudan have always been relatively vulnerable to losing their livelihoods due to erratic rainfall, but the above-noted combination of factors has propelled many pastoralists into a negative spiral of poverty, displacement, and in the worst cases, conflict. Their coping strategies, which have been well documented [4.16, 4.19], include:

- Abandoning pastoralism as a livelihood in favour of sedentary agriculture, or displacement to cities;
- Increasing or varying the extent of annual herd movements where possible, with a general trend towards a permanently more southerly migration;
- Maximizing herd sizes as an insurance measure (assisted by the provision of water points and veterinary services);

- Changing herd composition, replacing camels by small animals, mainly sheep, in response to the curtailment of long-distance migration;
- Competing directly with other grazers for preferred areas of higher productivity (**entailing a conflict risk**);
- Moving and grazing livestock on cropland without consent (**entailing a conflict risk**); and
- Reducing competition by forcing other pastoralists and agriculturalists off previously shared land (**as a last resort - the proactive conflict scenario**).

Variations of all of these strategies can be observed throughout Sudan, particularly in the drier regions.



*Displaced populations settle on the outskirts of existing towns, as seen here in El Fasher, Northern Darfur, where the new settlement is distinguished by white plastic sheeting. These new arrivals add to the environmental burden on the surrounding desert environment*





*Camel herders from the Shanabla tribe at a water point in El Tooj, Southern Kordofan. The southward migration of camel herders is a harbinger of renewed conflict in the Nuba mountains*

### **CS 4.1 The southward migration of camel herders into the Nuba mountains and subsequent resource competition**

The Nuba mountains region in Southern Kordofan provides an example of the increase in natural resource competition and local conflict that results from the combination of agricultural expansion, land degradation and the southward migration of pastoralists.

At the start of the civil war in the 1980s, cattle-herding pastoralists from the Hawazma Baggara tribe started penetrating deeper into the Nuba mountains in search of water and pasture for their cattle, due to the loss of grazing land to mechanized agriculture and drought. The rivalry that ensued with the indigenous Nuba tribe, who practised a combination of sedentary farming and cattle-rearing, contributed to the outbreak of large-scale armed conflict. Meanwhile, as some of the dry season pastures around Talodi were off-limits during the conflict years, the Hawazma had to remain in their wet season grazing lands in Northern Kordofan, exerting greater pressure on the vegetation there.

In 2006, UNEP observed the return of Hawazma Baggara to their former grazing camps in conflict zones in Southern Kordofan, for example near Atmoor. UNEP also witnessed the presence of the camel-herding Shanabla tribe in the midst of thick woodland savannah at El Tooj (now reportedly reaching up to lakes Keilak and Abiad).

This new southward migration of camel herders constitutes an indicator of livestock overcrowding and rangeland degradation in Northern Kordofan, and is a harbinger of further conflict with the Nuba. At Farandala in SPLM-controlled territory, the Nuba expressed concern over the widespread mutilation of trees due to heavy lopping by the Shanabla to feed their camels, and warned of 'restarting the war' if this did not cease.