

Conclusions on the role of environmental issues in conflicts over rangeland and rain-fed agricultural land

Pastoralist societies have been at the centre of local conflicts in Sudan throughout recorded history. The most significant problems have occurred and continue to occur in the drier central regions, which are also the regions with the largest livestock populations, and under the most severe environmental stress.

As there are many factors in play – most of which are not related to the environment – land degradation does not appear to be the dominant causative factor in local conflicts. It is, however, a very important element, which is growing in significance and is a critical issue for the long-term resolution of the Darfur crisis. The key cause for concern is the **historical, ongoing and forecast shrinkage and degradation of remaining rangelands in the northern part of the Sahel belt.**

Much of the evidence for UNEP's analysis is anecdotal and qualitative; it has been gathered through desk study work, satellite images and interviews of rural societies across Sudan. The consistency and convergence of reports from a range of sources lend credibility to this analysis, although further research is clearly needed, with a particular emphasis on improved quantification of the highlighted issues and moving beyond analysis to search for viable long-term solutions.

A conference on the topic of environmental degradation and conflict in Darfur was held in Khartoum in 2004. The proceedings [4.20] illustrated the depth of local understanding of the issue. Given the situation observed in 2007, however, UNEP must conclude that this high-quality awareness-raising exercise was unfortunately apparently not transformed into lasting action.

4.5 Assessment of the environmental impacts of conflict

Introduction

This section approaches the linkages between conflict and environment from the reverse angle to the above analysis, by examining **if and how armed conflict has resulted in negative or positive impacts on the environment in Sudan.** Direct impacts, indirect impacts and

key conflict-related issues are identified and discussed in this chapter. Detailed discussion and recommendations on the various environmental issues of concern (e.g. deforestation) are referred to the corresponding sector chapter.

Definitions and impact listings

The following definitions are used for direct, indirect and secondary environmental impacts of conflict in Sudan:

- **Direct impacts** are those arising directly and solely from military action;
- **Indirect and secondary impacts** are all impacts that can be credibly sourced in whole or in part to the conflicts and the associated war economy, excluding the direct impacts.

On this basis, UNEP has developed the following list of impacts for discussion:

Direct impacts include:

- landmines and explosive remnants of war (ERW);
- destroyed target-related impacts;
- defensive works; and
- targeted natural resource destruction.

Indirect and secondary impacts include:

- environmental impacts related to population displacement;
- natural resource looting and war economy resource extraction;
- environmental governance and information vacuum; and
- funding crises, arrested development and conservation programmes.

Direct impacts

Landmines and explosive remnants of war

Landmines and other explosive remnants of war (ERW) are a major problem in Sudan. Thirty-two percent of the country is estimated to be affected [4.4], with the greatest concentration in Southern Sudan (see Case Study 4.2). As many as twenty-one of the country's twenty-five states may be impacted, although the true extent of Sudan's landmine problem remains unknown, as a comprehensive survey of the issue has not been undertaken to date.



In 1983, southern military forces sabotaged these generators powering the Jonglei canal excavator. Plans to restart the giant water project constitute a major potential flashpoint for renewed conflict

The reported and registered number of landmine casualties over the past five years totals 2,200, though again, no systematic data collection and verification mechanism exists. In addition, there is no data at all on animal casualties from mines in Sudan, but these are expected to be much higher than the human casualty rate. The impacts of landmines on wildlife would only be significant (at the ecosystem level) if individual losses affected locally threatened populations of key species.

The potential impacts of landmines and ERW can be divided into chemical and physical categories. Conventional explosives, such as TNT and RDX, found in artillery shells and mines are highly toxic and slow to degrade. While they present an acute toxic hazard if ingested, the toxic risk is considered insignificant compared to the risk of injury from explosion.

Apart from human casualties, another major impact of landmines is impeded access to large areas for people and their livestock. In Sudan, access to some areas has been reduced for decades, as they have remained mined or suspected as such since the beginning of the conflict.

In all but the driest areas, the result of reduced access has been the relatively unimpeded growth of vegetation. UNEP fieldwork, in the Nuba mountains in particular, revealed extensive areas of woodland regrowth in suspected minefields. Such regrowth can have a beneficial effect on the affected areas and associated wildlife populations, but the flow of benefits to people is usually reduced, as they cannot safely extract resources (e.g. water, fuelwood, fodder) from these sites. Despite the risks, however, UNEP teams witnessed people walking, herding cattle and gathering fuel in clearly marked minefields.



The dumping of waste on minefields and on top of unexploded ordnance creates a major safety problem (top); unexploded ordnance is loosely stacked and scattered across the area (bottom)

CS 4.2 Unexploded ordnance, minefields and deforestation at Jebel Kujur, Juba district

The Jebel Kujur massif near the city of Juba in the state of Central Equatoria (Bahr el Jabal) clearly illustrates the localized but severe impacts of conflict affecting many urban centres in Southern Sudan, as well as the environmental governance challenges facing the new government.

During the 1983-2005 conflict, Juba was a garrison town for the central government military, and was continuously under siege and frequently attacked by SPLA forces. The town itself still shows extensive scarring, and overgrown entrenchments, minefields and scattered unexploded ordnance are visible on the fringes. Deforestation and soil erosion are severe, particularly at Jebel Kujur, which originally supported a dense forest cover. A quarry is also operating at one end of the range.

In late 2006, clean-up was ongoing, but there were still minefields and areas of stacked ordnance in the foothills of Jebel Kujur. Despite the obvious risks, cattle grazing, scrap recovery and waste dumping were routinely taking place in these areas. Plastic waste was being dumped directly on top of unexploded artillery shells and rocket-propelled grenades, creating obvious serious hazards for site users and greatly increasing the future cost of de-mining and rehabilitation.

The removal of explosive remnants of war (ERW) from Jebel Kujur is a difficult but short-term activity. The greater challenges are sustainable solutions for waste management for the growing city and reforestation of the massif.

Destroyed target-related impacts

Target-related impacts refer to the effects on the environment of direct military action on targets, irrespective of the method. The physical destruction of the environment from conventional weaponry (bombs, artillery shells and mortars) principally takes the form of cratering, and damaged or destroyed buildings, trees, and industrial facilities.

Though cratering has been reported by de-mining staff in Southern Sudan, there is no indication that more than a few hectares are affected at each conflict location. Similarly, the destruction of trees by direct military action is considered negligible compared to other causes of deforestation in Sudan. No lasting environmental damage is expected either from the destruction of buildings, apart from the generation of inert solid waste as rubble.

The single most significant industrial target in conflicts to date is the Jonglei canal excavator, which was sabotaged 40 km north of Padak in Jonglei state. The rusting excavator is currently used as a nesting site by eagles and is home to several beehives. UNEP experts inspected the excavator and its surroundings, and concluded that its direct environmental impact was negligible.

Neither the oilfields in the south, nor the transfer pipeline to Port Sudan were ever successfully attacked to the extent that significant environmental damage ensued.

UNEP concludes that the absence of vulnerable industrial targets in historical conflict zones has prevented any major environmental contamination from chemical spillage, and that other target-related impacts have been insignificant in environmental terms.

Defensive works

Major defensive works such as trench networks and bunkers were noticeably absent throughout the country, but de-mining staff in Southern Sudan reported that limited defence works could be found on the outskirts of besieged garrison towns.

Southern communities gave consistent reports of government forces clearing trees from the periphery of the garrison towns to deny cover to attacking forces. UNEP site inspections of the outskirts of Juba, Malakal and Aweil certainly indicated that deforestation has occurred, but it was not possible to attribute this solely to defensive works, as several other causes of deforestation were also evident at these locations (see Chapter 9).



In many rural areas of Southern Sudan, the only direct and lasting evidence of the conflict is scattered steel scrap, such as this grenade fragment outside Juba, Jonglei state

Targeted natural resource destruction

In Darfur, the deliberate targeting of vital natural resource-related infrastructure, such as rural water pumps, has been well documented by NGOs and inspection reports from the African Union Mission in Sudan (AMIS)[4.21]. Local populations in Darfur have also reported many instances of deliberate natural resource destruction by raiding militia, whose principal targets are trees, crops and pastures. Crops and pastures are burned and trees are cut. UNEP directly observed evidence of destructive tree-cutting in destroyed and deserted villages east of El Geneina in Western Darfur (see Case Study 4.3). Aid workers have reported similar targeted tree-cutting in other parts of Darfur.

Given the lack of quantifiable data on field conditions in Darfur, it is not possible to estimate the significance of this phenomenon. UNEP can only state that it is occurring and that it will add to the deforestation problem in the region (see Chapter 8).

Indirect and secondary environmental impacts of conflict

The environmental impacts of population displacement

After civilian deaths and injuries, the most significant effect of conflict on the population of Sudan has been displacement – people fleeing conflict zones seeking security. An estimated five million people (7 to 12 percent of the estimated total population of Sudan) have been displaced to date, and less than one million have returned. The number of displaced is rising due to the continuing conflict in Darfur. The great majority of the displaced have come from rural areas and migrated to camps on the outskirts of towns and cities. Over two million have relocated to the capital city, Khartoum.

The severe and complex environmental consequences of displacement include:

- deforestation in camp areas;
- devegetation in camps areas;
- unsustainable groundwater extraction in camps;

- water pollution in camp areas;
- uncontrolled urban slum growth;
- the development of a ‘relief economy’ which can locally exacerbate demand for natural resources;
- fallow area regeneration and invasive weed expansion; and
- return- and recovery-related deforestation.

Not all displacement in Sudan is due to conflict. Drought and economic factors are also major contributing causes. For this reason, the environmental impacts of all the different types of displacement are separately discussed in Chapter 5.

Looting of natural resources - war economy resource extraction

Natural resource looting is defined as the uncontrolled and often illegal extraction of natural resources that commonly occurs during extended conflicts. In this context, natural resources are often badly impacted and also have a role in sustaining the conflict.

In Sudan, the resources in question are timber (lumber and charcoal), ivory and bushmeat. Although oil is a contested natural resource in Sudan, it is excluded from this discussion as UNEP found no evidence of significant uncontrolled, concealed or illegal extraction. The potential and actual environmental impacts of the oil industry are covered in Chapter 7.

The looting of timber occurred on both sides in the north-south conflict. The most significant extraction concerned high value timber in Southern Sudan and fuelwood for charcoal in the Nuba mountains.

In Southern Sudan, UNEP received consistent verbal reports, backed by literature [4.22], of extraction and export (regional and international) of plantation teak and natural mahogany by government as well as SPLA forces and associated militias, though extraction was limited on both sides to areas within their respective control and close to transportation corridors. Northern government forces extracted timber from Wau, exporting it north via the rail link, and from Juba and other Nile towns, exporting by barge. The SPLA exported plantation teak southwards, from the Equatoria states to Uganda.



An abandoned grinding stone in the former village of Hashaba, south-east of El Geneina, destroyed in the conflict

CS 4.3 Targeted natural resources destruction in Western Darfur

One of the defining impacts of the current conflict in Darfur has been the displacement of people from rural areas, and the destruction of villages and surrounding land by militias. During its field mission in June 2006, the UNEP assessment team, under armed escort from African Union forces, visited some of the areas south-east of El Geneina in Western Darfur. The mission found that the outlying villages had been damaged to the extent that hardly any evidence of their former existence remained. In addition to the demolition of infrastructure, the trees within village limits had been systematically cut down.

These observations from the areas around El Geneina were consistent with anecdotal information collected through interviews with IDPs in the camps of Northern, Western, and Southern Darfur.

While some trees may have been felled to provide fodder for livestock or to be sold for firewood in IDP camps, there is evidence that some were undoubtedly cut down maliciously. This is the case for mango trees, for instance, as their leaves are inedible for livestock. From a military perspective, destroying trees severs the former community's links to the land and reduces the likelihood of resettlement. The environmental consequences of the loss of tree cover include a net deficit of biomass available to the soil, as well as the loss of the trees' ability to fix nitrogen. Both result in a decrease in soil fertility.

UNEP has no data or basis on which to quantify the extent of this reported trade. It is clear, however, that it has come to an end or has at least been significantly reduced. For the northern forces, trade has been stopped by the closure of the Wau rail link and the demobilization of northern garrisons from the south, while the SPLA's extractions have been curtailed by the newly formed Government of Southern Sudan's 2005 ban on timber exports and customs controls on border roads.

In the Nuba mountains, UNEP field teams observed charcoal for sale at military checkpoints, indicating that the military may still play a role in this business in the area.

Both UNEP teams and the follow-up Darfur Joint Assessment Mission field teams found an active lumber industry in central Darfur, in historical as well as current conflict areas. While it was not possible to determine who the main actors in this trade were, it was clear that some uncontrolled logging linked to the conflict was occurring.

The elephant population in Southern Sudan was decimated during the north-south conflict. While it is likely that much of the ivory was shipped to Khartoum, which is the centre of ivory carving in the region, there is no firm evidence to identify the main actors of elephant poaching and ivory transportation. Note that while rhinoceros horn was undoubtedly a poaching target in Southern Sudan during the early stages of the conflict, this trade has stopped due to the virtual extinction of rhino in the region.

Though UNEP did not find proof of an ongoing widespread commercial bushmeat trade, local people in Southern Sudan reported that both sides in the north-south conflict had taken bushmeat to feed their forces, with the result that the larger edible mammals such as buffalo, giraffe, zebra and eland are locally extinct throughout much of the south.

In sum, the looting of natural resources has undoubtedly occurred in Sudan and has caused significant damage. However, the signing of the Comprehensive Peace Agreement has reduced the scale of such activities, though looting remains an issue for Darfur, and to some extent for the Nuba mountains.

Environmental governance and information vacuum

Conflict zones generally suffer from a lack of stable governance and limited observance of the rule of law. In environmental terms, this results in a complete lack of environmental protection as well as impunity for those, military or otherwise, who extract or process natural resources in an uncontrolled manner or cause other forms of environmental damage.

Conflict zones are also usually inaccessible for science-based data collection. In the case of Sudan, conflict-related security constraints have denied the environmental science community access to at least half of the country for over two decades. As a result, the true status of much of Sudan's environmental resources remains unknown or open to speculation, limiting rational decision-making for resource management and conservation.

Funding crises - arrested development and conservation programmes

Extended and major conflicts drain national resources and can lead to isolation from the international community. Decades of war in Sudan have helped ensure that it remain one of the world's poorest countries. Political issues have also constrained the flow of international knowledge and assistance to Sudan.

The result has been that conservation of the environment and the sustainable management of natural resources have not been regarded as priorities for Sudan since independence, and that even when they have been considered, they have generally not been sufficiently funded to bring about positive change.

The financial burden of virtually continuous warfare and the ensuing poverty can thus be considered as one of the root causes of the current state of the environment in Sudan.

Summary of the environmental impacts of conflict

The findings of UNEP's assessment of the environmental impacts of conflict in Sudan can be summarized as follows:

Direct impacts are overall minor:

- landmines and explosive remnants of war: significant;
- destroyed target-related impacts: not significant;
- defensive works: not significant; and
- targeted natural resource destruction: significant for Darfur, but currently not quantifiable.

Indirect and secondary impacts are major:

- environmental impacts related to population displacement: very significant;
- looting of natural resources: significant;
- environmental governance and information vacuum: significant; and
- funding crises: very significant.

These findings indicate that the way forward on environmental issues in post-conflict Sudan should not focus on the direct legacies of conflict (which are relatively minor). Attention should instead be paid to the indirect and secondary impact-related issues, as well as to chronic problems. This would be best achieved by integrating all of the issues into a holistic recovery programme rather than attempting to separate them on the basis of conflict linkages.

4.6 Conclusions and recommendations

Conclusion

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

Background to the recommendations

The analysis of the linkages between conflict and environment in Sudan has so far been largely confined to academic circles. In Sudan, only USAID has explicitly integrated peacebuilding into the design of its environmental programme in Southern Sudan [4.24]. It is important that this discussion be broadened to include the government and the United Nations. International peacekeeping initiatives and implementing organizations, such as the African Union Mission to Sudan (AMIS) and the United Nations Mission to Sudan (UNMIS), should particularly take this issue in account.

In addition to political solutions, practical measures to alleviate natural resource competition are urgently needed to help contain the current conflict and present a viable long-term solution for the development of rural Darfur. Elsewhere in Sudan, efforts should be focused first and foremost on identified environmental 'flashpoints', which are specific issues that constitute a potential trigger for the renewal of conflict. The most important of these is the environmental impact of the oil industry, but there are several others, including the charcoal industry in central Sudan, the potential for ivory poaching and the development of a timber mafia in Southern Sudan.



Parched and overgrazed land surrounding a dry livestock supply dam south of El Fasher, Northern Darfur, in June 2006. Environmental scarcity and degradation are two of the important contributing factors in the Darfur crisis

Possible measures – which are listed as recommendations in this and other chapters – include agricultural policy reform, developing the timber industry, and strengthening environmental governance. Such measures should be considered vital investments in conflict prevention and resolution rather than purely environmental conservation projects.

In summary, in the context of the CPA and the ongoing Darfur crisis, the attention of the environmental sector should be focused on the following three areas in order to assist peacebuilding and conflict resolution in Sudan:

1. reducing the environmental impact of the oil industry in central Sudan;
2. promoting more sustainable agriculture and pastoralism in dryland Sudan; and
3. providing information and technical assistance on environment-conflict issues to the national and international community working on peacebuilding and conflict resolution throughout Sudan, with an initial focus on Darfur.

Recommendations for the international community

R4.1 Bring the issue of environmental degradation and ecologically sustainable rural development to the forefront of peacebuilding activities in Sudan. This will entail a major awareness-raising exercise by UNEP and the international community in Sudan, and will need to be incorporated into response strategies for bodies such as the African Union, the UN Development Group (UNDG) and the UN Department of Peacekeeping Operations (UNDPKO).

CA: AW; PB: UNDPKO; UNP: UNEP; CE: 0.5M; DU: 1 year

R4.2 Bring natural resource assessment and management expertise into the existing peacebuilding and peacekeeping efforts in Sudan. UNEP or other organizations would provide technical assistance to the existing actors in this area for the south, east and Darfur, joining in the decision-making process. This should include significant direct support to governments and to both the African Union Mission to Sudan and the United Nations Mission to Sudan.

CA: TA; PB: UNMIS; UNP: UNEP and FAO; CE: 2M; DU: 3 years

R4.3 Conduct a specific environmental assessment for rural Darfur conflict regions as soon as security conditions and political stability permit. The major conflict which flared up in northern and central Darfur in September 2006 is expected to change and worsen the situation, in both humanitarian and environmental terms. An updated, detailed assessment focusing on land quality is needed to assist in the development of an appropriate recovery plan (when the time for recovery arrives). This very technical work would be used to supplement the existing body of largely qualitative work presented in the Darfur JAM interim report.

CA: AS; PB: UNMIS; UNP: UNEP and FAO; CE: 0.4M; DU: 1 year

Recommendations for the Government of National Unity

R4.4 Undertake strategic reform of the agricultural and pastoral sector. Without resolution of the underlying rural land use problems, the issue of the links between environmental degradation and conflict will remain insoluble. This recommendation is not costed as it is essentially an internal culture and strategic policy issue for GONU.

Population Displacement and the Environment

Sudan has the largest population of displaced persons in the world today. Nearly two million are in Darfur, in large settlements such as Abu Shouk IDP camp in El Fasher, Northern Darfur.



Population displacement and the environment

5.1 Introduction and assessment activities

Introduction

Over five million internally displaced persons (IDPs) and international refugees currently live in rural camps, informal settlements and urban slums in Sudan. This represents the largest population of displaced persons in the world today. Living conditions in these settlements are in many cases appalling: they are crowded and unsanitary, food and water are in short supply, insecurity is high, and livelihood opportunities are generally lacking. Some of these temporary settlements have existed for over twenty years with no improvement, and the conflict in Darfur is generating a new wave of displacement that is worsening the situation.

This massive population displacement has been accompanied by major environmental damage in the affected parts of the country. This is not a new phenomenon, but 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. Moreover, environmental degradation is also a contributing cause of displacement in Sudan, so that halting displacement will require concurrent action to halt environmental degradation.

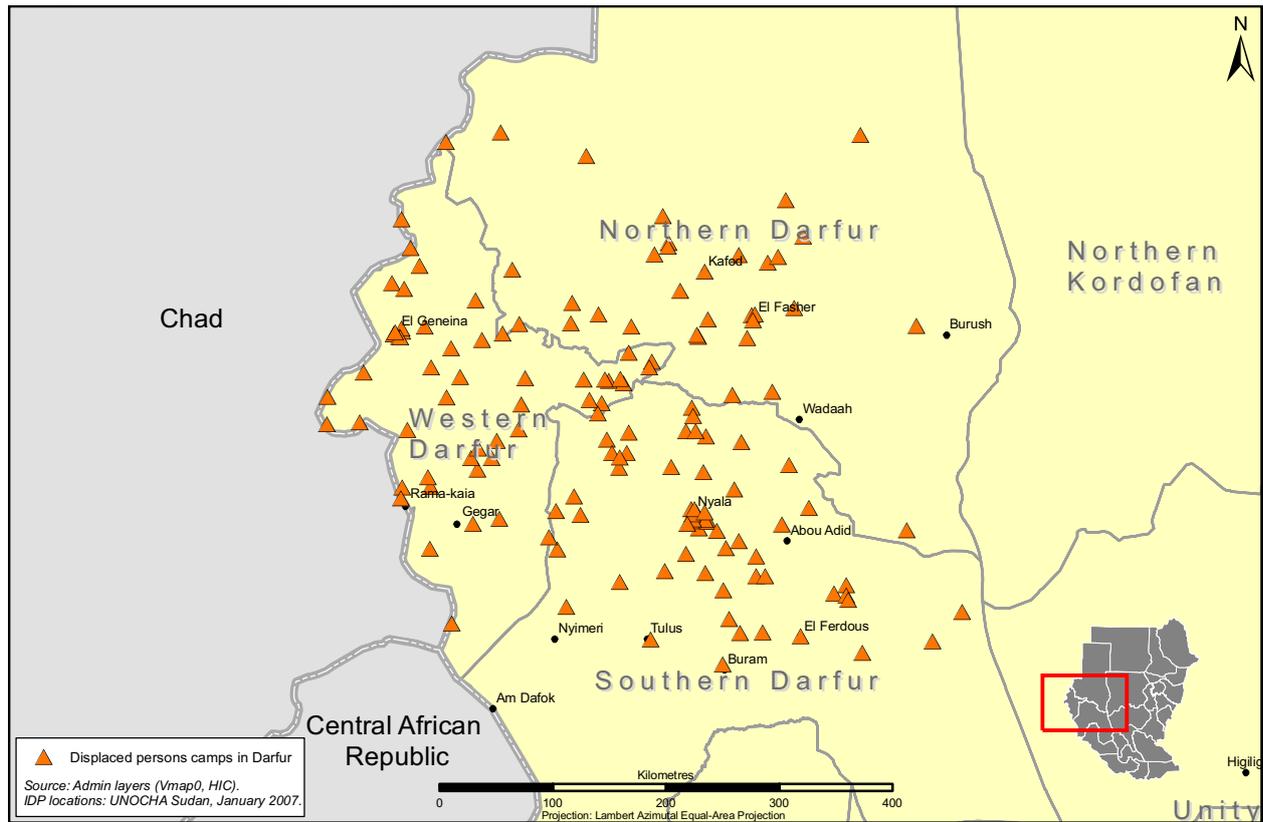
Assessment activities

The assessment of displacement-related issues was included in UNEP's general fieldwork, which covered many of the areas where displacement had occurred and where returnees were expected. The environmental impact of displaced populations was a principal theme of the fieldwork in Darfur, while the impact of returnees on the rural environment was one of the main subjects of UNEP's work in Jonglei state. Locations visited include:



Dinka teenagers, who were raised in Ugandan refugee camps, wait to board the barge bringing them back to Bor district, Jonglei state

Figure 5.1 Displaced persons camps in Darfur



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

- IDP and refugee camps in Darfur: Mornei-Um Shalaya, Zalingei, Kalma, El Fasher-Abu Shouk, Kebkabiya, and Kutum-Kassab;
- villages on the outskirts of El Geneina, Western Darfur, destroyed and deserted as a result of conflict;
- IDP settlements in Port Sudan, Khartoum and Juba;
- Jonglei state way stations and return sites in Bor and Padak districts; and
- rural return sites in the Nuba mountains, Southern Kordofan.

Interviews with displaced persons took place at all of the above locations.

These displacement-specific activities were considered sufficient to obtain an overview of the issues, particularly for Darfur camps and for the Southern Sudan return process.

5.2 Overview of population displacement in Sudan

The world's largest displaced population

Over the past few decades, Sudan has witnessed more involuntary movement of people within and around its territory than any other country in the world. At the end of 2005, UNHCR estimated that some 700,000 Sudanese refugees lived outside the country [5.1]. Sudan has also offered asylum to a significant number of refugees from other countries in recent years, primarily from Chad, the Democratic Republic of Congo (DRC), Eritrea, Ethiopia, Somalia and Uganda.

Some of the highest numbers of refugees in the country were recorded during the 1990s: in 1993, for example, Sudan was host to some 745,000 refugees, the majority from Eritrea (57 percent), Chad (19 percent), and Ethiopia (2 percent) [5.2]. By the year 2000, the overall number had dropped to around 418,000 [5.3]. Estimates for 2005 indicate that approximately 147,000 refugees were officially recognized in Sudan [5.1]. The steady decline in

numbers over this period is attributable to restored peace and security in neighbouring countries, and to a series of successful repatriation exercises.

The majority of refugees now seeking asylum in Sudan (77 percent) are Eritrean people [5.4] who live mainly in formal camps in the east. The influx of Eritrean refugees has been steady since 2003, as tension has increased in that country. In addition, there are 29,000 refugees from Uganda, DRC, Somalia, Ethiopia and other countries. With the exception of some 5,000 refugees from Chad, most live in Khartoum, Juba and other urban areas.

Besides hosting hundreds of thousands of refugees, Sudan has also generated more IDPs than any other country in the world – an estimated 5.4 million (see Table 6), or more than half the total IDP population on the continent [5.6, 5.5]. The International Displacement Monitoring Centre estimates that two million IDPs now live in Khartoum, most of whom have moved in with family members or set up squatter communities in neighbourhoods and fields around the capital. IDPs today account for 40 percent of Khartoum's total population [5.5]. In addition to squatter areas such as Soba Arradi, which hosts some 64,000 people, four official camps have been established to house IDPs: Omdurman es Salaam (120,000 people), Wad el Bashier (74,800 people), Mayo Farms (133,000 people) and Jebel Aulia (45,000 people).

Table 6. Location and number of internally displaced people in Sudan [5.5]

Location (state)	Number of IDPs
Khartoum	2,000,000
Northern	200,000
Red Sea	277,000
Kassala	76,000
Gedaref	42,000
Sennar	60,000
Blue Nile	235,000
White Nile	110,000
Upper Nile	95,000
Kordofan	189,000
Unity	135,000
Bahr el Ghazal	210,000
Equatoria	26,000
Greater Darfur	1,950,000
Total	5,805,000

Since 2003, internal displacement has occurred at an unprecedented rate in western Sudan. The Darfur crisis is reported to have affected some 2.4 million people, of whom 1.8 million are IDPs. Hundreds of thousands of people have already died, while conditions in many camps are far below international standards. In 2004, it was estimated that 465,000 households in Darfur would be in need of food assistance early in 2005 due to crop failure [5.7]. The same report noted that 90 percent of IDPs had lost their livestock, impeding income generation and water collection, and hindering return. Forty percent of the resident population had also lost their livestock.

The duration of displacement and the prospects for return

In Sudan as elsewhere, displaced populations return to their homelands if and when it is possible. For returns to take place on a large scale, however, a number of pre-conditions must be met:

- The original cause for displacement should have been removed, and physical security restored;
- Prospects for a livelihood in the homeland should be better than in the displaced location;
- Essential or important services (such as water, medical aid and schooling) should be available in the homeland and ideally equivalent to those in the displaced location;
- A practical means to travel back to the homeland safely (with possessions) should be available; and
- The return process must be sponsored or affordable for the displaced.

Because of these conditions, temporary displacements for any reason tend to turn into long-term processes or even permanent moves. Temporary settlements that exist for over a decade are not uncommon in Sudan. In Port Sudan, for instance, the UNEP team met IDPs from Northern Kordofan who had lived in informal settlements for twenty-three years and had no intention of returning to their homeland (see Case Study 5.1).



IDP camp residents told UNEP that they would rather remain in the Port Sudan area than return home, due to employment opportunities and improved education

CS 5.1 Fringe dwellers at Port Sudan: rural populations fleeing drought and seeking livelihoods in the cities

This informal settlement located in a *wadi* (seasonal riverbed) adjacent to the Port Sudan landfill is a typical example of uncontrolled urbanization triggered by natural causes. It houses over 500 families, the majority of which came from the El Obeid region in Northern Kordofan.

Interviewed residents stated that they had originally abandoned their farms due to extended drought and arrived in the region twenty-three years ago. The community was forcibly moved from a better site nine years ago by a land dispute and expanding urban development. The current site is seasonally flooded and has few amenities, aside from local schools and a water point installed by an aid project.

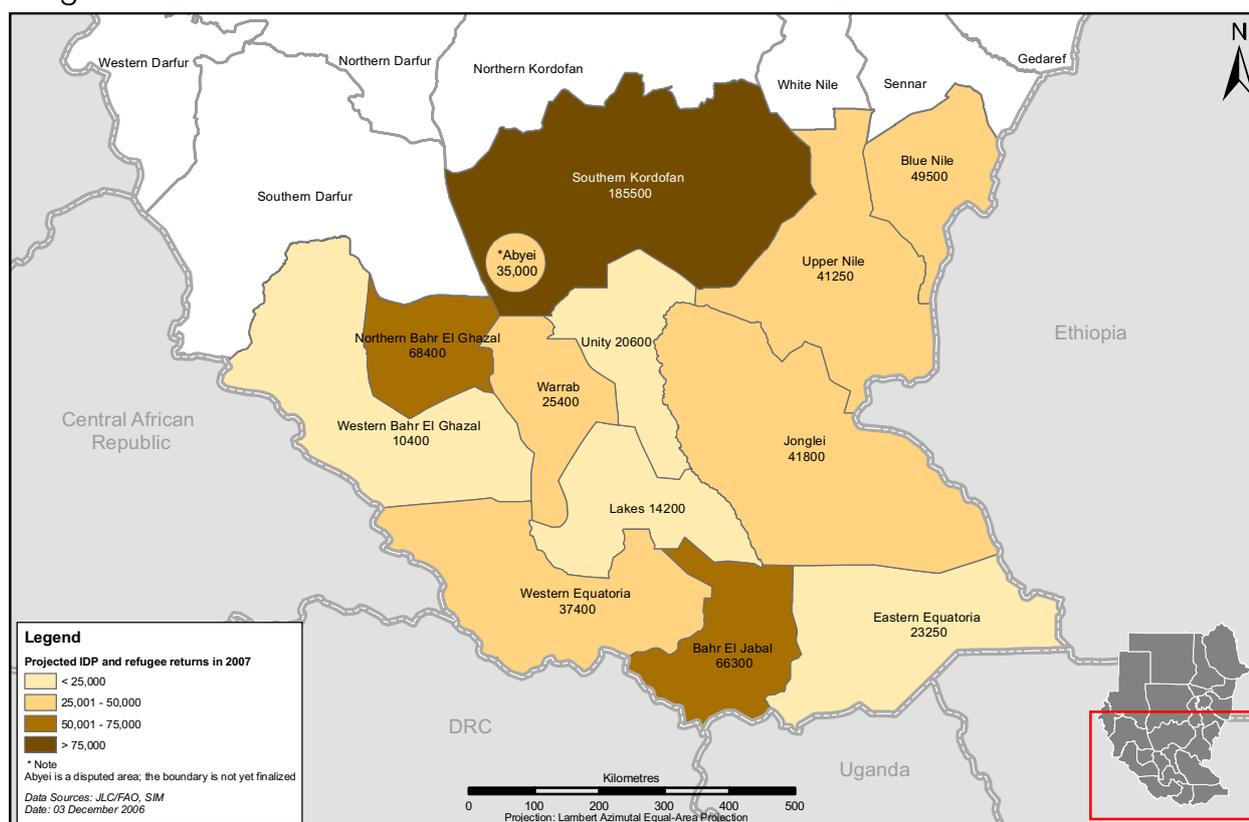
Despite the long-term nature of the settlement, all of the dwellings are temporary constructions. When asked about the potential for return to Northern Kordofan, the residents expressed no desire to do so, explaining that local employment and availability of schools were the determining factors in their decision to remain in Port Sudan. As the residents have no land tenure, however, they are at risk of being moved to even more distant fringes of Port Sudan as the city expands.

Large-scale returns of southern Sudanese currently in northern Sudan and in neighboring countries are now taking place but are expected to take several years to complete (see Figure 5.2). As of November 2006, over 17,000 refugees had returned to Southern Sudan through movements organized by UNHCR. An estimated total of

500,000 people returned to Southern Sudan, Abyei, and Southern Kordofan and Blue Nile states in 2006.

In Darfur, large camps appeared in 2003 and are presently increasing in population due to the intensification of the conflict in late 2006.

Figure 5.2 Forecast returns for Southern Sudan in 2007



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

5.3 Overview of displacement-related environmental issues

Displacement-related environmental issues are widespread and often highly visible in major camps, settlements, urban slums and return areas. The most significant are:

1. environmental issues as a cause for displacement;
2. impacts related to the concentrations of people in camps or settlements:
 - deforestation and the fuelwood crisis in dry-land camp areas;
 - land degradation;
 - unsustainable groundwater extraction; and
 - water pollution;
3. other impacts related to the initial displacement;
 - uncontrolled urban and slum growth; and
 - fallow area regeneration (generally a positive impact);
4. the impacts of returnees and the environmental sustainability of rural returns; and
5. international environmental impacts.

5.4 Environment as one of three major causes of displacement in Sudan

There are three principal causes of displacement in Sudan:

- conflict-related insecurity and loss of livelihoods;
- natural and environmental causes: drought, desertification and flooding; and
- government-sponsored development schemes.

The principal cause of displacement has historically been the major conflicts that have afflicted Sudan since its independence. The second is natural disasters: drought, desertification and flooding, which are discussed in detail in Chapter 3. The third cause of displacement is government-sponsored development schemes, specifically mechanized rain-fed agricultural schemes, such as the Aswan dam and the new Merowe dam. In these cases, displacement takes the form of organized resettlements and land allocation for new agricultural schemes. The environmental impact of agricultural schemes and dams are covered in Chapters 8 and 10 respectively.

5.5 Environmental impacts of camps and settlements

Governance of settlements including environmental issues

The environmental impacts of camps in Sudan vary not only according to their physical location but also to their type (IDP or refugee camps), and to how long they have been in existence.

Oversight of refugee camps is the responsibility of the UN High Commissioner for Refugees (UNHCR) which, in turn, works with a government counterpart (the Commissioner for Refugees) and a range of other agencies and institutions, national and international, as required.

Responsibility for IDP camps is much less clear, particularly in Sudan, where some are run by the government and others by local authorities, militant groups, or international NGOs. Resources (funds, technical assistance and so forth) available to IDP and refugee camps also vary considerably. In general, IDP camps tend to have fewer relief resources than refugee camps. UNEP field teams encountered many families who deliberately elected to go to a refugee camp in preference to

an IDP camp, because conditions were better in the former.

Environmental concerns have rarely – if ever – been a factor in the choice of sites for refugee or IDP camps in Sudan. No environmental assessment has ever been carried out prior to the site selection and establishment of any existing camp, nor is this a legal requirement.

A rapid environmental assessment conducted by OCHA at three camps in Darfur in 2001 highlighted another common concern which is addressed in this report: ‘While the environment is an important factor in the Darfur crisis, there is no international agency with a specific mandate to consider or incorporate environmental issues into relief operations and peace efforts. This contrasts with the case for Darfur refugees in Chad, where UNHCR has a mandate to incorporate environmental issues into relief and return efforts’ [5.8].

Deforestation and the fuelwood crisis in camp areas

One of the most significant environmental impacts of displaced population settlements is the severe deforestation that has occurred around the larger camps in the drier parts of the country.



Camp residents in Western Darfur cut wood chippings from a fallen tree for cooking fuel. The concentration of people into large settlements has also concentrated the demands on natural resources, resulting in severely deforested areas

This problem is related to the scale of the camps and to the standard of aid provision for displaced populations. Indeed, the level of assistance that displaced people receive in temporary settlements varies greatly. International refugees automatically qualify for assistance from UNHCR, while many IDPs do not. The assistance provided can include food aid, a water supply, basic sanitation facilities, tented accommodation or simply cover sheets and some basic household items.

What is virtually never provided is a source of energy for cooking food, boiling water or heating. In addition, when no formal accommodation is supplied, timber is needed to construct temporary dwellings. As a result, people living in camps and settlements are forced to find timber and fuelwood in the surrounding area. Livelihood strategies and the relief economy also play a role in the deforestation of camp areas: the collection of wood to fuel brick kilns, for example, is a major source of deforestation in a number of settlements in Darfur (see Case Study 5.2).

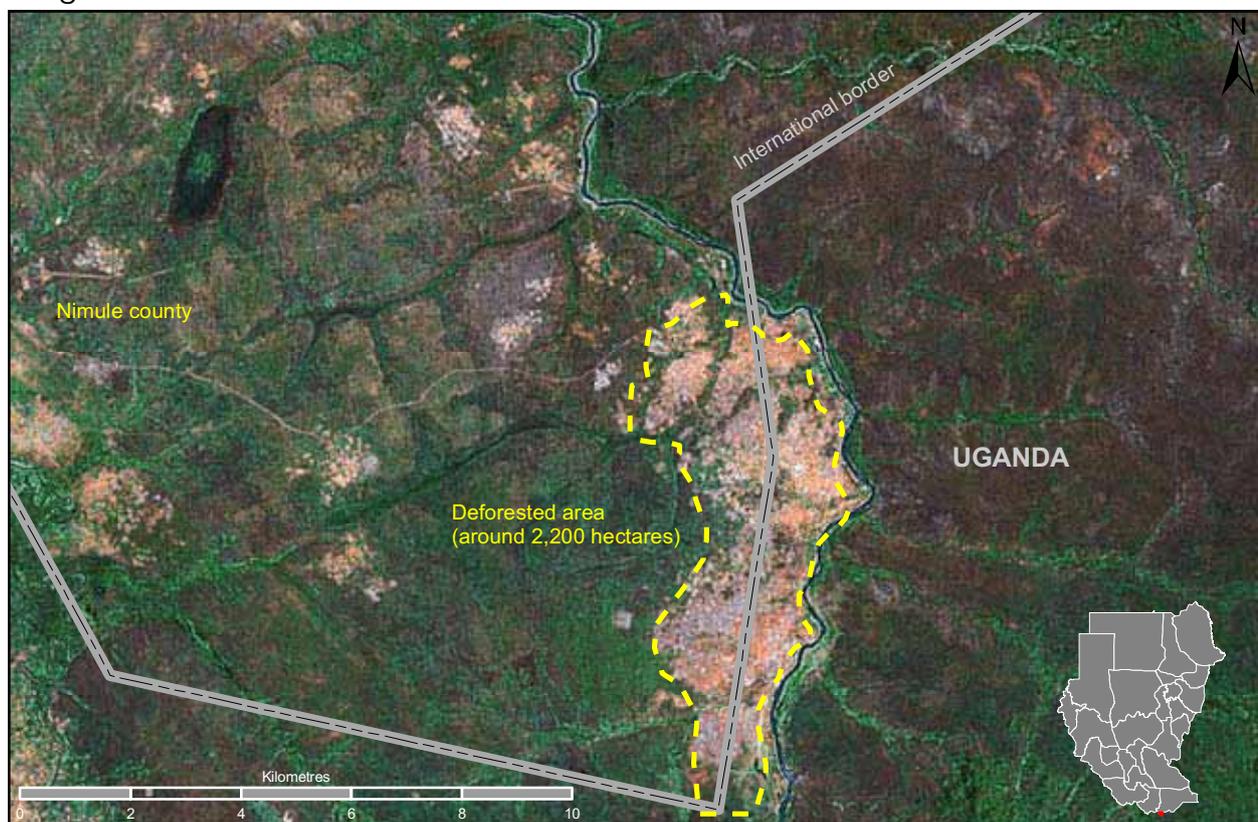
Deforestation is clearly visible around all major camp locations and can easily be detected by satellite in regions with otherwise good forest

cover. In Nimule county on the border with Uganda, for instance, the illicit felling of trees for firewood and to clear land for slash-and-burn agriculture on the outskirts of a local IDP camp has resulted in the deforestation of a large area surrounding the camp (see Figure 5.3).

In drier regions, the effects are more difficult to detect but even more damaging. Much of northern and central Sudan is relatively dry, with low woodland density and slow growth rates. Tree cover is particularly sparse in Northern Darfur and northern parts of Kassala, two regions that host large displaced populations. Besides, the majority of settlements have been established in locations that were already occupied, and where the existing burden on forest resources may or may not have been sustainable.

In eastern Sudan, camp-related deforestation has been occurring for at least twenty years. Corrective measures (prohibitions) were put into place by UNHCR and the Forests National Corporation (FNC) to prevent refugees from cutting down trees for fuel, but as their ongoing energy needs were not addressed, these were not effective.

Figure 5.3 Deforestation at Nimule



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



A brick kiln at Abu Shouk camp in Northern Darfur. One large tree is needed to fire approximately 3,000 bricks

In this mango orchard near Kalma IDP camp in Nyala, Southern Darfur, large amounts of clay have been extracted for use in brick-making. This has exposed the trees' root systems and will eventually lead to their death

CS 5.2 IDP brick-making, water use and deforestation in Darfur

Brick-making has become an important source of income for IDPs in Darfur, but has also caused considerable environmental damage around the camps. The impacts of the process include increased water consumption, damaged farmland and deforestation.

The clay for the bricks is dug from borrow pits by hand, in areas that were often previously farmed. In the wet season, these pits fill with stagnant water and contribute to environmental health problems such as malaria. The water necessary for the manufacturing process is obtained either from watercourses or from deep boreholes with submersible pumps installed by the aid community. The rate of extraction from such boreholes is not monitored, and may in some cases not be sustainable. Finally, trees are needed to fire the bricks in temporary kilns – local studies have found that one large tree is needed to fire approximately 3,000 bricks.

Simply banning such activities is not an appropriate or feasible option. A practical solution that still provides a livelihood for brick workers is urgently needed for Darfur as well as other parts of Sudan. One such option could be to use compressed earth technology rather than bricks. This would require a comprehensive introduction programme addressing both the demand and supply issues.

It should be noted that the international relief community is a major customer for the bricks, particularly to build the two-metre high compound walls required by international security standards. In Darfur especially, the relief economy has become a significant factor in the deforestation process.

In Darfur, fuelwood collection is effectively uncontrolled. Camp residents reported journeying up to 15 km to find timber, and UNEP fieldwork inspections revealed extensive deforestation extending as far as 10 km from the camps. This has contributed to a major security issue, as displaced women and girls are often at risk of rape, harassment and other forms of violence when they leave the camps to collect wood. This risk, however, is one they often have no choice but to take, since there are few other sources of cooking fuel or income available to them [5.9].

The fuelwood outlook for the major camps in Northern and Western Darfur is unpromising. Substantial deforestation has taken place over the last three years and the camps are likely to remain occupied for a number of years to come. In addition, renewed fighting since late 2006 has created a new wave of displacement and new camps.

It is possible that some camps in Darfur will exhaust virtually all viable fuelwood supplies within walking distance, resulting in major fuel shortages and/or high fuel prices. Without fuel for cooking, aid food such as cereals, legumes and flour cannot be eaten. This would add an additional facet to the ecological and human rights issues already troubling Darfur.

Some fuel conservation measures were noted by UNEP and reported by others. Though it is not universal, the use of fuel-efficient stoves, for instance, was found to be well established in Darfur. However, a detailed 2006 study by the Women's Commission on fuelwood and associated gender-based violence in Darfur showed that fuel conservation measures alone would not suffice, as the wood saved through the use of efficient stoves would continue to be gathered to be sold on local markets [5.9].

Finally, a number of very small tree plantations and nursery projects have been set up in Darfur, Khartoum state and Kassala (principally in the form of 'food for work' programmes for camp residents), but these are much too limited to meet current needs.

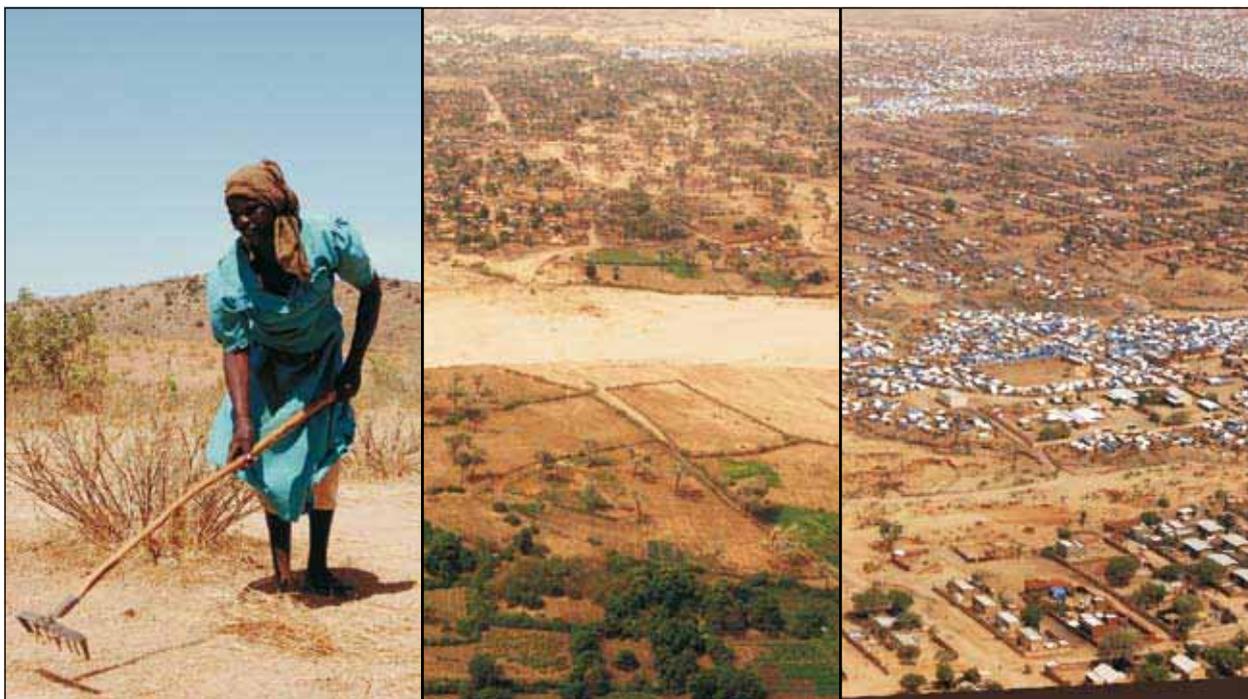
Land degradation in camp areas

Land degradation in camp areas is caused by over-harvesting of seasonal fodder and shrubs by camp residents and their livestock (commonly goats). Aside from its environmental impact, this activity places camp residents in direct competition and potential conflict with local residents (see Case Study 5.3).



The zone outside Abu Shouk camp in El Fasher, Northern Darfur, is completely devegetated

5 POPULATION DISPLACEMENT AND THE ENVIRONMENT



Camp residents seeking out livelihoods comb the drylands surrounding the camps. In this case, women are gathering fodder 13 km from the camp to sell on the local market

The prime agricultural land adjacent to the wadi in El Geneina has been cultivated by townspeople for many years, and is hence not available for camp residents

The IDP camps are all located on the fringes of town, facing waterless plains. Over the last four years, they have gradually become extensions of the town, which is benefiting economically from the associated influx of aid and labour

CS 5.3 Krinding IDP camp, Western Darfur

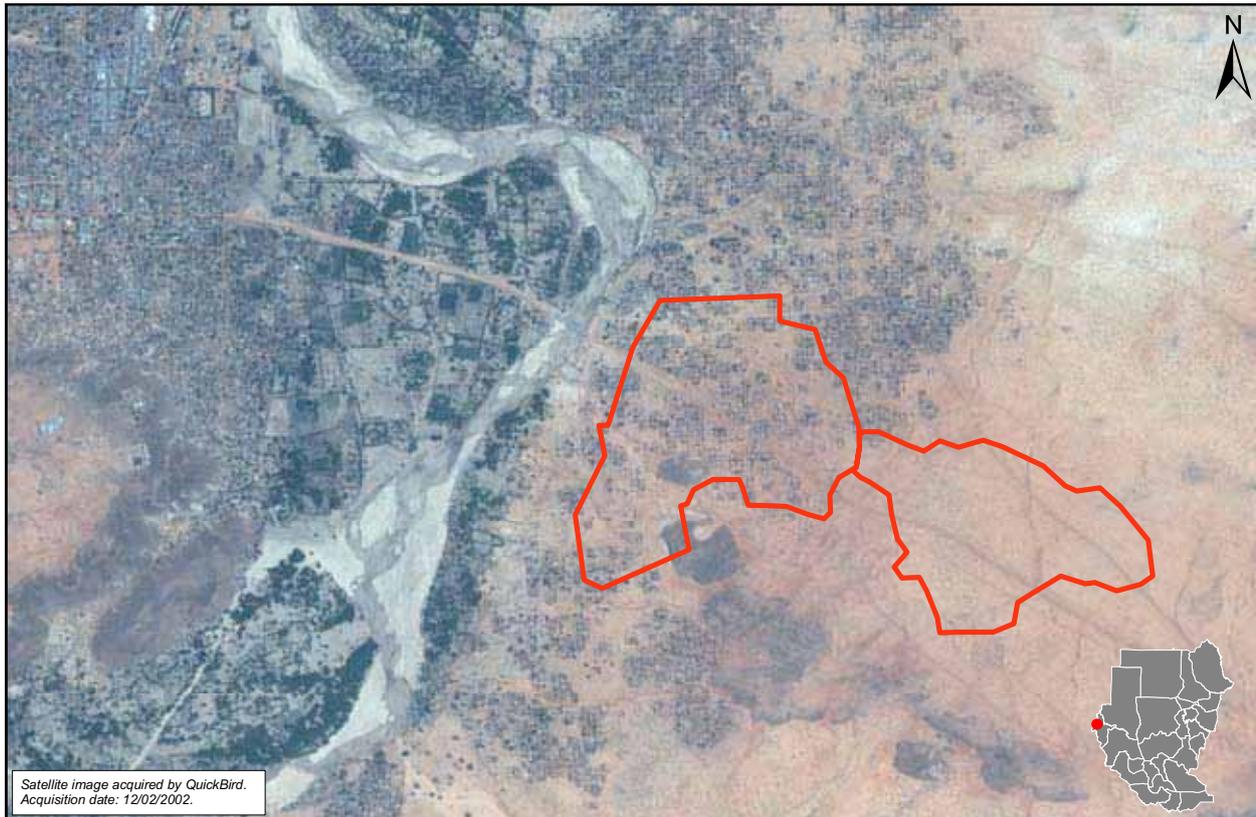
The Krinding IDP camp on the outskirts of El Geneina, Western Darfur, provides an example of the emerging urban environmental issues associated with the Darfur crisis. In economic terms, El Geneina in 2007 is a thriving town driven in part by the relief economy associated with the concentration of IDP camps and related activities in the region. Krinding (one of several camps in the El Geneina area) is located approximately four kilometres south-east of the town centre. Satellite images (see Figure 5.4) and photographs clearly show that the camp is effectively becoming an extension of the town, a fact confirmed by ground inspections. The environmental implication of this situation is that town and camp residents must now share or compete for the natural resources of this relatively dry and infertile region.

Most of the IDP camp residents were originally farmers, but the circumstances here and in most camps in Darfur severely restrict the potential for agricultural self-sufficiency and rural livelihoods. In El Geneina, the prime agricultural land next to the *wadi* was already being intensely utilized (principally for orchards and market gardens) prior to the creation of the camps. Unable to obtain a share in this prime land, the camp residents are left with very limited opportunities for agricultural livelihoods, as other available lands (to the east of the camps) are essentially waterless and suitable only for low-intensity grazing, fodder and fuel collection.

Thirteen kilometres outside the camp, UNEP interviewed a group of women from Krinding harvesting fodder for sale in Geneina markets. This provided a small insight into the practical links between the environment, natural resource competition, camp life and human rights. The women had walked from the camp without escort in a region UN security specialists considered so violent that the UNEP site visit required a dedicated armed escort from the African Union peacekeeping troops. The rape of female camp residents on such gathering missions is unfortunately routine in this region.

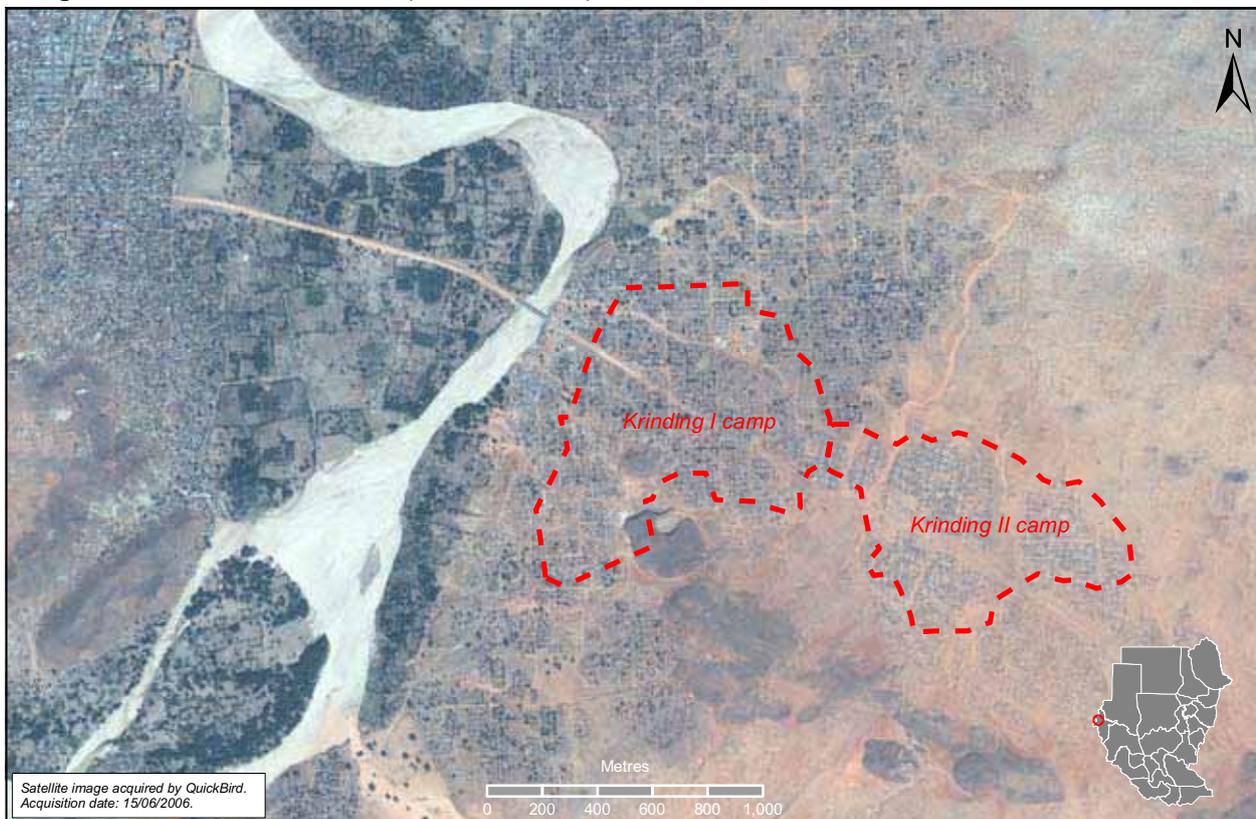
Money from the sale of gathered fodder and fuelwood is a small but vital supplement for camp residents who are otherwise completely dependent upon aid. Such efforts, however, bring camp residents in direct competition with locals (both pastoralists and agriculturists) for scarce natural resources, and undermine the sustainability of rural livelihoods in the area.

Figure 5.4a El Geneina (12.02.2002)



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

Figure 5.4b El Geneina (15.06.2006)



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



The water container queue at a wellpoint in Abu Shouk camp. Each water point services over a thousand people

Unsustainable groundwater extraction in Darfur camps

The provision of clean water is a standard component of the aid supplied to the major camps and settlements in Sudan by the international community. This can be difficult to achieve for a combined camp population of several million, particularly in arid regions. The acknowledged standard for water supply is 15 litres per person per day, and wherever possible aid agencies aim for this as a minimum.

In Darfur, the larger camps are commonly supplied with water via a network of groundwater boreholes fitted with either hand pumps or electric submersible pumps. For the larger camps, supplying to standards all year round is proving to be possible but difficult, requiring numerous deep boreholes (between 30 and 40 m in most cases), and there is a major uncertainty as to whether this rate of supply is sustainable in the drier regions and areas with low-yield aquifers.

In some cases, there are signs that it is not: Abu Shouk camp in Southern Darfur has a population of 80,000 and rising, requiring more than 1,000 m³ of water per day. In 2006, five of twelve boreholes ran dry, indicating a substantial drop in the water table. Unfortunately, as of March 2007, groundwater level monitoring is not being

conducted for any camp in Darfur, making it impossible to determine whether incidents such as the dry wells at Abu Shouk are isolated or rather the foretaste of a much larger problem looming in the future.

Short- to medium-term localized groundwater shortages are unlikely to have a major or permanent environmental impact. However, camps without a viable water supply may need to be moved, with all of the attendant issues, costs and risks that this would entail.

Water pollution

The concentration of a large number of people in temporary dwellings raises concerns for sanitation and bacteriological contamination of surface and groundwater. The standard solution is the construction of pit latrines, though these are not in place everywhere (this is particularly the case for IDP camps).

The most severe pollution problems were observed in IDP camps in the more humid regions of Sudan. UNEP field teams found major water pollution issues surrounding all informal camps visited in Southern Sudan. These same areas were epicentres for the cholera epidemic of 2006 (see Chapter 6). As detailed in Chapters 6 and 10, a lack of field data constrains more detailed analysis of this topic.

5.6 Other environmental impacts of displacement

Uncontrolled urban and slum growth

The majority of displaced people in Sudan are located in or close to towns and cities; there are over two million in the Khartoum region alone. Large-scale migration from the countryside to urban centres has been largely uncontrolled, with the result that a large number of urban slums or informal squatter settlements have been established. Urban slums are associated with a series of environmental and social problems, and are covered in detail in Chapter 6.

The urban issues associated with the north-south conflict have been ongoing for over twenty years. In contrast, the Darfur crisis is now creating new urban problems, as the majority of the displaced person camps are tightly linked to the regional towns and cities and are fast becoming a permanent part of those settlements.

Fallow area regeneration

One minor positive impact of historical displacement has been the natural regeneration of vacated lands. Large areas in the conflict zones have been partly or completely depopulated for a number of years, and this has eased the pressure on the land from farming, grazing, burning and

timber-cutting. The fallow period for the vacated areas ranges from five to twenty-five years. In the moderate to high rainfall regions, the result has been the re-growth of forests. UNEP field teams saw 'new' forests of this type throughout the Nuba mountains and north of Bor in Jonglei state. The distinguishing characteristics of 'new' forests are heavier undergrowth, the lack of fallen and older trees and fairly uniform maximum tree sizes.

The 'new' forests represent a return to a wild habitat that is expected to be reversed if the displaced populations return in equal or greater numbers than were originally present. As such, they represent both a livelihood burden (as trees need to be cleared to grow the first crops) and a windfall asset that could in theory be sustainably managed.

5.7 Environmental implications of the return process

The population return process for Sudan has very significant environmental consequences, which are presently not being addressed. Two major return processes are currently underway:

1. The ongoing return process for the approximately four million people displaced by the north-south conflict. Due to a range of practical, economic and political constraints, this is expected to take several years;



The population return and recovery process in Southern Kordofan has led to a surge in deforestation

5 POPULATION DISPLACEMENT AND THE ENVIRONMENT



Wau township, Western Bahr el Ghazal. One environmentally significant consequence of the return process for Southern Sudan will be the rapid growth of urban centres

2. The future return process for the approximately two million displaced in Darfur. The current instability is preventing this process from even being planned.

The key environmental question is whether the return areas will be able to support the new populations. Unfortunately, in some specific cases, it is clear that the return process will not be environmentally sustainable in the medium to long term. In the worst cases, environmental issues will make the process unsuccessful and lead to renewed displacement.

The strongest evidence for this unwelcome prediction is the current condition of many of the proposed return areas, where long-term land degradation is visible even with a reduced population. This is particularly clear in the drier Sahel belt and the area immediately southwards.

Badly degraded drylands cannot support high-density rural populations: crop yields are low and livestock-rearing is problematic due to a lack of fodder. Populations living on badly degraded land are frequently forced to move; this is already a common occurrence in the drier states such as Northern Kordofan.

UNEP has conducted a preliminary analysis of the environmental sustainability of the return process for each of the twenty-five states, based on the following factors:

1. current population density;
2. future return population and net impact on population density;
3. current land quality/extent of degradation, estimated by using a combination of desk studies, field reconnaissance and satellite data; and
4. rainfall, as the strongest indicator of resilience to environmental stress, particularly from overgrazing.

While virtually every state has environmental issues associated with displacement and returns, the most vulnerable states are considered to be Darfur (all three states, but especially Northern Darfur), Southern Kordofan, eastern Kassala, northern Blue Nile, northern Upper Nile, and northern Unity state.

The situation in Darfur is particularly clear. Many regions of Northern and Western Darfur are undergoing desertification and land degradation at a significant rate. The rural areas of these regions are now partially depopulated due to the conflict, though some tribes (principally pastoralists) are still present. Given the current condition of the land and the increasingly dry climate, traditional rural livelihoods are no longer viable, so large-scale returns to these areas cannot be recommended.

For most of Southern Sudan, the situation is relatively positive in that the higher rainfall provides for greater agricultural productivity, and hence a greater capacity to absorb returnees. Nonetheless, certain areas – particularly those surrounding major towns – are expected to come under significant stress from the predicted large-scale returns.



Food distribution at the Bor way station. UN-supported returnee families are supplied with two months worth of foodstuffs, seeds, tools and other items to assist their re-establishment

Part of a group of 75 orphans delivered to Padak county under the care of three women and an elder. The urgent priority for returnees such as these is to establish a livelihood, usually crop-raising

The dominant livelihood for most rural Dinka people is a combination of cattle-rearing and slash-and-burn agriculture. While the planned return areas were found to be generally in good to moderate condition, it is doubtful that they could provide sustainable livelihoods for the projected 47 percent increase in population

CS 5.4 The environmental impact of the return of the Dinka to Bor county, Jonglei state

The return of the Dinka people to Bor county in Jonglei state provides a case study in the likely impact of returnees on the rural environment of the south. The Dinka people are agro-pastoralists, combining cattle-rearing with wet season agriculture, and migrating seasonally according to the rains and the inundation of the *toic* (seasonal floodplains). A large proportion of the Dinka in Jonglei state were displaced from their home rangelands by the north-south conflict, and fled to the far south of the country or to refugee camps in Uganda. Localized displacement also took place as people left conflict hotspots and fled to the towns for safety. The conflict and displacement were accompanied by major cattle losses due to theft and abandonment, though some stock was retained and transported south.

In 2006, the UN and a range of NGOs commenced a managed return programme for the Dinka. Able-bodied men drove the cattle up from the far south of the country to the rangelands, while women and children were transported by barge and truck. This organized process of preparation, transportation and provision of supplies resulted (by the second half of 2006) in approximately 7,000 people returning to Jonglei state over a period of six months. This was accompanied by a substantial number of spontaneous and unassisted returns. Each assisted family was supplied with approximately two months worth of food, shelter items, seeds and agricultural tools. Livestock was not supplied.

For the people arriving at the start of the rainy season, the immediate priority was to establish shelter, clear a smallholding and plant a range of crops. This resulted in an upsurge of slash-and-burn clearance and tree felling in the return areas. The geographic extent of this clearance was focused on areas with permanent water supplies and access to community services (roads, schools, and clinics).

The UNEP team inspected a wet season agricultural area located 5 km east of the Nile and 10 km north of the township of Padak. Residents within the local *payam* (district administrative unit) provided relatively detailed statistics on what the returnee process meant for them: for a 180 km² area, the payam had a population of 19,000, giving a density of approximately 100 per square kilometre or one person per hectare. The Jonglei state government had provided the local administrator with an estimate of 9,000 returnees to the *payam* over a few years. Several hundred had already arrived as of April 2006, but when or whether the figure of 9,000 would be reached (particularly when contrasted with the rate of return monitored by the UN) was unclear.

The region still had good tree cover and large patches of fallow land. There was no sign of major overgrazing, soil erosion or soil fertility problems. As such, it was determined that the agricultural livelihood of the current population was probably sustainable. However, whether the area could sustain the projected 47 percent population increase was far from clear, and a significant risk of environmental degradation and food insecurity remained for the longer term, as well as the possibility that some of the population might have to migrate further.

5.8 International aspects of environment and displacement in Sudan

The export of environmental problems to neighbouring countries

The countries neighbouring Sudan host some 700,000 Sudanese refugees. In addition to a range of chronic environmental problems, these countries suffer from the impact of numerous large camps.

Refugees from Darfur in north-eastern Chad, for example, are a considerable burden to their host communities due to their sheer number (400,000 people). Since their arrival in 2003, pressure has mounted significantly on scarce natural resources such as water, fuelwood and fodder for livestock, access to which has often been a source of conflict in the region.

Uduk refugees from the Upper Nile province now living in Gambella refugee camp in western Ethiopia have, in the thirteen years since the camp was established, seriously degraded an area of almost 400 km² by clearing it for agriculture. Rehabilitating this and other areas will require considerable time and resources if the welfare of hosting communities is not to be further degraded.

5.9 Conclusions and recommendations

Conclusion

The links between displacement and the environment in Sudan are clear and significant. Environmental degradation is one of the underlying causes of displacement in dryland Sudan. Unless the process of widespread desertification and other forms of land degradation are halted, large-scale displacement is expected to continue, whether or not major conflict goes on.

The displacement of over five million Sudanese into slums, camps and informal settlements has been accompanied by major environmental damage to the often fragile environments where these settlements have developed. The larger camps, particularly in Darfur, have been epicentres

of severe degradation, and the lack of controls and solutions has led to human rights abuses, conflicts over resources and food insecurity.

The population return process is expected to result in a further wave of environmental degradation in some of the more fragile and drier return areas. In the worst cases, such as Northern Darfur, large-scale rural returns may be simply untenable as the remaining natural resources are so limited and degraded that rural livelihoods can no longer be supported.

Background to the recommendations

Because international humanitarian aid organizations are by far the strongest actors in the area of IDP and refugee camp management, recommendations linked to camps and returns are generally addressed to this community. Nonetheless, close government involvement (by both GONU and GOSS) is necessary and assumed. All recommendations are short-term (0.5 - 2 years).

Two key policy issues must be addressed by the relief community. First, the current approach to the environmental impact of camps in Sudan, particularly regarding deforestation, is largely to ignore it (with some creditable exceptions). This is not due to local attitudes or a lack of standards or other guidance on this topic – what is missing is sufficient investment in this area. This needs to be addressed at the highest level to improve the current imbalance between daily humanitarian needs and long-term sustainability.

Second, a fundamental principle of displaced population assistance is the ‘right to return’ to the original site of displacement. For the drier parts of Darfur, however, this issue needs to be critically examined in the context of desertification and intense competition for natural resources. Assisting people to return to areas which can no longer sustain them is not a viable solution for camp closure.

In the detailed recommendations set out below, it should be noted that while UNHCR is designated as the primary beneficiary for its role in the oversight of the displaced population issue, the actual beneficiaries are the displaced populations themselves.



Elders from Shaggarab camp and hosting communities inspect a year-old acacia tree plantation

Together with officials from the Forests National Corporation and the Commissioner for Refugees, representatives from both the hosting and the refugee communities inspect progress on preparations for a community tree nursery in Fau 5 camp

CS 5.5 Community-based rehabilitation of refugee-impacted areas in eastern Sudan

Some of the largest and longest-lasting refugee caseloads in Africa have been those of Ethiopian and Eritrean refugees settled in eastern Sudan (principally in Gedaref and Kassala states). The impact of such a large number of people – some 1.1 million refugees at its climax in 1985 – has been significant in environmental as well as social and economic terms.

In October 2002, a multidisciplinary assessment mission developed a comprehensive proposal to address the issue of camp closure and rehabilitation needs in the affected area. Initiated by UNHCR and the Government of Sudan, the Sustainable Options for Livelihood Security in Eastern Sudan (SOLSES) Programme was conceived as a scaling-down exercise of UNHCR's presence in the region, with simultaneous preparation for the hand-over of assets to local communities and authorities, as well as some environmental rehabilitation. Needs assessments were carried out to evaluate peoples' actual and anticipated needs from a range of environmental resources, as well as for health and education facilities, and water and sanitation.

The environmental component of the SOLSES Programme is managed by IUCN - The World Conservation Union. Its point of departure is the engagement of beneficiaries (both refugees and local communities) with clear links to the state's development plan and processes, through community environmental management planning.

By November 2006, Community Environment Management Plans had been established for nine refugee-impacted areas in the central states (Sennar and El Gezira), as well as for the Setit region in Kassala state. The development of such plans has been an important part of the overall needs assessment of affected communities, some of which include refugees who are not able to return to Eritrea. Many of these people have lived in camps for more than thirty years, and are essentially already integrated into the local community (in some instances it is no longer possible to determine between a camp and a local village).

Support through SOLSES is intended to build peoples' capacities and expertise so that they might become self-sufficient and, at the same time, less reliant or better able to manage the natural resources they still depend on.

Agroforestry and community/compound tree-planting have become an important component of the work to support sustainable development and income generation. In its first year alone, the sale of products from a two-hectare irrigated agroforestry plot in the Mafaza former refugee camp generated USD 1,200 in revenue. Developing management plans for forests that were established in the past fifteen to twenty years, and ensuring that these resources are cared for in the future are also part of the overall strategy. In 2005, for example, more than 14,000 ha of forest were handed over to local communities or state authorities for future management. In addition, the programme is working with local communities and forestry authorities to reafforest important areas as community forests.

As community members become more familiar and convinced of the approaches promoted through SOLSES, the programme is also helping to respond to other pressing needs, far beyond the original concept of environmental rehabilitation, such as the provision of clean water and waste disposal, the use of agricultural chemicals, and the diseases caused by dirty water or mosquitoes. It is important that environmental concerns, issues and opportunities be pro-actively built into all SOLSES and related activities in the future.

5 POPULATION DISPLACEMENT AND THE ENVIRONMENT

Recommendations for the international community

R5.1 Implement an IDP and refugee camp environmental and technical assistance project for Darfur. This project should include the provision of training, technical advice and guidelines for camp planners and management staff, and a number of small demonstration projects at the larger camps.

CA: TA; PB: UNHCR; UNP: UNEP; CE: 1.5M;
DU: 3 years

R5.2 Develop and implement a plan to resolve the Darfur camp fuelwood energy crisis. There are numerous options available and many studies have been conducted, so any major programme should be preceded by a rapid options analysis and feasibility assessment. Major investment is needed to address this large-scale problem.

CA: PA; PB: UNHCR; UNP: UNEP; CE: 3M;
DU: 3 years

R5.3 Conduct an environmental impact assessment for the return process for Southern Sudan and the Three Areas, and develop plans for impact mitigation. The assessment should also provide guidelines for state, county and *payam* (district administrative unit) officials. Area plans should be developed for identified hotspots.

CA: AS; PB: UNHCR; UNP: UNEP; CE: 0.5M;
DU: 1 year

R5.4 Conduct an environmental impact and feasibility assessment for the return process in Darfur. The assessment should be a multi-agency effort and focus on the potential for the projected return areas to adequately sustain rural livelihoods in the event of peace.

CA: AS; PB: UNHCR; UNP: UNEP; CE: 0.3M;
DU: 1 year



The devegetated outskirts of this IDP camp near Zalingei in Western Darfur clearly illustrate the impact of the concentrated exploitation of natural resources that were scarce to begin with

Urban Environment and Environmental Health

*The Port Sudan dumpsite.
Improvements in solid waste management
will first and foremost require increased
government investment in disposal facilities.*



Urban environment and environmental health

6.1 Introduction and assessment activities

Introduction

Urban environment and environmental health issues are some of the most visible symptoms of the challenges facing Sudan. Sprawling slums, litter and polluted waterways are prevalent in most urban centres, and health and development statistics quantify in some detail the massive impact of this situation on the quality of life of the Sudanese population.

Shelter, potable water, sanitation and waste management are cross-cutting issues, and deficiencies in any of these areas can be categorized as development, health or environmental problems. This chapter focuses on the environmental aspects of these issues and the associated challenges in development and governance.

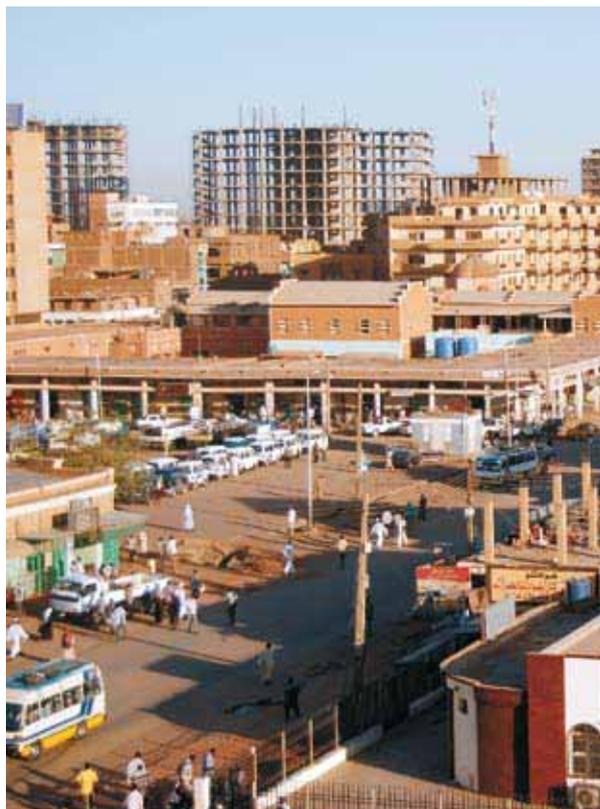
Assessment activities

Detailed desk study information was available on urban and environmental health issues, though statistical data on Southern Sudan was relatively scarce. UNEP's fieldwork included visits to urban centres of all sizes in twenty states. Particular attention was paid to the investigation of unplanned settlements, camps, waste management and sanitation. Three cities – Khartoum, Port Sudan and Juba – were selected for a closer assessment of urban services and housing.

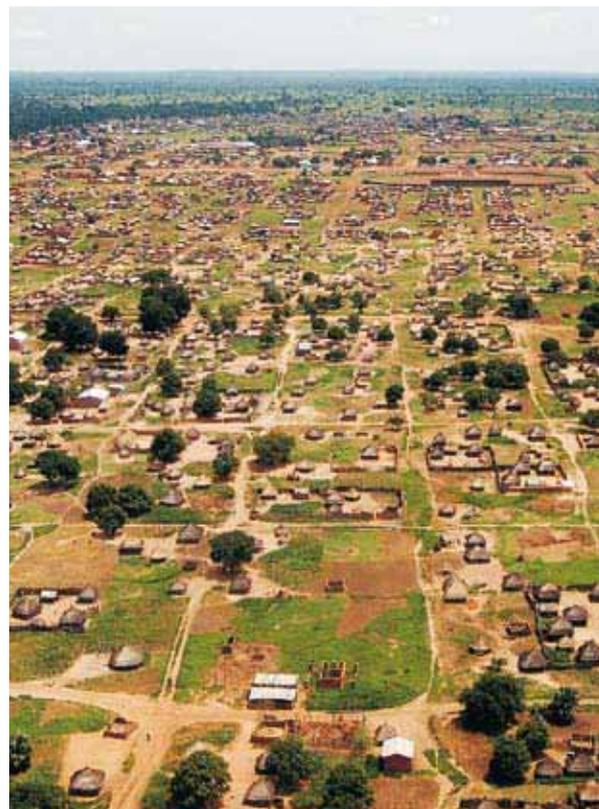
Available statistics on environmental health and services, which are a combination of government and UN data, tell a sombre story of poverty and underdevelopment. On the national scale, even these numbers are overly optimistic, as much of the detailed data has historically been collected in the more developed areas of the northern states. On a more positive note, however, the economic development resulting from the oil boom is completely absent from older statistics, so that some areas such as Khartoum state are expected to show significant improvement from 2000 onwards.



Introductory field training in Juba for the newly recruited staff of the GOSS Ministry of Environment, Wildlife Conservation and Tourism



The capital Khartoum is by far the largest city in Sudan



In Southern Sudan, the major towns, such as Wau, consist of a small centre built in colonial times and a large fringe of informal settlements

The scope of the assessment was considered adequate to address but not fully quantify the issues at the national level. In addition, the statistical evidence collected and presented here should be treated with caution; it is considered sufficient to present trends but not to form the basis for detailed planning.

6.2 Overview of demographics and major urban centres

Demographics

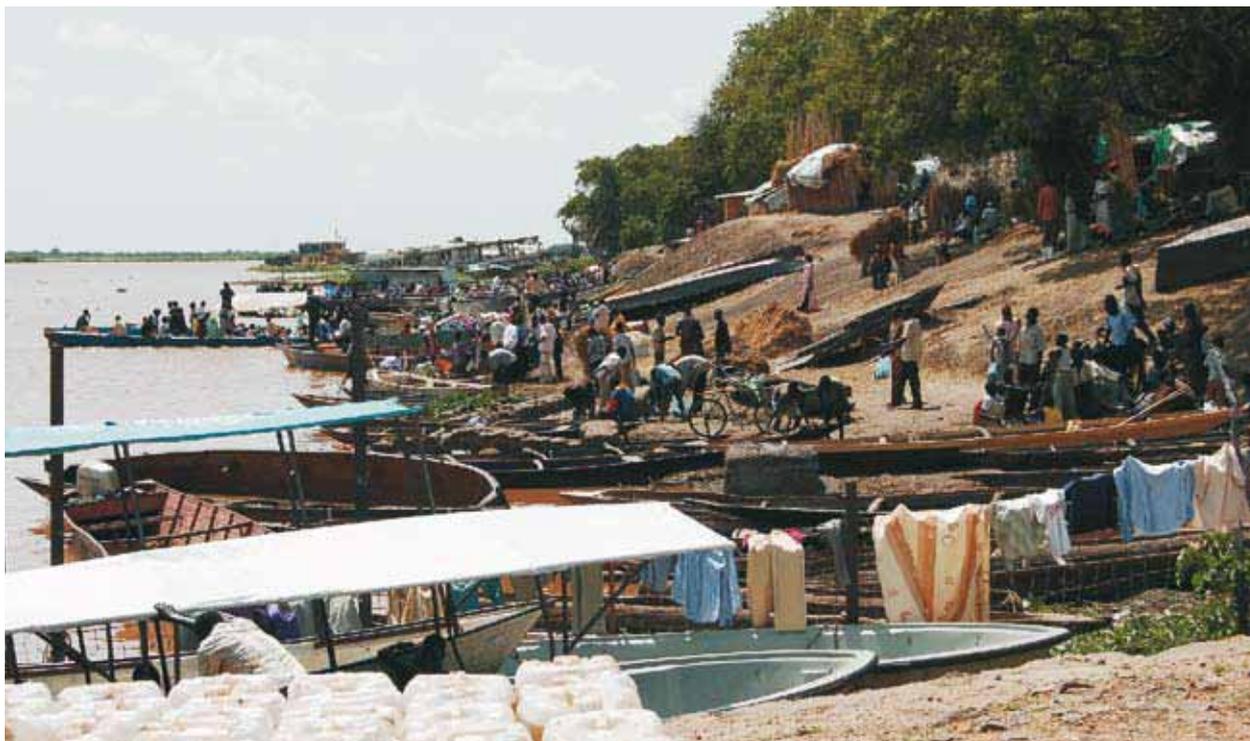
The majority of Sudan's population (estimated to be between 35 and 40 million) lives in villages and hamlets in rural areas. Exact figures on the rural and urban populations are not available, but UNEP estimates, from a compendium of incomplete and obsolete sources, that approximately 70 percent live in villages, hamlets or lead a semi-nomadic existence, and 30 percent are town and city dwellers, or live in displaced persons settlements [6.1, 6.2].

Major urban centres

The urban population is concentrated in only a few cities. Greater Khartoum is by far the largest: its population was 2,918,000 in 1993, but it is estimated to have grown to more than five million in 2006. A study using 1993 census data for the northern cities showed that 64 percent of the total population of the nine largest urban centres lived in Khartoum.

Table 7. Populations of the major cities in northern Sudan in 1993 [6.1]

City	Population	Percentage of total
Khartoum	2,918,000	64
Port Sudan	308,616	7
El Obeid	228,139	5
Nyala	220,386	5
Wad Medani	212,501	5
Gedaref	185,317	4
Kosti	172,832	4
El Fasher	141,600	3
El Geneina	127,187	3
Total	4,427,578	100



The busy port of Malakal, on the White Nile. Virtually all of the major urban centres in Sudan are located on rivers

Data on the size of the urban centres in Southern Sudan is extremely scarce. The largest towns are the state capitals of Juba, Wau, and Malakal, and the town of Yei. A 2005 urban planning study of Juba estimated the town population at 250,000 [6.3].

6.3 Overview of urban environment and environmental health issues

The UNEP assessment identified a long list of urban and environmental health issues in Sudan, but focused on those with the strongest link to the environment. In this sector, most issues are closely linked, so while the assessment could focus on individual problems, the solutions will need to be integrated. The issues investigated by UNEP were:

- rapid urbanization;
- urban planning;
- drinking water, sanitation and waterborne diseases;
- solid waste management;
- air pollution and urban transport;
- urban energy; and
- sustainable construction.

6.4 Urbanization and urban planning

Rapid urbanization

The two dominant demographic trends in Sudan are rapid population growth (estimated to be over 2.6 percent) and even faster urbanization, fuelled by population growth and a range of compounding factors including:

- drought and desertification eliminating rural livelihoods;
- mechanized agriculture schemes taking rural land from traditional farming communities;
- conflict-related insecurity forcing abandonment of rural livelihoods; and
- general flight from rural poverty in search of better livelihoods and services, such as hospitals and schools in the cities.

Moderately good data is only available for Khartoum (see Case Study 6.1). It shows growth estimates of over five percent per year from 1973 to 1993. Anecdotal evidence and data from studies conducted between 1993 and 2006 indicate that

6 URBAN ENVIRONMENT AND ENVIRONMENTAL HEALTH

the explosive growth of Khartoum has not ceased [6.4, 6.5, 6.6]. Given the Khartoum-centred economic boom, the Darfur crisis, and the rural environmental problems of the north, UNEP's forecast for the capital is continued growth, with rapid inflows from northern states somewhat countered by outflow to Southern Sudan.

Following the signing of the Comprehensive Peace Agreement (CPA) in January 2005, displaced persons from the north and outside of Sudan have started to return to their homelands in the south. Only very approximate numbers of returns are available as of the end of 2006, but these are thought to be in the order of 300,000.

The exact percentage of these returnees relocating to southern towns is unknown, but the larger urban centres, such as Juba, Yei, Malakal, Wau and Rumbek, are clearly experiencing very rapid growth. Available data and estimates for Juba, for example, show a population increase from 56,000 in 1973 to 250,000 in 2006, which converts to a growth of 450 percent, or 14 percent (linear) per year [6.3, 6.7]. Growth rates since 2005 are

expected to be much higher than this thirty-three year average.

This explosive urbanization is a severe challenge which has not been – and still is not – managed or adequately controlled by regional or local authorities. The result is chaotic urban sprawl and widespread slums, which are in turn associated with a number of health, environmental and social problems. UNEP teams observed informal settlements or slums on the outskirts of virtually every town visited in Sudan.

Urban planning

To date, not only has urban planning mostly been focused on metropolitan Khartoum, but the plans that have been developed have not been fully implemented due to under-investment in infrastructure and utilities, and underlying deficiencies in land tenure and the rule of law. While the capital has recently seen considerable investment, its size, high growth rate and historical lack of planning still constitute major challenges (see Case Study 6.1).



Large-scale informal settlements have multiplied in the Khartoum area since the 1980s. Most of these settlements have very limited access to water, and no sewage or waste management

CS 6.1 Urban planning and informal settlements in Khartoum

Metropolitan Khartoum, which comprises Khartoum, Khartoum North and Omdurman, has an area of 802.5 km². It is located at the point where the White Nile, flowing north from Uganda, meets the Blue Nile, flowing west from Ethiopia.

Founded as a military outpost in 1821, Khartoum soon became established as an important trading centre. It was chosen as the seat of government in 1823. Within the past century, the city has expanded 250 times in area and 114 times in population. The population of metropolitan Khartoum is now estimated to be more than five million, and it has a current estimated annual average growth rate of four percent, making it by far the largest and most rapidly increasing concentration of people in the country [6.6]. Some 40 percent of Khartoum residents are internally displaced persons (or children of IDPs) [6.17].

The capital is sprawling rather than dense: population density in metropolitan Khartoum was estimated at approximately 163 persons/km² in 2004 [6.4]. This low figure is due to the fact that 92 percent of Khartoum's dwelling plots contain one-level developments of 300-500 m² per plot. There are few multi-story residential buildings.

Key statistics for Khartoum are all obsolete and incomplete, but nevertheless illustrate the challenges in urban planning, transportation and provision of utilities and services.

Four master plans have been established for the development of Khartoum since independence. Most were only partially implemented, and a new plan is currently in process.

The most significant environmental health problems can be observed on the outskirts of the city, where the majority of unauthorized settlements are located. These settlements cover vast areas, contain no paved roads and offer negligible facilities for water, sanitation and solid waste management. The result is very poor sanitation, high disease rates, and difficulties in accessing basic services.

Khartoum authorities have attempted to address the issue of unauthorized settlements and squatters through a range of plans, initiatives and new settlement deals. Almost all of these have failed, and over the last ten years, authorities have turned to removing squatters by force, by bulldozing slum areas with little warning or compensation. Displaced persons settlements have been particularly vulnerable to this campaign.

At the same time, a sixty-five hectare central business district is currently being developed at the junction between the Blue and White Nile. The Almogran business district development, which is probably the largest such development in the region, includes plans for a six-hundred hectare residential estate and an eighteen-hole golf course built partly over the Sunut Forest Nature Reserve.

In sum, Khartoum's urban planning and utility provision challenges are considerable. In the absence of major investment and fundamental reforms in areas such as land tenure, the situation is likely to get significantly worse as the capital's population continues to grow.

Table 8. Key statistics for Khartoum [6.5]

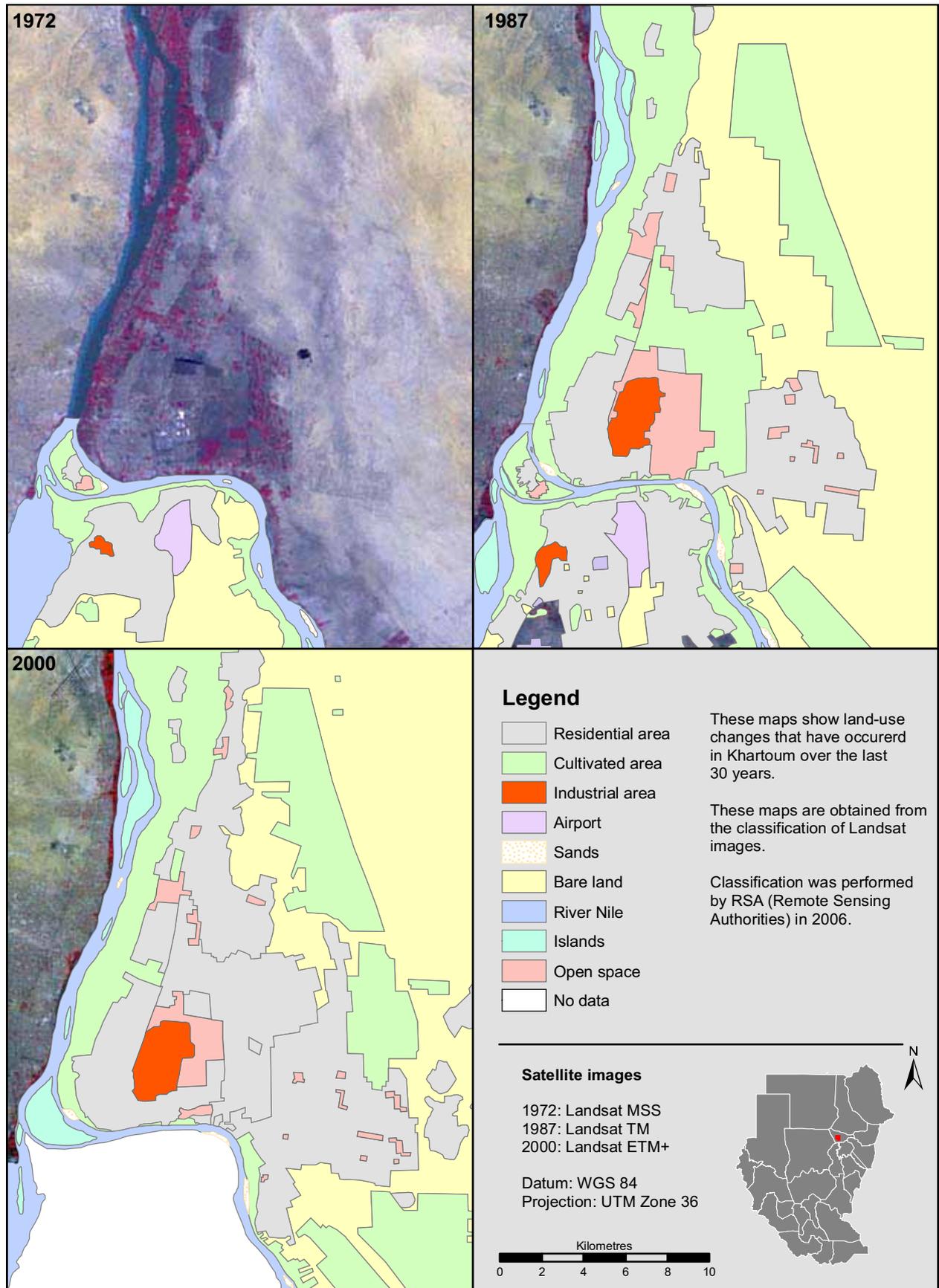
Indicator	Statistic
Annual growth rate	4 %
Number of shanty towns surrounding metropolitan Khartoum (1986)	96
Estimated population of unauthorized settlements	2-3 million
Percentage of central Khartoum covered by water network	71 %
Percentage of Khartoum connected to sewage system	28 %
Percentage of Khartoum using pit latrines or other basic systems	68 %

In Darfur, the cities of El Fasher, Nyala and El Geneina, as well as other urban centres, are severely impacted by the massive influx of displaced persons since the start of the conflict in 2003. The majority of the two million displaced are found on the fringes of urban centres which, in some cases, have increased in population by over 200 percent in three years [6.8, 6.9]. The

experience of Southern Sudan indicates that a significant percentage of these 'temporary' settlements in Darfur will become permanent additions to the towns.

In Southern Sudan, urban planning challenges are twofold. First, urban populations are swelling due to the return of displaced people, and second,

Figure 6.1 Growth of Khartoum 1972-2000



some of the towns are inherently badly located: the Nile swamps and floodplains are home to several million people, but are very difficult places to develop urban centres in, due to high water tables, annual flooding and a lack of building materials such as sand, gravel, rock and suitable clay. Malakal is a classic example of the constraints imposed by location (see Case Study 6.2).

The Government of Southern Sudan launched a major urban development initiative for the ten state capitals in 2005. Planned infrastructure works include water and sanitation, roads and drainage, power supply and government

buildings. The Juba civil works contracts, funded partly through the Multi-donor Trust Fund, were awarded in 2006 and on-site work is in progress. Discussions are currently being held to explore the financing of works in the other nine state capitals.

In parallel, UNDP has set up an Urban Management Programme for 2006-2009 to provide broad policy and technical support. UN Habitat has also commenced operations, and an international aid programme funded by USAID has started to conduct assessments and capacity-building in urban planning for Southern Sudan.



With limited soil absorption capacity and no gradient to allow for drainage, sewage remains stagnant in Malakal's town centre, increasing the risk of waterborne diseases

CS 6.2 Malakal: the environmental health challenges of urban development in the southern clay plains

Malakal (population approximately 200,000) is the capital of Upper Nile state. It is located on a flood plain near the junction of the White Nile and Sobat river. The town's location and local geology exacerbate the usual water and sanitation problems that afflict all of the major towns in Southern Sudan.

Indeed, the town is located on very flat ground consisting of heavy clay soil, and the water table is only 0.5 to 1.5 m below the surface. As a result, drainage is difficult. In the wet season, the town is frequently flooded for long periods of time. Because there are no significant rock or gravel deposits in the region, straightforward corrective measures like surface paving, minor relocations and raising settlements above the flood level are all extremely complex and costly, due to the need to import bulk materials.

Malakal's population is rising rapidly as people return from the north and from Ethiopia, and the limited public services are completely overstretched. There is no effective sewage system, and the open rainfall drains that serve as sewers in most of the town's streets commonly overflow in the wet season. Unsurprisingly, Malakal was one of the towns affected by the cholera epidemic of 2005-2006. Unless the problem of town sewage is addressed through a combination of investment and urban planning, preventing further outbreaks of waterborne diseases will be problematic.

6.5 Drinking water, sanitation and waterborne diseases

Access to safe and adequate drinking water

Sudan is one of the few countries in the world where the percentage of people with access to safe and adequate drinking water has declined over the

Table 9. Overview of potable water statistics in Sudan [6.10, 6.11, 6.12]

Indicator	Statistic
Northern and national figures	
Urban populations without access to 20 litres per day (North, 2005)	40 %
Rural populations without access to 20 litres per day (North, 2005)	60 %
Khartoum population with improved water access (2005)	93 %
Blue Nile state population with improved water access (2005)	24 %
Primary schools without access to safe water	65 %
Percentage of daily income spent on water purchase by the urban poor	Up to 40%
Average water consumption per person per day from rural water points	< 6 litres
Darfur	
Average water consumption per person per day	< 7 litres
Southern Sudan	
Rural population without access to safe water supplies (2005)	75 %
Percentage of the estimated 6,500 water points currently not functioning properly	65 %

last decade. Water access rates are comparable to poorer countries in sub-Saharan Africa.

Sudan actually has sufficient natural water resources in the form of rivers, lakes, seasonal streams and groundwater to supply drinking water for the population in virtually all areas, except for some parts of the northern desert (see Chapter 10).

The constraint in supplying adequate and safe drinking water is principally due to a lack of extraction and purification infrastructure. Under-investment and poverty are core obstacles for the supply of water throughout Sudan, and historical and current conflicts have exacerbated the problem.

Water availability for agriculture and industry (which can use over twenty times the amount required per capita for potable purposes) is much more limited, and constrained by the scale and reliability of the resources rather than just under-investment.



Water carts in Kassala state. Reliable water points are few and far between in the drier parts of Sudan. Many people rely on water purchased from vendors



A major aid-funded water drilling programme in Darfur has provided over a million people with access to clean water since 2003



Hand-operated well pumps provide a reliable water supply to millions of Sudanese people



The majority of the urban population of Sudan relies on basic latrines or septic tanks that are emptied by truck. In this case, the load is transferred to the Khartoum sewage works

Sanitation and sewage

Problems with sanitation are evident throughout Sudan, and inadequate facilities are the norm rather than the exception outside metropolitan Khartoum. Village fringes, disused lots and seasonal watercourses are commonly used as open toilets, with predictable health consequences.

Table 10. Overview of sanitation and sewage statistics in Sudan [6.10, 6.11, 6.12, 6.13]

Indicator	Statistic
Northern and national figures	
Urban population using improved sanitation facilities	80 %
Rural population using improved sanitation facilities	46 %
Primary schools with improved sanitation facilities	50 %
Percentage of Khartoum connected to sewage system	28 %
Darfur	
Population using improved sanitation facilities	< 20 %
Southern Sudan	
Population using improved sanitation facilities	< 30 %

Sanitation issues are most apparent in displaced persons settlements that have not been reached by international aid efforts. Such settlements are typically found on the outskirts of towns, and are generally very crowded and unsanitary. Large-scale aid-organized camps are usually in better condition but often face major challenges due to crowding and poor location.

Sewage systems have been installed in Khartoum, but these facilities, which cover only a quarter of the population [6.5], are now massively overstretched and not functioning properly. As a result, a large amount of untreated sewage is pumped back into the Nile, with obvious health implications for downstream communities. Most other cities have some form of sewage drainage system but no treatment, so that effluent is discharged directly into the nearest watercourse.

In the very dry areas and in towns without a sewage network, the standard solution for the more affluent communities (including the international aid community) is to use a septic tank. When tanks are full, they are emptied by a suction tanker and the contents are dumped, usually in the dry bed of a local seasonal watercourse. This process is particularly inequitable as it essentially transfers the waterborne disease risk from the affluent to the poor, who take their water from such watercourses.



In towns without sewage plants, septic waste tankers empty their loads on the city outskirts, in this case into the main wadi supplying drinking water to Port Sudan



Raw sewage flowing to the White Nile. Though there is a sewage network in Khartoum, it does not cover the entire city and no longer works properly, as it is stretched well beyond capacity



Waterborne diseases are a particularly severe problem in towns in Southern Sudan, due to the lack of water supply and sewage infrastructure in crowded informal housing areas like here in Juba

Waterborne diseases

The shortcomings in water quality and sanitation in Sudan are directly reflected in the incidence of waterborne diseases, which make up 80 percent of reported diseases in the country. The incidence of disease is highly seasonal: the greatest problems usually occur at the start of the wet season as the rains and run-off mobilize the faecal matter and pollution that have accumulated during the dry season.

The very limited water monitoring that has been carried out has confirmed bacteriological contamination of the Nile in Khartoum state and elsewhere in northern Sudan [6.12]. Limited groundwater monitoring in metropolitan Khartoum also confirmed bacteriological contamination [6.5]. There is practically no data for Southern Sudan.

Apart from the routine waterborne illnesses such as cholera, dysentery, hepatitis A and a range of parasitic

infections like schistosomiasis, a number of tropical diseases including malaria, sleeping sickness, river blindness, guinea worm and visceral leishmaniasis are still prevalent. Southern Sudan is particularly afflicted, with an estimated 70 percent of the world's cases of guinea worm occurring there [6.13].

In 2005 and 2006, Southern Sudan experienced a major cholera outbreak in several cities including Yei, Juba, Bor and Malakal. The total number of victims recorded by WHO was over 16,000, with over 470 deaths [6.14]. Cholera is a waterborne disease linked to faecal pollution of drinking water. A UNEP team visited one of the epicentres of an outbreak in Juba in February 2006 (see Case Study 6.3) and found that water and sanitation problems were so severe and endemic that it would have been very difficult to pinpoint a single source, though according to WHO, untreated water from the White Nile and shallow open wells were the most likely suspects [6.15].

6.6 Solid waste management: consistent problems on a national scale

Solid waste management practices throughout Sudan are uniformly poor. Management is limited to organized collection from the more affluent urban areas and dumping in open landfills or open ground. In the majority of cases, garbage of all types accumulates close to its point of origin and is periodically burnt.



Open air burning is the most common method of waste disposal in IDP settlements such as this one on the southern fringe of Khartoum



Carefully designed water points, such as this one that is connected to a deep well in Western Darfur, can help control the spread of waterborne diseases

Litter – plastic bags in particular – is a pervasive problem across the country, with Khartoum state being worst affected due to its population density and relative wealth.

UNEP field teams visited a number of municipal dumpsites in Port Sudan, Khartoum, El Obeid, El Geneina, Wau, Juba, Malakal and Bor, as well as in smaller towns and villages. Of all of the sites visited, only Khartoum and Juba were found to have organized systems of dumping waste into pre-defined moderately suitable locations. In all other cases, dumping took place on the outskirts of urban centres (see Case Study 6.4). Moreover, there was no waste separation at source, and slaughterhouse offal, medical wastes, sewage and chemicals were seen within the normal waste stream. Waste was also commonly dumped directly into seasonal watercourses or rivers, thereby contributing to water pollution and waterborne diseases.



Wind-blown litter is an endemic problem in the countryside around major towns in northern and central Sudan



Offal and effluent from the slaughter yard flow past the well towards the White Nile

UNEP found that this hand-pump supplied both the slaughter yard and the nearby local settlement. Waterborne diseases such as cholera occurred in this area in 2006

CS6.3 Juba slaughter yard and community well

The slaughter yard on the eastern edge of Juba is the largest of several relatively small and primitive facilities used for slaughtering cattle, sheep and goats in the town. The site is surrounded by IDP settlements, and is approximately 200 m from the Nile and 400 m upstream of the town's municipal water extraction point.

The facility consists of an open concrete yard with a number of drains and open washbasins. On the day of UNEP's inspection, the facility was covered in blood and offal. Most of the non-commercial offal was washed into an open drain leading towards the river. The edges of the facility were used for dumping non-usable solid animal waste, and as an open latrine.

A community water point in constant use was located on the premises, within five metres of the offal drain and communal latrine. The surface of the water point was surrounded by stagnant noxious water and waste. The depth of the water table was estimated by the team to be in the order of two to three metres. Interviews of water point users revealed that many people in IDP settlements nearby had been struck with cholera.

This particular case of apparent contamination of community water supplies illustrates the problem of locating shallow groundwater wells in an urban setting in the absence of any real form of water and sanitation infrastructure or protection measures.

Since UNEP's visit, however, it has fortunately been reported that the replacement of the slaughter yard is being carried out as part of current infrastructure works in Juba. A new abattoir with modern facilities will be constructed on a new site to the north of the city.



A waste picker burns tires in order to retrieve wire to sell as scrap metal (left)

Abattoir waste was left in the open air for scavenging dogs and birds (top right)

Medical waste was found across the site and along the main road (bottom right)

CS6.4 The Port Sudan landfill

The case of Port Sudan (population approximately 500,000) illustrates the solid waste management problems that exist throughout Sudan. The city has several uncontrolled waste disposal sites on its fringes. The largest by far is located along the banks of a broad *wadi*, approximately six kilometres from the city centre.

The boundaries of the site are difficult to determine, as open dumping takes place along the access routes and in vacant or common land throughout the district. In total, it is estimated that no less than 5 km² are covered with a layer of mixed waste ranging from 0.1 to 1 m in thickness.

The site is virtually uncontrolled and presents obvious health and environmental hazards. Waste is burned and recycled by a resident group of waste pickers who live in terrible conditions on site. Animals observed feeding on the waste include dogs, goats, cattle and camels, as well as crows, kites and vultures.

The types of waste dumped on site include clinical wastes (syringes, catheters, blood packs, drugs and bandages), plastics and paper, drums and other metal scraps, small-scale chemical wastes, abattoir and food wastes, and septic tank solids and liquids.

The root cause of problems such as those seen at Port Sudan is inadequate investment in public services, including in all aspects of sanitation and waste management.

6.7 Air pollution and urban transport: a complete data vacuum

UNEP found no evidence of systematic air quality monitoring in Sudan. UNEP itself did not conduct any quantitative analysis, and thus cannot present any solid findings on the topic.

With respect to health, the most significant air pollutant in most of Sudan is dust generated by wind moving over dry and exposed soil. Indeed, large parts of northern Sudan are routinely enveloped in sand and dust storms, with high levels of atmospheric dust persisting for days at a time. This extent of exposure undoubtedly takes a toll on the population's respiratory health, although UNEP was not able to find solid statistics on this issue.

According to local authorities, the last significant air pollution and associated environmental health survey was conducted in Khartoum in 1990. This study reportedly focused on health impacts to traffic police, but the results were not available for interpretation. In 1979 and 1981, limited studies

investigated particulate (dust) and sulphur dioxide (SO₂) levels in Khartoum; again, the results were not available.

On an anecdotal basis, industrial- and vehicle-based air pollution do not appear to be regional-scale problems in Sudan, though localized issues with factory and traffic emissions are evident in central Khartoum.

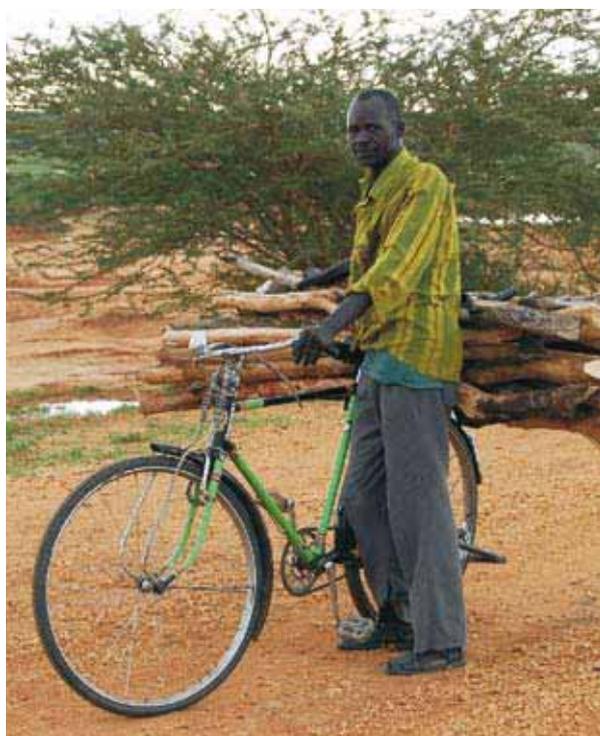
The current Environmental Framework Act of 2000 does include some general prohibitions on air pollution, but no numerical quality standards. As a result, there are no criteria against which the performance of individual facilities can be judged. There is also no measurement capacity within the regulatory authorities. Nonetheless, at least one state government has taken action on air pollution issues, forcing a cement factory to treat its emissions (see Case Study 7.3).

These and other positive steps at the local level should be supported via technical and legal development work, including data collection and the establishment of air quality and plant performance standards.

6.8 Urban energy: a declining dependence on wood

Sudanese cities are unusual even in the developing world in that the level of electrification is overall extremely low, and that the majority of the urban population still relies on wood for energy: a 1998 survey reported that 90 percent of urban households still depended on charcoal and wood for fuel. It is the energy needs of these ten million urban dwellers of northern and central Sudan that drive the large-scale and very unsustainable commercial charcoal industry (see Chapter 9).

There is some cause for optimism, however. Liquefied petroleum gas (LPG) is being introduced into northern Sudan – and Khartoum in particular (see Chapter 7). In addition, the electricity supplied by the Merowe dam project is expected to double the national electrical output in 2007-2008, ushering in a major switch to electricity (see Chapter 10). This move from one energy source to others with different environmental impacts is a typical example of the environmental trade-offs that occur with development.



Carting firewood back to Juba: towns in Southern Sudan rely on a combination of firewood and charcoal for most energy needs

6.9 Sustainable construction opportunities: alternatives needed to reduce deforestation rates

Sudan is currently experiencing a construction boom, which is greatly increasing the demand for construction materials, and particularly for bricks. All bricks in Sudan are baked using a low efficiency kiln system fuelled by firewood. The demand for wood has intensified the pressure on forests in most parts of the country, and especially in central Sudan and Darfur.

The cost of ‘modern’ construction remains extremely high, especially in Southern Sudan and Darfur, where transportation costs can be punitive. For example, the cement used for UN compounds built in 2006 in remote parts of Southern Sudan was generally airlifted – an extremely expensive approach for bulk commodity transport.

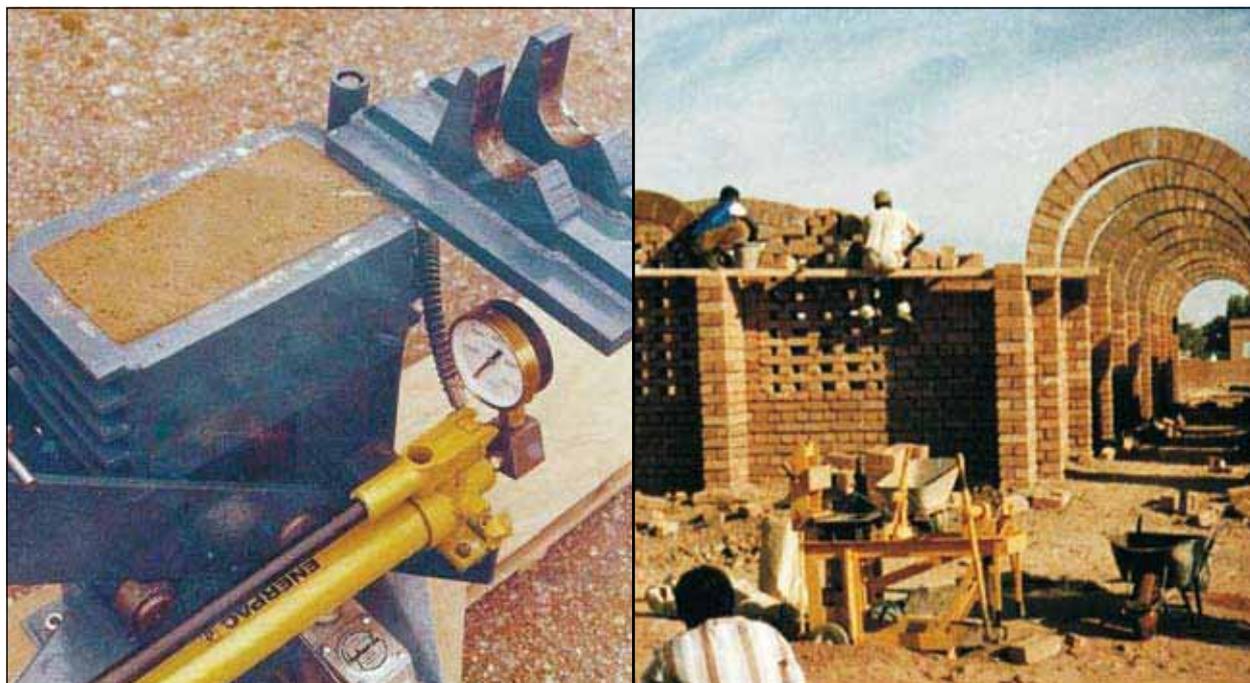
This building boom represents an opportunity to introduce sustainable and cost-effective construction techniques into the country. Techniques such as stabilized earth technology are already used on a small scale in Sudan and simply need promotion. Other practices, such as solar-aided hot water systems, have been introduced but have yet to be widely adopted.

6.10 Urban and health sector environmental governance: local management and funding issues

Under the terms of the 2005 Interim Constitution, practical management of the urban and health sectors in Sudan is largely the responsibility of state governments, which in turn delegate down to county and city governments. Cross-cutting this structure are federal ministries for physical development, health, water and irrigation, and transport.



Traditional buildings such as this barn under construction near Mabor in Jonglei state require a large number of young trees



Stabilized earth bricks are obtained by placing a mixture of clay, silt, sand and a stabilizing agent into a mechanical or hand-powered press, which crushes the mix into a hard, dense block that is then dried naturally

Stabilized earth construction techniques combine the advantages of traditional earth and modern brick construction. Compressed earth blocks have been used in the construction of several buildings in Khartoum

CS 6.5 Sustainable construction using stabilized earth blocks: an opportunity for the UN and others to do less harm to the environment

Traditional soil construction techniques are used in 80 percent of buildings in Sudan, and this figure rises to over 90 percent in rural areas (2000 data). The advantages of soil are its very low cost, its local availability and the simplicity of construction. Its disadvantages are its low strength and durability, particularly in high rainfall areas. The more affluent Sudanese therefore rely on brick construction instead, and the demand for fuel to fire bricks is one of the causes of the deforestation occurring in Sudan.

Compressed and stabilized earth construction techniques combine the advantages of both traditional earth and modern brick construction. The method can be summarized as follows: suitable moist soil consisting of a mixture of clay, silt and sometimes sand, is blended for uniformity before a stabilizing agent such as cement, lime, gypsum or bitumen is added. The material is then placed in a mechanical or hand-powered press, which crushes the soil-stabilizer mix into a hard, dense brick that is dried naturally, gaining strength in the process. The bricks obtained can be used just like fired clay or concrete bricks.

Modern compressed earth technology has proven effective in many parts of the world, and several buildings, such as the Haj Yousef experimental school in Khartoum North, have already been constructed in Sudan as demonstration projects [6.18, 6.19].

The environmental savings are significant, as studies have shown that compressed earth construction uses approximately only one to two percent of the energy for material development per cubic metre that cement and fired bricks use [6.18]. For Sudan, this translates into potentially major savings in fuelwood.

The economics of compressed earth indicate that – if introduced correctly – the technology can be commercially self-sustaining, as it can compete with brick and cement on cost grounds. The main obstacle to market entry is its novelty and a lack of local knowledge.

UN agencies in Sudan and elsewhere in developing countries use considerable amounts of fired bricks to build their offices and residential compounds. In fact, the MOSS (Minimum Operating Security Standard) requirement for a two-metre high solid wall surrounding compounds is the direct cause of the felling of thousands of trees in Sudan and elsewhere. Compressed earth technology offers the opportunity for the UN and other international aid organizations to reduce the negative impact of their presence and extend the ‘do no harm’ principle to include the environment.

The main issue for state governments in Sudan (outside of Khartoum) in areas such as urban planning and environmental health is insufficient funding: local officials are generally quite aware of the problems but cannot act in the absence of funds.

The second major obstacle to tackling urban and environmental health issues is the pace of urban growth and slum development: it is difficult to enforce basic planning and environmental health standards when uncontrolled settlements are set up on land that is either unsuitable for inhabitation or needed for the provision of adequate infrastructure. A particular problem arises where illegal settlements are established in flood plains and partly block existing drainage basins and corridors, resulting in increased flooding and the spread of waterborne diseases.

6.11 Conclusions and recommendations

Conclusion

While urban environment and environmental health issues are clearly apparent to all living in Sudan, attempts to change this situation have met with little success to date. The main obstacle for improvement in these areas is a lack of investment, but other problems, such as the widespread lack of adequate urban planning, also play a role.

Background to the recommendations

Water and environmental sanitation are major areas for international humanitarian funding; in the UN, work in these sectors is led by UNICEF. Solid waste management and urban planning are traditionally not well supported, though this is now changing.

It is extremely clear that neither humanitarian nor development aid efforts in these sectors will be fully successful or sustainable without greater government support, principally increased government funding. Issues such as land tenure, unauthorized settlements and chronic solid waste management problems can also only be resolved by national and local authorities.

On this basis, UNEP's recommendations are focused on increasing government capacity and support for these sectors rather than implementing site-specific projects. The exceptions are the need for practical solid waste management and sustainable construction projects in one or more locations to demonstrate the way ahead. It should be noted that a substantial humanitarian water and sanitation programme is separately promoted and managed by UNICEF and others on an annual basis, and is hence not repeated here.

Recommendations for the Government of National Unity

R6.1 Invest in urban planning capacity-building for all northern and central states, and for Darfur. This will entail a process of importing expertise and 'learning by doing' through improved master planning for each state capital. Particular attention should be given to Darfur state capitals, where the need is greatest due to the influx of people displaced by the conflict. To improve political support, assistance should be channeled in part by the Governor's office in each state.

CA: CB; PB: GONU state governments; UNP: UN Habitat; CE: 2M; DU: 3 years

R6.2 Increase investment in environmental health-related infrastructure and services in all northern and central states, and in Darfur. There is no substitute for significant investment in solving issues such as sanitation and solid waste management. Any major investment programme should proceed in stages, attempt to introduce self-sustaining financing and involve the private sector. A proportion of the total cost should be directed toward human resource capacity-building and awareness-raising. Note that this recommendation is not costed, but that the investment required to attain even a basic level of service is anticipated to be in excess of USD 1 billion over a period of more than a decade.

CA: GI; PB: GONU state governments; UNP: UN Habitat; CE: NC; DU: 10 yrs+

R6.3 Promote the growth of the LPG market in major urban centres. This measure will directly reduce the pressure on remaining forests in dryland Sudan by substituting for charcoal

as an urban fuel source. Promotion may entail some form of initial subsidization of the LPG cylinders. Fuel should not be subsidized, as this would create a distorted market in the long term. Costs and duration of the programme are flexible and scalable.

CA: GI; PB: Public via MoF; UNP: UNEP; CE: 1M; DU: 2 years

R6.4 Complete a stabilized earth technology demonstration project for Khartoum and three other states including Northern Darfur.

This should entail the construction of a UN and government-used building in a prominent position to maximize exposure, and should include extensive capacity-building components. The technology and capacity already exist within the Ministry of Environment and Physical Development.

CA: CB; PB: MEPD; UNP: UNOPS; CE: 1M; DU: 2 years

R6.5 Complete a stabilized earth technology demonstration project for Juba and three other states. The technology and capacity already exist within the GONU Ministry of Environment and Physical Development, and GONU assistance to GOSS on this topic would be a positive example of north-south cooperation.

CA: CB; PB: MEPD; UNP: UNOPS; CE: 1M; DU: 2 years

Recommendations for the Government of Southern Sudan

R6.6 Invest in urban planning capacity-building for all southern states. This will entail a process of importing expertise and 'learning by doing' through improved master planning for each state capital. To improve political support, assistance should be channeled in part by the Governor's office in each state.

CA:CB; PB: GOSS state governments; UNP: UN Habitat; CE: 2M; DU: 3 years

R6.7 Increase investment in environmental health-related infrastructure and services in all southern states. This recommendation matches R6.2 above with similar anticipated costs and time scales.

CA: GI; PB: GOSS state governments; UNP: UN Habitat; CE: NC; DU: 10 yrs+

Recommendations for the United Nations in Sudan

R6.8 Construct a MOSS-compliant compound perimeter for at least one base in Southern Sudan using stabilized earth technology. Such a demonstration project potentially has very high added value if explicitly endorsed by the UN.

CA: PA; PB: GONU MEPD; UNP: UNMIS and UNOPS; CE: 1M; DU: 2 years

Industry and the Environment

An oil well being drilled at Heglig field, Southern Kordofan. The rapid growth of the oil industry is set to change Sudan's economy, society, and environment.



Industry and the environment

7.1 Introduction and assessment activities

Introduction

Sudan's industrial sector is currently undergoing rapid change and expansion. Historically limited to utilities and small-scale food processing, the sector is now booming thanks to oil production, which began in 1999.

Environmental governance of industry was virtually non-existent until 2000, and the effects of this are clearly visible today. While the situation has improved significantly over the last few years, major challenges remain in the areas of project development and impact assessment, improving the operation of older and government-managed facilities, and most importantly changing attitudes at the higher levels of government.

Industries covered in this chapter include oil production, power generation, food-processing, transportation, chemicals and construction.

Assessment activities

UNEP teams visited a range of industrial facilities across the country. In some cases, a full tour of the facility was possible; in others only brief inspections were carried out due to limited time or access. The sites visited include:

Port Sudan region, Red Sea state:

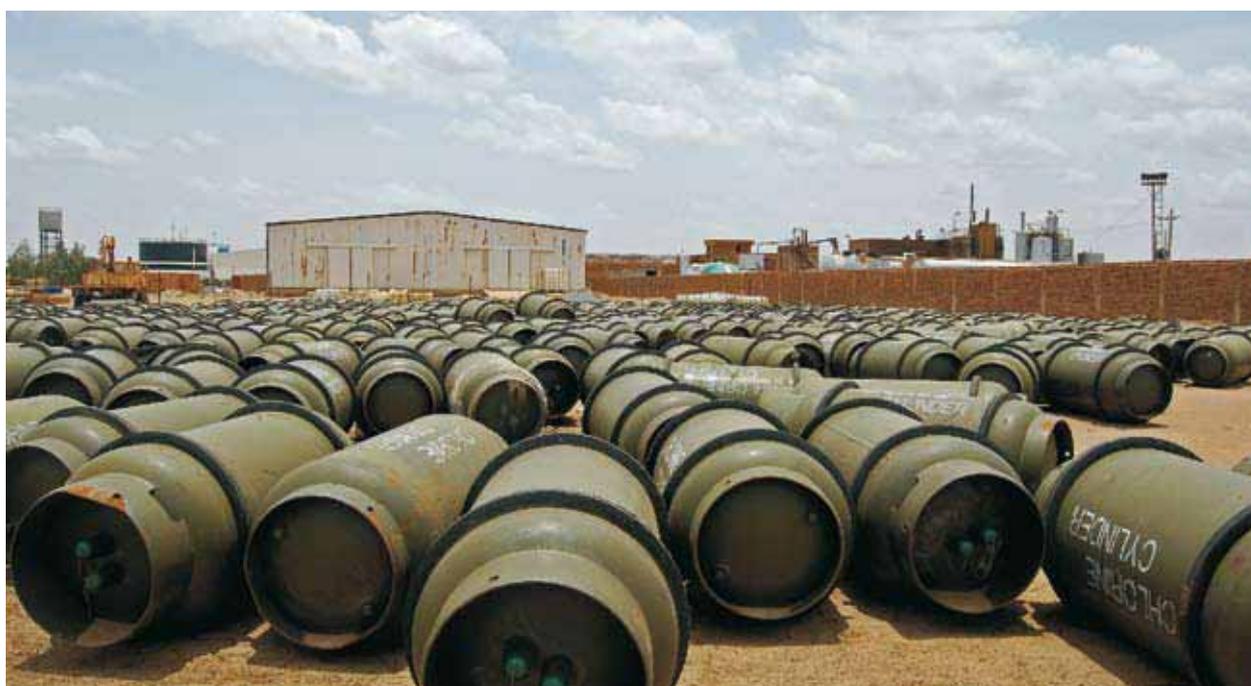
- harbour operations and warehousing (site meetings and full tour);
- several very light industry sites (site inspections);
- saltworks (full site tour);
- desalination plant (full site tour);
- power station (external viewing only); and
- refinery (site meeting only).

Khartoum state:

- Comfort soap and toothpaste factory (brief site visit); and
- GIAD car assembling complex (brief site visit).

Gezira state:

- Baggier industrial complex (brief site visit);
- Aqsa cooking oil factory (brief site visit); and
- Hibatan tannery and leather factory (closed).



Chlorine storage cylinders outside a chemical plant in Barri, Metropolitan Khartoum. UNEP's assessment of the industrial sector included visits to many factories. Access was normally granted without restriction



A small sesame seed oil pressing plant in Port Sudan. Food processing represents a significant part of the light industry sector in Sudan

Sennar state:

- Kenana sugar factory (full site tour); and
- Asalaya sugar factory (full site tour).

Southern Kordofan:

- Heglig crude oil production complex (site meetings and full tour).

Jonglei state:

- oil exploration seismic survey base and line sites (site meeting and tour).

Northern state:

- Merowe dam site (Khartoum meetings, no access to the site, visited the downstream region, see Chapter 10 for details); and
- Atbara cement factory (brief site visit).

The number of sites visited was considered sufficient to evaluate the environmental governance of industry in Sudan; the assessment was supported by an analysis of both general and site-specific legislation and enforcement practices.

Oil-related sites were visited, but not in sufficient depth and number to gain a comprehensive picture of the industry. The implications of this data gap are addressed further in this chapter.

7.2 Overview of the industrial sector in Sudan

General industrial structure

Sudan is experiencing rapid industrialization due to the growth of the oil industry and associated service industries and imports. For the purposes of this environmental assessment, industry is divided into five sectors, as follows:

1. the upstream oil industry;
2. the downstream oil products industry;
3. utilities (power generation and water supply);
4. food processing (sugar, sesame oil, cereals); and
5. miscellaneous (including mining, textile manufacturers, tanneries and workshops).

Oil, utilities and food processing dominate the industrial sector. Until recently, virtually all of the major industries in Sudan were state-owned or controlled. This has now changed, as many of the main manufacturers have been privatized. Apart from the newer oil facilities, the industrial sector has suffered from a lack of investment which is reflected in the condition of the plants and their environmental performance.

Oil industry structure

The oil industry is conventionally divided into three sectors:

- The **upstream** sector, which covers exploration for crude oil and gas, extraction, and transport via pipelines and tankers to markets;
- The **downstream oil products** sector, in which the supplied oil and gas are refined and converted into usable products (petrol, diesel, lubricants) and sold to customers; and
- The **petrochemicals** sector, in which oil and gas are converted into chemicals and materials such as solvents and plastics.

Sudan's upstream oil industry is set to dominate industrial activity in the country for the next generation. UNEP interviews indicated a nationwide concern about the environmental impacts of exploration and extraction of oil, and this topic is addressed in some detail below. In contrast, the downstream sector in Sudan is relatively small and set for moderate growth only. There is no petrochemical industry in Sudan yet.

Oil industry exploration and production history

Oil exploration in Sudan started in 1959, but the first major find was only made in 1980 by the US company Chevron (now Chevron-Texaco), north of Bentiu in Western Upper Nile state (now renamed and boundaries changed to Unity state). Further finds were made in 1982, 70 km north of Bentiu in the Heglig district, in Southern Kordofan [7.1, 7.2].

Oil production in Heglig and Bentiu was delayed until 1996 by the north-south civil war, which was itself partly caused and sustained by the competition for control of the oilfields. The conflict and political changes during this period were accompanied by a shift in international oil development partners. Most western companies gradually withdrew, due in part to pressure in their home countries. They were replaced by Chinese, Malaysian and Indian national oil companies, which now manage the oilfields in Sudan together with representatives from the Government of National Unity.



Well casings lined up beneath the Heglig drilling rig. Oil production is rapidly increasing in Sudan, as new fields are developed and transport infrastructure such as trunk pipelines and marine terminals is constructed



A crowned crane on 'toic' grassland near Padak. Much of the planned oil exploration is set to take place in the Nile flood plain, an environmentally very sensitive area

Current oil industry activities

Sudan started exporting oil in 1999. According to official figures, oil production in Sudan was approximately 400,000 barrels per day as of mid-2006, and was expected to rise to 500,000 barrels per day within a short period of time [7.3, 7.4]. Based on an oil price of USD 67 per barrel [7.5], the latter production level equates to a theoretical revenue stream of USD 33.5 million per day or USD 12.2 billion per year, which represents 14 percent of the 2005 estimated gross domestic product for Sudan (USD 85.5 billion) [7.6].

Sudan also has significant gas reserves (some 3 trillion standard cubic feet) [7.7, 7.8] and currently produces gas as a by-product of oil production in central Sudan. Unfortunately, no large market has yet been developed for this gas in Sudan. As a result, most of it is burned off by flaring. Efforts are ongoing to tap this supply by increasing the existing liquefied petroleum gas (LPG) market.

As of mid-2006, the principal oil and gas production facilities in Sudan are:

- production wells and initial treatment complexes in the fields of Heglig (Southern Kordofan), Bentiu (Unity state), Thar Jath, Muglad and Adar (Upper Nile state); some of these facilities are still under development but expected to start or increase production within the next two years;
- four crude oil export pipelines connecting the fields to Port Sudan, with a combined length of 3,900 km; and
- a marine oil export terminal at Port Sudan.

Oil exploration and production plans

Sudan's commercially recoverable oil reserves are currently in the approximate range of 500 to 800 million barrels, and total oil reserves are estimated

to be up to eight billion barrels [7.8, 7.9, 7.10]. At present and projected extraction rates, these reserves will last for approximately a decade, though it is expected that further reserves will be discovered and exploited over time. Current plans are to expand production to 1.5 million barrels per day by 2008 [7.3, 7.11].

Only a small portion of central Sudan has been explored thoroughly, and only a fraction of that small area is in production. Before the Comprehensive Peace Agreement (CPA) was signed in 2005, exploration was limited to military-controlled areas in the north-south border regions. The establishment of peace and security is now allowing exploration to expand into the rest of Southern Sudan, as well as Southern Darfur.

There are nine exploration concessions in Sudan (see Figure 7.1), totalling approximately 250,000 km² or ten percent of the country's land area. Most of the important unexplored areas are in Southern Sudan. Accordingly, large-scale oil exploration and perhaps development are expected to come to Southern Sudan within the next ten years. Some activity has already started: the White Nile Petroleum Company has been conducting seismic surveys in Padak County, Jonglei state since 2006 (see Case Study 7.2) and plans to commence drilling in the second quarter of 2007.

7.3 Overview of industry-related environmental issues

Industry-related environmental issues can be divided into those applicable to all industries and those applicable to the upstream oil industry only.

General issues are:

- absence of environmental considerations in the development of new projects; and
- poor environmental performance at operating sites.

Upstream oil industry issues are:

- isolation from governance and scrutiny;
- existing impacts and future risks of oil exploration;
- produced water;
- produced gas flaring and utilization; and
- oil spill risks from sea transportation.

7.4 General industry-related environmental issues

An absence of environmental considerations in the development of new projects

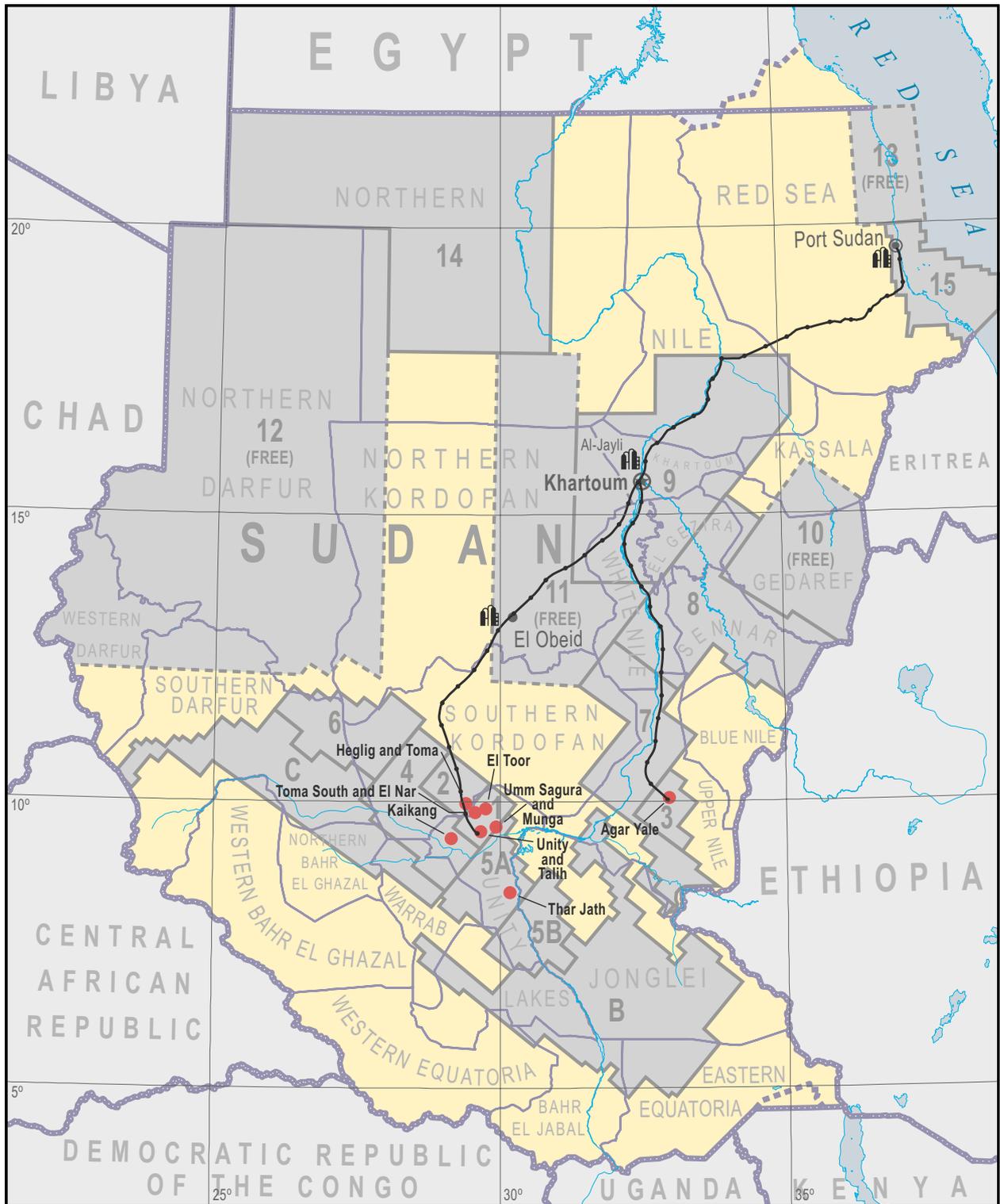
Environmental issues have rarely been considered in the development of major industrial projects in Sudan over the last forty years. This has been the case throughout Sudan for all aspects of project implementation: design, feasibility, site selection, and facility construction and operation.

As a result, a number of large projects have had very negative impacts on the environment. Unfortunately, new projects are still being implemented without environmental consideration today (see Chapter 10 for section on dams). What's more, development in Sudan has historically been driven by a series of national-level plans and mega-projects, such as the Gezira agricultural scheme and the Jonglei canal. These schemes tend to have high-level political backing and progress rapidly from conception to construction, without opportunity for assessment or public consultation.



The construction of this major new harbour facility in Port Sudan proceeded without an environmental impact assessment or mitigation of its impacts

Figure 7.1 Sudan oil industry



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

-  Oil refinery
-  Oilfield
-  Oil pipeline
-  Concession block and id

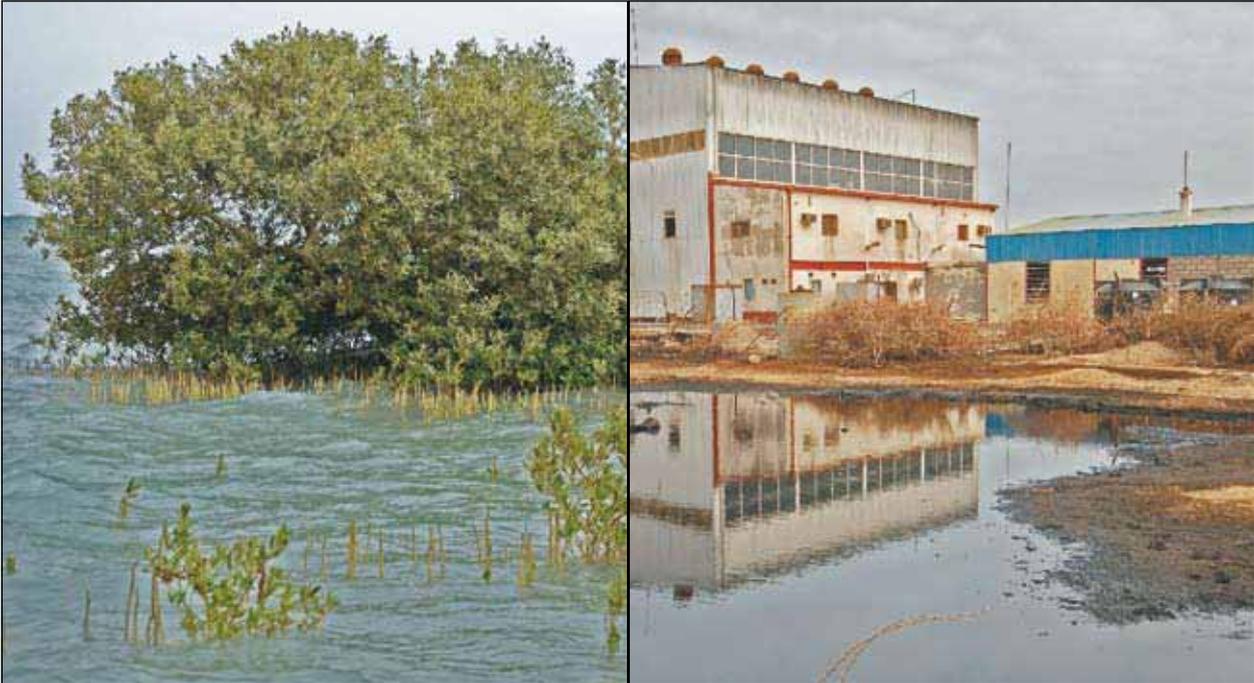
Kilometres

0 100 200 300 400 500

Lambert Azimuthal Equal-Area Projection

UNEP/DEWA/GRID-Europe 2006

Sources:
ECOS; SIM (Sudan Interagency Mapping); USGS; vmapiv0, NIMA;
various reports, maps and atlases; UN Cartographic Section.



Stand of mangroves located some 500 m from the power station

The waste oil that is regularly dumped outside this Port Sudan power station migrates towards a lagoon and mangrove forest on the outskirts of the city

CS 7.1 Port Sudan power station waste oil dumping

The lack of environmental governance in the industrial sector is readily apparent throughout Sudan. In Port Sudan, for example, electricity is supplied by several government-operated oil-fired power generation stations. Power Station C is located 5 km south of the city on the Port Sudan-Suakin road. It is built on what were previously salt marshes and located approximately 200 m from a shallow lagoon, 500 m from one of the only remaining mangrove forests and at an equal distance from the principal coastal recreation site outside the city.

The diesel generators require regular oil changes, generating large quantities of waste oil. The UNEP inspection team witnessed this oil being simply poured onto the ground in vacant land next to the station, whence it gradually flowed into the lagoon; open channels had been cut in the sediment to aid its flow.

Poor environmental performance at operating sites

UNEP site inspections revealed chronic serious environmental problems at the majority of industrial facilities visited. The issues noted ranged from air emissions and water pollution to hazardous and solid waste disposal. There was no correlation with scale: large facilities had the same performance as smaller ones, if not worse. Air and liquid discharges were found to be mostly uncontrolled, and untreated effluent was seen to be discharged directly into watercourses at several sites.



Used asphalt drums dumped on the outskirts of Port Sudan

7 INDUSTRY AND THE ENVIRONMENT



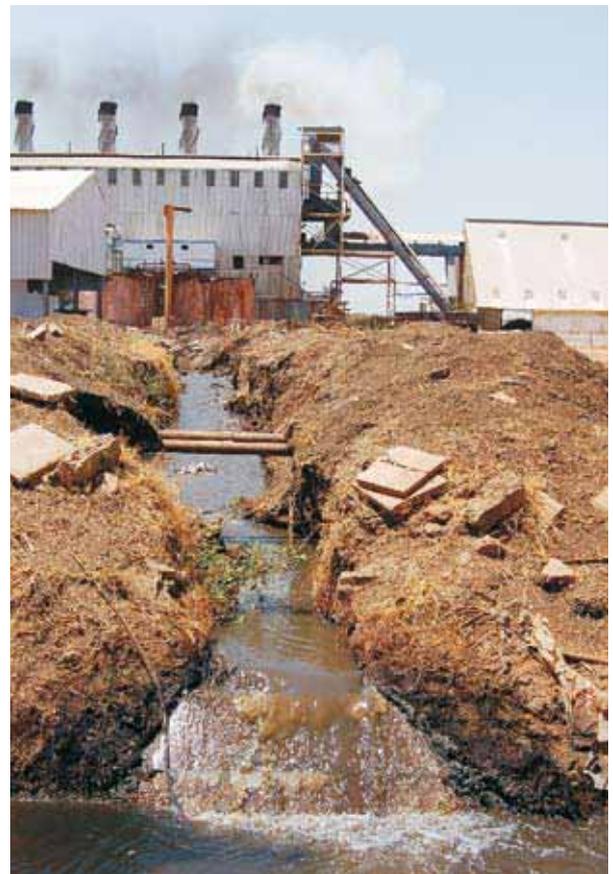
Fuel oil spillage at the Rabak cement factory, in White Nile state

The environmental performance of the two utilities visited by UNEP in Port Sudan – the water desalination plant and Power Station C – was very poor (see Case Study 7.1). Utilities are still generally owned by the state and suffer from a lack of investment. They are also effectively immune from legal sanctions because they provide vital services that cannot be interrupted.

At the country's five main sugar estates, the key problem was the release of effluent. All sugar factories were found to be releasing factory wastewater directly into the Blue and White Nile without pre-treatment. This wastewater contains an elevated biological oxygen demand (BOD), which can reach 800-3,000 ppm. The resulting pollution of river water is suspected to be the leading cause of frequent fish kills, particularly in the Blue Nile. It should be noted that the Kenana factory is in the process of constructing a wastewater treatment plant to address this problem. Others have yet to follow suit.



Waste oil discharged onto the ground from a lubricant factory in Khartoum state



Untreated effluent flows directly from the Assalaya sugar factory to the Blue Nile

7.5 Environmental issues specific to the upstream oil industry

Generic issues

The generic environmental impacts and risks associated with the oil industry are well known and include:

- oil spills during any part of the process with a particular risk related to sea transport;
- very large-scale intrusion into previously undeveloped or inaccessible areas via access roads for exploration, production plants and pipelines;
- generation of water pollutants (produced water from well fields is a particular problem);
- generation of general and chemical solid wastes;
- air emissions, particularly from gas flaring; and
- secondary development impacts as the oil facilities attract populations seeking employment and other benefits.

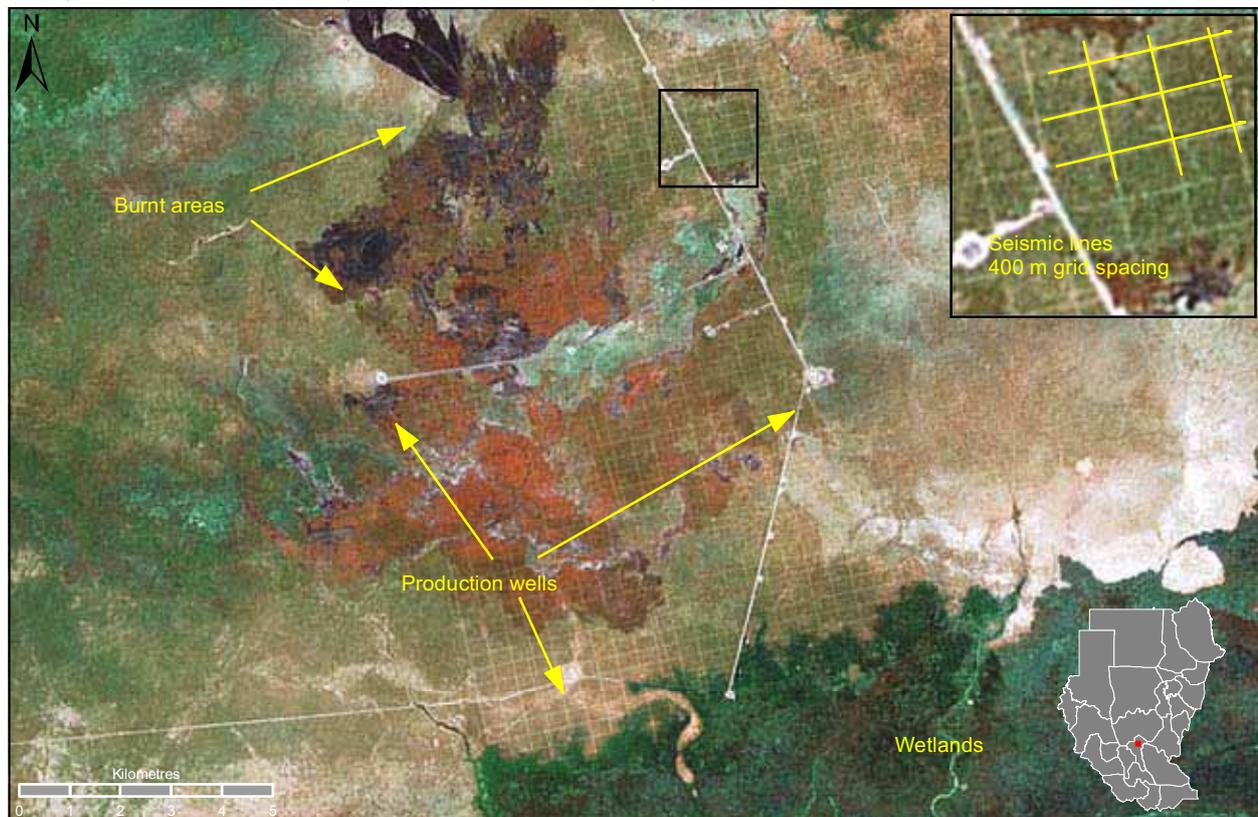
The significance of these impacts can vary dramatically from one oilfield or plant to another, depending on the scale of the facility, the sensitivity of the location and the standards of operation.

As noted in the introduction, UNEP's assessment did not cover the full extent of the industry. Detailed comments are hence restricted to what was physically viewed and verified by the UNEP team, and to what was reported by oil industry personnel. Unverified statements with significant implications are recorded as such.

UNEP also received numerous and generally extremely negative anecdotal reports from southern Sudanese, which focused on the following:

- discharge of untreated produced water;
- damage to pastoral land and dwellings from road building; and
- oilfield chemical dumping.

Figure 7.2 Um Sagura seismic survey grid



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

The seismic lines and access roads in the Abyei region were cleared by bulldozer. They are visible as a grid at least ten years after completion of the survey, indicating significant damage to the vegetation and drainage patterns



Airboats used for seismic surveying access in the swamps and floodplains of Jonglei state, reducing the need for access roads in the first stages of oil exploration

A UNEP inspection of a portion of the seismic line through wooded savannah in Padak county revealed minimal long-term impact due to the limited clearance methods used

CS 7.2 Seismic surveys for oil exploration

The first stage of oil exploration that has any significant impact in the field is the construction of access roads and seismic surveying. Seismic surveys entail the capture of subsurface data in a grid pattern over thousands of square kilometres with line spacing of anywhere between 500 m and 5 km. Each line requires access by truck, and it is common practice to use a bulldozer to cut a track of four to twelve metres in width. This process can be very destructive in wooded regions and in wetlands, though the extent of the damage depends on the habitat, survey method and behaviour of the clearance teams.

Seismic lines in the Bentiu and Abyei districts, which were placed in the 1990s on behalf of the Greater Nile Petroleum Company, cross relatively open terrain and soft ground. These lines are still clearly visible in 2003 satellite images, indicating a deep cut method of clearance with significant impact on the vegetation and drainage patterns (see Figure 7.2).

In contrast, UNEP inspected a one month-old seismic line placed by Terra Seis on behalf of White Nile Petroleum in sparsely wooded and settled terrain in the Padak region. The method of clearance used was scrub clearance, avoiding trees and dwellings by offsetting the line by a few metres. The UNEP team walked one line for two kilometres and found negligible impact, apart from the stated scrub clearance.

These two examples indicate that while oil exploration will inevitably impact the environment of Southern Sudan, the impact can be greatly reduced with appropriate controls.

Additional accounts of environmental problems have been documented in some detail by a number of NGOs and international observers over the last ten years [7.12, 7.13, 7.14, 7.15]. These accounts are not reproduced here due to lack of verification by UNEP on these critical and sensitive issues.

Upstream oil industry isolation from governance and scrutiny

The upstream oil industry in Sudan is essentially self-regulated and has never been subject to independent technical scrutiny. Due to the limited scope of the assessment, UNEP cannot comment in detail on the actual performance of the upstream oil industry in Sudan. Elsewhere in the world however, the general experience is that

the industry's level of environmental performance is closely linked to the level of external scrutiny – secrecy is bad for performance.

Existing impacts and future risks of oil exploration

If it is not well managed, the exploration process can have the greatest impact on the environment of all the phases of oil production, due to the large areas affected and the temporary nature of the work. Exploration is unsuccessful in over 90 percent of cases, and when the results are negative, oil companies abandon the areas surveyed. Unless it is remediated, the environmental legacy of exploration can last for generations.

The most significant of these impacts are access roads for very heavy equipment, seismic survey lines and drilling sites. The damage is mainly physical, comprising deforestation and devegetation, erosion and watercourse siltation, and disrupted drainage patterns. Extensive damage of this type was observed by the UNEP team north of the Heglig facility in Southern Kordofan. Inspections of seismic lines in Jonglei state, however, revealed a much lower level of impact (see Case Study 7.2).

The areas targeted for oil exploration in Southern Sudan are particularly vulnerable to exploration-related damage, as they do not have many existing roads, are relatively well forested, have very soft soils, and flood for several months a year. Control of such impacts should therefore be a top priority for the industry. While appropriate control measures would increase the cost of exploration, exploration itself would not be undermined, as it would be prohibited only in the most sensitive areas, and then only at certain times of the year.

Produced water

The single most significant environmental issue for crude oil production facilities in Sudan is the disposal of produced water. Produced water is the water extracted from the reservoir along with

crude oil, and separated from it before the oil is transported via pipeline. The volume of water can be very large, particularly in the later years of production, when the wells tend to produce more water and less oil as reservoirs become depleted. The Heglig facility alone currently generates over ten million cubic metres of produced water annually. Full production of the central Sudan fields in ten years time may yield five to twenty times that amount.

Appropriate treatment and disposal options exist for produced water, but they can be costly. In the absence of regulations, it is unfortunately common practice around the world to simply discharge it to the nearest watercourse. Legislation and investment in treatment facilities are required to protect the environment from this type of pollution.

UNEP's inspection of the Heglig facility in March 2006 noted an operational produced water treatment facility based on reed bed technology. However, the GONU State Minister for Energy and Mining, as well as oil industry personnel, reported to UNEP in November 2006 that produced water was now being discharged untreated from the complex; volumes were not specified. The reasons given for the lack of treatment were a recent major increase in produced water flow rates and under-sizing of the treatment plant.



Produced water flowing into a holding pond at Heglig. Produced water can be difficult and expensive to treat, but has serious impacts on the environment if released untreated



Experimental reed bed for the treatment of produced water at Heglig. Like all treatment facilities, it needs to be properly designed, sized and maintained to be efficient

Produced gas flaring and utilization

The gas produced as a by-product of crude oil in Sudan is presently not all used. Some of it is flared (burned off) at the production site. Precise figures for gas flaring were not available to UNEP at the time of the assessment, but irrespective of scale, this practice has three negative impacts:

- needless emission of large volumes of greenhouse gases;
- waste of an energy resource that could feasibly replace much of the charcoal that is the cause for extensive deforestation in central Sudan; and
- local air quality issues (generally a minor problem).

The petroleum gas that is being flared could potentially be converted to bottled LPG. Though there is still ample room for growth (present market penetration is approximately 18 percent [7.7]), the market for LPG is currently developing in Sudan. In 2005, the domestic consumption – mainly in

cities in the northern states – was 102,000 tonnes, but the potential domestic demand for LPG has been estimated by government sources at 554,000 tonnes per year. Sudan also exports LPG through a terminal at Port Sudan, and this market could be expanded as well.

The development of the domestic LPG market and other uses for co-produced gas, such as electricity generation, would reduce the demand for fuelwood dramatically. In the long term, this could be the single most important factor in reversing the deforestation observed in the central and northern states.

Sea transport oil spill risks

There are two main sources of risk for oil spills arising from export operations in the Red Sea. The first is the process of loading the ships from the shore; the second is the navigation of the loaded tankers through the Red Sea.

Spills associated with loading have occurred, but have apparently been very minor. One such incident reported by the Government in 2004 was a spill of approximately 10 m³ at the loading point of the marine oil terminal (details not verified). Given that the marine oil terminal facilities are very modern, the risk of a major spill occurring during the loading process is considered moderate to low, provided operations are well managed.

Oil tanker transport presents a larger risk. The Red Sea is a busy shipping corridor connecting Europe to the Arab Gulf states and Asia. The traffic at the Port Sudan oil terminal is a new and growing load, with over 200 tankers anticipated per year as the industry develops.

The Red Sea generally has relatively calm weather but it is littered with navigational hazards in the form of over 1,000 very small islands, sandbars and shallow submerged coral reefs. Much of the coastline is fringed by reefs and there are few safe havens able to take large vessels. In addition, the presence of coral reefs and seagrass beds makes the Red Sea highly sensitive to pollution.

Oil-spill response resources in Sudan and elsewhere are structured according to a recognized international scale:

Tier 1 Small spills that can be managed using the resources available to the facility (or to a local government unit in the case of small ship or coastal spills);

Tier 2 Small- to intermediate-scale spills that require a coordinated response using local and national resources; and

Tier 3 Large spills requiring both national-level mobilization and the importation of international specialized spill response resources. There are many centres worldwide capable of providing such equipment, but only three major centres (Southampton, Singapore and Dubai) are designed for rapid and large-scale international responses.

The marine oil terminal and Port Sudan both have Tier 1 facilities (not verified). The oil terminal management has conducted several training exercises to build capacity, including spill containment boom deployment. However, there is reportedly no oil dispersant (surfactant) capacity in country, and UNEP interviews indicated that Tier 2 planning was not well advanced due to

difficulties in communication between different ministries and government bodies. The Ministry of Energy and Mining reported that the marine oil terminal had a Tier 3 agreement with Oil Spill Response Limited in Southampton (not verified).

Interviews also revealed that small oil slicks (1-10 m³) caused by passing ships clearing bilges in international shipping lanes were very common in Sudanese territorial waters. This is an endemic international problem, and is not linked to Sudan's oil industry.

To summarize, while it is impossible to eliminate the threat of a major oil spill, the risks observed and the safeguards reported to be in place for Sudan's oil export industry appear to be generally in line or only slightly below those for oil export facilities worldwide. The most important areas for improvement would be the ability to mobilize surfactant-based responses, and better coordination at the Tier 2 level. Notwithstanding the response capacity, the risk of an oil tanker incident is still considered relatively high due to the abundance of navigational hazards.



Waves breaking on a coral reef just off the marine terminal in Port Sudan



Industrial waste burning on vacant land in Khartoum state. Waste management and water pollution are two areas in need of improved governance

7.6 Industrial sector environmental governance

General industrial facilities

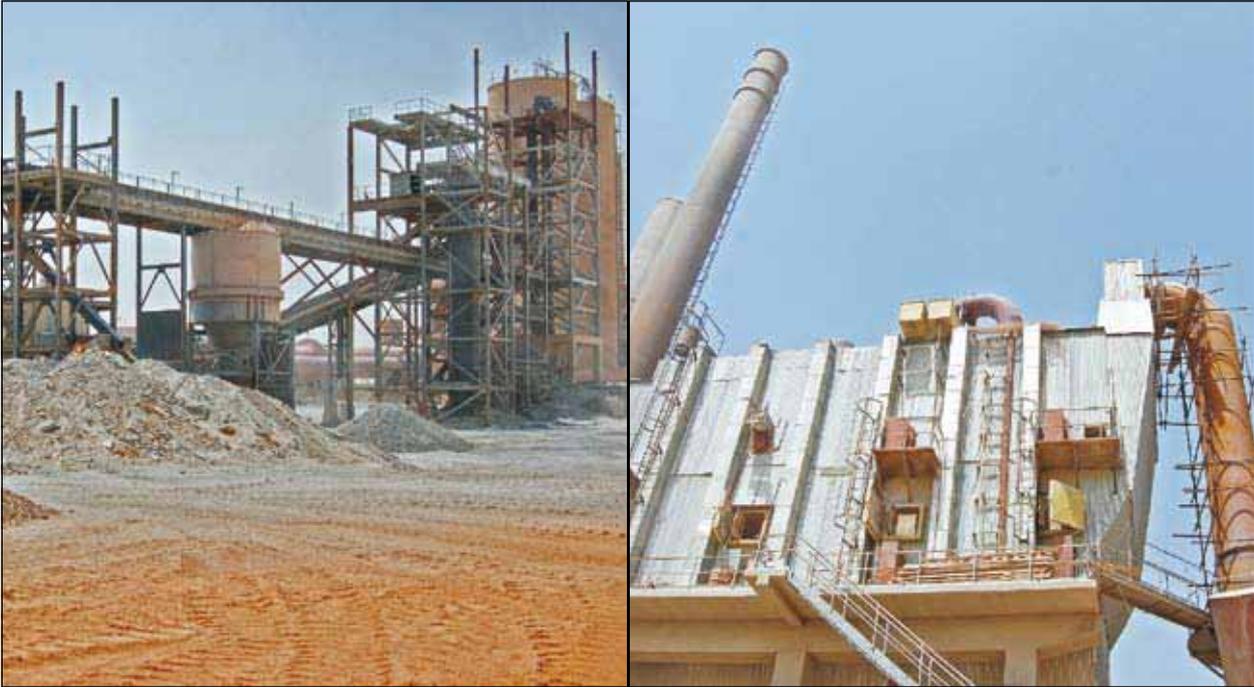
Industry is subject to national- and state-level environmental legislation, but the enforcement of existing laws is limited and difficult.

At the national level, Sudanese industry is governed by the Environmental Framework Act of 2001. In some cases, it is also regulated by the need to obtain and renew operating licences issued by state governments. While there is no specific national-level statute addressing the environmental impacts of industry, individual operating permits may have provisions regarding air emissions or effluents.

The most direct form of environmental governance observed by UNEP during the assessment was at the state level, where local complaints of large-scale air and water pollution had led to action by the State Governor and a form of state-level environmental council. In two cases reviewed (a cement factory and a tannery), the action was successful: the cement factory was upgraded and the tannery was shut down (see Case Study 7.3). In one other case, the facility (a lubricant plant) was resisting control.



Settlement pond under construction at the Kenana Sugar Company, located near Kosti, which has recently invested heavily in the construction of water treatment facilities



The Atbara cement factory is now privately owned

The newly installed bag house filter treats emissions from the main furnace

CS 7.3 Upgrade of the Atbara cement factory

The Atbara cement factory in Northern state is a positive example of the potential benefits of local governance and foreign investment in improving environmental performance.

The factory is one of only two major cement production facilities in Sudan. It was established in 1947 as a private sector shareholder company and began production in 1949, with second-hand equipment. It was nationalized in 1970, before being privatized and purchased by a foreign company in 1994. One of the conditions for privatization was that the existing plant emissions be significantly reduced. An eighteen-month window was given for the installation of the necessary equipment.

When this had not occurred by the deadline, the Governor of Nile state closed the plant by decree. Within three months, the company had completed installation of a filtration system and the plant was permitted to re-open. Emissions are now reported to be significantly lower and the plant is undergoing a number of other improvements.

Oil industry

The oil industry in Sudan is managed by the Ministry of Energy and Mining, and governed by directives from the highest levels of the Government of National Unity (GONU). Oil industry staff report that, in terms of environmental performance, companies are regulated by clauses of the 1998 Petroleum Wealth Act.

The White Nile Petroleum Company is an exception, as it is not controlled by GONU. Rather, the Government of Southern Sudan (GOSS) is a minor shareholder in the venture, and the company's government counterpart is the

GOSS Ministry of Industry and Mining. However, UNEP's assessment of the company's operations and the Ministry's capacity has made clear that the company is effectively self-regulated.

In theory, the Environmental Framework Act of 2001 applies to the oil industry, but discussions with the GONU Ministry of Environment and Physical Development revealed that MEPD personnel could generally not gain access to oil industry sites and had never applied any form of sanction for violation of any legislation.

In addition, UNEP enquiries did not uncover any form of publicly available environmental or social

impact assessment for the oil industry, although interviews with industry personnel indicated that some environment-related studies had been conducted. One management document, the (now obsolete) Marine Oil Spill Response Plan, was publicly available [7.16].

Project development and environmental impact assessments

As detailed above, environmental impact assessment (EIA) processes exist on paper in Sudan but are not followed in practice. The Environmental Framework Act of 2001 includes a basic EIA and approval process, which is not applied effectively to the majority of projects, and not applied at all to upstream oil projects.

7.7 Conclusions and recommendations

Conclusion

Environmental governance in the industrial sector of Sudan is problematic and in need of major improvement and reform. Due to the relatively limited level of industrial development to date, environmental damage has so far been moderate, but the situation is expected to worsen rapidly as Sudan embarks on an oil-financed development boom.

The main problems include:

- absence of sector-specific legislation and statutory guidance;



Oil well drilling pits such as these at Heglig are normally remediated after use. At present, however, there is no oversight of the oil industry's performance or detailed environmental standards for such work

- lack of performance standards and enforcement capacity; and
- immunity of the oil industry, state-owned firms and major new projects to public scrutiny.

The upstream oil industry and water pollution from industrial sites are sources of particular concern. There are, however, some positive examples of governance at the state level for individual facilities.

Background to the recommendations

Two key issues strongly influence the recommendations for Sudan's industrial sector. First, unlike many other sectors of the economy, industry generally has the capacity to invest its own funds in improving environmental performance, and site-specific solutions are usually straightforward. If required, capacity-building can also be purchased in the commercial market. For GONU and GOSS, industrial environmental performance is considered first and foremost to be a governance issue.

Second, the environmental impact of the oil industry in central and Southern Sudan clearly has the potential to catalyse conflict between the industry and local interests. Accordingly, resolving this issue is considered to be of the highest priority.

Recommendations for the Government of National Unity

R7.1 UNEP or another fully independent body should undertake an environmental assessment of the upstream oil industry. The scope of this assessment should encompass the impacts of past exploration, current operational practices and proposed exploration. The agreed final results should be made public, so as to eliminate the atmosphere of suspicion caused by the current information vacuum.

CA: AS; PB: MOEM; UNP: UNEP; CE: 0.4M; DU: 6 months

R7.2 Develop a national oil industry environment act with accompanying statutory guidelines and standards. This would be a major venture requiring a cooperative approach with the oil industry and GOSS. Due to the complexity, and political and

financial implications of this recommendation, the highest levels of political will and cooperation as well as international assistance are required. The cost estimate is for legislation development. The cost of legislation implementation is expected to be tens of millions of US dollars over five years to be adopted by industry into existing projects and then implemented as standard.

CA: GROL; PB: MOEM; UNP: UNEP; CE: 0.5M; DU: 2 years

R7.3 Develop a national-level, independent environmental enforcement unit for the industrial sector, including the oil industry. This would entail greatly strengthening the capacity of the Ministry of Environment and Physical Development (or a similar body) to enable it to review EIAs, issue environmental permits, conduct inspections, support prosecutions and carry out similar governance tasks.

CA: GROL; PB: MEPD; UNP: UNEP; CE: 2M; DU: per annum

Recommendations for the Government of Southern Sudan

R7.4 Establish an interim environmental screening and industrial permitting process for all new projects on GOSS territory. This would be designed to cover the urgent requirements for project assessment before adequate longer-term controls can be established. A multi-ministry committee could be appointed to review all significant project proposals and issue construction and interim operating permits (up to five years).

CA: GROL; PB: MEWCT; UNP: UNEP; CE: 0.3M; DU: 2 years

R7.5 Monitor GONU progress on R7.2 and R7.3; if not implemented within one year, commence a regional governance programme similar to that described above. Development of the oil and general industry sector will go ahead in Southern Sudan, and governance is definitely and urgently needed. A uniform approach at the national level is the preferred approach, and GOSS should lobby for this.

CA: GROL; PB: MIM; UNP: UNEP; CE: 0.7M; DU: 2 years



It is completely feasible to reduce the environmental impact of oil exploration and production to acceptable levels in all but the most ecologically sensitive areas. That, however, requires both commitment and substantial investment

Agriculture and the Environment

In this view of the Jebel Berkel archeological site in Northern state, a thin irrigated strip of date palms bordering the Nile is visible in the background. The Nile has supported agriculture in the Sahara desert for over 5,000 years, but upstream dam construction is threatening the existence of this ancient and previously sustainable form of cultivation.



Agriculture and the environment

8.1 Introduction and assessment activities

Introduction

Agriculture, which is the largest economic sector in Sudan, is at the heart of some of the country's most serious environmental problems: land degradation in its various forms, riverbank erosion, invasive species, pesticide mismanagement, water pollution, and canal sedimentation.

The significance of land degradation in Sudan cannot be underestimated: not only are 15 percent of the population partly or wholly dependent on imported food aid, but the population is growing by more than 2.6 percent per annum and per hectare crop yields are declining. In addition,

conflict linked to competition over scarce agricultural resources continues in Darfur.

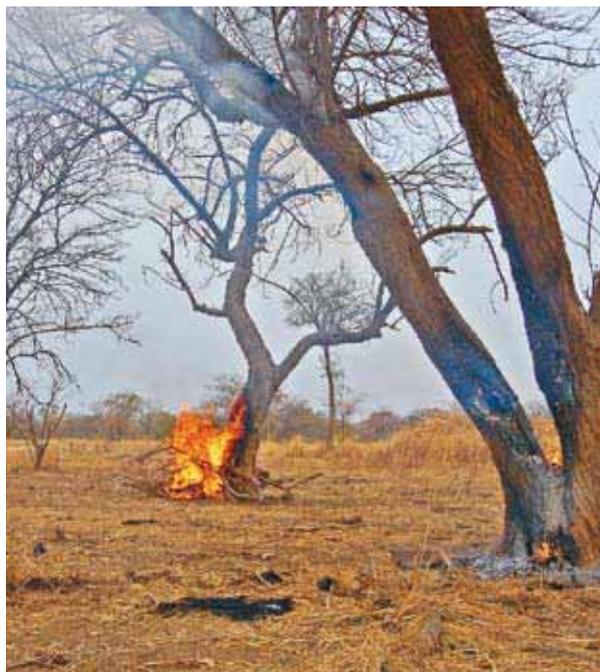
Without major action to stop the wave of degradation and restore land productivity, the natural resource base will simply continue to shrink, even as demand grows. Resolving this issue is thus central to achieving lasting peace and food security.

Assessment activities

UNEP first conducted a thorough desk study based on a large body of national and local knowledge on the subject of agriculture in Sudan. In the field assessment phase, UNEP teams were able to cover all principle farming systems and regions in the country. Agricultural sites were visited in twenty-one states (excluding Unity, Warrab, Eastern Equatoria and Upper Nile) and particular attention was paid to thirteen of these: Blue Nile, Gedaref, El Gezira, Jonglei, Kassala, Khartoum, Northern Kordofan, Nile, Northern, Red Sea, Sennar, Southern Kordofan, and White Nile.



Early morning at a Dinka cattle camp, Jonglei state



Large areas of woodland are being cleared for crop-planting by the returning population in Southern Kordofan

In addition to these core team efforts, UNEP – in cooperation with the Food and Agriculture Organization of the United Nations (FAO) – commissioned the World Agroforestry Institute (ICRAF) to lead a consortium of local NGOs and institutes in a detailed study of rural land use changes and degradation in fourteen locations across Sudan. The ICRAF team first performed remote sensing analyses – each covering approximately 2,500 km² – of the fourteen target areas. Field teams then visited nine of these sites to conduct ground truthing.

8.2 Overview of agriculture in Sudan

The largest economic sector in Sudan

Estimates of Sudan's cultivable area range from 84 to 105 million hectares, or 34 to 42 percent of the country. Of this cultivable area, between 12.6 and 16.65 million hectares or 15-16 percent (1980-2002 data) are actually farmed in a given year, depending largely on rainfall levels [8.1, 8.2, 8.3]. Hence the frequent claim that Sudan is the potential 'breadbasket' of Africa and the Middle East.

The FAO country report for 2004 indicates that the agricultural sector is the main source of sustained growth and the backbone of Sudan's economy in terms of contribution to the gross domestic product (GDP). Although the sector's economic stake is declining with the emergence of the oil industry, Sudan continues to depend heavily on agriculture, whose share currently fluctuates around 40 percent of the GDP [8.1]. The value of the crop and livestock sub-sectors, which together contribute 80 to 90 percent of non-oil export earnings, is almost equal at 47 and 46 percent respectively [8.4].

Five main types of farming are practised in Sudan, and each has a specific set of environmental impacts:

- mechanized rain-fed agricultural schemes;
- traditional rain-fed agriculture;
- mechanized irrigation schemes;
- traditional irrigation; and
- livestock husbandry/pastoralism.

Fifty-eight percent of the active workforce is employed in agriculture, while 83 percent of the population depends on farming for its livelihood: 70 percent depends on traditional rain-fed farming, 12 percent on irrigated agriculture and only 0.7 percent on mechanized agriculture [8.4]. Sorghum, millet and maize are the main food crops. Other important produce for the domestic market includes sugarcane, dates, wheat, sunflower, pulses and forage. The principle export crops are cotton, gum arabic, sesame, groundnuts, fruits and vegetables.

Commercial agricultural activities are mostly concentrated in a belt at the centre of the country, which extends approximately 1,100 km from east to west between latitudes 10° and 14° north, in the semi-arid dry savannah zone. Small-scale subsistence agriculture is found throughout Sudan, and is dominant in Southern Sudan and Darfur. On average, traditional and mechanized agriculture account for 55 and 45 percent respectively of the rain-fed cultivated area [8.3, 8.4]. Due to the vagaries of rainfall, however, and to the fact that significant swathes of mechanized agriculture have been abandoned because of land degradation, economic collapse and conflict, these estimates are only indicative.

Figure 8.1 Major agricultural schemes



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

Irrigated Agricultural Schemes

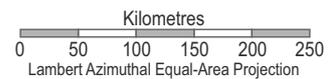
1. Gezira and Managil	870'750 ha	7. Guneid Sugar	15'795 ha
2. New Halfa	152'280 ha	8. Assalaya Sugar	14'175 ha
3. Rahad	121'500 ha	9. Sennar Sugar	12'960 ha
4. Gash Delta	101'250 ha	10. Khashm El-Girba	18'225 ha
5. Suki	35'235 ha	11. Kenana Sugar	45'000 ha
6. Tokar Delta	30'780 ha		

Mechanized Agricultural Schemes

(planned and unplanned)

1. Habila	7. Gedaref
2. El-Dali	8. Southern Kordofan
3. El-Mazmum	9. White Nile
4. El-Raheed	10. Upper Nile
5. El-Sharkia	11. Blue Nile
6. Dinder	

Agricultural schemes boundaries are approximate.



Sources:
SIM (Sudan Interagency Mapping); FAO; vmaplv0, gns, NIMA;
The Gateway to Astronaut Photography of Earth, NASA;
various reports, maps and atlases; UN Cartographic Section.



UNEP/DEWA/GRID-Europe 2006

The largest irrigated area in sub-Saharan Africa

Sudan boasts the largest irrigated area in sub-Saharan Africa and ranks second only to Egypt on the continent. Given that only two-thirds of the estimated potentially irrigable area of 2.8 million hectares are utilized and that this figure does not include Southern Sudan's virtually unused vast potential, there is significant opportunity for further expansion.

Irrigated agriculture in Sudan falls into two broad categories: traditional irrigation and modern schemes. Approximately 90 percent of the irrigated area is managed under the latter [8.1, 8.2]. Sorghum is the main cultivated crop, followed by cotton, fodder, wheat, vegetables, groundnuts and sugarcane.

The importance of the irrigated sub-sector is reflected in the fact that while it makes up only 7 percent of the cultivated area, it accounts for more than half of the crop yields. Although large-scale irrigation schemes have been Sudan's leading economic investment in the past century, various studies indicate that their performance has been considerably below potential. Of the 1.9 million hectares prepared for irrigation, only half was actually cultivated in 2005, owing largely to dilapidated irrigation and drainage infrastructure [8.1]. Environmental factors such as canal sedimentation have also contributed to low irrigation returns.

A livestock herd of over 130 million

Estimates of grazing land vary between 97 and 117 million hectares, or 39 and 47 percent of the country. Rangeland is found in almost all of Sudan's ecological zones, with the exception of montane and real desert areas. As is the case with arable land, however, an overwhelming proportion (80 percent) is found in semi-desert and low rainfall savannah zones characterized by unpredictable rainfall and frequent droughts [8.1, 8.5]. The rangeland's vulnerability to overgrazing is thus high, and its overlap with cultivation is a major source of potential conflict.

The livestock population consists mainly of camels, sheep and goats in the desert and semi-desert areas, and of cattle in the low to high rainfall savannah and Upper Nile floodplains. The estimated 134 million livestock in Sudan are almost entirely reared under nomadic and semi-pastoral systems [8.5].

8.3 Cross-cutting environmental issues and impacts

A broad array of issues and impacts were observed in the course of the assessment. The majority related to one or two of the agricultural sub-sectors only, but four cross-cutting issues were noted:

- population pressure, conflict and displacement linkages;
- climate and climate change;
- desertification and land degradation; and
- invasive species, namely the mesquite tree in northern and eastern Sudan.

Population pressure, conflict and displacement linkages

As discussed in Chapters 4 and 5, the issues of conflict and displacement, environmental degradation and Sudan's rising population are considered to be intrinsically linked. The situation in many of the drier parts of rural Sudan today can only be described as an intense and unremitting competition amongst an impoverished population for scarce and diminishing natural resources. Episodic events such as droughts, conflicts and waves of displacement are important, but considered to be part of a larger trend of rural landscapes stretched beyond their limit and declining in long-term capacity as a result.

Climate and climate change

This issue is addressed in detail in Chapter 3. In sum, the agricultural sector in Sudan is highly vulnerable to shortages in rainfall. There has been a substantial decline in precipitation in the dryland parts of the country, and global warming models predict that this trend will continue.

Desertification and other forms of land degradation

Land degradation is a critical issue throughout the country, including in areas with the highest rainfall. Its various forms are deforestation, devegetation and species changes, loss of soil fertility and seed bank, and the physical loss of soil through erosion. In the drier regions, degradation is usually referred to as desertification. In Sudan, its principal causes are crop cultivation, overgrazing, cutting trees for firewood and charcoal, and climate change.

Invasive species: the mesquite tree in northern and eastern Sudan

The invasive tree species known as mesquite (*Prosopis juliflora*) has taken over large areas of land in both pastoral regions and irrigation schemes. While it is a particular problem for spate irrigation schemes, it has proven highly useful for dune stabilization in other areas (see Case Study 8.1). Because of its negative impacts, the government of Sudan passed a law in 1995 to eradicate the tree. This has proven very difficult, however, as the species has very deep-seated root systems and can regenerate even if cut down below ground level.

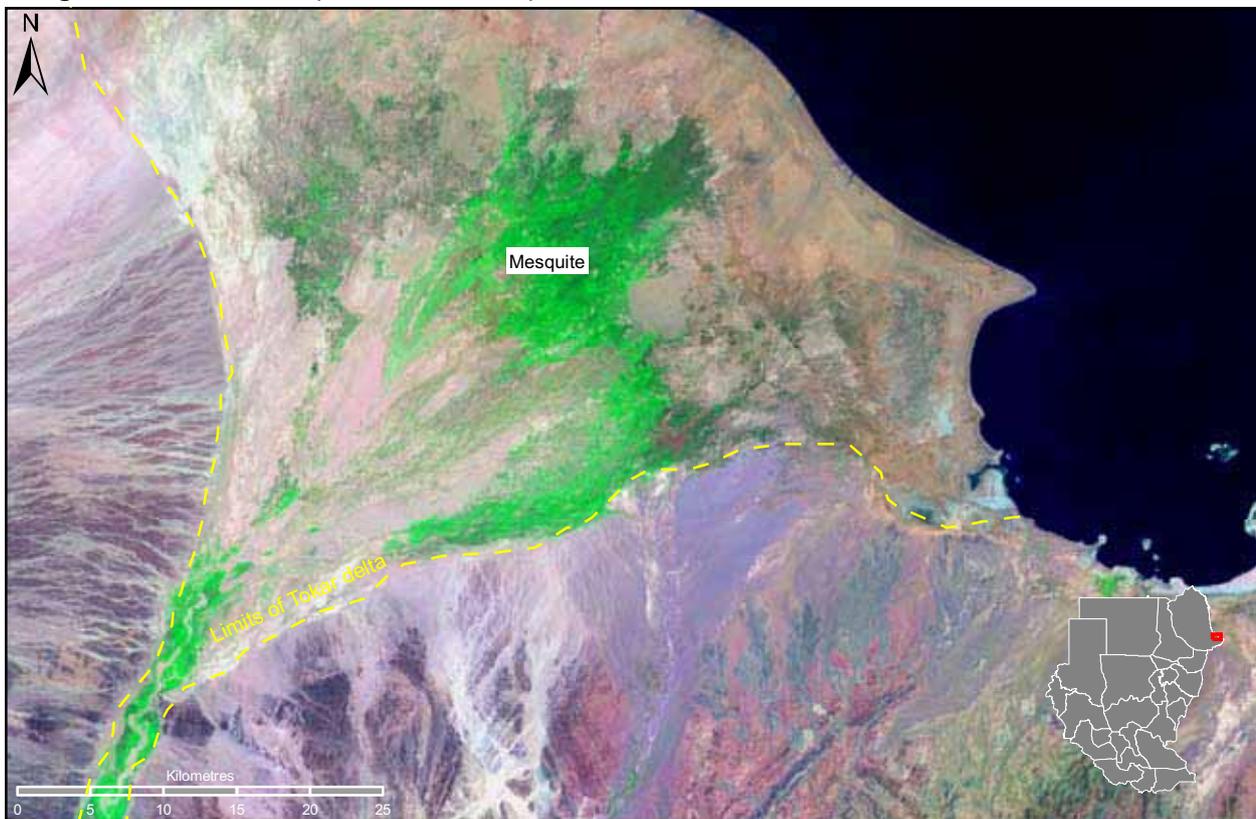
Mesquite is currently still spreading, and complete eradication of the tree in Sudan is considered by UNEP and others in the forestry and environmental management field to be physically impossible, economically unviable and more importantly, not warranted. The recommended alternative is control, with elimination in high-value irrigated land only. Because mesquite seed pods are distributed in the droppings of animals, any control measure

will need to address the issue of the uncontrolled communal grazing of existing tree stands.

At the same time, efforts need to be made to maximize the benefits of mesquite. If managed from seedlings, mesquite can grow in a manner that allows it to be used for shade, fruit, fuelwood and construction timber. Given the dire deforestation situation in northern and central Sudan, the opportunity of this renewable resource should not be underestimated.

Though there are potentially viable native alternatives to mesquite, their use in new dune stabilization projects has been limited to date. It is therefore recommended that greater investment be made in researching the potential of native plants and trees, and capitalizing on indigenous knowledge in environmental rehabilitation and desertification control. Some of the promising native plant species include *Tamarix aphylla* (Tarfa), *Leptadenia pyrotechnica* (Markh), *Salvadora persica* (Arak), *Imperata cylindrica* (Halfa) and *Capparis decidua* (Tundub).

Figure 8.2 The spread of mesquite in the Tokar delta



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



Clearing mesquite in the Tokar delta, Red Sea state

A mesquite thicket in Red Sea state

CS 8.1 Positive and negative aspects of mesquite

The mesquite tree (*Prosopis juliflora*) is the most important invasive species in Sudan. It is a fast growing and highly drought-resistant small tree that is spread by the distribution of its seed pods in the droppings of grazing animals. The tree is characterized by a high density of long, sharp and hard thorns, and very tangled dense growth. Mesquite out-competes a range of native species in arid areas. Where conditions are most suitable, it can become the dominant form of vegetation, forming monoculture thickets and forests.

Mesquite was reportedly first brought to Sudan from Egypt and South Africa in 1917 by a British government botanist. It was then deliberately introduced on a large scale into northern and eastern parts of Sudan in the 1970s and 1980s, for the purposes of dune stabilization. It has since spread in an uncontrolled manner.

The species has proven to be well suited for dune stabilization, but overall problematic for Sudan. For pastoralist societies, its principle disadvantage is that its foliage is essentially inedible by all herd animals, so that it provides negligible fodder compared to the native species it replaces. For farmers, mesquite is a major menace in the wetter *wadi* regions most prized for crop-raising, where it crowds out native and edible plants, blocks drains and irrigation canals and forms dense impenetrable thickets. These same features, however, make mesquite trees ideal for use as dune stabilizers and windbreakers. Besides, the plant also yields fruit, timber for construction, and fuelwood.

The contrasting views on mesquite are best illustrated in two case study locations: the Tokar delta and the Gandato irrigation scheme. The Tokar delta in Red Sea state is a water-rich and fertile oasis in an otherwise very arid and barren coastal desert environment. Water and sediment from the neighbouring mountains converge onto the delta and replenish it on an annual basis, providing perfect conditions for high-yield agriculture without irrigation. The area was used for cereal production for centuries, before being developed as a major cotton production centre during the 20th century.

In 1993, the border conflict between Sudan and Eritrea engulfed the delta region, forcing the local population off the land, which then lay effectively untouched until early 2005. Within this twelve-year period, the approximately 50,000 hectares were completely covered by a dense thicket of mesquite. Early efforts at hand clearance proved ineffective, but a major mechanical clearance project (funded by the European Commission) commenced in 2004. By February 2006, approximately 3,000 hectares had been cleared and converted back to agriculture. While this type of mechanical clearance may be economically viable for recovering high-value agricultural land, it is unlikely to be viable for low-value pastoral land, where other solutions such as land abandonment or reduction in grazing intensity may be required.

In the Gandato irrigation scheme, in White Nile state, traditional farmers have used mesquite to stabilize dunes which would otherwise overrun prime farming land. Thanks to its bushy habitus with branches down to the ground, *Prosopis* is one of the best tree species to use in shelterbelts against sand and wind encroachment. Shelterbelts or buffer zones of mesquite trees can reduce the speed of wind to half of what it is in bare landscapes, and trap the sand carried by the wind so that villages and cultivated fields inside the shelterbelt are almost entirely protected. Physical protection against sand invasion is a highly important positive environmental service provided by *Prosopis*.

Given the impossibility of eradication and the continuing need for dune stabilization, the recommended strategy for mesquite is a combination of control and better utilization in areas where it is already established, and replacement by native species as a preferred option for new stabilization projects.

8.4 Mechanized rain-fed agriculture sector impacts and issues

A history of rapid and uncontrolled development

Generally speaking, the development of mechanized agriculture in Sudan has been accompanied by large-scale destruction of the environment. Not only does the sector have major environmental problems of its own, but its uncontrolled expansion and replacement of other forms of agriculture have triggered a wide range of negative impacts in other sectors as well.

The core of the issues related to mechanized agriculture can be found in the lack of control and planning that accompanied the rapid development of the sector during the last half of the 20th century. The mechanization of rain-fed agriculture was initiated by the British in Gedaref in 1944 to meet the food needs of their army in East Africa. Following independence in 1956, the government adopted a policy to expand

mechanized farming and encouraged the private sector to invest in new schemes [8.2].

Today, mechanized agriculture occupies a swathe of the clay plains in the high rainfall savannah belt estimated to be 6.5 million hectares, extending from the Butana plains in the east to Southern Kordofan in central Sudan. This area covers parts of the states of Gedaref, Kassala, Blue Nile, Sennar, White Nile, Upper Nile and Southern Kordofan. The principle crops cultivated are sorghum, sesame, groundnuts and, to a lesser extent, cotton and sunflower. UNEP visited three mechanized farming areas: Habila in Southern Kordofan; Dali-Mazmum in Sennar state; and the region bordering Dinder National Park in Gedaref.

Original plans called for the government to set aside large blocks of land (up to several hundred thousand hectares) and divide them into plots of 420 or 630 hectares. Half of the parcels were to be leased to private tenants, while the other half was left as grass fallow. After four years, farmers were to exchange the formerly leased land with adjacent fallow plots to allow the soil to recover [8.2].



A typical mechanized agriculture landscape in Dali, Sennar state, with Mount Moya providing some relief to an otherwise flat topography



Although authorities require that at least ten percent of all new mechanized agricultural schemes be protected by shelter belts, implementation is irregular and problematic

This model, however, has almost never been followed in practice. As demand outstripped the capacity of government to demarcate land, not only were fallow periods increasingly not observed, but private farmers illegally seized large areas outside the designated blocks. In Gedaref, for example, almost 66 percent of the 2.6 million hectares under mechanized agriculture in 1997 were unauthorized holdings, referred to as non-planned schemes [8.6]. In the Habila region, some 45 percent of mechanized farms in 1985 were unsanctioned [8.7]. In Sennar state, officials from the State Ministry of Agriculture confirmed that mechanized schemes were introduced in the 1950s with virtually no planning, and that pastoral routes were adversely affected as a result. The Ministry's reports reveal that 60 percent of Sennar's two million hectares under rain-fed agriculture are occupied by non-authorized mechanized schemes, while 30 percent are under planned mechanization and 10 percent under traditional agriculture. These changes in land use continue to lead to violent clashes between farmers and nomads, as in Dali and Mazmum.

Mechanized farming in Sudan has in effect degenerated into a crude form of extensive shifting cultivation with a tractor, exploiting land to

exhaustion. The resultant suite of environmental, social and economic consequences, which has been highly damaging, includes the destruction of forests and pre-existing agricultural and social systems, soil erosion and increased flash floods, soil depletion and a collapse in yields.

To counter this accelerating environmental degradation, the federal Ministry of Agriculture and Forestry has required of new leases since the mid-1990s that 10 percent of the proposed scheme area be allocated to shelterbelts. UNEP observed, however, that this requirement was by and large ignored; a fact that was also widely corroborated in discussions with the responsible authorities. Reasons for this failure include limited outreach to farmers and lack of incentive, as shelterbelts are the property of the forest authorities. Moreover, farmers' interest in planting *A. senegal* shelterbelts fluctuate with gum market prices.

Even if it were implemented, the 10 percent quota would be insufficient. In addition to shelterbelts, which should be implemented at more frequent intervals (i.e. every 250 m rather than the current 500 m), forest reserves equivalent to no less than 25 percent of the farmed area should be created within and around the overall scheme. This would contribute to enhancing soil fertility and mitigating the impacts of flash floods.

These problems have been well documented by national and international researchers, but no significant or proactive corrective measures have been introduced to date. In contrast, the GONU Ministry of Agriculture and Forestry's 2006 plans (the 2006 'Green Programme') call for further investment in the large-scale expansion of mechanized agriculture.

Destruction of forests and pre-existing agricultural and social systems

Land taken by mechanized schemes was generally not vacant. Instead it supported either pastoralism, traditional shifting rain-fed agriculture or wild habitats, principally open woodlands and treed plains. This was all appropriated without compensation and is now permanently lost. Important wildlife habitats and sources of wood products have vanished, and mechanized farming is now even encroaching

on legally protected areas like Dinder National Park. The clearing has been so disorderly that forest authorities believe that in some cases the real intent was charcoal and firewood production rather than agriculture. Forest officials in Southern Kordofan reported that they had at times been obliged to issue permits for forest clearance even where trees covered more than 50 percent of the land.

Soil depletion, yield collapse, desertification and abandonment

Mechanized agriculture schemes have traditionally used neither fertilizers, nor organized crop rotation or fallow systems. The inevitable and well documented result has been a collapse in per hectare yields. In Gedaref state, for example, sorghum and sesame yields in 2002 had reportedly dropped by about 70 and 64 percent respectively from 1980 levels in established areas [8.8]. Given the region's wide climatic variations and patchy agricultural data, more detailed analysis is required, but a general trend of diminishing harvests is evident. As a direct result of this decline, sponsors of mechanized schemes have been forced to expand the total area under cultivation just to maintain output.

The final stage of mechanized agriculture as it is practised in Sudan is the abandonment of land due to yields dropping below economic limits. The total area abandoned to date is unknown, but estimated by GONU Ministry of Agriculture and Forestry officials to be in the order of millions of hectares. Abandoned land is generally found in the northern part of the mechanized scheme belt. Desertification is clearly apparent in such regions, particularly in Khartoum state, Kassala and Northern Kordofan. In a country with massive food insecurity and ongoing conflicts over land, such waste of natural resources is tragic and raises the spectre of the intensification of existing problems.

A new and serious development with both environmental and conflict-related implications is that there is now little available land left for expansion of the schemes in northern and central states. Major new schemes can only be developed in two areas, with serious environmental, social and political consequences in either case:



The tractor has enabled a massive expansion of mechanized agriculture, fundamentally altering the landscape of central Sudan, as here in Gedaref state

- Southern Darfur and southern parts of Northern Darfur, on the sandy *goz* soils, which are well recognized as very fragile, thin and prone to wind and water erosion; and
- territory within the Three Areas and ten states of Southern Sudan, which may be more suitable for agriculture but are currently occupied (mainly by pastoralists) and extremely sensitive politically and socially. The introduction of such schemes into Southern Kordofan and Blue Nile state was a catalyst for conflict in the past and would in all likelihood be in this case as well.

Given this track record of problems and the ongoing loss of fertile land, GONU plans for further expansion of the sector are a source of deep concern.

8.5 Traditional rain-fed agriculture sector impacts and issues

Population pressure and lack of development

The principle problem facing the traditional rain-fed sector is population pressure driving unsustainable rates of exploitation. This is also a main cause of deforestation in Sudan (see Chapter 9). This issue is actually a missed opportunity as well as a symptom of under-development: in the bid for immediate food security, traditional farmers are burning and clearing forests that would have a much higher return as agroforestry plantations than as short-term crops. In Southern Sudan, high-value timber trees are being burnt simply to clear land for a few years of low-intensity maize production.

The core of food security for Sudan

A majority of Sudanese farmers (70 percent) rely on rain-fed farming for their sustenance. This is generally a low input/low yield production system characterized by small farms ranging from two to thirty hectares in size and relying on labour-intensive cultivation with hand tools. Available estimates (virtually all from northern and central Sudan) show that the traditional rain-fed sector contributes the entire production of millet, 11

percent of sorghum, 48 percent of groundnuts and 28 percent of sesame in the country [8.1]. Despite its importance, this sub-sector has suffered from low social and economic investment, resulting in negligible technical development. Given the heavy dependence on food crops produced by traditional rain-fed agriculture, however, its critical role in upholding food security cannot be overemphasized.

Unsustainable land clearing and crop-raising observed in all areas

Across Sudan, UNEP noted a general trend of intensification of traditional rain-fed agriculture and associated land degradation. In the drier areas, repeated monoculture without crop rotation and adequate fallow periods has led to a decline in soil fertility. This has, in turn, increased run-off and topsoil erosion, further degrading the soil and inhibiting re-establishment of non-pioneer vegetation and potential restoration of wildlife habitats.

In the very dry regions of Northern Kordofan and Darfur, farmers have long relied on a relatively sophisticated system of rotation and inter-cropping, producing both cereal crops and gum arabic from *Acacia senegal* trees. This system is now breaking down due to pressures from drought, desertification, population increase and mechanized agriculture (see Case Study 8.2).



Farmers outside of Mornei, Western Darfur. Traditional rain-fed agriculture is very labour-intensive



A gum arabic farmer from the Jawama'a tribe in El Darota in the heartland of Northern Kordofan's gum belt

*This badly degraded land near El Azaza maya, now dominated by *Calotropis procera*, used to be vegetated by *Acacia senegal**

A freshly exuded 'gum tear'. Sudan is the world's largest exporter of gum arabic, though its stake is reportedly declining

CS 8.2 Gum arabic production: an age-old system under extreme pressure

Acacia senegal (hashab) – the tree that produces gum arabic – grows naturally in the low rainfall savannah zone, an area extending from eastern Darfur to the Blue Nile and covering one fifth of the country. A 1989 survey estimated the number of mature *A. senegal* trees to be 400 million, approximately one tenth of which was found in gum gardens [8.9].

A. senegal has effectively been 'domesticated' through the development of an indigenous bush-fallow system, whereby agricultural cropping and forest regeneration are practiced in sequence. With the completion of the forest rotation (the bush period), the land is cleared for crop farming. At the same time, important trees such as *Balanites aegyptiaca* (heglig) are left intact. Fertilized by the nitrogen-fixing acacia, yields are typically high and cultivation can continue for five to seven years before the land is forsaken for another bush rotation.

Traditionally, farmers would organize their land into five blocks under a system managed on a twenty-five year rotation. This was successful as long as the farm functioned as a single unit. With the growing population and fragmentation of holdings, however, farmers can no longer afford the space to pursue twenty-five year gum garden rotations. In many cases, rotations have been shortened to only ten or twelve years, which is far too short to restore soil fertility [8.6]. Moreover, the *goz* sands (arenosols) on which *A. senegal* flourishes are highly susceptible to wind and water erosion. As a result, extensive land degradation, particularly along the belt's upper extent, has ensued.

In the sandy plains of Bara province, the removal of acacia trees has led to dune mobilization and sand encroachment on agricultural lands. The situation has been further exacerbated by recurrent droughts. The 1989 drought alone is reported to have killed up to half the gum trees – an event from which the gum belt has not yet fully recovered.

The general trend is of a southward decline of the gum belt: the Gum Arabic Research Station in El Obeid has reported that *A. senegal* is no longer found north of 13° 45' and that it is sparse north of 13°. This represents a contraction of 28 to 110 km compared to the Harrison and Jackson baseline of 1958. This decline also correlates with a southward shift of isohyets. These changes, however, are not fully substantiated and more detailed scientific evidence is needed to document fluxes in the gum belt. Similar problems have beset other traditional bush-fallow systems reliant on indigenous tree species, such as *Acacia seyal*, from which gum is also extracted.

Population increases and displacement are also forcing the size of individual plots down, with the average size falling to around four hectares in some northern states. This is too small a land base to practice bush-fallow shifting cultivation. As farmers become locked into shorter rotations, the pressure on the land increases, inhibiting the restoration of soil fertility.

Gum farmers are trying to cope with these pressures by switching from sequential rotation to simultaneous inter-cropping of *A. senegal* with food crops such as millet, sorghum, faba beans, sesame and groundnuts. The Gum Arabic Research Station is also promoting the adoption of such agroforestry practices, but limited resources to conduct research and a poor agricultural extension service are curtailing its efforts. In addition, the profitability of gum cultivation has been affected by changes in real producer prices, making it less attractive to farmers.

In the wetter regions of Sudan, the stress on the land is evidenced by the gradual replacement of *harig* (slash-and-burn) patterns of vegetation with large areas that remain permanently cleared of forest. The UNEP-ICRAF analysis and fieldwork indicated a similar pattern of deforestation and growth in rain-fed agriculture in Yambio, Yei, Wau, Aweil and Bor. In certain areas of Southern Sudan such as Yei and Yambio counties, population pressure has reduced the fallow period from an estimated average of twenty years to five years or less. Such short turnover periods are insufficient for forest regeneration or restoration of soil fertility (see Figure 8.3).

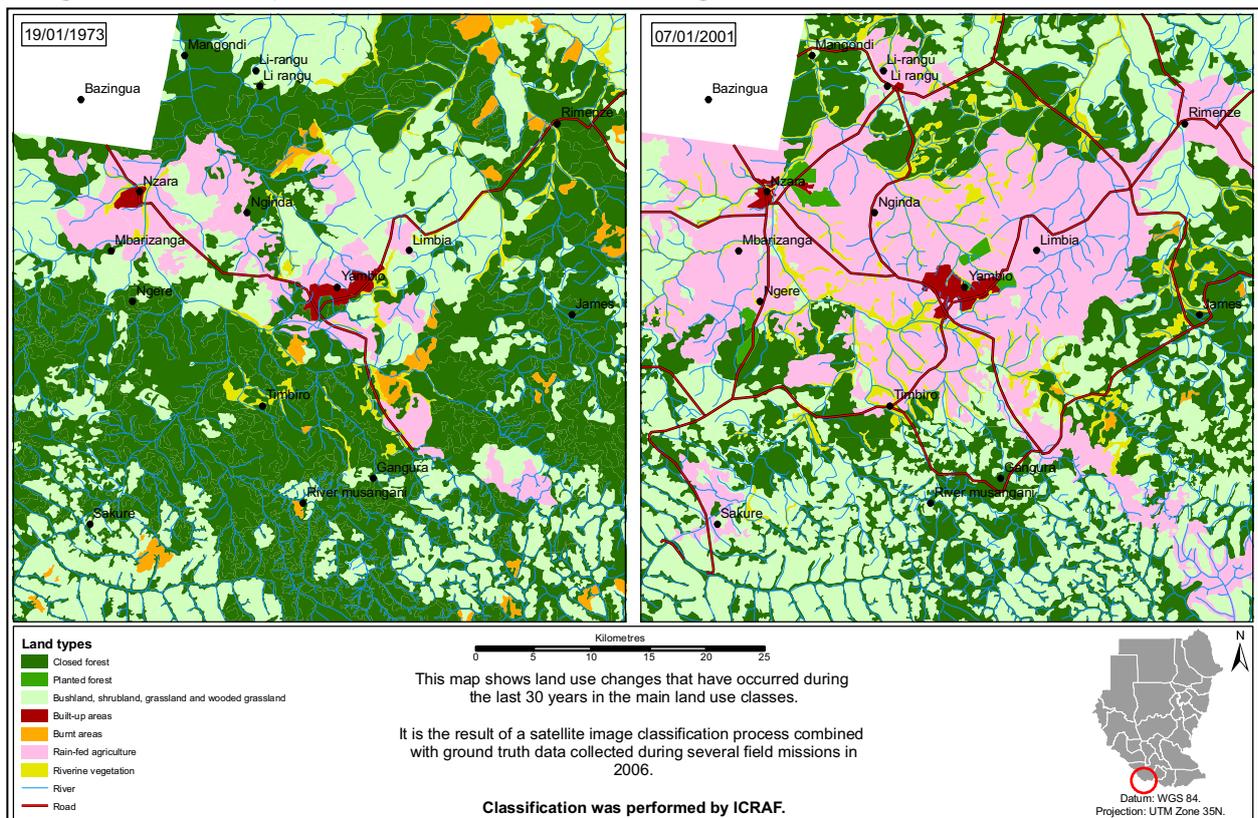
The Nuba mountains are in a comparable but more severe situation. During the conflict, Nuba people lost access to some of their best land and were constrained to continuously farm the same holdings, causing serious soil impoverishment. Peace has unfortunately not significantly improved the situation, as much of the land remains unavailable, having been taken over by mechanized agricultural schemes [8.10, 8.11].

Difficult choices facing the sector

Traditional rain-fed agriculture has been practised in Sudan for millennia and has proven to be stable and self-sustaining when population density is low. Demographic, political, and technical challenges are now upsetting this balance, and Sudan is experiencing a breakdown in long-held patterns and an unsustainable intensification of farming.

There are only two viable options available to reverse this trend and both are difficult. Firstly, the introduction of modern hybrid methods of sustenance agriculture, such as agroforestry, will benefit areas where it is not already practised (gum gardens are an example of agroforestry that existed well before the term was developed). Secondly, large-scale out-migration from rural areas could act to ease the pressure before major and permanent damage is done. Without these measures, large-scale out-migration will occur regardless, as a result of food insecurity.

Figure 8.3 Expansion of slash-and-burn agriculture in Yambio



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

Land class analysis of satellite images from Yambio district in Western Equatoria, Southern Sudan, illustrates the pace and scale of the expansion of slash-and-burn agriculture in the region. Between 1973 and 2006, cleared agricultural land increased from 6.8 percent of the study area to 27.7 percent, mainly at the expense of closed forest and wooded grasslands

8.6 Mechanized irrigation sector environmental impacts and issues

The mechanized irrigation sector is associated with a range of environmental issues, including:

- ongoing use of pesticides and a legacy of obsolete pesticide stocks;
- water pollution from sugar factories;
- potentially unsustainable expansion plans into desert regions; and
- canal siltation, soil salinization and yield reduction.

These issues are considered to be significant, but potentially more manageable than those related to mechanized rain-fed schemes.

The major irrigation schemes

The Gezira irrigation scheme (including its Managil extension) between the Blue and White Nile covers nearly half of Sudan's total irrigated area and is reportedly the largest contiguous irrigation scheme under single administration in the world. Alone, it consumes 35 percent of Sudan's share of Nile waters [8.12]. The other two

major schemes are the Rahad on the bank opposite Gezira, and the New Halfa on the Atbara river. The latter was until very recently severely affected by an infestation of mesquite, but the scheme administration reported that 60-70 percent had been cleared as of mid-2006.

In addition, there are five major sugar schemes of which four are government-run. The fifth and largest sugar plantation is the Kenana Sugar Company, which is an international public-private joint venture.

The few irrigation schemes in Southern Sudan (the Aweil rice scheme, and Mongalla and Melut sugar companies) ceased operations during the conflict, but there are plans to revive them as well as initiate new projects.

Ongoing pesticide management problems

The use, storage and disposal of pesticides are some of the most serious environmental issues related to the agricultural sector, which is by far the leading user of chemicals in Sudan. The application of pesticides in large-scale irrigation schemes and the treatment of obsolete pesticides are particular causes for concern.



The Gezira scheme main canal and the Managil extension are used by farmers for drinking water and fishing



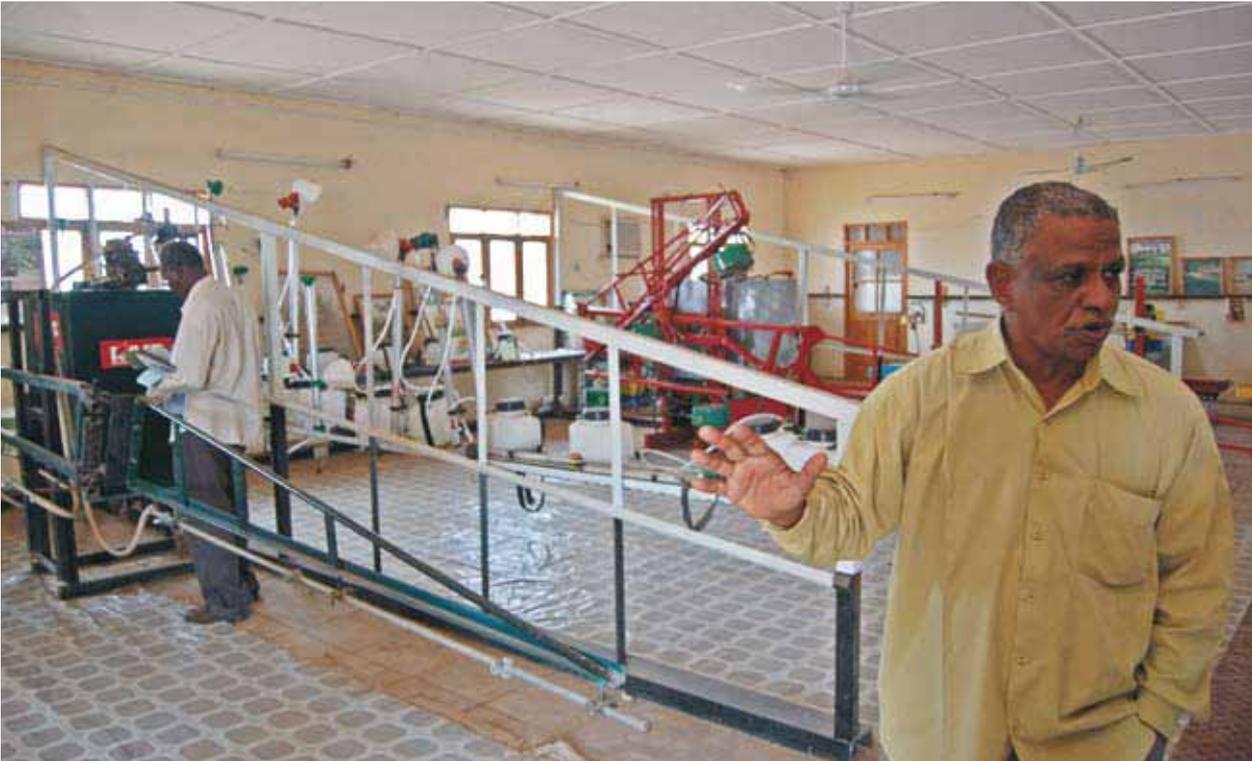
In addition to the lack of protective gear, derelict and leaky equipment exposes workers of the Crop Protection Department in El Kajara, Gedaref, to serious occupational health hazards

The bulk of pesticide application in irrigated schemes is carried out by aerial spraying under the command of the respective scheme administrations. The Gezira Board has reported that an estimated 125,000 to 205,000 hectares of cotton and 62,000 hectares of wheat fields are sprayed annually. Past studies have revealed widespread pollution of surface waters and irrigation canals due to extensive aerial spraying, and it is likely that this remains a problem today [8.13, 8.14].

Aerial spraying of pesticides is a particular issue in the Managil extension, where the irrigation supply canal is also the main source of drinking water. There is no pesticide monitoring programme or any regular surveillance system to analyse the environmental fate of pesticides in water, soil or food. Most studies date back to the early 1980s and there is a major information gap regarding the current situation. Previous analysis has shown that DDT and its derivatives were the most widespread contaminants. Moreover, residue testing on food products, such as goat milk in the



Over 250,000 ha of cultivated land are sprayed annually in the Gezira scheme



The head of the Technical Centre for Pesticide Spraying at the Kenana Sugar Company explains the use of modern application techniques and selective pesticides

Gezira region, has indicated that organochlorine pesticide levels including the POPs heptachlor, aldrin and dieldrin, as well as endosulfan and HCH significantly exceeded standards set by the FAO/WHO Codex Alimentarius [8.1, 8.13].

Most workers queried had not received training in pesticide handling and application, and lacked protective equipment or refused to use it due to its unsuitability in a tropical climate. Surveys conducted in 1989 showed that pesticide applicators were largely ignorant of the hazardous nature of the chemicals handled and did not observe safety measures [8.13]. The same was evident during UNEP visits. Moreover, protective gear examined was often of sub-standard quality, and replacements were reportedly not provided if damaged. Mixing and spraying equipment was derelict, corroded and often leaking. As a result, the risk of occupational exposure and soil and water contamination from spills was considered to be very high.

In Gezira, there has been a positive policy shift to reduce pesticide application by discontinuing routine calendar spraying and linking application to field checks of pest infestation levels. This has

reportedly resulted in a reduction of pesticide spraying on cotton from a previous average of nine to eleven times a year to an average of two to three times a year. Other positive measures include the application of selective rather than broad-spectrum pesticides that can harm beneficial insects and lead to pest resistance. To reduce contamination from spillage, greater use is intended of closed mixing/loading systems, as well as GPS technology to limit the risk of aerial spray drift into sensitive areas such as irrigation canals. Use of this advanced equipment, however, remains the exception and not the norm. The adoption of integrated pest management practices is reportedly intended, but has not been implemented in a systematic manner due to lack of resources.

Pesticide management appears to be considerably better in the sugar companies, particularly in Kenana, where there are well-defined procedures for the use of chemicals. The company's recent adoption of a corporate environmental strategy – one of the few of its kind in Sudan – should help reinforce responsible pesticide stewardship [8.15]. This could provide a model for other agricultural corporations.

Obsolete pesticide stockpiles: a major hazard

Sudan has very large stockpiles of obsolete pesticides that are stored in very hazardous conditions across the country.

A preliminary inventory by the Plant Protection Directorate (PPD) in the early 1990s estimated the expired stock at 760 tonnes and 548 m³ of contaminated soil [8.16]. A survey completed in 2006 under a GEF-POPs project found this stock to have increased to 1,200 tonnes of obsolete pesticides and 16,000 m³ of contaminated soil [8.17]. These figures do not include several hundred tonnes of expired dressed seeds and containers. Moreover, the survey only covered some of the provincial capitals in Darfur and Southern Sudan and is therefore incomplete for those regions.

UNEP visited four stores where large stocks of expired chemicals were kept, including Hasahesa and Barakat (Gezira scheme), El Fao (Rahad scheme) and the Gedaref PPD store. In addition, a visit to the Port Sudan commercial harbour revealed a large stock of expired pesticides and

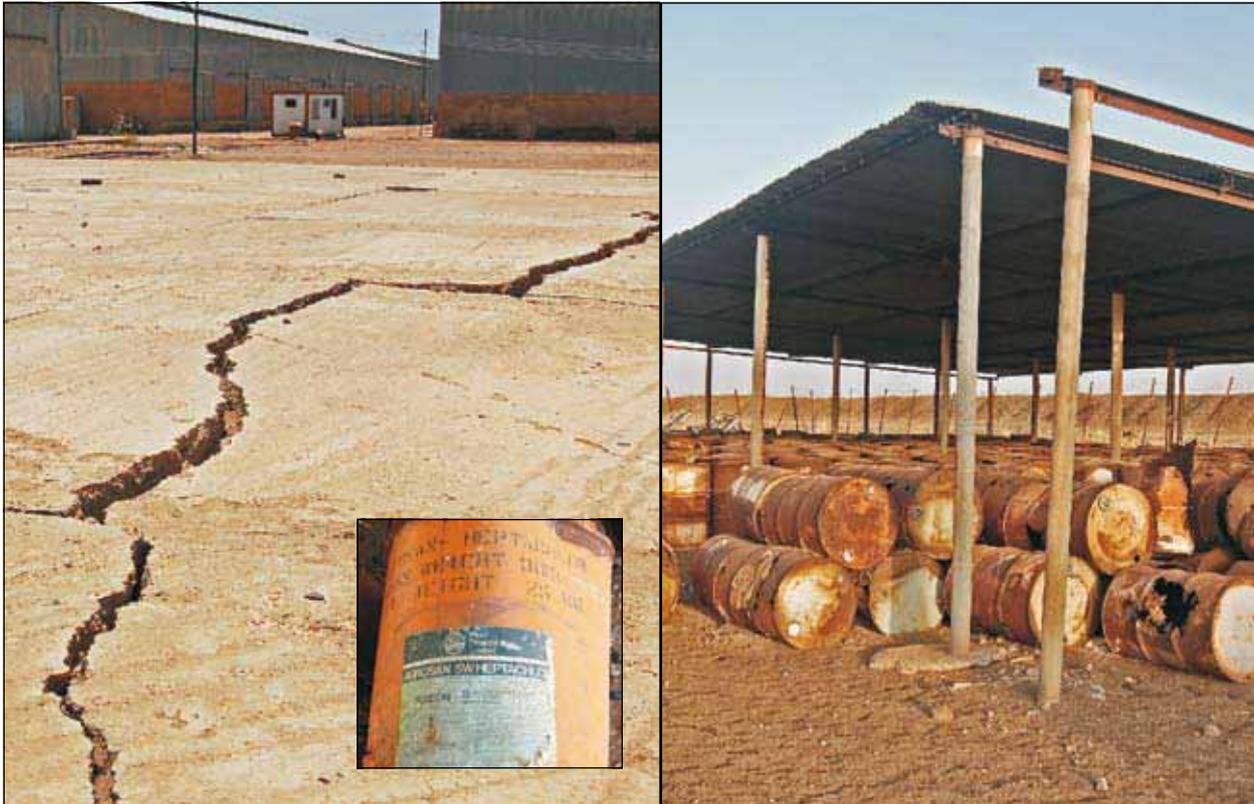
other chemicals. While storage conditions were overall very poor, three sites in close proximity to inhabitations (Hasahesa, El Fao and Gedaref) were considered dangerous toxic ‘hotspots’ (see Case Study 8.3).

Obsolete pesticides constitute a severe environmental and public health threat and must be treated as hazardous waste. Now that an inventory of the stockpile has been completed (except for Southern Sudan and Darfur), the first step should be to collect all the materials – with a special emphasis on persistent organic pollutants (POPs) and contaminated soil – for storage in one central location.

Elsewhere in the world, safe disposal or destruction by incineration of unwanted organic pesticides and highly contaminated soil costs in the order of USD 500 to 2,000 per tonne (not including any international transportation costs). UNEP estimates that the total cost of safely resolving the pesticide legacy problem in Sudan would exceed USD 50 million. Given this amount, a permanent solution is expected to take some time and interim measures to reduce the risks are clearly needed.



Corroding drums of obsolete pesticides are stored in unsuitable conditions at Port Sudan, 30 m from the water



This cement-lined pit in Hasahesa – where an obsolete pesticide stockpile has been buried – has cracked, releasing a strong stench and exposing groundwater to a high risk of contamination. Highly hazardous and persistent heptachlor was buried in Hasahesa (inset)

An estimated 110,000 litres of very hazardous endosulfan have leaked into the ground at the main Rahad Irrigation Scheme warehouse in El Fao

CS 8.3 Obsolete pesticide storage: three extremely hazardous sites

UNEP visited three expired pesticide storage sites in central Sudan that were considered to represent a significant risk to human health and the environment.

In Hasahesa – a controversial site commonly known as the ‘pesticide graveyard’ – a misguided decision was made in the mid-1990s to bury a large stockpile of pesticides in a cement-sealed pit in the ground. UNEP observed that the cement casing had cracked, releasing a strong stench and exposing the groundwater to a high risk of contamination. The site was unguarded and people and livestock were seen to be trespassing. Moreover, the powder contents of torn bags, cardboard boxes and empty drums littered the site, which was adjacent to a residential community.

In El Fao, obsolete pesticides were kept in an open shed with a dirt floor. The shed was clearly not designed for long-term storage. The drums were all damaged and had leaked an estimated 110,000 litres of liquid endosulfan (a persistent organochlorine) into the soil. The gravity of the situation was amplified by the fact that an irrigation canal was located some 12 m behind the shed. Although at the time of its construction in 1977, the Fao facility was situated far from any inhabitation, migrant labourers soon settled around it. By 1993, it was decided to transform the informal settlement into a planned residential area, even though the pesticide warehouse was in its midst. The airstrip used by the pesticide spraying aircraft was also divided into residential plots within this housing scheme, clearly reflecting a poor level of land use planning [8.18].

At the Gedaref PPD store, pesticide containers were scattered haphazardly all over the site and large piles of exposed treated seed were decaying. None of the site guards had protective or first-aid equipment, or basic services such as water and electricity.

In the three aforementioned sites, complaints of ailments and allergies by neighbouring inhabitants were attributed to the noxious smell and polluted run-off, particularly during the rainy season.