Potentially unsustainable expansion plans into desert regions

Major plans for irrigation schemes downstream of Khartoum in Nile and Northern states are likely to give rise to significant environmental concerns in the next fifteen to twenty years. In Northern state, for instance, ambitious estimates by official planning place the potentially irrigable area at 800,000 to 2 million hectares. This represents a two and a half to sixfold increase of the presently cultivated area. The planned expansion is almost entirely in the upper terraces of the Nile, and a substantial proportion (around 300,000 hectares) is to be irrigated by the Merowe dam reservoir once it is completed [8.12, 8.19, 8.20]. The long-term sustainability of these reclamation projects is questionable, and they should proceed with care based on prior environmental impact assessment studies.

Water pollution from sugar factories

The main environmental problem associated with the country's five major sugar estates is the release of effluent from the sugar factories. Industrial water pollution issues are discussed in Chapters 7 and 10.

Canal siltation, soil salinization and yield reduction

Most of the major schemes have been seriously affected by heavy siltation in canals, a process that is accentuated by upstream watershed degradation. For example, the average sediment load entering the main canal in Gezira increased more than fivefold between 1933 and 1989, from 700 ppm to 3,800 ppm. It is estimated that 15 percent of the Gezira scheme is now out of production due to siltation [8.17]. Sedimentation of canals also leads to water stagnation and the emergence of weeds that provide an ideal habitat for the proliferation of water- and vector-borne diseases, in particular schistosomiasis and malaria. Chronic incidence of these diseases has been exceptionally high in the irrigation schemes.

Due to the nature of the heavy clay cracking soils, the two major problems of soil salinization and water logging typically associated with irrigated agriculture are not prevalent in Sudan's schemes. Nevertheless, there is reportedly significant salinization at local levels in the drier north-western reaches of the Gezira near Khartoum, as well as in the Guneid sugar scheme. Monoculture farming and poor implementation of crop rotation has also led to deterioration in soil fertility and a significant decline in yields.

Sugarcane is one of the major crops of the mechanized irrigated agriculture sector

8.7 Traditional irrigation sector impacts and issues: a highly productive system under threat

Traditional irrigation is concentrated on the floodplains of the main Nile downstream of Khartoum, but is also practised over substantial areas along the White and Blue Nile and the Atbara river, as well as on the Gash and Tokar deltas. Crops are irrigated in three ways. The method most widely used is based on cultivation of quick maturing crops on the highly fertile lands (*gerf*) that are exposed following the withdrawal of annual floods. This technique capitalizes on the residual moisture in the soil profile that is available when the floodwaters recede. The second type of traditional irrigation, which is based on the *shaduf* (hand-operated water lever) and the animal-driven water-wheel (*saqia*), has been almost entirely replaced by small-scale irrigation pumps. The third type, known as spate irrigation, relies on the capture and redirection of seasonal run-off to flood wide areas of arable land.

Traditional irrigation is not considered to have significant environmental impacts: in contrast, it is a relatively sustainable sector that is actually under threat from external factors including environmental problems. UNEP identified three such environmental threats, which in combination are anticipated to significantly reduce this sector's output:

Cultivation of the highly fertile 'gerf' lands in Khartoum state

- sand dune encroachment (see Chapter 3);
- riverbank erosion, including downstream erosion from the new Merowe dam (see Chapters 3 and 10); and
- mesquite invasion.

All of these factors lead to the loss of arable land, which in turn increases poverty levels and threatens the food security of local communities. Riverbank erosion and sand dune encroachment have both had major socio-economic consequences resulting in the abandonment of entire villages.

Encroaching sand dunes, seen here in Arji in Northern state, threaten to smother the narrow strip of arable land along the Nile's floodplain, which sustains thousands of communities

Encroaching sands have displaced entire communities, such as the people of the village of Jadallah in Nile state

8.8 Livestock husbandry impacts and issues

Rangeland degradation and shrinkage

Rangeland degradation due to the overuse of shrinking resources is the most prominent environmental problem associated with livestock husbandry in Sudan. Although there is no systematic and quantitative inventory of rangeland conditions or rangeland carrying capacity on a national scale, discussions with national experts and various studies point to three negative trends:

- explosive growth in livestock numbers, particularly in central Sudan;
- major reduction in the total area of available rangelands; and
- widespread deterioration of the remaining rangelands, caused largely by drought, climate change and overstocking.

Extensive annual rangeland burning in south and central Sudan is another important environmental issue, as this practice degrades and alters the natural environment in low rainfall savannah regions.

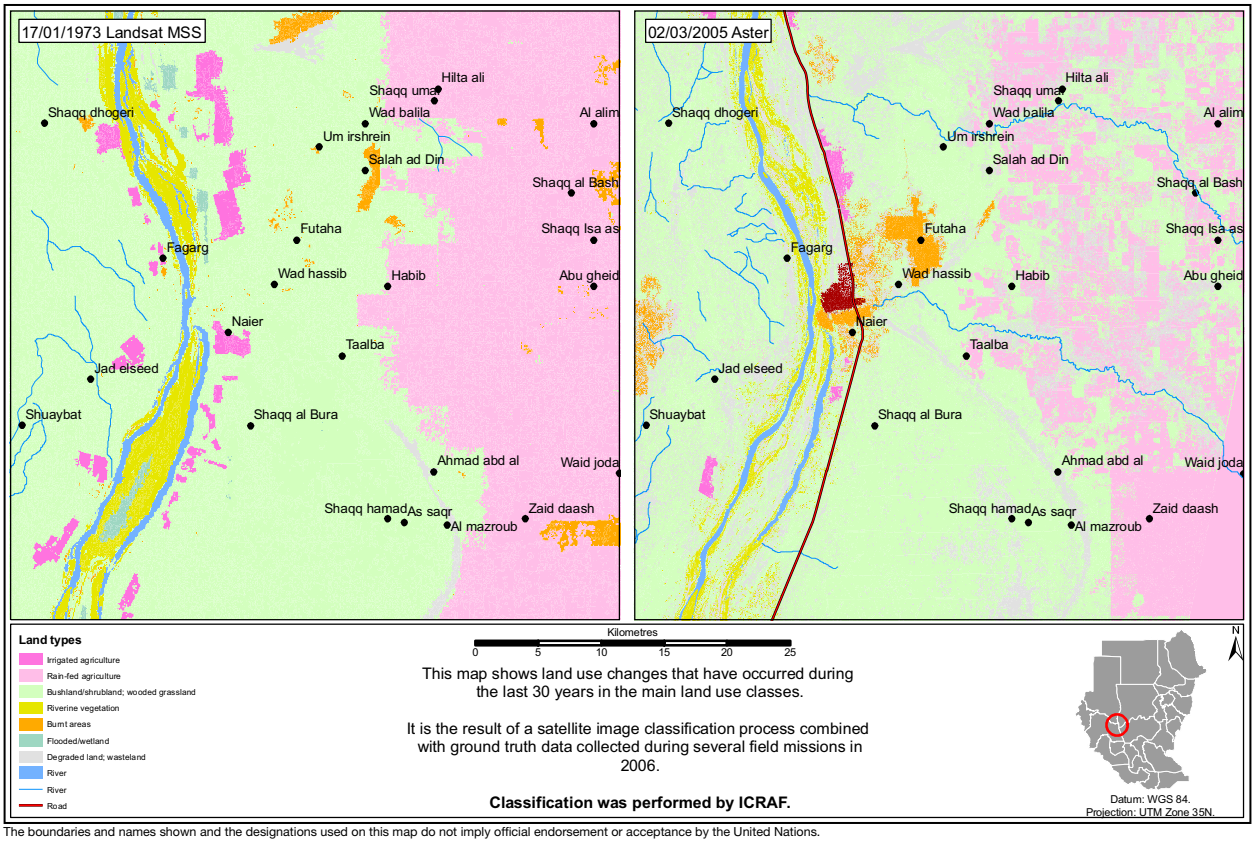
The evidence for rangeland degradation

Though the degradation of rangelands has not been quantified, it has been extensively documented and was again confirmed by UNEP and ICRAF fieldwork and satellite image analysis in 2006 (see Case Study 8.4).

At the ground level, the most visible indicator of overgrazing is simply less forage and more exposed earth, though it is difficult to quantify the rate of degradation using such anecdotal indicators without a baseline. The UNEP-ICRAF satellite image analysis found that it was also extremely difficult to distinguish between bare earth caused by overgrazing and bare earth associated with tilled and empty fields for crops. Only in one image – of Renk district in Upper Nile state – was it possible to confidently quantify land degradation within areas that had remained rangelands (see Figure 8.4). In this case, the proportion of degraded land as marked by bare earth increased from 0.8 percent of the total area in 1973 to 15.4 percent in 2006.

The second indicator of overgrazing is the marked replacement of palatable perennial grasses by annuals of low environmental and nutritional value. This has been confirmed by technical studies in at least six states (Northern, Gedaref, Kassala, Northern Kordofan and Northern Darfur). In Gedaref, the Range and Pasture Administration estimates that 50 percent of the state's rangelands are in a degraded state, with a severe incidence of invasive species. There are reports of valuable range species vanishing, including *Blepharis edulis* in Butana, *Andropogon gayanus* in western Kordofan, *Blepharis lenarrifolia* in Northern Kordofan and *Aritida paposa* in Northern Darfur [8.5, 8.21].

Figure 8.4 Land degradation in Renk district



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Land degradation in Renk district, Upper Nile state. In this 2,500 km² area, the rangeland is a mix of open grassland and bushland. In 1973, open rangeland made up 6.9 percent of the total land area, but had fallen to 2.8 percent by 2006, when fragmentation was very apparent. Bare and degraded land increased from 0.8 percent of the total area in 1973 to 15.4 percent in 2006. Some of the abandoned cultivated land has reverted to bushland and could potentially be used for grazing but it has major access constraints

Herders set fire to the Um Hureiza forest reserve in Sennar state before the onset of the rains

Some heavily grazed areas have undergone a notable shift from grassland to woody thickets. The encroachment of mesquite in rangelands in Kassala, Red Sea state and Gedaref, for instance, is linked to overgrazing not only because its seed is carried in droppings, but also because degraded landscapes favour the spread of such competitive pioneer species.

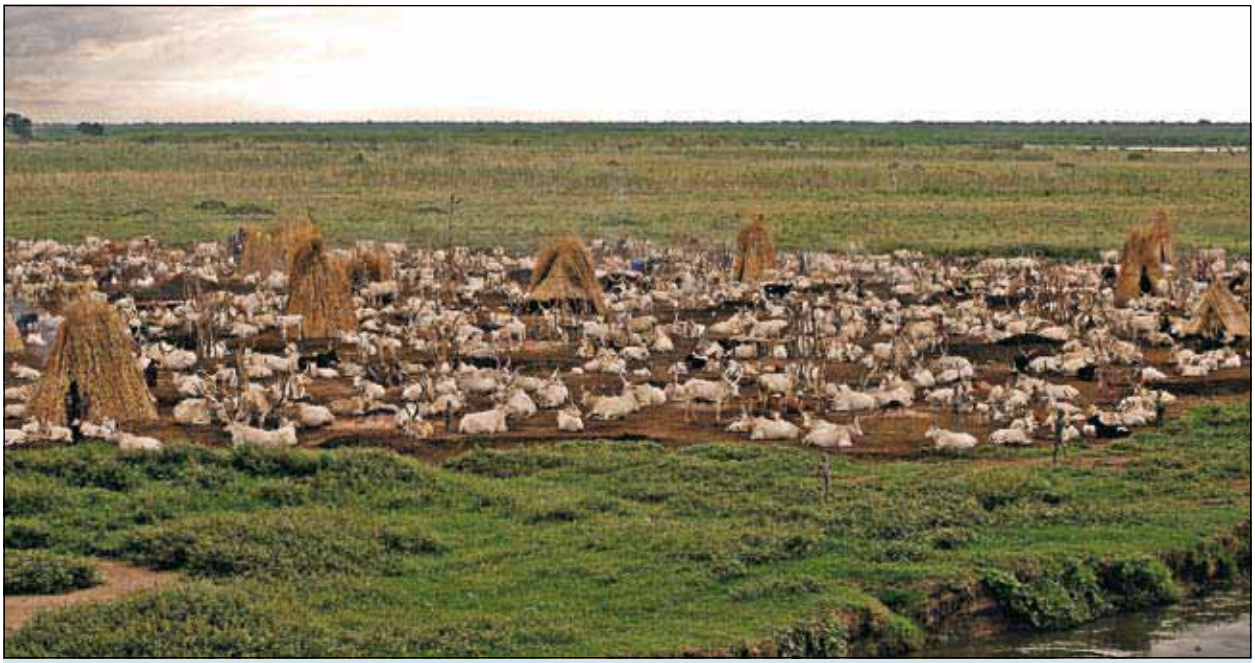
Bare earth in non-desert areas is an indication of both overgrazing and livestock trampling damage. Excessive trampling in dry conditions can lead to the break-up of soil, which accelerates wind erosion, and to compacting, which reduces water infiltration capacity. This is particularly noticeable around boreholes and rainwater storing dugouts known as *hafirs*, as well as along livestock migration routes throughout Sudan.

A host of factors have enabled uncontrolled overgrazing to develop, but there are two critical forces driving this process:

- explosive growth in livestock numbers over the last fifty years, resulting directly in overstocking and overgrazing; and
- a reduction in available grazing land due to desertification and unfavourable land use changes.

Agricultural encroachment onto pastoral migration routes, as evidenced here by the uprooted path markers in the region of Wad el Kabo in Gedaref state, is a major cause of conflict

When pasture is limited, pastoralists often resort to slashing trees trunks and branches to enable their livestock to feed on the otherwise unreachable parts of the tree, as seen here in the Al Ruwashida forest reserve in Gedaref state



A Mundari tribe cattle camp by the White Nile in Central Equatoria at the start of the wet season 2006

CS 8.4 Land degradation due to cattle-rearing in Southern Sudan

Pastoralist societies in Southern Sudan have developed a lifestyle closely tuned to the challenges presented by the climate and geography of the region. Each area has its own nuances, but the general pattern is of a semi-nomadic (transhumant) lifestyle dominated by cattle-rearing, with agriculture practised in the wet season only.

The possibilities for cattle-rearing in the great plains of Southern Sudan are largely constrained by the availability of water and by disease. Though the wet season generates extensive floodplains, the hot climate results in rapid evaporation and limited water supplies in the dry season.

In the wet season, the problems of mud and insect-borne diseases in the flooded areas drive pastoralists to drier ground, generally found to the north or further from the Nile tributaries. In the dry season, however, cattle camps concentrate along the fringes of swamps and watercourses.

In the far south-eastern corner of Sudan, near the Kenyan and Ethiopian borders, the climate is much drier but the soil is poorer, resulting in a lower yield of fodder and a different annual migration pattern.

UNEP has carried out a qualitative assessment of land degradation in Southern Sudan and the Three Areas using a combination of remote sensing and ground reconnaissance. Results indicate that the land is in overall moderate condition, with some clear negative trends and problem areas.

Within the southern clay plains, land degradation is generally limited to strips alongside watercourses, though topsoil losses can be critical at the local level. In the drier south-east however, land degradation is severe. Regional problems are also evident on the boundary between the large-scale agriculture schemes in the north and the southern pastures, and a band of degradation surrounds some of the larger towns.

The Imatong region south-east of Kapoeta in Eastern Equatoria consists of a number of mountain ranges separated by gently sloping valleys. The region is climatically linked to the drylands of the Kenyan Lake Turkana district, and the low valleys receive 25 to 50 percent less rainfall than the plains to the north. Nomadic pastoralism is the main rural livelihood in these dry valleys. Figure 8.6 clearly shows the soil erosion that is occurring: bare subsoil exposure is visible as ochre in contrast to the more vegetated uplands and riverine strips (in green). The primary cause of this degradation is overgrazing of pastures that are naturally vulnerable to erosion due to poor soil quality and low rainfall.

The Government of Southern Sudan hopes to develop the rural sector and improve cattle production through water projects and the provision of veterinary assistance. The warning signs of land degradation indicate that any increase in cattle numbers would constitute a risk of significant damage to pastures which are already worked close to or over their sustainable yield. Any such rural development project should accordingly include land condition and sustainability components to avoid creating new problems. In degraded regions, development projects should avoid increasing stock levels and look instead for options for rehabilitation and resource recovery.

Figure 8.5 Grazing impact in Bor county, Jonglei state

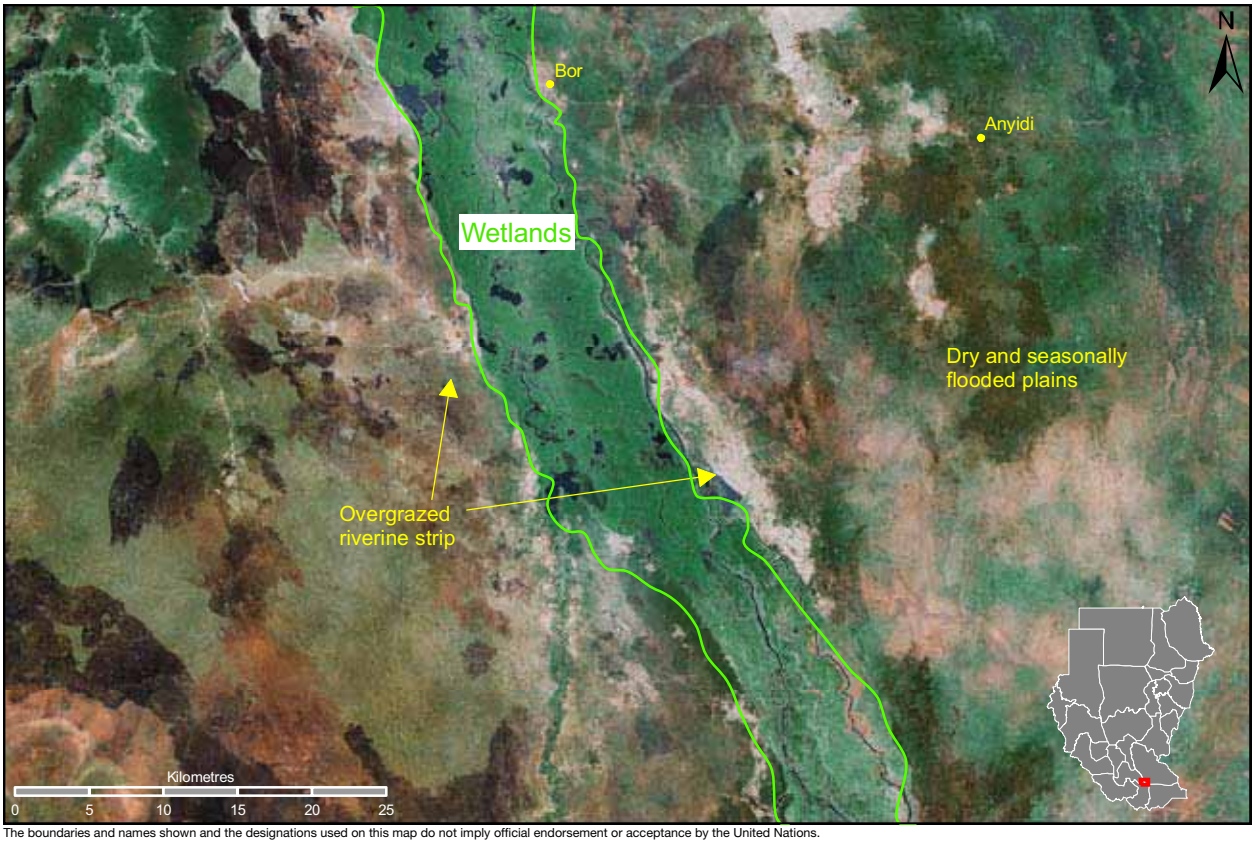


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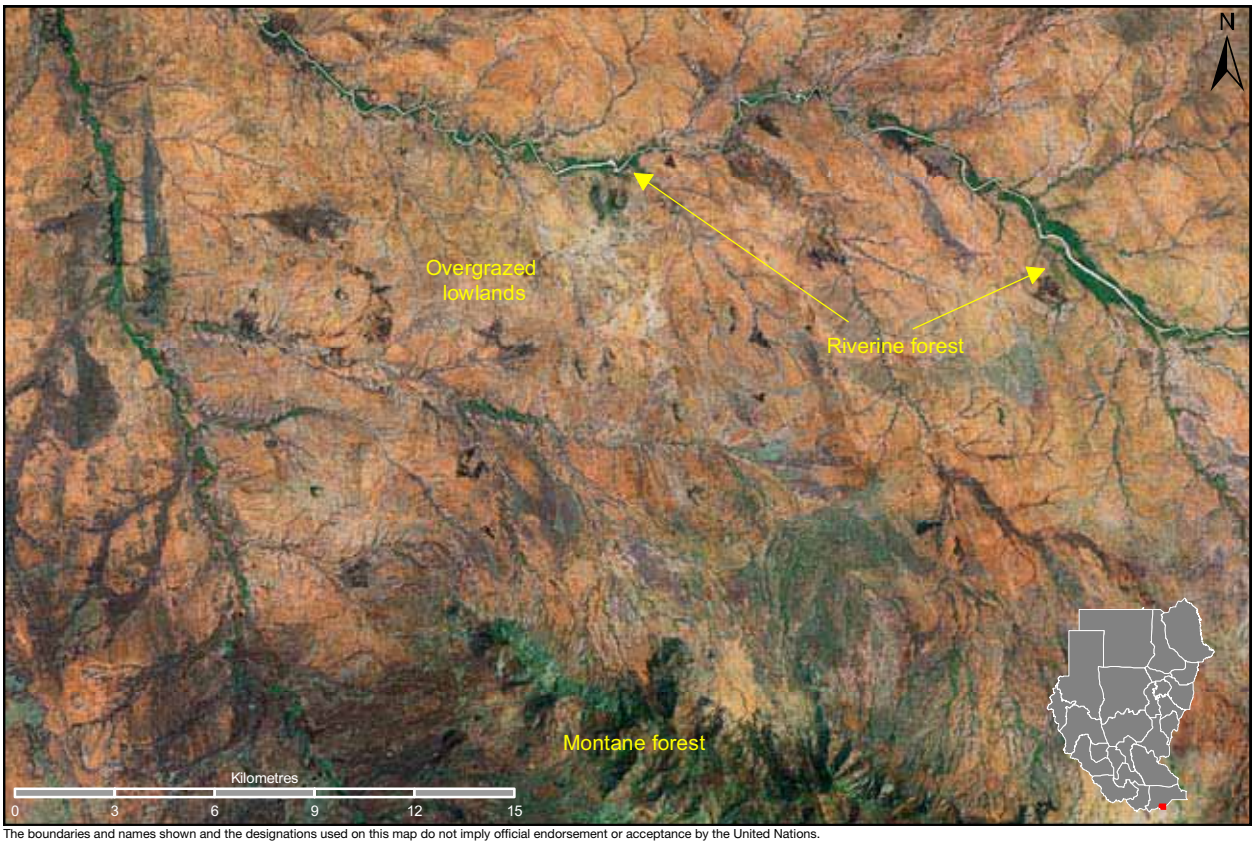
Figure 8.6 Grazing impact in Kapoeta county, Eastern Equatoria



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

The primary cause of overgrazing: overstocking

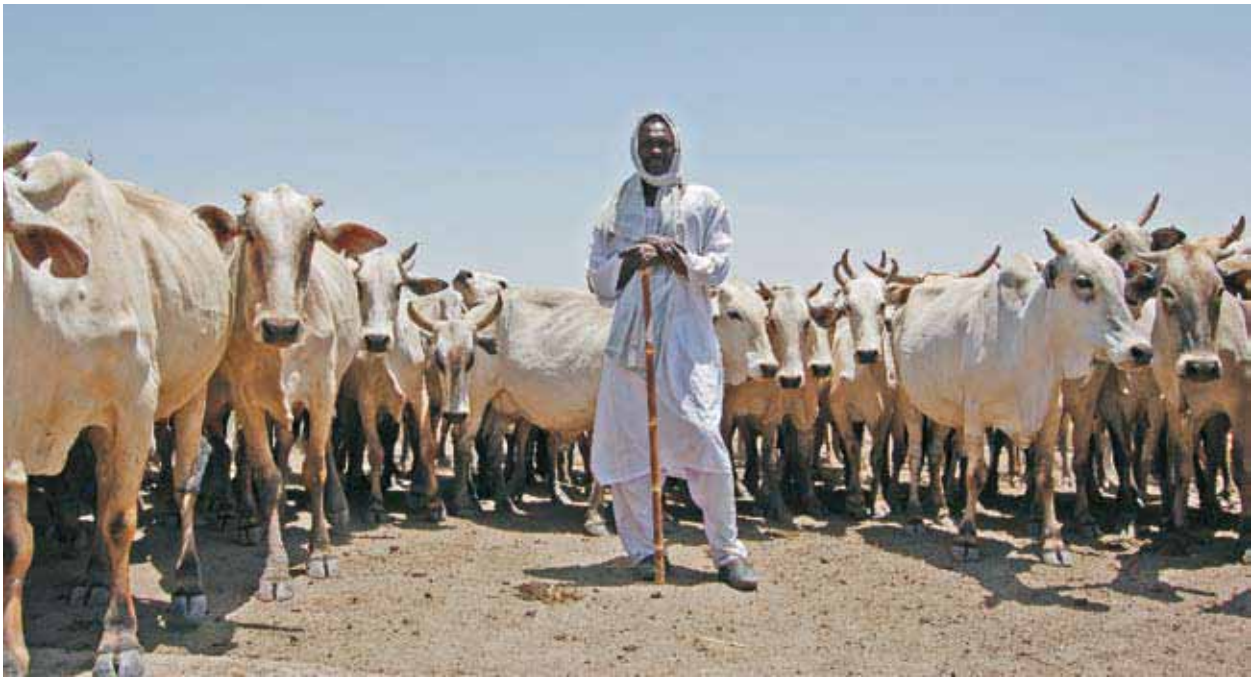
With the second largest herd on the continent (after Ethiopia), livestock is a central component of Sudan's agricultural sector. Livestock-rearing is typically categorized into three types: (i) pure nomadism, based largely on the herding of camels, sheep and goats by the Abbala in the semi-arid and arid north; (ii) semi-nomadic agropastoralism, combining the herding of cattle and some sheep with a form of cultivation by the Baggara and Dinka/Nuer in central and south Sudan as well as in the seasonal *wadis* of the north; and (iii) a sedentary system, where cattle and small livestock are reared in close proximity to villages, mainly in the central belt from Gedaref to Kordofan/ Darfur [8.22].

Livestock husbandry in its various forms is practised by an estimated 40 percent of the population. This figure is even higher in Southern Sudan, where over 60 percent of the population depend on livestock [8.23]. Geographically, livestock-keeping is found virtually throughout the country, with the exception of the extreme arid north and the tsetse fly-infested areas in the far south.

The livestock population (cattle, sheep, goats and camels) is impressive, with a head count of approximately 135 million in 2004. Its rate of growth has been equally remarkable: the stocking rate has increased sixfold in less than fifty years, from a population size of 22 million in 1959. No livestock census has been carried out recently in Southern Sudan, where estimates of the population range from 12 to 22 million [8.5, 8.22].

Table 11. Growth of the livestock sector

Livestock type	1961 (million)	Percentage of population	1973 (million)	Percentage of population	1986 (million)	Percentage of population	2004 (million)	Percentage of population	Times population has increased
Cattle	10.4	36	14.1	35	19.7	36	39.8	30	3.8
Sheep	8.7	30	13.4	33	18.8	34	48.9	36	5.6
Goats	7.2	25	10.5	26	13.9	25	42.2	31	5.9
Camels	2.3	8	2.7	7	2.7	5	3.7	3	1.6
Total	**28.6**	**100**	**40.7**	**100**	**55.1**	**100**	**134.6**	**100**	**4.7**



Cattle herders in Kosti, White Nile state. Livestock populations in central Sudan have increased sixfold in the last forty years

The second cause of overgrazing: a major reduction in rangelands in central and northern Sudan

Concurrent with the increase in livestock, a substantial reduction in rangeland areas has occurred over the past several decades due to three factors:

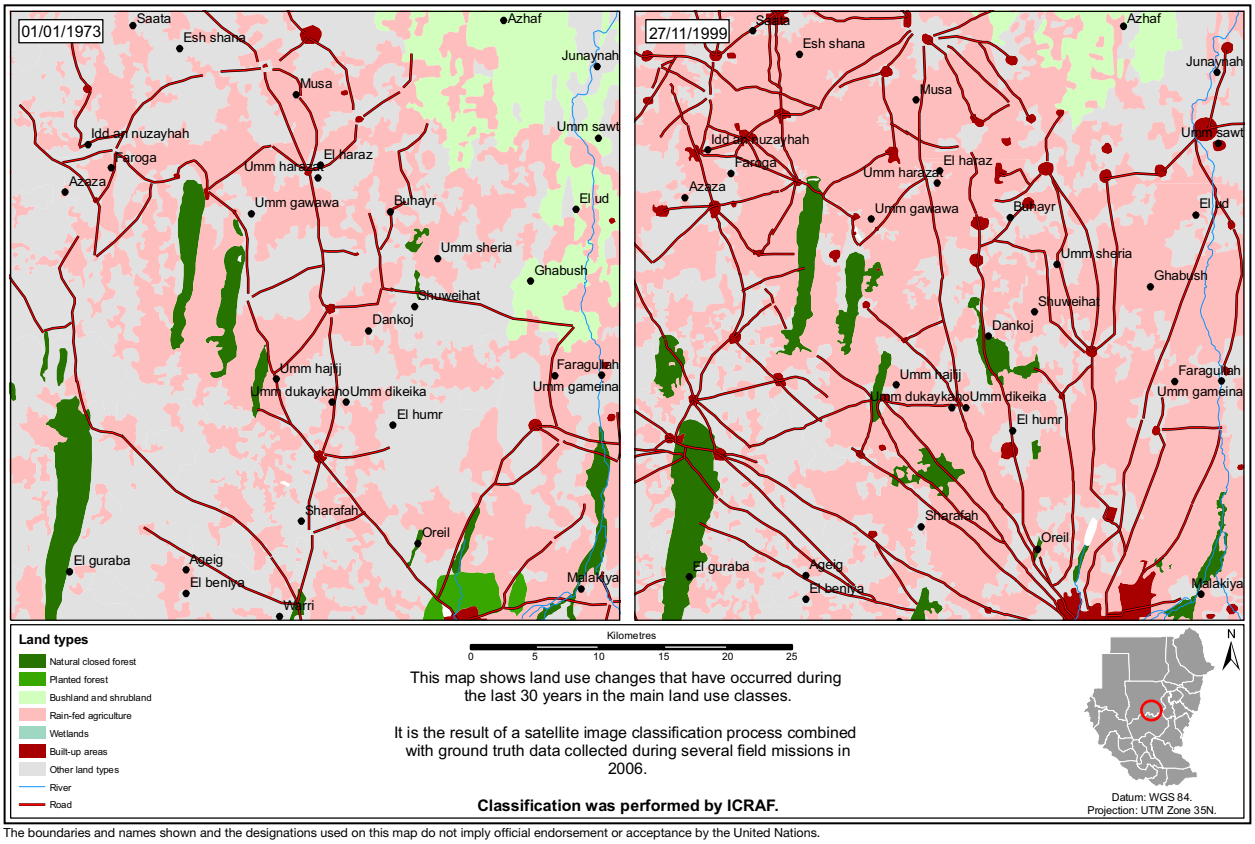
- uncontrolled expansion of mechanized and traditional rain-fed agriculture;
- desertification; and
- expansion of irrigation schemes (a lesser issue).

Rangeland reduction is most prevalent in northern and central Sudan. The UNEP-ICRAF rural land use study provides an indication of the overall trend.

Table 12. Changes in rangeland cover at UNEP-ICRAF study sites across Sudan

Study area and state	Original and current pasture land (% of total area)	Annual linear rate + (period loss)	Comments
North, east and central Sudan			
Ed Damazin, Blue Nile	18.5 to 0.6 from 1972 to 1999	- (96.7 %)	Loss due to the expansion of mechanized agriculture and increase in bush and shrubland
El Obeid, Northern Kordofan	50.4 to 33.5 from 1973 to 1999	- (33.5 %)	Loss due to the expansion of mechanized agriculture, increase in closed forests
Gedaref and Kassala states	13.0 to 8.2 from 1972 to 1999	- (37 %)	Decrease due to expansion of rain-fed agriculture and increase in closed forests
Kassala B	36.1 to 26.4 from 1972 to 2000	- (2.6 %)	Increase in wetland, loss of soil fertility due to wind erosion resulting in loss of pasture lands
Sunjukaya, Southern Kordofan	39.2 to 13.7 from 1972 to 2002	- (34 %)	Loss due to the expansion of mechanized agriculture, increase in bush and shrubland, riverine vegetation and wooded grassland
Tokar delta, Red Sea state	10.0 to 11.7 from 1972 to 2001	+ (1.7 %)	Increase in wooded grassland, and decrease in bush and shrubland, flooded/wetland and riverine vegetation
North-east and central Sudan		**- (50 %)**	**Highly variable but a major loss of rangeland overall due to agricultural expansion**
Darfur			
Jebel Marra, Western Darfur	5.9 to 23.0 from 1973 to 2001	+ (289 %)	Increase in open forest land, decrease in closed forest and bush and shrubland
Timbisquo, Southern Darfur	65.4 to 59.3 from 1973 to 2000	- (9.3 %)	Loss due to the expansion of mechanized agriculture, bush and shrubland, and flood and wetland
Um Chelluta, Southern Darfur	42.4 to 32.7 from 1973 to 2000	- (65 %)	Loss due to the expansion of mechanized agriculture, increase in degraded areas and flooded land, and decrease in grassland area
Darfur		**NA**	**No simple trend: Jebel Marra anomalous, Southern Darfur similar to Southern Sudan with agricultural expansion**
Southern Sudan			
Aweil, Northern Bahr el Ghazal	78.4 to 63.9 from 1972 to 2001	- (18 %)	Increase in rain-fed agriculture and riverine vegetation
Wau, Western Bahr el Ghazal	39.2 to 47.1 from 1973 to 2005	+ (20.1 %)	Decrease in closed forest, degraded land and riverine vegetation, and increase in burnt areas due to slash-and-burn agriculture
Renk, Upper Nile	6.9 to 2.8 from 1973 to 2006	- (59.4 %)	Pastureland lost due to increased land degradation and bush and shrubland
Yambio, Western Equatoria	26.0 to 27.7 from 1973 to 2006	+ (6.5 %)	Increase due to decrease in closed forests
Yei, Central Equatoria	30.9 to 17.5 from 1973 to 2006	- (42.7 %)	Loss due to increase in bush and shrubland, and decrease in wooded grassland
Southern Sudan		**- (18.5 %)**	**Highly variable but loss of rangeland overall due to agricultural and pastoral expansion**

Figure 8.7 Loss of rangeland in El Obeid district



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This time lapse satellite image of El Obeid shows a 57.6 percent increase in cultivated land over the period 1973 to 1999. This increase is achieved at the expense of pastoralism, as indicated by the 33.5 percent reduction in rangeland over the same period. In one generation, a third of the pastoralists' territory has been lost or converted to cultivation. Given that this region is considered to be extremely vulnerable to desertification, the sustainability of the intense land use noted here is highly questionable

In summary, the last generation of pastoralists has seen rangelands shrink by approximately 20 to 50 percent on a national scale, with total losses in some areas. It should be noted, however, that the UNEP-ICRAF study focused on the semi-desert and wetter regions. It did not include the losses due to desertification in historically important regions that are now desert or badly degraded semi-desert.

In addition to direct land loss, the reduction in rangelands has caused problems for the pastoralists' mobility. Pastoralists in Sudan have historically been very mobile, but have kept their annual herd migrations to relatively well-defined routes. Their general pattern is to move north and south to optimize grazing conditions and minimize pest problems. In the dry season, the movement is southwards towards the better pastures and later rainfall; in the wet season, it is generally northwards to follow new growth and avoid the flooding, mud, and insect-borne diseases prevalent in the more humid regions. A similar pattern of migration, though over shorter distances, occurs in the hilly regions, where valleys are grazed mainly in the dry season and high rangeland mainly in the wet season.

In order to reach new pastures, pastoralists pass through agricultural regions. In a land without fences where agricultural and grazing zones are not clearly delimitated, competition for land is at the heart of many local conflicts. Indicative pastoral routes for Sudan and Darfur are shown in Figures 8.8 and 8.9, respectively. The indicated routes are general and include only the largest scale movements. Numerous and often contrasting smaller scale movements occur on a local and seasonal level.

This major reduction in the amount, quality and accessibility of grazing land is considered to be a root cause of conflict between pastoralist and agriculturalist societies throughout the drier parts of Sudan, as discussed in Chapter 4.

Figure 8.8 Annual pastoral migration routes in Sudan

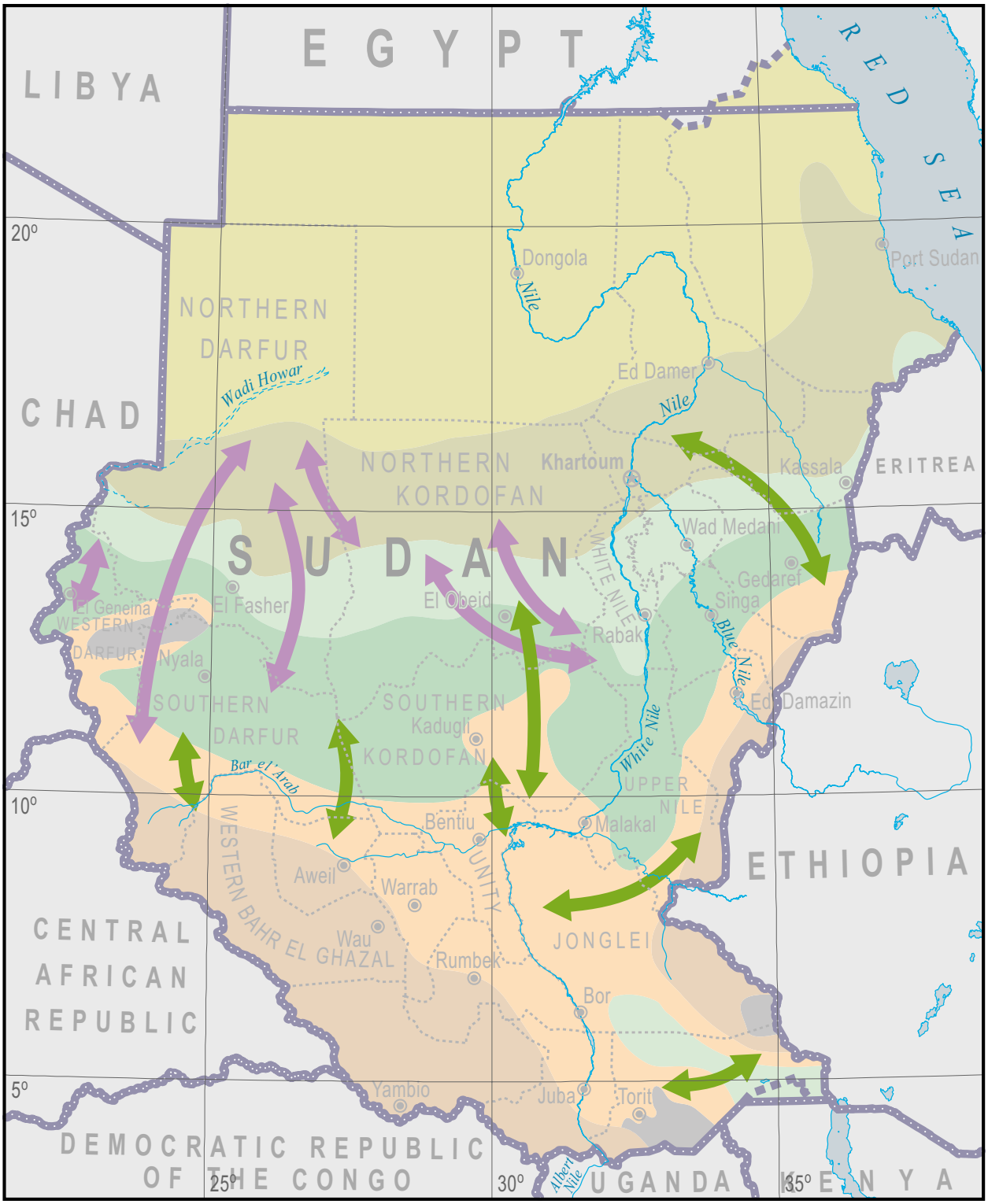
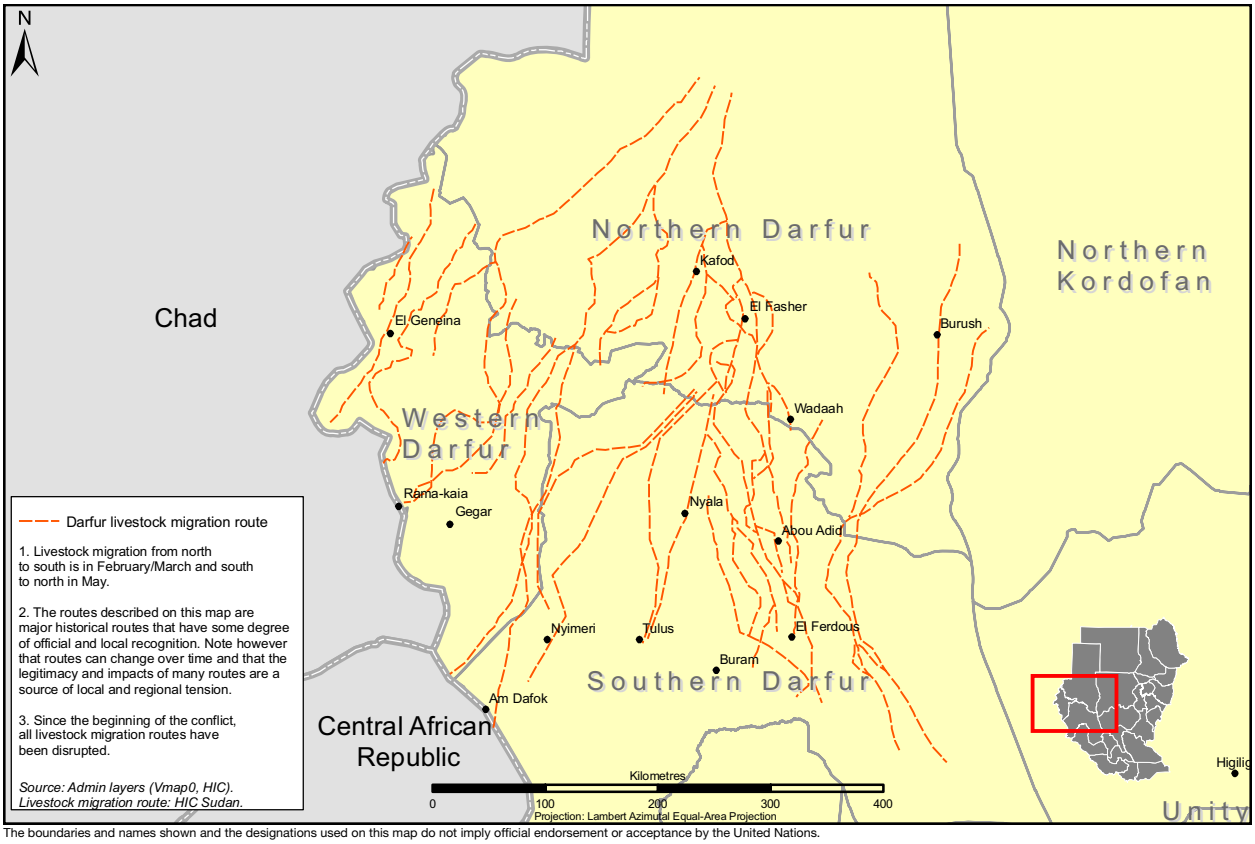


Figure 8.9 Annual pastoral migration routes in Darfur



Pastoral migration routes in Darfur. The very mapping or classification of pastoral routes in Darfur is a contentious issue, particularly as many routes have been blocked or changed by the recent conflict. These routes as indicated from government sources show the scale of seasonal migration and the multiplicity of potential routes but the actual lines of travel and the associated rights are not always confirmed or agreed, either in a legal sense or in the sense of having community-level acceptance

Rangeland burning in south and central Sudan

The dry season in Sudan is also the burning season. Grassfires are visible in pastoralist regions throughout the country, while slash-and-burn clearance can be observed in the southern half.

The great majority of pasture burning is deliberate. Herders set fire to the dry grass to remove old unpalatable growth, fertilize the soil with ash and promote new shoots that are more suitable as fodder. The scale of the pastoralist burning can be gauged by satellite and by aircraft (see Figure 8.10). The open clay plains of Jonglei and Upper Nile states, for example, are heavily burnt, and UNEP estimates that virtually the entire region is burnt on a two- to four-year cycle.

There is no doubt that annual burning succeeds in its purpose of short-term pasture regeneration, but it also has a number of negative impacts even when timed and executed with care. When done poorly or with hostile intent, it is highly destructive for the environment, the rural economy and society. Regular burning destroys young trees and shrubs, thus maintaining much of central and south Sudan as open plain, when its undisturbed natural state is open woodland savannah. The great plains of Southern Sudan may appear to be 'wild' but are in fact highly modified environments.

One of the long-term negative effects of very regular burning is the loss of nutrients and soil organic matter, which are lost to combustion, and water and wind erosion. For sloping terrain regions such as the Nuba mountains, such losses are clearly important. Pasture burning can also cause problems between different communities with intermingled land uses. In the extreme case of Darfur, pasture burning is used as a weapon to destroy competing livelihoods.

8.9 Agricultural sector environmental governance

Sector governance structure and issues

Governance of the agricultural sector is relatively straightforward and well structured: both GONU and GOSS have ministries of agriculture and ministries of animal resources. These ministries, however, are under strong pressure to provide policies and projects that will rapidly increase food security. This in turn results in a tendency to promote major agricultural development projects that are often environmentally unsustainable. Insufficient technical capacity and under-funding also constrain the ministries. Furthermore, the linkages between the agricultural and livestock ministries and the environment ministries are weak in both GONU and GOSS.

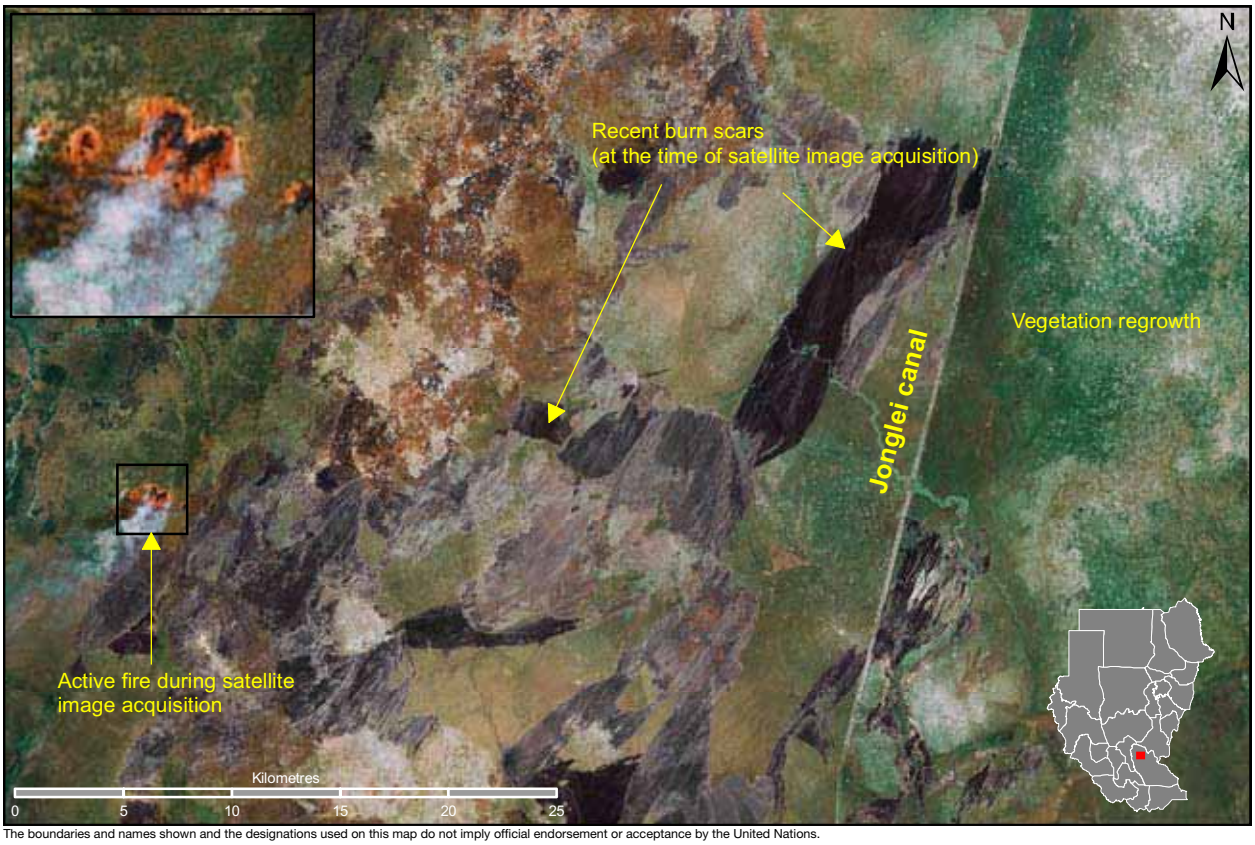
The most environmentally damaging aspect of government policy has been the promotion of rain-fed mechanized agriculture and the subsequent failure to address its negative consequences when these first became clearly apparent. Likewise, the lack of governance in the area of pesticides management has left Sudan with a difficult and expensive environmental legacy. Land tenure, as detailed below, is another important failure.

Land tenure

The land tenure situation in Sudan constitutes a major obstacle to sustainable land use. Prior to the 1970s, communal title to shared rural land was generally acknowledged at the local level but undocumented. The traditional community-based land management systems that were in place were reportedly reasonably effective. This situation was radically changed in the 1970s by a number of ill-planned initiatives, the consequences of which are still felt today.

The imposition of the 1971 Unregistered Lands Act effectively sequestered most of the untitled land (the majority of rural Sudan) as government property. In the same year, the People's Local Government Act took the authority away from the pre-existing traditional land management systems, which had until then provided vital checks and balances in the absence of a modern land tenure system [8.19].

Figure 8.10 Rangeland burning in Jonglei state



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As a result of this legislation and subsequent related acts, the majority of Sudanese now farm and rear livestock on government land, without any real supervision or form of title. As the pre-existing control measures are either weakened or completely destroyed, there is an effective governance vacuum on rural land use in much of the country.

This deficiency in rural land tenure is one of the root causes of many agricultural, environmental and social problems in Sudan. Without ownership, people have little incentive for investment in and protection of natural resources. Land owners, and smallholders in particular, are also vulnerable to more economically powerful or better armed groups, who may wish to dispossess them in order to use the land for their own purposes.

The Comprehensive Peace Agreement envisaged the immediate establishment of a new body, the Land Commission, to analyse land tenure issues and propose a way forward. As of end 2006, it has yet to be formed.

8.10 Conclusions and recommendations

Conclusion

Sudan's major investment in agricultural development over the past century has proceeded with little consideration of environmental sustainability. The resulting environmental issues are uniformly worsening and now represent a major threat to Sudan's food security. In the absence of significant action on these problems, large-scale ecological and social breakdown in the dryland regions of Sudan are considered to be a real risk in the medium to long term. It could be argued that this has already occurred to some extent in Darfur.

Agricultural authorities in the north and in Darfur face the most severe challenges, with an array of environmental problems closely tied to the social, political and economic issues affecting the region. The ongoing destruction resulting from the current system of rain-fed mechanized agriculture schemes in northern and central Sudan needs to be halted if food insecurity and conflicts are to be avoided in the future. This does not call for a reversion from mechanization back to traditional methods, but for a revision of current practices in order to combine the best of both approaches in a sustainable manner.

At present, Southern Sudan only faces severe agriculture-related environmental issues along its northern boundaries, but there are numerous warning signs that action is needed to forestall damaging overtaxing of the environment in the more populated regions in the far south. It is therefore extremely important that lessons from other regions be learnt, and that agricultural development in the south proceed with extreme care to ensure its environmental sustainability.

Background to the recommendations

GONU government reform and capacity-building in land use planning and environmental sustainability are the central themes of the recommendations for this sector. Specific environmental rehabilitation programmes are definitely needed, but in the absence of major reform in the approach to agricultural development in northern and central Sudan, further ad hoc investment in environmental initiatives is considered to be highly risky.

In Southern Sudan, the rapidly developing agricultural policies as seen by UNEP in late 2006 appear to be generally sound, with one major gap. A high priority should be given to conversion of traditional agricultural systems to more modern hybrid systems such as agroforestry, which preserves tree cover and boosts per hectare productivity while improving environmental sustainability.

Recommendations for the Government of National Unity

R8.1 Establish the proposed Land Commission. The proposed commission is a key part of the CPA and a good initiative that warrants support. The international community already has funds set aside for this initiative.

CA:GROL; PB: MAF; UNP: FAO; CE: nil; DU: 3 years

R8.2 Impose a moratorium on new mechanized rain-fed agriculture schemes and conduct a major review and study on the way forward. The objective is to understand the real impacts and control the unplanned expansion of mechanized agriculture, and improve sustainability. Priority states are Southern Kordofan, Blue Nile, Gedaref, White Nile and Sennar.

CA: GROL/AS; PB: MAF; UNP: FAO; CE: 0.2M; DU: 2 years+

R8.3 Invest in technical assistance, capacity-building and research in seven environment-agriculture subject areas. The overall objective is to embed the culture and capacity for the sustainable development of agriculture into the Ministry of Agriculture and Forestry, the Ministry of Animal Resources and a number of linked institutes. The investments need to be spread between the federal and state levels and various ministries. The target subjects are:

- meteorology services;
- sustainable rural land use planning;
- rangeland conservation;
- agroforestry;
- Water Use Associations (WUA) in irrigation schemes;
- integrated pest management and pesticide management; and
- rehabilitation of desert regions using native species.

CA: TA; PB: MAF; UNP: FAO; CE: 8M; DU: 3 years

R8.4 Develop policies and guidelines to prevent future accumulation of pesticide stockpiles. Policy development should be based on multi-stakeholder consultations involving relevant government authorities, industry, aid agencies and development banks, and farmers.

CA: GROL; PB: MAF; UNP: FAO; CE: 0.1M; DU: 1 year

R8.5 Collect all obsolete pesticide stocks for safer long-term storage, treatment and disposal, and conduct a feasibility assessment for safe final disposal. Prior to final disposal, the stocks disseminated across the country will need to be assessed, categorized, and made safe for transport and interim storage. A single well-sited, well-designed and maintained interim storage place would be a major improvement on the current situation. Any major investment in final disposal will require a cost and feasibility study to select the best option and assist financing.

CA:PA; PB: MAF; UNP: UNEP; CE: 3M; DU: 2 years

R8.6 Assess the full extent of riverbank erosion and invest in practical impact management plan based on Integrated Water Resource Management (IWRM). This should be considered an investment in the preservation of high-value agricultural land.

CA:PA; PB: MAF; UNP: FAO; CE: 3M; DU: 2 years

R8.7 Develop a national strategy and priority action plan for mesquite control in the agricultural sector. The Presidential Decree should be amended at the same time as the plan is developed to avoid a legislation-policy clash.

CA:GROL; PB: MAF; UNP: FAO; CE: 0.3M; DU: 1 year

Recommendations for the Government of Southern Sudan

R8.8 Impose a moratorium on new mechanized agriculture schemes in southern states, and a major review and study on the way forward. The objective is to understand the real impacts and control the unplanned expansion of mechanized agriculture, and improve sustainability. For GOSS, applicable to Upper Nile state.

CA: GROL/AS; PB: MAF; UNP: FAO; CE: 0.2M; DU: 1 year

R8.9 Invest in technical assistance, capacity-building and research in a range of environment-agriculture subject areas. The overall objective is to embed the culture and capacity for the sustainable development of agriculture into the Ministry of Agriculture and Forestry, Ministry of Animal Resources and a number of linked institutes. The investments need to be spread between the federal and state levels and various ministries.

CA: TA/CB; PB: MAF; UNP: FAO; CE: 4M; DU: 3 years

R8.10 Design and implement agroforestry demonstration projects in each of the ten southern states. The objective is to demonstrate the benefits of switching from shifting agriculture to more sustainable land use models.

CA: PA; PB: MAF; UNP: ICRAF; CE: 5M; DU: 5 years

Forest Resources

Plantations such as this teak stand in Kagelu, Central Equatoria, are a valuable asset and potential source of hard currency for Southern Sudan. Commercial exploitation of the forest resources of Southern Sudan is expected to expand with peace and road network improvements. The challenge will be to develop the industry in an environmentallysustainable manner.

Forest resources

9.1 Introduction and assessment activities

Introduction

The rural population of Sudan, as well as much of its urban population, depends on forests. Trees are the main source of energy and provide timber for roofing and building. In rural Sudan, the extensive benefits derived from forests include grazing, hunting, shade, forest foods in the form of tree leaves, wild fruits, nuts, tubers and herbs, tree bark for medicinal purposes, and non-wood products such as honey and gum arabic. In addition, the commercial lumber industry is a small but growing source of employment. According to FAO, the forestry sector contributes as much as 13 percent to the gross domestic product of Sudan [9.1].

This valuable resource is threatened, however, by deforestation driven principally by energy needs and agricultural clearance. Moreover, the unbalanced distribution of forests in Sudan – most of the remaining forests are found in the south, while the demand for forest products is highest in the north – presents a potential threat for north-south peace, but also a significant opportunity for sustainable north-south trade development.

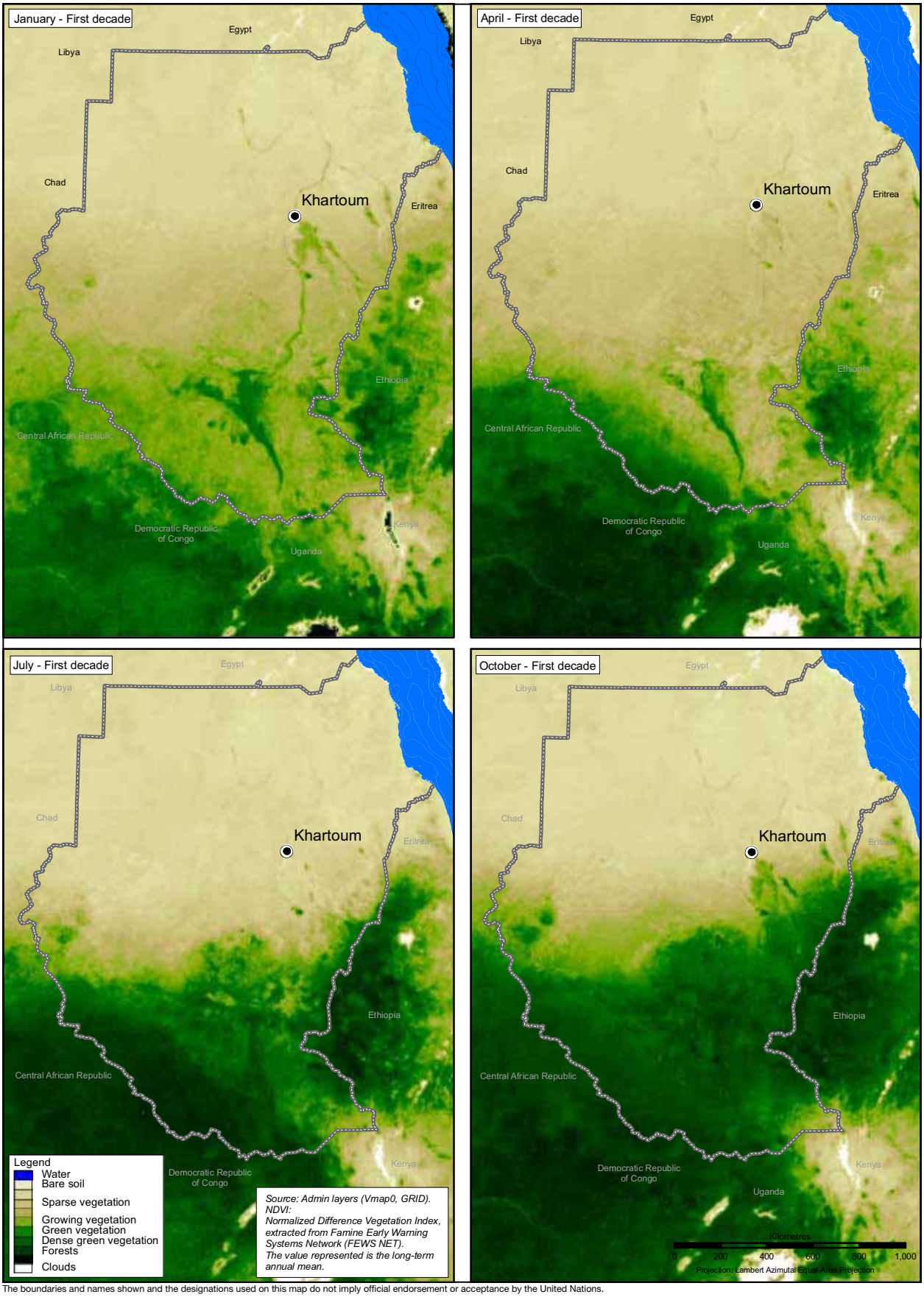
Assessment activities

Forestry was a priority topic for the UNEP assessment, and was also included in the scope of the ICRAF study on rural land use changes commissioned by UNEP in cooperation with FAO. In addition, the forestry sector assessment was marked by strong and welcome support from the Forests National Corporation (FNC) in northern and central Sudan.

UNEP teams visited forests in over twenty states. Particular attention was paid to deforestation pressures in different regions. Satellite imagery analysis of fourteen sites included a quantitative assessment of deforestation, and satellite reconnaissance was widely used to search for deforestation 'hotspots'. In Southern Sudan, the Kagelu Forestry Training Centre worked with ICRAF to provide UNEP with detailed information on the Equatorian states timber reserves. However, security constraints prevented access to important forests in Darfur; the Jebel Marra plateau, for instance, was almost completely inaccessible at the time of the survey.

A commercial mahogany stand in the Nuba mountains, Southern Kordofan. Northern Sudan's major timber deficit is currently being met principally through unsustainable logging in central Sudan. Viable and sustainable alternatives include increased use of plantations

Figure 9.1 Sudan forest cover



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

With the exception of central Darfur, UNEP's forestry-related activities were considered comprehensive enough to develop an accurate picture of the status of Sudan's forests and prevailing trends across the country.

9.2 Overview of forest resources

A wide range of forests and related vegetation types is found in Sudan due to regional variations in soil and rainfall. The most important types are listed below, in rough order of distribution from the arid north to the tropical south:

- desert and semi-desert trees and shrubs;
- riverine forests;
- low rainfall woodland savannah;
- high rainfall woodland savannah;
- montane and gallery forests;
- tropical forests; and
- plantations.

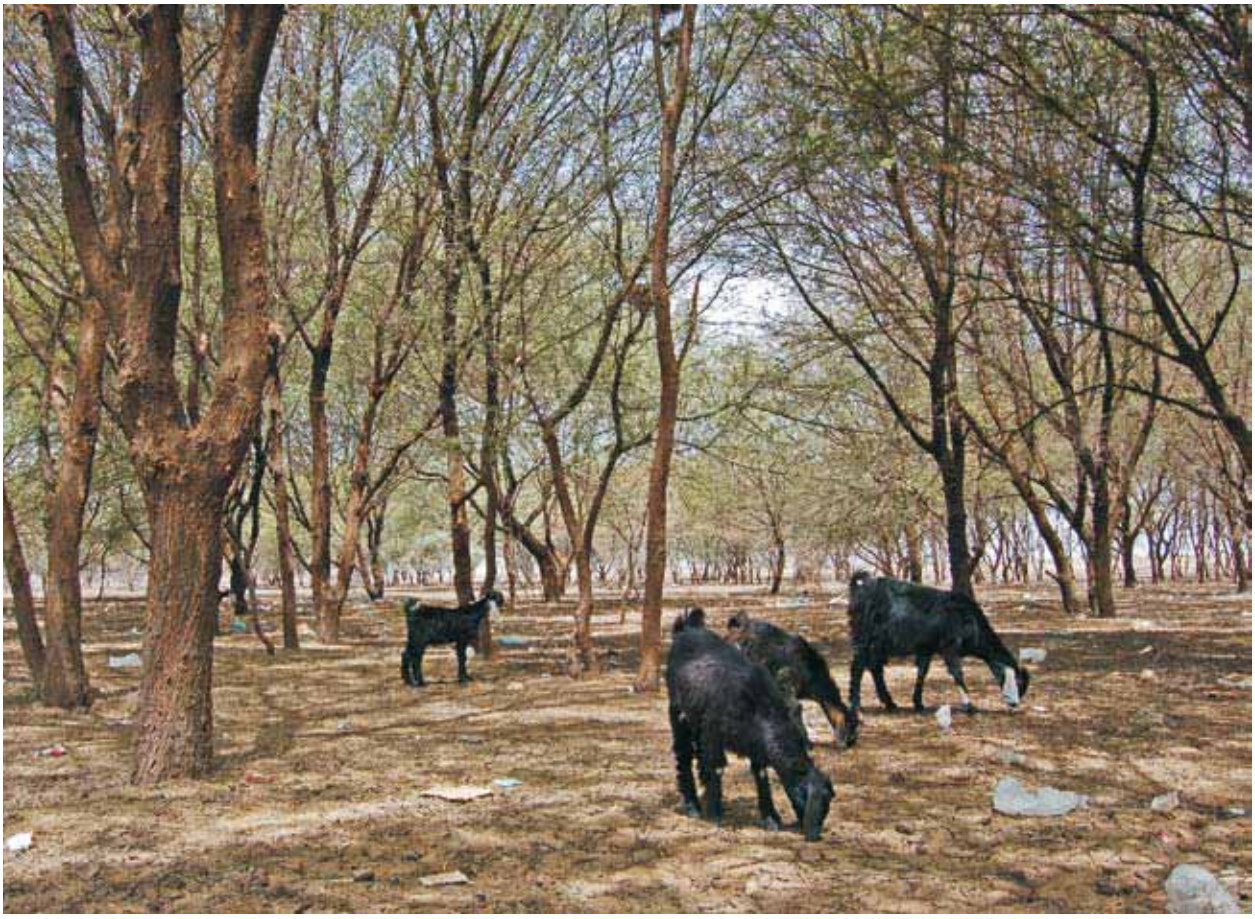
Most trees in Sudan grow in open to semi-closed woodlands with numerous under-storeys of grasses and shrubs. Fully closed forests are only found in a few of the most humid areas in the south. This complicates attempts to quantify the extent of forests and deforestation in the drier regions, as there is rarely a clear deforestation or ecosystem boundary, but rather a gradual thinning out of trees over a large area.

The long-term Normalized Difference Vegetative Index (NDVI) is a measurement of the overall vegetation density, including trees, shrubs and grasses over different seasons. The images in Figure 9.1 (see previous page) clearly show the dominant impact of the Sahara desert and low rainfall zones on vegetation cover and the associated north-south difference in tree cover.

Desert and semi-desert trees and shrubs

Desert vegetation in the northern states (Northern, Northern Darfur, Northern Kordofan, Kassala and Red Sea) is limited to xerophytic (drought-resistant) shrubs, such as *Acacia ehrenbergiana, Capparis decidua, Fagonia cretica* and *Leptodemia pirotechnica*. Scrub formations occur in the semi-desert zone (the northern half of Kordofan and Blue Nile states, all of Khartoum state, most of Red Sea state, and some parts of Darfur), where the vegetation is a varying mixture of grasses and herbs with widely scattered shrubs.

Forest resources in the desert and semi-desert northern states are extremely limited and in continual decline



Acacia nilotica in Sennar state. The density and variety of tree cover increases further south, following rainfall patterns

Riverine forests

Riverine forests are a critical resource for the northern states. They occupy the lands that are flooded when rivers rise in the latter part of the wet season. *Acacia nilotica* – the dominant species – is found as pure dense stands over large areas from the Egyptian border in the north to as far south as Jebelein on the White Nile, and Roseires on the Blue Nile. The species also occurs along the Dinder and Rahad rivers. In less frequently flooded basins along the Atbara river and in some inland sites, *Acacia nilotica* is replaced by *Hyphaene thebaica* (Dom palm) forests.

Low rainfall (< 900 - 1,000 mm) woodland savannah

The low rainfall woodland savannah region lies in the centre and south of the country, with the exclusion of the flood region. Rainfall is confined to a few months of the year (March or April to July), and is followed by a long hot dry season. The vegetation is composed of mixed grass types with bushes and trees, but species distribution within the low rainfall savannah zone varies with rainfall and soil type. Sandy soils dominate in the west and central regions, and clay soils are prevalent in the east and south. In the drier parts, trees are nearly all thorny and low in stature, with a predominance of species of acacia. Broadleaved deciduous trees become prevalent in the wetter parts, but there is not as great a variety of species as in the high rainfall woodland savannah, and thorn trees are usually present. The gum arabic belt lies within this zone. The belt occupies an area of 520,000 km² between the latitudes of 10° and 14° N, accounting for one-fifth of the total area of the country. Its importance is reflected in the fact that it accommodates approximately one-fifth of the population of Sudan and two-thirds of its livestock, and that it acts as a natural barrier to protect more than 40 percent of the total area of Sudan from desert encroachment [9.2].

High rainfall (> 900 – 1,000 mm) woodland savannah

The high rainfall woodland savannah extends into most parts of Bahr el Ghazal and Equatoria states in the south. Trees in this region are generally tall and broadleaved. Coarse tall tussocks of perennial grasses predominate and fires are hence usually fiercer than in the low rainfall woodland savannah. The most important tree species are *Khaya senegalensis* and *Isoberlina doka*. Other species are *Parkia oliveri, Daniella oliveri, Afzelia africana*, *Terminalia mollis*, *Burkea africana* and *Vitellaria paradoxa*.

Tropical forests

Sudan's tropical forests are confined to a few small and scattered localities: the Talanga, Lotti and Laboni forests at the base of the Imatong mountains and the Azza forest in Maridi in Western Equatoria, and other small areas on the Aloma plateau and near Yambio. Species occurring in these tropical forests are similar to those found in the drier parts of the forests of West Africa. The most common are *Chrysophyllum albidum* and *Celtis zenkeri,* with *Holoptelea grandis* in the Azza forest. A number of valuable timber trees are also found, including *Khaya grandifolia* (mahagony), *Chlorophora excelsa*, and *Entrandrophragma angolense*.

Montane and gallery forests

Mountains in Sudan are characterized by higher rainfall, resulting in different and more robust woodlands than in the surrounding areas. The Jebel Marra plateau in Darfur is the most important ecosystem of this type in the drier parts of Sudan.

Coniferous forests occur in the montane vegetation of the Imatong and Dongotona ranges in Eastern Equatoria state, as well as in the Red Sea hills in the north-east. Important species include *Podocarpus milanjianus, Juniperus procera* and *Pinus radiata*. Planted exotics include *Eucalyptus microtheca* and *Cupressus spp.* In the more humid areas of the Imatong and Dongotona ranges, the vegetation is similar to that of low rainfall woodland savannah.

Gallery forests occur on the banks of streams. They are generally found in relatively deep U-shaped valleys, and benefit from both the extra water supply from the streams and the protection against fires afforded by the steeply sloping banks. Important species are *Cola cordifolia*, *Syzygium guineense* and *Mitragyna stipulosa* in swampy places.

Plantations

Plantations were first established in Sudan by the Anglo-Egyptian administration. The most significant of these were the teak (*Tectona grandis*) plantations of Southern Sudan, many of which are still standing (see Case Study 9.1). This process was continued by the government forestry administration, and by the mid-1970s, plantations totaled some 16,000 additional hectares of hardwoods and 500 to 600 hectares of softwoods [9.3].

Today, most of the remaining plantations are found in Central and Eastern Equatoria states, in Southern Sudan. They include stands of teak in the far southern regions and pine in the higher elevations of the Imatong mountains. Elsewhere in Sudan, plantations are comprised of riverine *Acacia nilotica* forests, *Acacia senegal* plantations in abandoned mechanized farms, inside forest reserves, in private gum orchards, and in isolated shelter belts planted in Northern Kordofan and other central states, pine and eucalyptus plantations in the Jebel Marra region in Darfur, and eucalyptus in the irrigated agricultural areas.

Southern Sudan still retains the majority of its forest cover, but deforestation is occurring at a steady rate

These teak trees have not been tended for 20 years, so the productivity of the plantation is well below potential. The plantations, however, are a valuable asset

CS 9.1 Yei county teak plantations: a valuable colonial legacy

Teak (*Tectona grandis*) plantations are spread all over Yei county. Prior to the conflict, the largest and best managed plantations were located in Kagelu, 8 km south-west of the town of Yei, between 04°03'34" N and 30°36'56" E.

The community living around the plantation, the Kakwa ethnic group, mainly practises subsistence agriculture, though some members also plant their own woodlots for cash income and construction materials. Before the war, the community benefited from the infrastructure provided by the government forest plantation project in terms of employment, education, health services and improved road access. Other benefits included extension services, fuelwood and other forest products from the reserve.

Between independence and the second civil war, the teak plantations in Yei county were managed by the Sudan German Forestry Team, funded by GTZ (German Technical Aid), but the project was shut down in 1987 due to the intensification of the conflict. During the war, all of the teak plantations were subject to uncontrolled felling and export to Uganda. The entire process was managed on the black market by foreign-owned logging companies, and royalties from the timber went to the SPLA.

With the end of the conflict and the establishment of the GOSS Ministry of Agriculture and Forestry, H.E. Martin Elia Lomoro ordered a review and evaluation of commercial logging activities. The committee that conducted the review found that all of the contracts that were issued were illegal and that they did not conform to best forestry practices. This prompted the Minister to issue a decree annulling all the contracts and banning logging in both the teak plantations and natural forests. This ban, while admirable, is not expected to hold much beyond 2006 due to the need for foreign currency and construction timber in Southern Sudan.

There is accordingly an urgent need for the GOSS to develop an appropriate governance regime, including a transparent licensing process, strict quotas and reforestation obligations.

Table 13. Teak plantations in Yei county [9.8]

Name of forest reserve	Size in hectares
Loka	918
Kagelu	1,045
Kajiko North	750
Kajiko South	90
Korobe	50
Mumory	30
Yei Council	2
Total	**2,985**

9.3 Forest utilization

A range of ecosystem services

The forests of Sudan have economical, ecological, and recreational values, known collectively as ecosystem services.

Wood products from the forestry sector include fuelwood, sawn timber and round poles. The Forest Product Consumption Survey conducted by the FNC in Northern Sudan in 1995 found that the total annual consumption of wood was 15.77 million m³. FAO calculated that in 1987, Sudan produced 41,000 m³ of sawn timber, 1.9 million m³ of other industrial round wood, and more than 18 million m³ of firewood. Each of these categories showed a substantial increase from production levels in the 1970s [9.4].

The ecological benefits of forests include sand dune stabilization in fragile semi-desert environments, amelioration of soil through nitrogen fixation, and the provision of natural ecosystems for wildlife and the conservation of biodiversity.

Fuelwood and charcoal production

The felling of trees for fuelwood and charcoal production occurs throughout Sudan, but the pressure is generally greater on the more limited resources of the north and the areas surrounding the country's urban centres. An additional growing use for fuelwood in all parts of Sudan is for brick-making. In Darfur, for instance, brick-making provides a livelihood for many IDP camp residents, but also contributes to severe localized deforestation (see Case Study 5.2).

Fuelwood market in Nyala, Southern Darfur

Brick kilns on the banks of the Blue Nile, in El Gezira state. The brick-making industry is a major market for fuelwood

As is the case for many natural resource management issues in Sudan, the data on wood consumption is incomplete and often obsolete. What is available, however, provides a picture of substantial and increasing demand. The 1995 FNC survey indicated that fuelwood contributed 78 percent of the energy balance of Sudan, the rest being provided by oil (8 percent), generated electricity (8 percent) and agricultural residues (6 percent). With a per capita annual consumption of approximately 0.68 m^3, the total fuelwood requirement for 1995 was estimated at 22 million m^3 [9.4, 9.9]. These figures were extrapolated by UNEP to estimate the fuelwood requirement for 2006 at 27-30 million m^3.

In theory, forest authorities in northern and central Sudan direct the commercial logging of *Acacia nilotica* and *Acacia seyal* for supply of firewood and charcoal to the cities. Wood is meant to be extracted mostly from the thinning of branches of *Acacia nilotica* in reserved riverine forests, and the clearing of *Acacia seyal* and other species from areas allocated for agriculture. In practice, however, the process is much less controlled and the felling less selective.

Rural inhabitants use most of the tree species in the low rainfall savannah for fuelwood. The removal of dead trees and branches is permitted for people living around forests in all parts of Sudan.

A charcoal market in Khartoum

Sawn timber

In the northern and central states, logging for the production of industrial timber is carried out by contractors under the supervision of sawmill and industry managers who are directly responsible to the State Director of Forests within their respective states. In the southern states, the industry is currently stagnant, but was managed by the military forces on both sides during the conflict.

The sawn timber in the north is mainly from *Acacia nilotica*; in the south, it is extracted from a range of high rainfall savannah woodland species including *Isoberlinia doka, Khaya grandifolia, Milicia excelsa, Khaya senegalensis, Olea hochstetteri, Afzelia africana, Daniellia oliveri, Sclerocarya birrea,* and *Podocarpus milanjianus*.

Traditional construction

There is no detailed data available on wood product usage in traditional construction. One figure much quoted to UNEP, from unknown sources, is that it takes approximately ten young trees to build one *tukul* (traditional round dwelling). With a rural population of over thirty million, the total demand is therefore significant, but anticipated to be much below the fuelwood demand from the same population.

Dried wild fruit for sale in the Tokar region, Red Sea state. Non-wood forest products such as fruit, nuts, and medicinal herbs are important but often under-valued components of the overall value of forests

Sawn teak in Wau, Western Bahr el Ghazal

Non-wood forest products

Gum arabic is Sudan's most important non-wood forest product, with an annual exported crop of approximately 45,000 tonnes. The grey-barked *Acacia senegal* produces *hashab* gum, while the usually red-barked *Acacia seyal* gives *talh* gum. The latter is inferior in quality. The dom nut, a vegetable ivory, is obtained from *Hyphaene thebaica*. Dom nuts are sliced and used as button blanks; an average of 1,500 tonnes is exported annually. Minor products include bee honey and bees wax, the latter being exported at a rate of 80 tonnes per year, palm oil (*Elaeis guineensis*), garad tanning pods obtained from *Acacia nilotica*, lulu (shea oil and butter) from *Vitellaria paradoxa* and the fruits of the shrub species *Capsicum frutescens*. Other vegetal non-wood forest products are fodder (e.g. *Ziziphus spp.*, *Acacia spp.*), edible oils (e.g. *Balanites aegyptiaca*), medicines (e.g. *Tamarindus indica*), dyes (e.g. henna from *Lawsonia inermis, Prosopis africana*), fibres (e.g. *Borassus aethiopum*) and latex (e.g. *Landolfia ovariensis*).

9.4 Forestry sector environmental impacts and issues

There are three key environmental issues for the forestry sector in Sudan:

1. deforestation;
2. the charcoal industry, which constitutes a potential north-south conflict 'flashpoint'; and
3. the southern timber industry development opportunity.

Deforestation – an overall and effectively permanent reduction in the extent of tree cover – is the dominant environmental, social and economic issue affecting the forestry sector in Sudan. The removal of trees has a range of very negative impacts, including increased land and water resource degradation, and the loss of livelihoods from forest ecosystem services.

The second important issue is the risk of renewed conflict over the exploitation of timber resources for charcoal in the north-south border regions. Directly linked to this is the economic opportunity afforded by the forests of Southern Sudan and the challenge of developing a significant new industry while at the same time avoiding deforestation.

A further issue for the forestry sector is the management of invasive species, and specifically of mesquite (*Prosopis juliflora*), which was discussed in the previous chapter. It should be noted that the solutions to this problem are linked to improved management of this resource rather than its elimination.

9.5 Deforestation rates and causes

Measuring the rate of deforestation at the national scale

In the late 1970s, FAO estimated that the country's forests and woodlands totaled approximately 915,000 km², or 38.5 percent of the land area. This figure was based on a broad definition of forests and woodlands as 'any area of vegetation dominated by trees of any size'. It also included an unknown amount of cleared land that was expected to have forest cover again 'in the foreseeable future' [9.5].

An estimate by the forestry administration in the mid-1970s, however, established the total forest cover at some 584,360 km², or 24.6 percent of the country's land area. More than 129,000 km² (about one quarter) of this amount was located in the dry and semi-arid regions of northern Sudan [9.9].

Given this nearly 50 percent difference in baseline depending on definition, it is difficult to make a comprehensive quantitative comparison of deforestation on the national scale since the 1970s, and UNEP has not attempted to do so for this assessment. More exhaustive and rigorous information is available from 1990, when FAO Forest Resources Assessments (FRAs) started to cover Sudan in more detail. The latest assessment work, which was released in 2005, is set out in Tables 14 to 16.

Table 14. Extent of forest and other wooded land in Sudan [9.6]

Extent of forest and other wooded land			
FRA 2005 categories	**Area (1,000 hectares)**		
	1990	**2000**	**2005**
Forest	76,381	70,491	67,546
Other wooded land	–	54,153	–
Forest and other wooded land	**76,381**	**124,644**	**67,546**
Other land	161,219	112,956	170,054
...of which with tree cover	–	–	–
Total land area	**237,600**	**237,600**	**237,600**
Inland water bodies	12,981	12,981	12,981
Total area of country	**250,581**	**250,581**	**250,581**

Table 15. Characteristics of forests and other wooded land in Sudan [9.6]

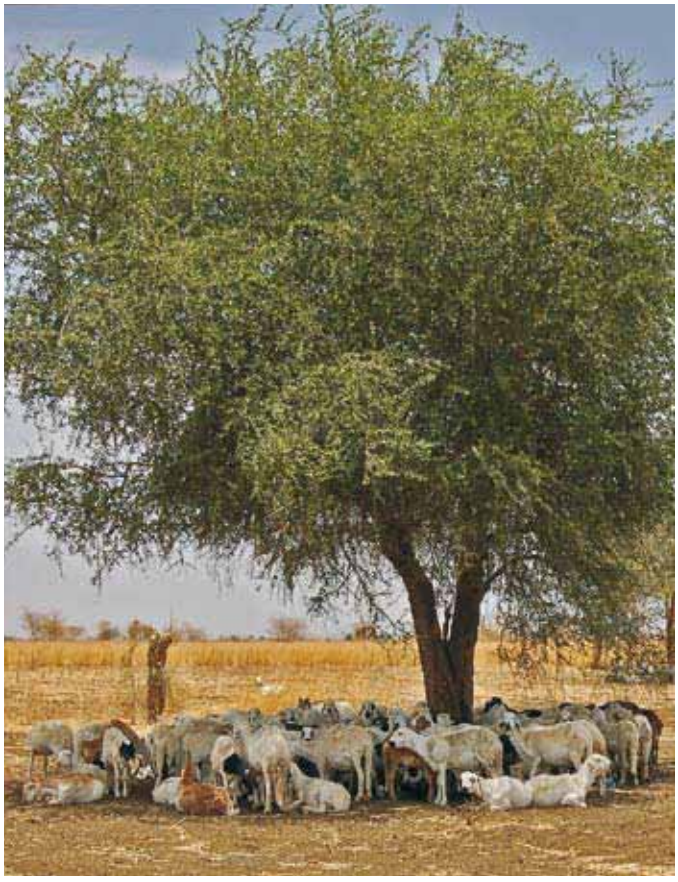
Characteristics of forest and other wooded land						
FRA 2005 categories	Area (1,000 hectares)					
	Forest			Other wooded land		
	1990	2000	2005	1990	2000	2005
Primary	15,276	14,098	13,509	–	–	–
Modified natural	53,467	49,344	47,282	–	54,153	–
Semi-natural	1,528	1,410	1,351	–	–	–
Productive plantation	5,347	4,934	4,728	–	–	–
Protective plantation	764	705	675	–	–	–
Total	**76,381**	**70,491**	**67,546**	**–**	**54,153**	**–**

Table 16. Growing stock in forests and other wooded land in Sudan [9.6]

Growing stock in forests and other wooded land						
FRA 2005 categories	Volume (million m³ over bark)					
	Forests			Other wooded land		
	1990	2000	2005	1990	2000	2005
Growing stock in forests and other wooded land	1,062	980	939	–	–	–
Commercial growing stock	–	–	–	–	–	–

It should be noted that the above table is the result of various inventories and assessments over time, and that the calculation of the change rate is based on World Bank 1985 (reference year 1976) and Africover data (reference year 2000). Due to different classification systems, the change rate was calculated on the combined area of forest and other wooded land and allocated proportionally to the two classes according to the latest estimate (Africover 2000).

Though some agricultural land that was abandoned due to the conflict has regenerated naturally, the clear trend overall has been for significant and consistent deforestation across the country: according to FAO, Sudan lost an average of 589,000 hectares (5,890 km²) of forest per year between 1990 and 2000. This amounts to an average annual deforestation rate of 0.77 percent. Between 2000 and 2005, the rate of deforestation increased by 8.4 percent to 0.84 percent per annum. In total, between 1990 and 2005, Sudan lost 11.6 percent of its forest cover, or around 8,835,000 hectares.



Balanites trees provide vital shade for livestock in 40°C heat

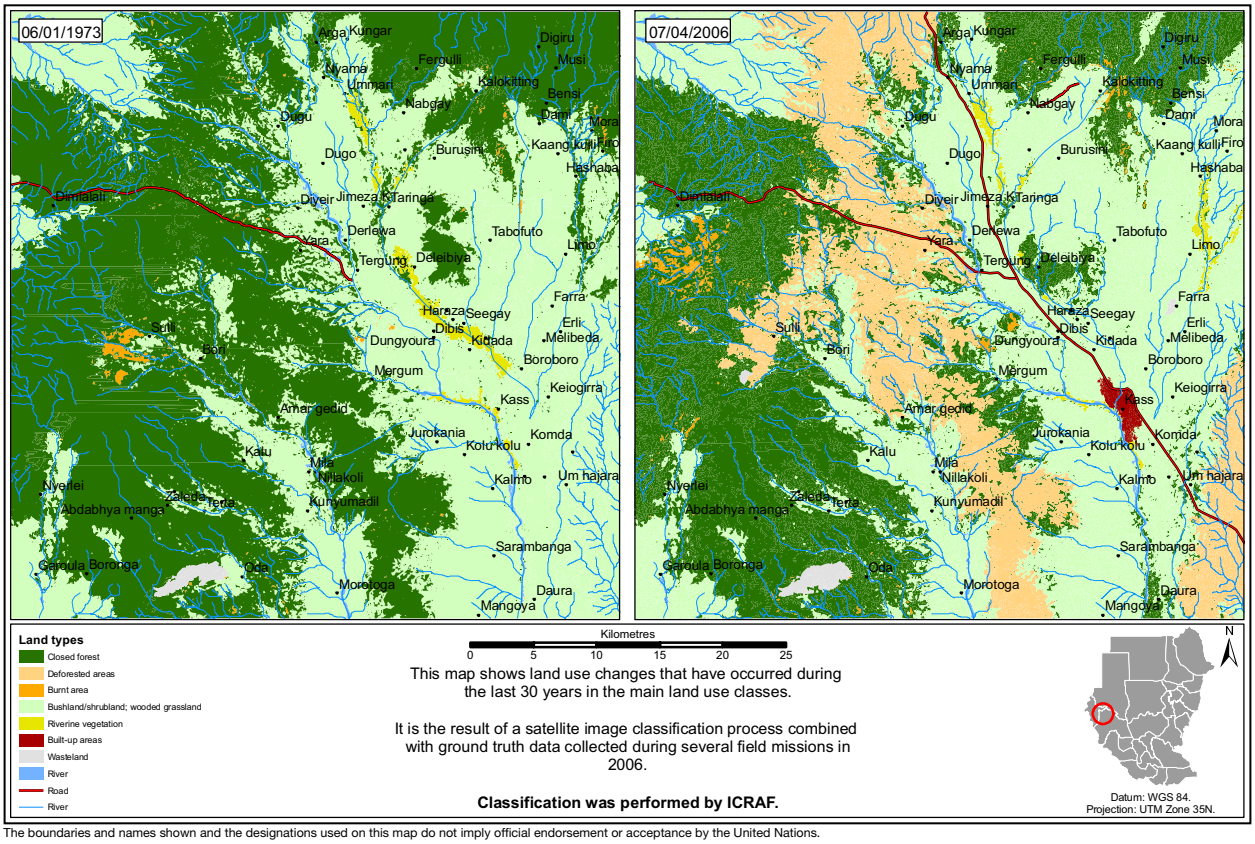
Measuring the rate of deforestation at the district scale

The ICRAF study included detailed remote sensing analysis of fourteen regions over time periods of up to thirty-three years. Each study site covered an area of 2,500 km² and included a number of different land uses. The rate of deforestation was estimated for each site, and is set out in the table below. Note that 'deforestation' here refers to calculated changes in percentage of land use from forested land forms to others, including from closed forests to more open wooded grasslands.

Table 17. Summary of deforestation rates in Sudan from 1973 to 2006

Study area and state	Original and final forest and woodland cover	Annual linear deforestation rate + (period loss)	Comments
North, east and central Sudan			
Ed Damazin, Blue Nile	7.5 to 0.1 from 1972 to 1999	3.6 % (98.6 %)	Wooded grassland replaced by rain-fed agriculture. Some regrowth of closed forest (verification required).
El Obeid, Northern Kordofan	12.0 to 8.7 from 1973 to 1999	1.05 % (27.5 %)	Wooded grassland replaced by rain-fed agriculture. Shelter belts remain.
Shuwak, Kassala	–	–	Non-measurable arid zone, now with both irrigation and mesquite invasion.
New Halfa, Kassala	–	–	Non-measurable arid zone, now with both irrigation and mesquite invasion.
Sunjukaya, Southern Kordofan	29.2 to 8.4 from 1972 to 2002	2.37 % (71.2 %)	Wooded grassland replaced by traditional rain-fed agriculture. Some regrowth as scrubland.
Tokar delta, Red Sea state	15.8 to 26.8 from 1972 to 2001	Mesquite + 2.4 % (+ 170 %)	Reforestation. Non-precise arid zone with mesquite invasion replacing agriculture.
North, east and central Sudan case study averages	Natural forest only	2.37 % (65.7 %)	**Complete deforestation is two-thirds complete by 2001. Predicted to be over 70 % by 2006. Extrapolated near total loss within 30 years.**
	Including invasive species	1.15 % (31.8 %)	Reforestation by invasive species is compensating in total cover by 50 % but still a major net loss.
Darfur			
Jebel Marra, Western Darfur	50.7 to 35.8 from 1973 to 2001	1.04 % (29.4 %)	Closed forest changing to open forest land and burnt areas.
Timbisquo, Southern Darfur	72.0 to 51.0 from 1973 to 2005	1.33 % (29.1 %)	Closed forest and wooded grassland replaced by burnt areas and rain-fed agriculture.
Um Chelluta, Southern Darfur	23.8 to 16.1 from 1973 to 2000	1.20 % (32.4 %)	Closed forest replaced by burnt areas, pasture and rain-fed agriculture.
Darfur case study averages		1.19 % (30.3 %)	**Rapid and consistent deforestation approximately one-third complete by 2006.**
Southern Sudan			
Aweil, Northern Bahr el Ghazal	11.9 to 7.2 from 1972 to 2001	1.38 % (39.4 %)	Closed forest changing to wooded grassland and pasture.
Wau, Western Bahr el Ghazal	76.5 to 51.8 from 1973 to 2005	1.00 % (32.3 %)	Closed and riverine forest and wooded grassland replaced by traditional rain-fed agriculture.
Renk, Upper Nile	6.5 to 0 1973 to 2006	> 5 % (100 %)	Wooded grassland and riverine forest replaced by degraded land.
Yambio, Western Equatoria	80.2 to 51.5 from 1973 to 2006	1.12 % (35.8 %)	Closed forest and wooded grassland replaced by traditional rain-fed agriculture.
Yei, Central Equatoria	29.8 to 19.3 from 1973 to 2006	1.53 % (35.2 %)	Closed forest and wooded grassland replaced by open forest and traditional rain-fed agriculture.
Southern Sudan case study averages		> 2 % (40 %)	**Rapid and consistent deforestation approximately 40 % complete by 2006. Extrapolated near total loss within 50 years.**
National average based on FAO study	30.4 to 26.9 from 1990 to 2005	0.76 % (11.5 %)	**Remote sensing work only.**
National average based on UNEP case studies	Natural forest only	> 1.87 % (48.2 %)	**Rapid deforestation has resulted in the loss of the majority of forests in the north and the same pattern is visible elsewhere in Sudan.**

Figure 9.2 Jebel Marra deforestation



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

This time lapse satellite image of Jebel Marra shows a very destructive pattern of land use change. The closed forest has been extensively degraded to burnt areas and open woodland, with a deforestation rate of 1.04 percent per annum. This clearing has not been matched by an increase in agricultural areas. The only gain has been a marginal increase in grazing land on the steep slopes

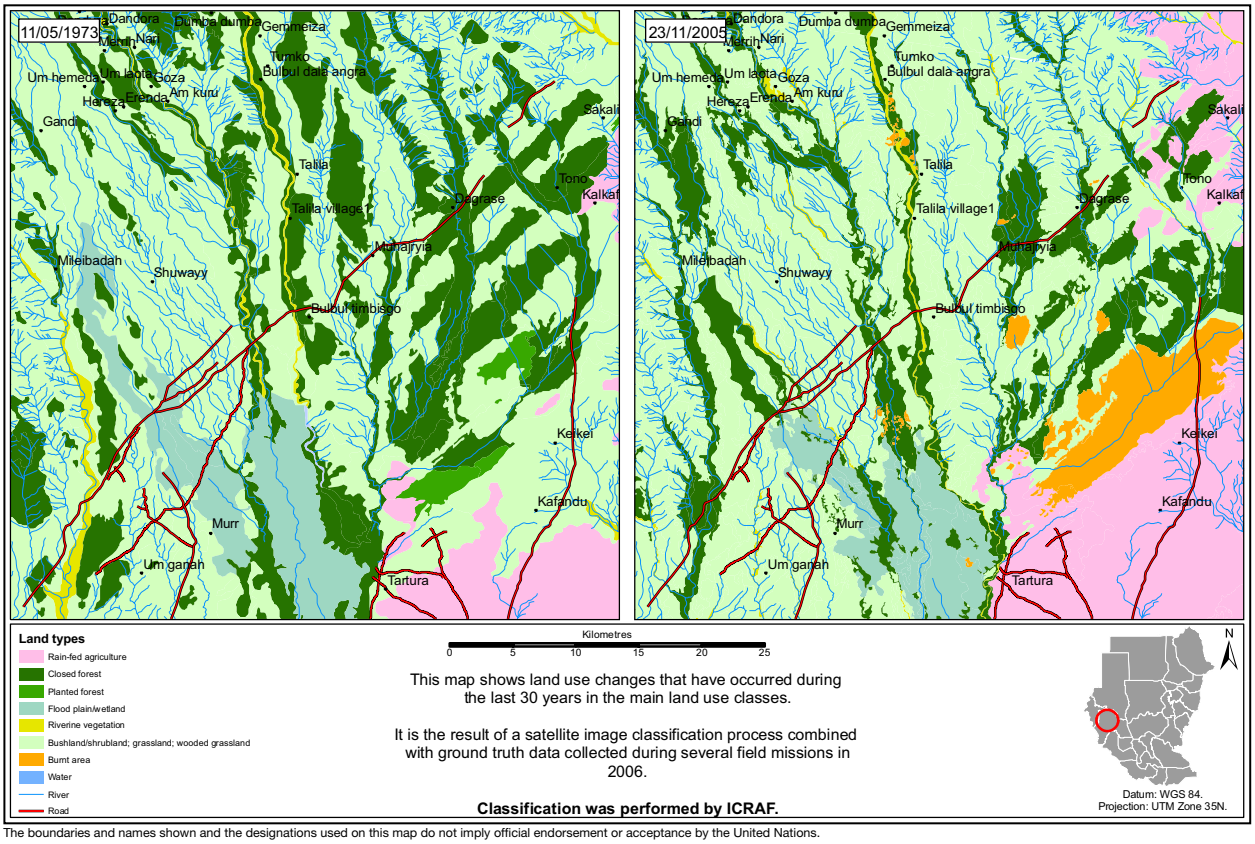
The summary in Table 17 is a gross simplification of the complex land use patterns and changes occurring at each of the fourteen sites, but the overall trends are clear:

1. Northern, eastern and central Sudan have already lost the great majority of their forest cover. The removal of remaining forests is ongoing but has slowed, except in the southern border regions, where removal of the last of the major forests is progressing rapidly. Reforestation of northern and eastern states by invasive species is locally significant.
2. Darfur has lost more that 30 percent of its forests since Sudan's independence and rapid deforestation is ongoing.
3. Southern Sudan has lost some of its forests since Sudan's independence and deforestation is ongoing due to the total dependence on fuelwood and charcoal as the main sources of energy. Deforestation is worst around major towns such as Malakal, Wau and Juba. The study did not include areas distant from major towns, where it is expected that the extent of deforestation could be less severe.

The substantial difference between UNEP and FAO work is considered to reflect the difficulty in quantifying a system with extreme seasonal and annual variations, as well as classification problems due to blurred boundaries between land classes. Based on its fieldwork, UNEP considers its figures to be the best currently available, though they are probably an under-estimation given that most of the quantitative work is based on images one to seven years old, and that all factors point to a gradual increase in deforestation rates over time.

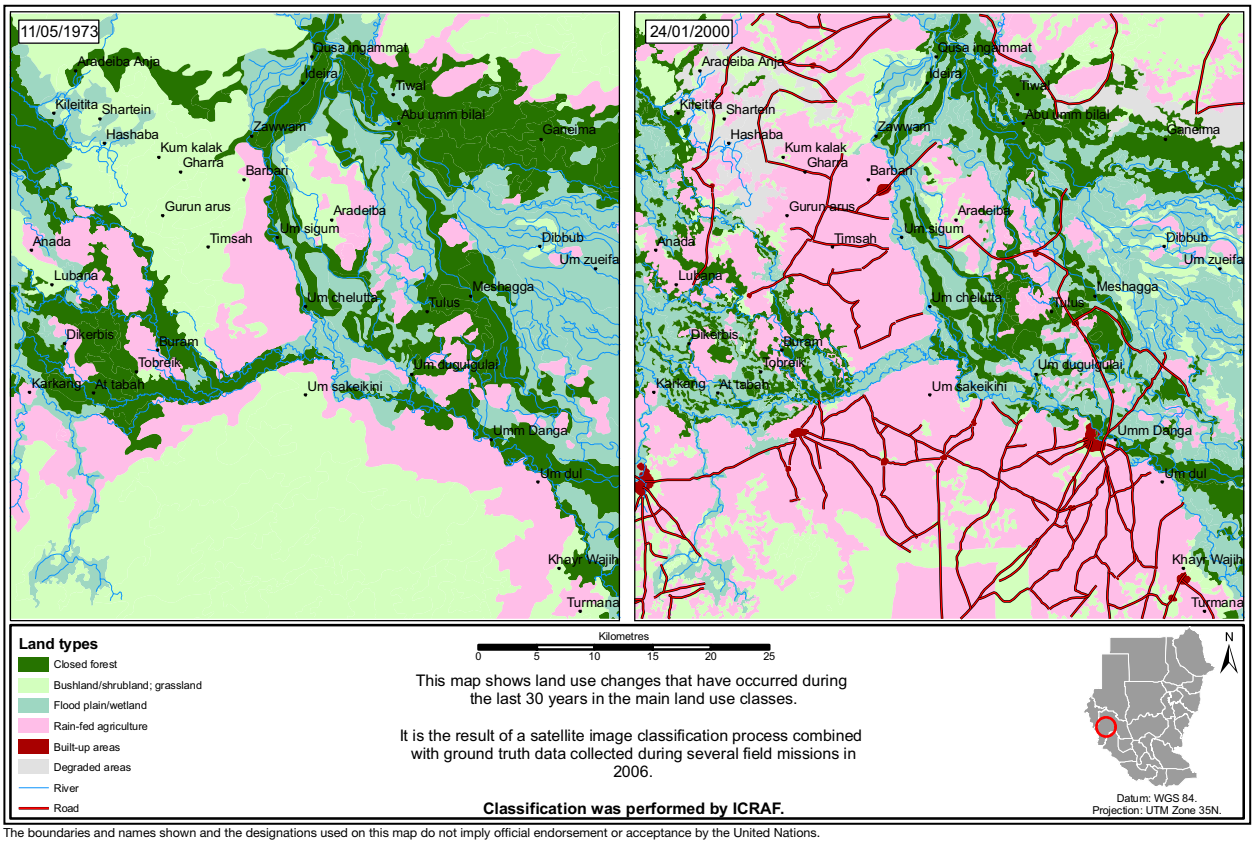
In Figures 9.3a and 9.3b, time lapse satellite images of two sites in Southern Darfur show a similar deforestation trend: the forest is being fragmented and removed in large areas, and replaced largely by traditional slash-and-burn agriculture, which has also taken over rangelands. The annual deforestation rates are calculated at 1.33 percent for Timbisquo and 1.20 percent for Um Chelluta.

Figure 9.3a Southern Darfur deforestation – Timbisquo



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

Figure 9.3b Southern Darfur deforestation – Um Chelluta



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

Causes of deforestation

There are several underlying causes of deforestation; these are cumulative in nature and vary considerably from region to region:

- fuelwood and charcoal extraction;
- mechanized agriculture;
- traditional rain-fed and shifting agriculture;
- drought and climate change;
- overbrowsing and fires;
- direct conflict impacts;
- commercial lumber and export industry (not a major factor); and
- traditional construction (not a major factor and not discussed).

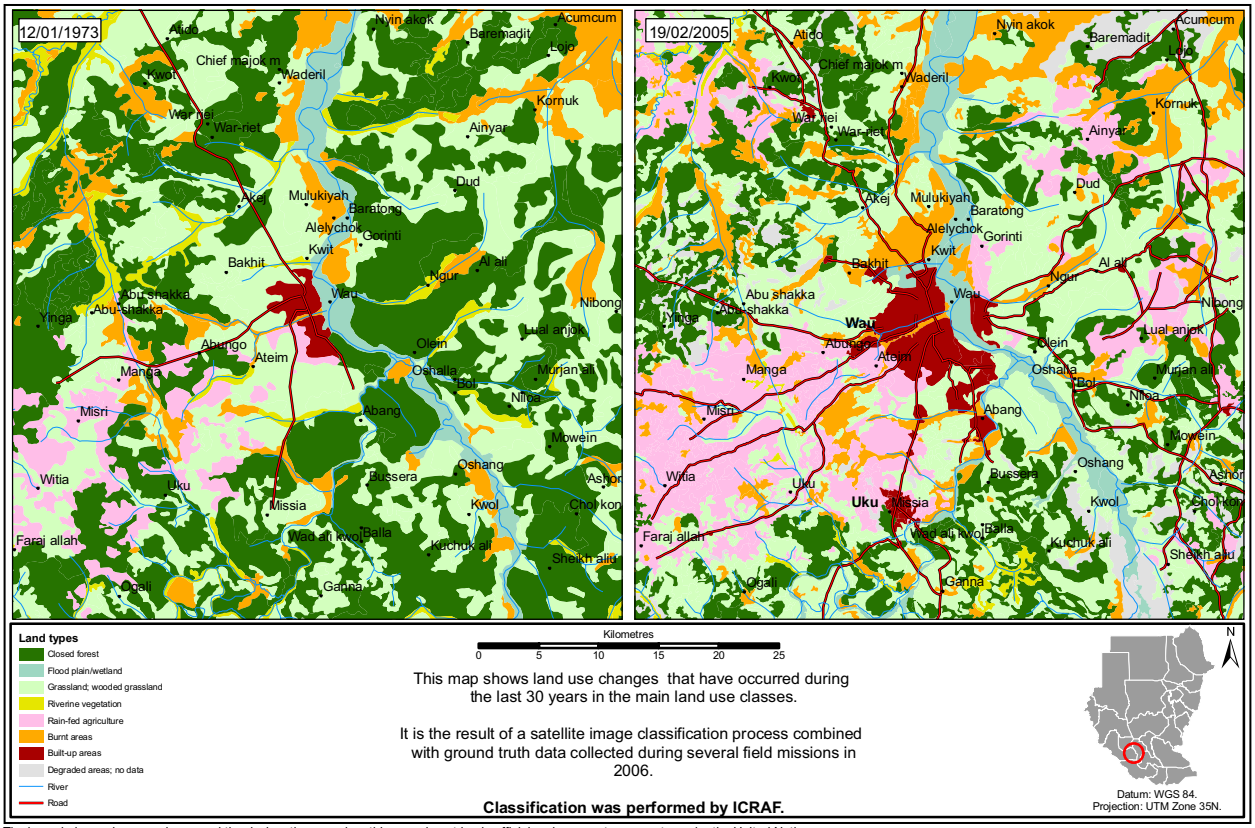
Unsustainable rates of fuelwood extraction

As noted in previous chapters, the unsustainable extraction of fuelwood is a major problem in northern and central Sudan, as well as in refugee and displaced persons camps all over the country and particularly in Northern Darfur. The acacia groves of the Sahel have been extensively harvested for fuelwood, with a resulting rapid advance of deforestation.

The supply of charcoal to northern cities is a major business that is currently depleting the forests of central, southern and western Sudan, particularly Southern Kordofan, the northern part of Upper Nile state and eastern parts of Darfur.

According to the FNC, the charcoal and mechanized agriculture interests work closely together, with

Figure 9.4 Wau deforestation



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

These time lapse satellite images of Wau district in Western Bahr el Ghazal show a complex pattern of intensifying land use leading to deforestation at a rate of one percent per annum and extensive forest fragmentation. Forests are replaced largely by expanding traditional slash-and-burn agriculture and new rangelands. Bare degraded land has appeared in previously forested areas, indicating either overgrazing or exhaustion from traditional cultivation

A brick kiln near Kadugli, Southern Kordofan. The remaining forests of Southern Kordofan are being consumed by the fuelwood and charcoal industries

some cases of unsuitable land being 'cleared' for agriculture in order to collect fuelwood. Together, these two industries are considered to be the primary cause of deforestation in central Sudan.

Expansion of mechanized agriculture

The expansion of mechanized agriculture in central Sudan (see Chapter 8) has occurred at the direct expense of forests. Large amounts of woodland have been cleared in the development of mechanized rain-fed farming in the eastern and central states, as well as smaller amounts in Upper Nile and Southern Kordofan states. Legal requirements to avoid the development of agricultural schemes in forest areas and to retain ten percent of forest as shelter belts have been systematically ignored. These forests were valuable chiefly as protection against desertification, but also as a source of fuel for pastoral people in those regions.

Intensification of traditional rain-fed and shifting agriculture

When practised sustainably, traditional shifting agriculture does not result in a net loss of forest cover. However, the current unsustainable practices induced by population growth are resulting in major loss and fragmentation of forests. The ICRAF study shows that this is the main cause of deforestation in Southern Sudan and Darfur.

Before it was cleared for mechanized agriculture, this land in Blue Nile state consisted of low rainfall savannah and rangeland

Wau district, Western Bahr el Ghazal. When shifting agriculture becomes unsustainable, forest cover disappears permanently

Drought, climate change and desertification

The repeated droughts of the 1970s and 1980s killed a large number of trees in the Sahel belt. Many of these areas have not been recolonized by trees since, as drier conditions and increased land use pressure have reduced the potential for seed distribution, germination and new growth. In regions such as Northern Darfur, the longer-term drop in precipitation has shifted the northern limit for several tree species a significant distance (50 to 200 km) to the south.

It is generally accepted that deforestation can promote desertification due to soil depletion, erosion and sand encroachment. At the same time, the development of hostile conditions causes gradual deforestation as trees die and are increasingly not replaced.

Pastoralist impacts: wildfires and tree browsing

The annual burning practised by pastoralist societies to renew grass and suppress shrubs and tree seedlings has a major impact on tree cover. Another issue is the use of foliage for camel fodder, which is a particular problem in areas like Southern Kordofan and Northern Darfur, where camel herders have migrated into land occupied by cattle herders and farmers. Some slow-growing species such as mangrove forests in Red Sea state have been devastated by camel browsing.

Direct conflict impacts

The scorched earth tactics used by militias in Darfur have resulted directly in localized deforestation. At present, UNEP does not have any detail on the scale of this phenomenon, and can only note its existence.

A settlement in the semi-desert north of El Fasher, Northern Darfur. The combination of drought, desertification, over-population and over-exploitation has drastically reduced forest cover in Northern Darfur

Wildfire in Blue Nile state. Fires lit by pastoralists to promote grass growth destroy existing trees and suppress sapling regrowth

Commercial lumber and export industry

In contrast to the situation in many countries, the commercial finished timber industry has not been a major factor in deforestation to date. Despite the existence of large forest resources in the south, Sudan actually imports finished timber, as poor transportation links and a lack of infrastructure have so far made commercial timber extraction difficult.

During the north-south conflict, both sides were involved in the illicit extraction of hardwoods, but the scale of extraction was limited by security, access and transportation constraints. In Southern Sudan, the main areas partially deforested due to this commercial activity are in the vicinity of Wau, Yei, Nimule and south of Torit. This trade has effectively stalled since the signing of the peace agreement.

This open woodland adjacent to a burnt village near El Geneina, Western Darfur, has been deliberately destroyed

The challenges of tackling deforestation in Sudan

At the national level, current observed rates of deforestation will reduce forest cover by over ten percent per decade. In some areas under extreme pressure, total loss has already taken place or is expected within the next ten years. There is clearly major cause for concern and an urgent need for corrective action.

Inspection of a two-year old plantation in Um Haraza, Sennar state. Reforestation has been successful in central Sudan when the FNC and state officials have been given adequate resources and mandates

The wide range of causative factors for deforestation in Sudan and the extent of regional variation indicate that solutions will have to be area-specific even while addressing national-scale demands. UNEP considers that the task of turning back deforestation in Sudan is unfortunately too large and too difficult to have a realistic chance of success in all regions.

Given the finite resources available to both GONU and GOSS, the first priorities in tackling deforestation should not be to launch large-scale investments in tree-planting or similar ventures. Despite obvious good intentions, there are many examples of destroyed communal forests and shelter belts in the northern states, where deforestation rates have only increased over time. Tree-planting on anything but a gigantic and economically non-feasible scale is unlikely to reverse this trend.

The recommended alternative approach is to analyse the situation in each region, start to resolve the underlying political, social, legal and economic issues, and only then prioritize areas and issues where some degree of success is most likely.

Many areas on the northern edge of the Sahel belt in Sudan are too degraded and too dry for large-scale reforestation to be feasible. Natural regeneration over time may be the only option

This timber bound for sale in Khartoum comes from 500 km south, near Renk in Upper Nile state

9.6 Potential conflict 'flashpoint' over the charcoal industry in Southern Sudan

The unmanaged mining of forest resources by the charcoal industry in the north-south boundary zone is one of several issues that could – in a worst-case but realistic scenario – constitute a potential trigger for renewed conflict at the local level (see Chapter 4).

At present, the charcoal industry in northern Sudan obtains its wood mainly from Southern Kordofan and riverine forests in Blue Nile and Upper Nile states. Current extraction rates are completely unsustainable, and as a result, the industry moves its operations gradually southwards each year.

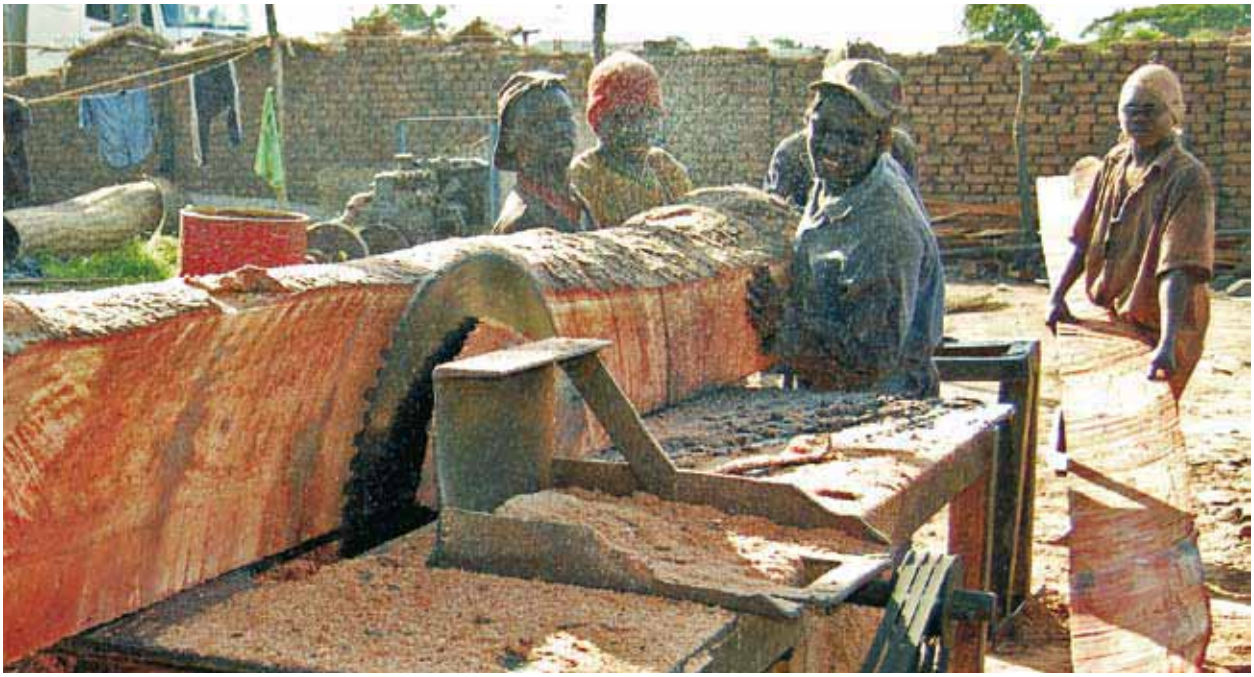
UNEP predicts that within five to ten years, the northern states of Sudan will only be able to obtain sufficient supplies of charcoal from Southern Sudan and Darfur, as all other major reserves will have been exhausted. The extraction of charcoal from Southern Sudan is currently occurring outside any legal framework on resource- and benefit-sharing, and often without local agreement.

In essence, the benefits of the commercially-driven deforestation of the southern state of Upper Nile are flowing north, while the negative impacts are felt in Upper Nile state. This situation provides another catalyst for local conflict in the sensitive border zone.

9.7 Development opportunities for the timber industry in Southern Sudan

Southern Sudan's considerable forest reserves are commercially valuable and could – if managed well – support a significant wealth-creating export industry on a sustainable basis. Existing teak plantations alone could potentially generate up to USD 50 million per year in export revenue. Mahogany reserves could be the source of substantial hard currency as well. The sale of charcoal to the north is also a likely high-growth market.

Yet these resources are currently being wasted and the opportunity lost. Reserves are shrinking due to a combination of slash-and-burn clearance for agriculture, poor harvesting techniques and illegal logging. Meanwhile, a lack of governance discourages legitimate investors. The commercial timber industry needs to be radically reformed, as the trade is widely



The opportunity exists for Southern Sudan to extract much better value from each felled tree than is obtained at present. Teak plantations alone could potentially generate up to USD 50 million per year in export revenue, but the commercial timber industry is in need of reform to ensure that its practices are environmentally sustainable

perceived as badly managed in many parts of the country. Official Southern Sudan Agricultural Revitalization Programme (SSARP) statistics show that some 8,000 m^3 have been exported since 2000, whereas other sources suggest that the figure is more likely to be around 90,000 m^3 [9.7].

The new GOSS Ministry of Agriculture and Forestry declared a temporary ban on timber harvesting in January 2006 and intends to introduce revised timber sales procedures to reduce corruption and illegal logging, and enable the potential of Southern Sudan's forest reserves to be realized. The current harvesting ban is unlikely to remain in place for long, however, as timber is needed for the expanding local construction industries. Foreign logging concessionaires that exported teak in the past are also interested in acquiring new concessions.

Economic drivers will ensure that an export timber industry of some sort will evolve rapidly in Southern Sudan. What is at stake is the environmental sustainability of this industry, and how much benefit flows through to local populations. Political will and rapid action from GOSS, as well as support from the international community, are urgently needed. USAID, the European Commission and others have already started to fund small-scale capacity-building programmes, but more investment is required.

9.8 Forestry sector governance

Robust legislation in the north

Legislation on the use of forests was first developed in the colonial period, with the Woods and Forests Ordinance of 1901, the Forests Ordinance of 1908, and the Forest Conservation Rules of 1917, which designated most forests as government property and established extensive forest reserves.

After independence, the authority of state and local administrations to manage forests was confirmed, and the comprehensive Forest Act of 1989 laid out a range of ownership categories and control measures. Controls over tree-cutting outside reserves were tightened by the requirement of permits. In addition, investors in agricultural schemes were obliged to conserve no less than ten percent of the total area of rain-fed projects and no less than five percent of the total area of irrigated projects to serve as shelter belts and windbreaks. Investors were also obliged to convert cleared trees

into forest products. To manage forestry resources according to the Forest Act of 1989, the Forests National Corporation (FNC) was established as a semi-autonomous self-financing body in the same year. Forestry legislation was again strengthened and significantly modernized by the Forests and Renewable Resources Act of 2002.

Following the signing of the CPA and the adoption of the Interim Constitution in 2005, the responsibility for the management of forestry resources in the south was explicitly assigned to the new Government of Southern Sudan.

Northern and central Sudan enforcement issues

Northern governance issues relating to forests are simple at core: the legislation and structures are appropriate but enforcement and government investment is generally weak.

Throughout its time working with FNC officials in northern and central Sudan, the UNEP team witnessed extensive good work by the organization, but also a complete inability to enforce forestry laws due to a lack of resources and judicial support at the local level. Well-connected elements of the charcoal industry and the mechanized agriculture schemes appeared to be able to bypass the FNC and evade sanctions for obvious major violations. Minor violations are endemic and almost impossible to police.

In consultations, the FNC leadership stated that political support at the federal level was good, but called explicitly for the enforcement of existing legislation and for sound management practices to be translated to the state level. This gap between top level support and conditions on the ground indicates that the challenge will be to transform political will into practical action.

The FNC is in many respects a model organization for natural resource management in Sudan as it is self-managed, technically very competent and has a strong field presence. Its effectiveness, however, is crippled by a lack of support at the ground level. UNEP therefore considers that resolving the forestry governance issues for most of northern Sudan will be relatively straightforward, as only political will (at all levels) and appropriate investments are required. Other success factors are already largely in place.

Illegal charcoal production is a major cause of deforestation in Southern Kordofan

Darfur governance vacuum

Though the FNC is present and GONU legislation remains valid, the current situation in Darfur has led to an effective governance vacuum, with all of the associated negative implications.

Southern Sudan's current vulnerability

The situation in Southern Sudan is completely different from the rest of the country. Since 2005, the management of forests in the south falls to the GOSS Ministry of Agriculture and Forestry. The Ministry is very new and weak, and there are virtually no laws, detailed policies, or operational plans governing the forest resources of Southern Sudan.

No management activities are currently being conducted due to a lack of qualified forest managers. The Department of Forestry, in collaboration with the Kagelu Forestry Training Centre, is attempting to bridge this gap by offering refresher courses to forestry staff in the fields of silviculture, inventory and forest management, but it is expected that it will be some time before best forest practices are applied in the south. The forestry resources of Southern Sudan are thus presently extremely vulnerable to illicit exploitation.

9.9 Conclusions and recommendations

Conclusion

Sudan is in the midst of a genuine deforestation crisis. Most of the resources in northern, eastern and central Sudan have already been lost and the remainder is being depleted at a rapid pace. The large-scale timber resources of Southern Sudan are also disappearing quickly, and are generally being wasted as trees are burnt to clear land for crop-planting and to promote the growth of grass.

The sustainable use of the remaining timber resources in Southern Sudan represents a major development opportunity for the region, and requires both encouragement and the urgent development of governance to avoid potential over-exploitation.

Background to the recommendations

In simple terms, the solution to the deforestation of Sudan is to slow deforestation rates and increase replacement. In practice, however, this is anticipated to be very difficult to achieve, particularly in regions that are still in conflict or under extreme stress due to water shortages. As stated earlier, the recommended approach is to analyse the situation in each region, start to resolve the underlying political, social, legal and economic issues, and prioritize areas and issues where some degree of success is possible.

In Southern Sudan, it is likely that the timber industry will become a self-sustaining major tax and foreign exchange earner for GOSS. Industry and governance development work should therefore be regarded as an investment to jump-start an important industry. The focus should be on infrastructure, environmental and social sustainability, and governance.

Recommendations for the Government of National Unity

R9.1 Undertake an awareness-raising programme at the political level. The delivery of the latest facts and consequences of deforestation in Sudan to its leadership is a high priority. This will entail some further technical work to cover other parts of the north.

CA: AR; PB: MAF; UNP: UNEP and FAO; CE: 0.2M; DU: 1 year

R9.2 Invest in and politically support the Forests National Corporation. At present, this otherwise very capable institution cannot fulfill its mandate due to a lack of political support and funding.

CA: GI; PB: MAF; UNP: FAO; CE: 5M; DU: 3 years

R9.3 Introduce the concept and practice of modern dryland agroforestry techniques. This would entail a combination of awareness-raising, technical assistance and capacity-building, and practical action through demonstration projects in several states.

CA: TA; PB: MAF; UNP: FAO; CE: 2M; DU 5 years

R9.4 Develop a new national management plan and guidelines for mesquite and update the Presidential Decree to fit. This would entail a range of activities including assessment, cost-benefit analysis, governance and capacity-building.

CA: GROL; PB: MAF; UNP: FAO; CE: 0.4M; DU: 1 year

R9.5 Develop and implement a plan to resolve the Darfur camp fuelwood energy crisis. There are numerous options available and many piecemeal 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

Recommendations for the Government of Southern Sudan

R9.6 Undertake an awareness-raising programme at the political level. The delivery of the latest facts and consequences of deforestation in Southern Sudan to its leadership is a high priority.

CA: AR; PB: MAF; UNP: UNEP and FAO; CE: 0.1M; DU: 1 year

R9.7 Undertake capacity-building for the forestry sector. A large-scale multi-year programme is required.

CA: CB; PB: MAF; UNP: FAO; CE: 4M; DU: 3 years

R9.8 Develop legislation for the forestry sector. This work needs to progress from first principles, as soon as possible.

CA: GROL; PB: MAF; UNP: FAO; CE: 0.5M; DU: 2 years

R9.9 Complete a forestry inventory for the ten southern states and set up systems to monitor deforestation rates. This work could be combined with capacity-building.

CA: AS; PB: MAF; UNP: FAO; CE: 0.5M; DU: 1 year

R9.10 Regularize, reform and control the charcoal trade in Southern Sudan, with a focus on Upper Nile and Central Equatoria states. The multiple objectives include conflict risk reduction, resource management, control of corruption and the generation of tax revenue.

CA: GROL; PB: MAF; UNP: FAO; CE: 0.4M; DU: 2 years

R9.11 Introduce the concept and practice of modern agroforestry techniques. This would entail a combination of awareness-raising, technical assistance, capacity-building and practical action through demonstration projects in several states.

CA: TA; PB: MAF; UNP: FAO; CE: 2M; DU: 5 years

R9.12 Introduce the concept of forest product certification for timber export from Southern Sudan. This would entail a sustained development process to set up and embed the system into GOSS.

CA: GROL; PB: MAF; UNP: FAO; CE: 0.3M; DU: 2 years

Recommendations for the international community

R9.13 Introduce the concept and practical aspects of carbon sequestration to Sudan and attempt to integrate this into the forestry sector in the north and south. First and foremost, this would entail research to attempt to match commercial opportunities with potential carbon sinks. Suitable opportunities would then require development, support and oversight for a number of years before becoming commercially self-sustaining.

CA: GROL; PB: GONU and GOSS MAF; UNP: UNEP; CE: 0.3M; DU: 2 years

Freshwater Resources

With almost two-thirds of the Nile basin found within its borders, Sudan enjoys a substantial freshwater resource base. At the same time, 80 percent of the country's total annual water resources are provided by rivers with catchments in other countries. This leaves Sudan vulnerable to externally induced changes in water flows.

Freshwater resources

10.1 Introduction and assessment activities

Introduction

In a country that is half desert or semi-desert, the issue of freshwater availability is critical. At present, much of Sudan's population suffers from a shortage of both clean water for drinking, and reliable water for agriculture. These shortages are a result of natural conditions as well as underdevelopment. Development in this sector is surging ahead, however, and there is now an urgent need to ensure that this growth is environmentally sustainable.

Sudan has a substantial freshwater resource base (from now on referred to simply as water resources). Indeed, almost two-thirds of the Nile basin is found within its borders and its groundwater reserves are considerable. Yet there is a very broad disparity in water availability at the regional level, as well as wide fluctuations between and within years. These imbalances are a source of hardship in the drier regions, as well as a driving force for resource-based conflict in the country.

The unfinished Jonglei canal project in Southern Sudan played an important role in triggering the resumption of the north-south civil war. More recently, large-scale projects such as the Merowe dam have been strongly contested by local communities, and in the arid regions of Darfur, the current conflict also stems partly from issues of access to and use of water. The equitable use of water resources and the sharing of benefits are therefore considered key for the development of the country and the avoidance of further conflict.

In addition, there are several long-standing as well as emerging issues facing Sudan's water sector, including the challenges of providing potable water and sanitation services to a growing population, waterborne diseases, water pollution, aquatic weed infestations, the degradation of watersheds and freshwater ecosystems, and the construction of dams, which is expected to be the dominant factor that will fundamentally alter the environmental integrity of the country's rivers and wetlands over the next twenty-five years.

Wetlands throughout Sudan face a wide range of threats, including dam construction, upstream catchment degradation and oil exploration

Assessment activities

The study of freshwater resource issues in Sudan was an integral part of the general assessment, as water is a cross-cutting subject for virtually all sectors. UNEP teams visited dams, rivers, *khors* (seasonal watercourses), canals, *hafirs* (traditional small water reservoirs), wells and irrigation schemes in twenty-two states. Important sites visited include:

- the main Nile north of Khartoum through to Dongola;
- the White Nile from Juba to Bor and at Malakal, Kosti and Khartoum;
- the Blue Nile throughout Gezira, Sennar and Khartoum states;
- the Gash river at Kassala;
- the Atbara river at Atbara;
- the unfinished Jonglei canal in Jonglei state;
- major dams in central Sudan: Jebel Aulia on the White Nile, the Sennar and Roseires dams on the Blue Nile, and the Khashm el Girba on the Atbara; and
- *hafirs* in Darfur, Khartoum state, Northern Kordofan and Kassala state.

UNEP was not granted access to the Merowe dam but was able to assess the area downstream of the site.

10.2 Overview of the freshwater resources of Sudan

A large but highly variable resource

Sudan's total natural renewable water resources are estimated to be 149 km^3/year, of which 80 percent flows over the borders from upstream countries, and only 20 percent is produced internally from rainfall [10.1]. This reliance on externally generated surface waters is a key feature of Sudan's water resources and is of critical importance for development projects and ecosystems alike, as flows are both highly variable on an annual basis and subject to long-term regional trends due to environmental and climate change.

As detailed in Chapter 3, the share of water generated from rainfall is erratic and prone to drought spells. In dry years, internal water resources fall dramatically, in severe cases down to 15 percent of the annual average.

The main basins

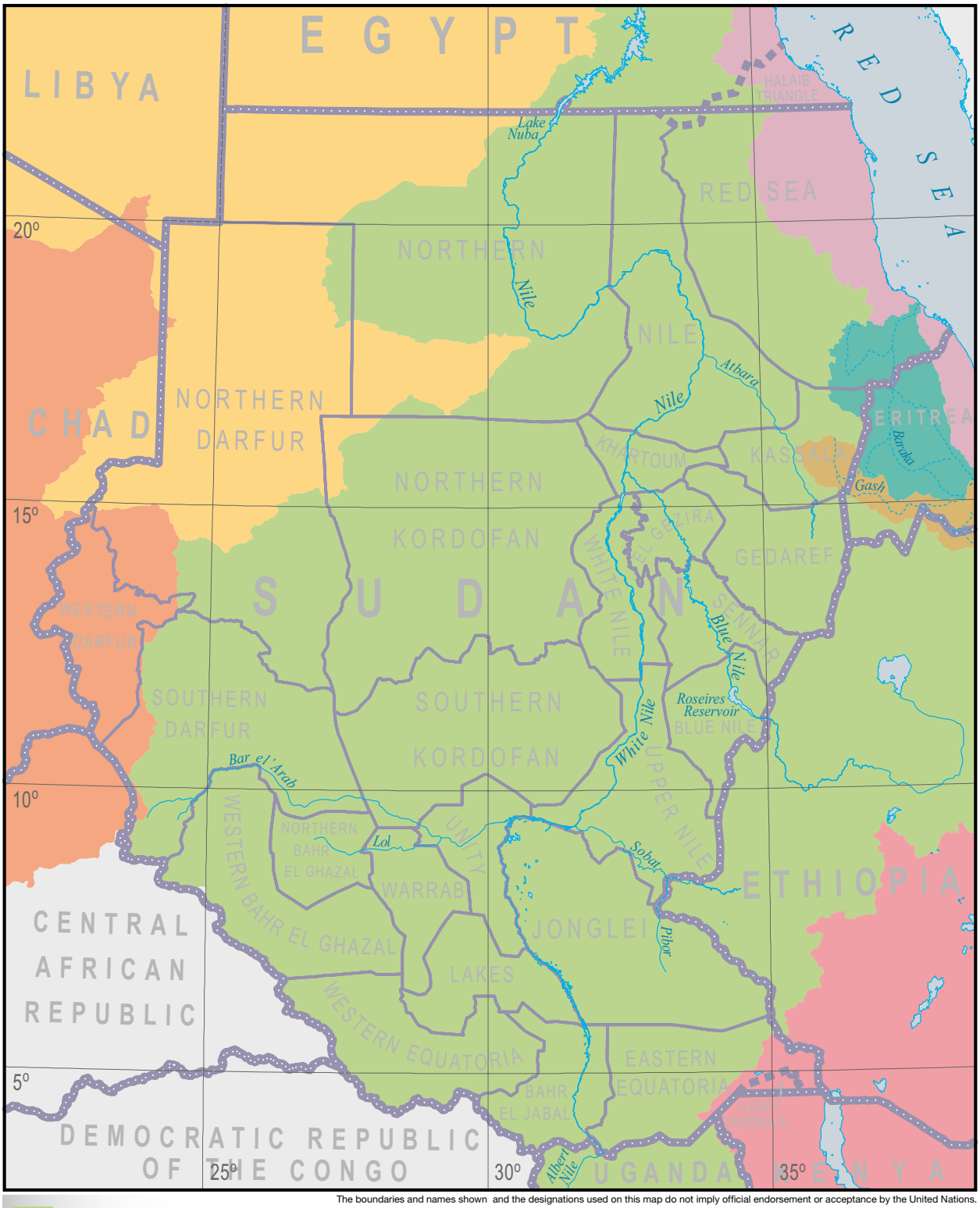
At the watershed level (the basic unit for integrated water resources management), Sudan comprises seven main basins:

- the Nile basin (1,926,280 km^2 or 77 percent of the country's surface area);
- the Northern Interior basins, in north-west Sudan (352,597 km^2 or 14.1 percent);
- Lake Chad basin, in western Sudan (90,109 km^2 or 3.6 percent);
- the Northeast Coast basins, along the Red Sea coast (83,840 km^2 or 3.3 percent);
- Lake Turkana basin, in south-eastern Sudan (14,955 km^2 or 0.6 percent);
- the Baraka basin, in north-eastern Sudan (24,141 km^2 or 1 percent); and
- the Gash basin, a closed basin in north-eastern Sudan (8,825 km^2 or 0.4 percent).

Table 18. Summary data for Sudan water balance [10.1]

Statistic and measurement period or report date	Data /estimate
Water balance (1977 - 2001)	
Internal sources – rain and groundwater recharge	30 km^3 per year
River inflows from other countries	119 km^3 per year
Total	149 km^3 per year
Water currently available for sustainable use (1999)	
Sudan share of Nile water under 1959 Sudan-Egypt treaty	20.5 km^3 per year
Non-Nile streams	5.5 km^3 per year
Renewable groundwater	4 km^3 per year
Total	30 km^3 per year
Nile treaty targets for swamp reclamation (1959)	
Proposed total additional from swamp reclamation projects	18 km^3 per year
Sudan share from proposed projects	9 km^3 per year

Figure 10.1 Sudan hydrological basins



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

- Nile Basin
- Lake Chad Basin
- Northern Interior Basin
- Northeast Coast Basins
- Baraka Basin
- Gash Basin
- Lake Turkana Basin

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

Sources:
SIM (Sudan Interagency Mapping); FAO; vmaplv0, NIMA; hydro1k, USGS; UN Cartographic Section; various maps and atlases.

UNEP/DEWA/GRID~Europe 2006

The dominance of the Nile basin is evident in the fact that nearly 80 percent of Sudan lies within it, and that conversely, 64 percent of the Nile basin lies within Sudan. With the exception of the Bahr el Ghazal sub-basin, all of Sudan's drainage basins – including the main Nile sub-basins – are shared with neighbouring countries. Nile waters, as well as those of the seasonal Gash and Baraka rivers, mainly originate in the Ethiopian highlands and the Great Equatorial Lakes plateau [10.1].

The Lake Chad and Bahr el Ghazal basins are the only ones to receive important contributions from rainfall inside Sudan. These hydrological characteristics underline the importance of international cooperation for the development and sustainable management of Sudan's water resources.

Wetlands, fisheries and groundwater

Sudan boasts a significant number of diverse and relatively pristine wetlands that support a wide range of plants and animals and provide extensive ecosystem services to local populations. The principle wetlands are the Sudd – which is a source of livelihood for hundreds of thousands of pastoralists and fishermen – Bahr el Ghazal, Dinder and other Blue Nile *maya*s, the Machar marshes, Lake Abiad and the coastal mangroves. In addition, there are a large number of smaller and seasonal wetlands that host livestock in the dry season and are important for migrating birds.

The rivers and wetlands of Sudan support significant inland fisheries, which are exploited for sustenance as well as on a commercial basis. Fisheries development is generally limited and is unbalanced, as most of the resources are in the wetlands of Southern Sudan, while most of the fishing is practised in the more limited waters of central and northern Sudan.

Sudan also possesses significant groundwater resources. Indeed, one of the world's largest aquifers – the deep Nubian Sandstone Aquifer System – underlies the north-western part of the country, while the Umm Rawaba system extends over large areas of central and south Sudan, and has a moderate to high recharge potential. In Western Darfur and south-western Sudan, groundwater resources are generally limited but locally significant, due to the basement complex geology. In the coastal zone, finally, the limited groundwater is brackish to saline.

Sudan's wetlands support fisheries, which in turn support communities. Fish caught from a seasonal lake by the While Nile dries on the roof prior to being packed for local markets

Papyrus mat weaving is one of the main sources of livelihood for displaced persons and impoverished communities along the banks of the White Nile

Water consumption

Sudan consumes an estimated 37 km^3 of water per year, of which 96.7 percent are used by the agricultural sector. Withdrawals by the domestic and industrial sectors amount to 2.6 and 0.7 percent respectively [10.1]. Water consumption is mainly reliant on surface waters, but groundwater extraction is rapidly growing. At present, groundwater is chiefly used for domestic purposes and small-scale irrigation in the Nile flood plain and its upper terraces, as well as in the *wadis*.

10.3 Environmental impacts and issues of the water sector

The single most critical issue related to water resources in Sudan today is the new and planned large dams and related development schemes. A number of other issues were also noted in the course of the assessment.

Large dams and water management schemes:

- impacts and issues of existing large dams;
- the Merowe dam;
- the Jonglei canal; and
- planned large dams and schemes.

Other issues:

- traditional dams;
- wetland conservation;
- invasive plant species;
- water pollution;
- groundwater exploitation;
- transboundary issues and regional issues; and
- freshwater fisheries.

10.4 Large dams and water management schemes

Existing large dams: performance problems and major downstream impacts

The situation with existing dams in Sudan can be used as a benchmark to help evaluate the balance of benefits and disadvantages of the country's proposed future dams (next section). UNEP visited all of Sudan's existing large dams: Jebel Aulia on the White Nile, the Sennar and Roseires dams on the Blue Nile, and the Khashm el Girba dam on the Atbara river.

For Sudan, the development benefits of large dams are very clear: they provide the majority of the electricity in the country and support large-scale

irrigation projects. As such, they can be considered a cornerstone of development for the country.

However, like most major water and infrastructure projects, large dams also have a range of negative effects, including environmental impacts. All of the dams visited by UNEP were found to have both performance problems and visible, though variable, negative impacts on the environment. Much of the issues noted are irreversible and possibly unavoidable. Nonetheless, they provide important lessons that can help minimize impacts of future dam projects through improved design and planning.

UNEP's inspection of existing dams highlighted two principal environmental issues:

- performance problems caused in part by upstream land degradation; and
- downstream impacts due to water diversion and changes in flow regime.

Loss of active dam storage by sediment deposition

UNEP considers the performance problems of existing large dams to be cases of environment impacting infrastructure, rather than the reverse. With the exception of the Jebel Aulia dam, all of the reservoirs of Sudan's existing dams are severely affected by sediment deposition. It is estimated that 60 percent of Roseires's storage capacity, 54 percent of Khashm el Girba's, and 34 percent of Sennar's have been lost to siltation [10.3]. The construction of the Roseires dam upstream of Sennar in 1966 significantly decreased the sedimentation problem in the latter.

Islands and seasonal grasses are visible in the Sennar dam reservoir, which is now 60 percent full of sediment

At the Roseires dam reservoir, a dredger is continuously used to remove sediment from the electric turbine water inlets. Soil washed from the Ethiopian highlands is the main source of the sediment

Table 19. Existing large dams in Sudan [10.2, 10.3]

Name	Location	Year of commissioning	Purpose	Capacity (10^9 m^3)		Capacity loss
				Design	Present	
Sennar	Blue Nile	1925	Irrigation, flood control	0.93	0.37	60 %
Jebel Aulia	White Nile	1937	Hydropower	3.00	3.00	0
Khashm el Girba	Atbara river	1964	Irrigation, flood control	1.30	0.60	54 %
Roseires	Blue Nile	1966	Flood control, hydropower	3.35	2.20	34 %
Total Sudan storage capacity				**8.58**	**6.17**	**28 %**
Percentage of Sudan's storage capacity of its share				**46 %**	**33 %**	**13 %**

At Roseires, which currently accounts for 75 percent of Sudan's electricity production, sediments have reached the power intakes, affecting turbine operation and undermining electricity production. Though a proposal exists to raise reservoir storage capacity by increasing dam walls by ten metres, it is unlikely to be a sustainable solution in the long term.

Sediment accumulation is even more severe in the Khashm el Girba reservoir. Flushing is carried out during the flood peak, but this leads to massive fish kills downstream and the reservoir lake is virtually fishless as a result. Reservoirs in seasonal *wadis* are similarly affected: a significant portion of the El Rahad reservoir capacity in *khor* Abu Habil in Northern Kordofan, for instance, has been lost due to high sediment loads. The same is true for the many small check-dams in the Nuba mountains.

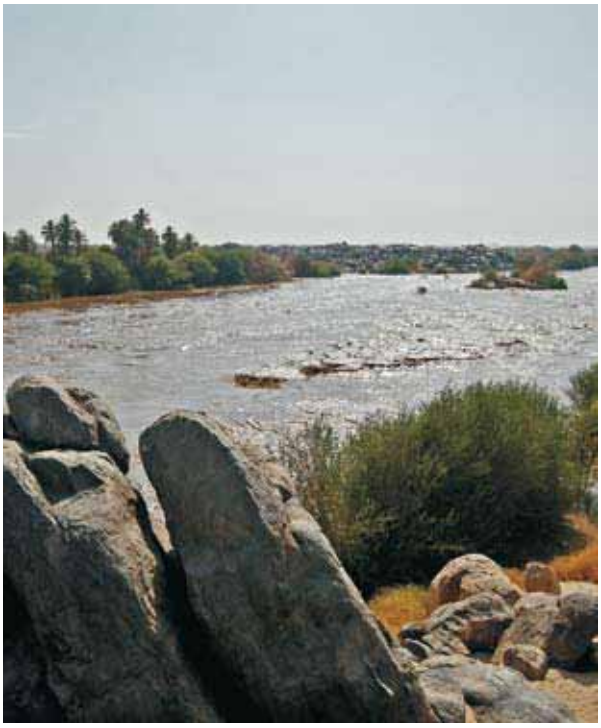
The root cause of the dams' performance problems is linked to upstream land degradation. The high rate of sedimentation in the Blue Nile and Atbara rivers is partly natural, and partly the end result of land degradation and soil erosion in the drainage basins of both Sudan and Ethiopia. Addressing the cause of the sedimentation would therefore require a regional-level undertaking involving substantial revegetation of the watershed and other major works. At present, dam operators are forced to attempt to address only the symptoms of this problem.

Degradation of downstream ecosystems

Sudan's existing large dams have resulted in a major degradation of downstream habitats. The three impacts of most concern are reduced annual flow, removal of annual flood peaks and increased riverbank erosion. These impacts are associated with major dam projects worldwide and are not unique to Sudan.

In simplistic terms, the removal of water and sediment (which silts up the dam reservoirs instead) has resulted in the partial destruction of downstream ecosystems. Both *maya* wetlands (swamps dominated by *Acacia nilotica*) on the Blue Nile, and Dom palm (*Hyphaene thebaica,* an endangered species in Sudan) forests along the Atbara river, have been adversely impacted by the construction of dams, which suppress the flood pulses that nourish these economically valuable ecosystems. The large-scale disappearance of the Dom palm forests in the lower Atbara is at

Prior to the construction of the Khashm el Girba dam, riparian communities relied on water pools of the Atbara river during the dry season. Annual flushing of the dam has sealed many of these ponds with sediment, leaving communities and livestock thirsty



Old plans to construct a dam at the Nile's Third Cataract, near Kerma, have recently been resuscitated as part of Sudan's major dam development programme. Environmental impact assessments and public participation need to be strengthened to ensure that environmental sustainability and social equity are fully integrated into dam building

least partly attributable to the construction of the Khashm el Girba dam. On the Blue Nile, infrequent flooding of the *maya* systems has led to a change in species composition; in some cases their survival has been threatened by hydrologic disconnectivity from the main river [10.4, 10.5].

Downstream of its juncture with the Blue Nile and the Atbara river, the main Nile is threatened by serious riverbank erosion, a phenomenon known locally as *haddam*. Dams on the Blue Nile and Atbara rivers have significantly altered daily and seasonal flows, both in terms of water and sediment flows and in terms of velocity and current direction. Riverbank erosion is discussed in more detail in Chapter 3.

A lack of environmental impact assessment and mitigation

No environmental impact assessments were carried out for the existing large dams in Sudan and their current operation is clearly not influenced by the need to limit ongoing impacts to downstream ecosystems and communities.

There is no doubt that the dams have had a major positive impact on the development of the country and that significant benefits have flowed to the recipients of the diverted waters (the large irrigation schemes). What is unclear is the overall environmental and economic balance of such projects, as the losses to downstream communities and ecosystems have not been fully accounted for. Given the cost of the dams and the observed rate of sedimentation, the economics of future dam projects in this region should be carefully examined.

The Merowe dam

The Merowe dam – which is currently the largest new dam project in Africa – was in the late stages of construction at the time of the UNEP survey. Environmental impacts (outside of construction) had therefore yet to occur, but there was no opportunity to further influence the design, for environmental or other reasons.

The Merowe dam project followed the same pattern as older dams in Sudan. The dam is set to bring massive benefits to the country through electricity generation, but the displacement of upstream communities in the dam reservoir zone has led to unrest and local conflict. What has not occurred is a full and transparent environmental, economic and social impact assessment, to weigh the positive and negative features of the project, and attempt to maximize the positives while mitigating the negatives.

UNEP has completed a very preliminary appraisal of the potential environmental impact of the dam, using the limited documentation available, field visits to the areas downstream of the dam, and the background information provided by visits to existing large dams, agricultural schemes and desert regions in Sudan in 2006 [10.6, 10.7, 10.8, 10.9] (see Case Study 10.1). This analysis shows that the impacts on the downstream communities and ecosystems may be severe and that further assessment is needed as the first step towards mitigating these impacts. Secondly, the envisioned plans for the new irrigation schemes should be reviewed based on the experiences of existing dams and schemes in Sudan.

CS 10.1 UNEP appraisal of the environmental impact of the Merowe dam

The Merowe dam, which is set to double the electricity production of Sudan [10.6], will undoubtedly contribute massively to the development of the country and provide a host of benefits. It is the first large dam project in the country to include any form of environmental impact assessment (EIA). It also features an organized resettlement plan for affected downstream populations.

However, like all new large dams worldwide, the Merowe project is surrounded by controversy related to its projected and actual social, environmental and economic impacts. UNEP, focusing on the environmental aspects only, has conducted an appraisal of the Merowe EIA process, associated documents and the actual environmental issues. The findings indicate several areas of concern.

The Merowe dam is the most upstream major development on the main Nile and is currently the largest dam development in Africa after the Aswan dam in Egypt. Reservoir impoundment will lead to the loss of 200 km of riverine farmland and habitat [10.7], permanently and radically changing the downstream ecosystem of a region that supports hundreds of thousands of people. A major new irrigation scheme is also planned.

The Merowe dam EIA license was only issued in 2005, over two years after work on the project physically started in early 2003. The EIA document was developed by a foreign consultancy working primarily on the dam design process, and had little connection to the potentially impacted communities. The report is apparently now publicly available from the Ministry but has not been disseminated, and no public hearings have been held concerning its findings.

Properly undertaken, an EIA process can provide a credible framework for the affected people to communicate their concerns and gain the trust of the project's proponents. In this case, however, the delays and closed approach undermined the entire process in terms of impact analysis and mitigation, and public buy-in.

UNEP's technical analysis and reconnaissance fieldwork downstream of the dam site indicated several significant impacts that were not addressed in the EIA:

- **Silt loss for flood recession agriculture and dam sedimentation:** The dam will collect the fertile silt that kept the downstream riverine agricultural systems (*gerf* land) viable. This issue alone places the downstream communities at major risk. As other existing large dams, the Merowe dam is likely to be affected by high rates of sedimentation. During consultation, Ministry officials indicated that a sediment flushing routine is planned during operations, but the details and impacts of this are unclear.

- **Riverbank erosion:** The dam's power plant is scheduled to operate at full capacity during four hours per day releasing 3,000 m^3/s; during the remaining time, only two of the ten turbines will run, generating 600 m^3/s [10.6]. The concentration of discharge over a short time period and the resulting strong four to five metre daily fluctuations in water levels will almost inevitably have major detrimental effects on the riverbanks and adjacent agricultural schemes.

- **Reduced river valley groundwater recharge:** The Nile is typically full for five to six months of the year, but the dam's construction will lower the base flow considerably, which is likely to disrupt groundwater refilling over a great distance downstream of the dam. This could have significant consequences for the expanding cultivation of the upper terraces, which relies increasingly on small tube wells (*mataras*) for year-round irrigation.

- **Questionable net gain on food production:** In combination, the above effects may seal the fate of much of the downstream farmland. While the dam project does include a planned new irrigation scheme, assessments of existing schemes in Sudan indicate that they commonly perform well below design expectations (see Chapter 8). In the case of Merowe, the proposed new irrigation areas are low fertility desert soils in a hyper arid and extremely hot environment. The overall net gain in terms of food production should be re-examined closely based on prior dam performance and projected downstream economic losses.

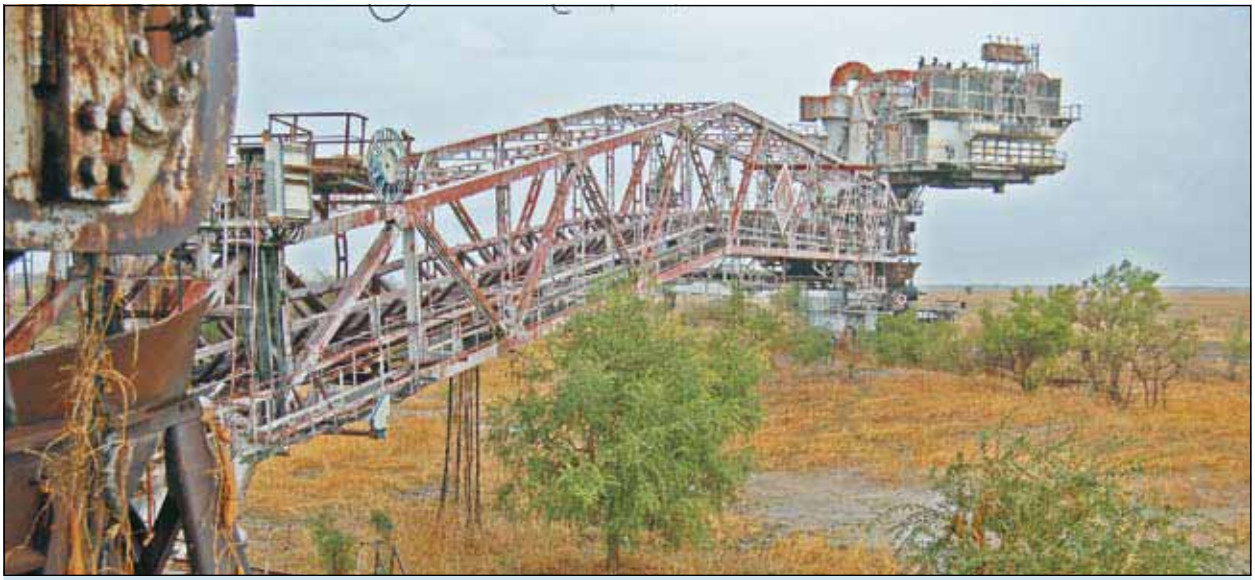
- **Blocking of fish migrations and the impact on locally endangered species** like the Nile crocodile. These issues were not addressed in the EIA.

None of the downstream scheme managers and farmers interviewed by UNEP had been presented with the findings of the dam's EIA report. Neither were they aware of any studies to assess the dam's impact on bank erosion, or consulted about its potential implications, despite the fact that they reportedly made repeated requests to the dam authorities for clarification on this issue. Ministry officials have indicated that a consultation process for downstream communities is planned.

The dam is now built and filling up. It is therefore too late to make any changes to its core design. What is possible and indeed needed, however, is an urgent follow-up impact analysis aimed at assessing what can be done to minimize the negatives and accentuate the positive impacts of this mega-project. Key areas to address include the planned flow regime and the irrigation scheme plans.

Figure 10.2 Merowe dam

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



The main channel excavator is composed of several self-propelled sections. Once the largest of its type in the world, it now lies in a derelict state in the canal bed

CS 10.2 The Jonglei canal

Launched in 1980, the construction of the Jonglei canal was interrupted by the outbreak of conflict in Southern Sudan in 1983. Though the economic motivations for the project still exist for some parties, a combination of political issues, economics and environmental concerns make the resumption of construction unlikely.

The idea of using a canal to bypass the Sudd wetlands was first conceived in the early 1900s by Egyptian and British authorities. The White Nile loses up to 50 percent of its annual flow through evaporation and evapotranspiration as it winds through the Sudd. A canal could potentially capture this water for downstream users, as well as partially drain the wetlands for agriculture [10.10, 10.11].

The project in its modern form was developed during the 1970s. The project team included multinational contractors and financiers, and had the strong support of the Khartoum government, as well as of Egypt and France. In contrast, there was little knowledge and even less acceptance of the project by local stakeholders, who were principally transhumant pastoralists and a minority population of subsistence farmers and fishermen. It is likely that the project would have resulted in a net negative impact for local communities, due to the loss of *toic* grazing land and fishing sites.

Of the canal's planned 360 km, approximately 260 km were excavated before southern Sudanese rebel military forces sabotaged the main excavator in 1983, rendering the construction too dangerous to continue. The canal excavator now lies in a derelict and corroded condition, and is probably irreparable. The canal itself does not connect to any major water bodies or watercourses, and acts only as a giant ditch and embankment superimposed on a very flat seasonally flooded plain. It is approximately eighty metres across and up to eight metres deep, including a four-metre embankment.

The canal channel has gradually filled due to erosion and lack of maintenance, reducing the angle of its slopes to a maximum of 35 degrees. It has been extensively reclaimed by vegetation, with sparse to dense woodland and scrub found along both sides. In addition, the central channel is seasonally flooded to a depth of one to two metres and supports a significant fish population and an evolving ecosystem.

The canal bank is now being used as the route for the new Juba-Malakal road, which is expected to have significant direct and indirect impacts on the environment of the canal.

The canal course cuts across the migration pathways of the white-eared kob (*Kobus kob leucotis*) and the tiang (*Damaliscus lunatus tiang*) [10.12, 10.13], and was noted to be a partial barrier to migration in the 1980s, causing concentration at preferred crossing points and increasing losses due to falls, predators, poaching and drowning. In its current condition, however, the canal is not considered to represent a significant physical barrier to larger wildlife, except in the wet season when swimming is required to cross some sections. In order to fully remove the migration barrier and avoid any inadvertent hydraulic connection to the Nile, the canal would need to be partially filled in to form land bridges at a number of points.

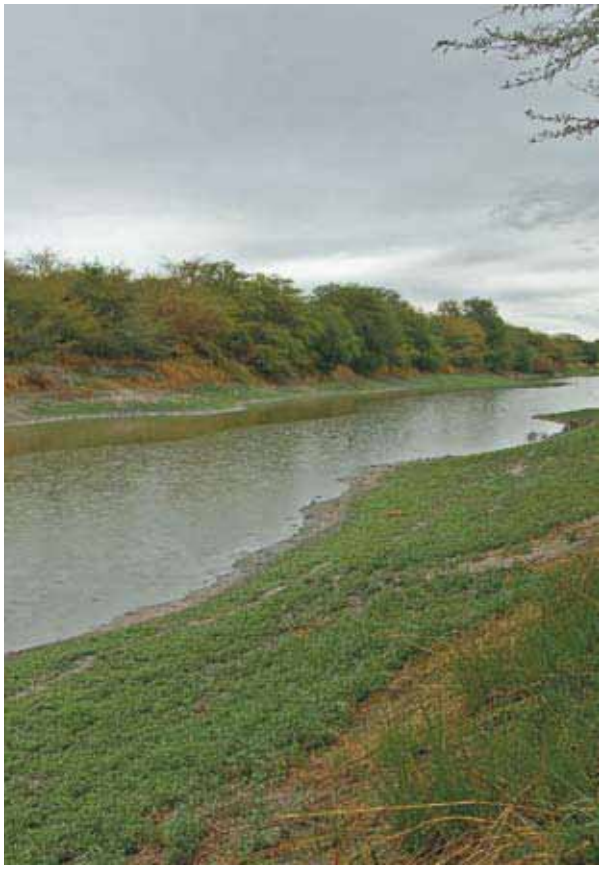
In its original design, the canal project would have had major negative environmental impacts on the Sudd wetlands [10.14]. The viability of the project is questionable on these grounds alone, irrespective of the numerous social, political and economic issues attached to any potential resumption of the construction. However, the principal lesson learnt from the Jonglei canal is that major ventures lacking local support are at risk, and that achieving such support requires both broad consultation and benefit-sharing.

The Jonglei canal

The Jonglei canal project – an unfinished project to build a canal to bypass the Sudd wetlands and capture the water for downstream users – was closely linked to the resumption of north-south conflict in 1983 and had strong international ties. As it was never completed, its anticipated major environmental impacts never came to pass. However, lessons learnt from this project (see Case Study 10.2) should be applied to both existing efforts in peacebuilding between north and south, and to future development plans for the Nile, as promoted by a range of local, regional and international interests.

Massive dam development in the planning stages

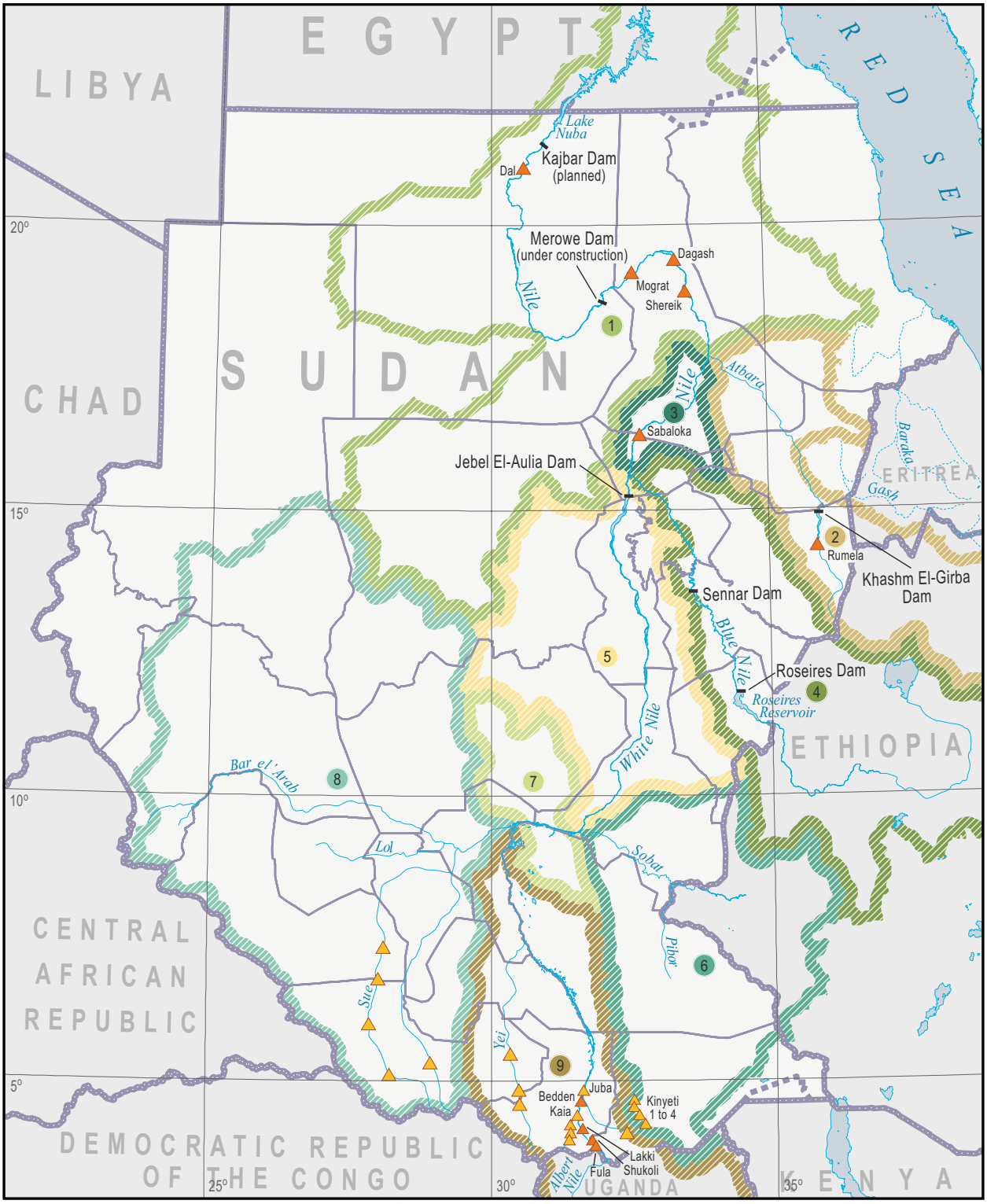
As of late 2006, the Government of National Unity is on the verge of launching a new and ambitious dams building programme (in addition to the Merowe dam). The importance conferred on dams is reflected in the September 2005 decision by Presidential Decree No. 217 to place the Dams Implementation Unit (formerly known as the Merowe Dam Project Implementation Unit) under the President's Office. More than two dozen dam feasibility studies are planned or currently underway. In Southern Sudan, an important hydropower programme is envisioned on the White Nile.



As the unfinished Jonglei canal is not connected to any major watercourse or water body, it is currently a 260 km-long ditch. The channel has been eroded and revegetated, and is seasonally flooded, supporting a new ecosystem

The unfinished Juba-Malakal trunk road project includes a 250 km stretch to be built on the west bank of the Jonglei canal. Approximately 100 km had been built by mid-2006, opening this remote area up for development

Figure 10.3 Nile sub-basins, dams and hydroelectric schemes



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

Nile Sub-Basins

1 Lower Nile
2 Atbara
3 Nile
4 Blue Nile
5 Lower White Nile
6 Sobat
7 White Nile
8 Bar el Ghazal
9 Upper White Nile

Potential Hydroelectric Sites

Major hydroelectric site
Minor hydroelectric site

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

Sources:
SIM (Sudan Interagency Mapping); FAO; vmaplv0, NIMA; hydro1k, USGS; GONU Ministry of Water Resources; UN Cartographic Section; various maps and atlases.

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The history of major water scheme development in Sudan is mixed. This is partly linked to the method of project development: dams and water schemes have historically been promoted by decree at the federal level, with limited or no local consultation, and no environmental impact assessments. This approach failed for the Jonglei canal in 1983 and has elicited problems for the Merowe dam project as well.

Controversy generated by major water schemes is certainly not unique to Sudan. Dams have and continue to be strongly contested in many countries. In recent years, they have been the subject of an intensive debate at the international level, most notably by the World Commission on Dams [10.15].

However, as Sudan surges ahead with its construction plans, it is in an advantageous position to re-examine its own national experience, as well as draw on the knowledge base and latest lessons learned from regional and global dam reviews, so as to avoid repeating past mistakes.

Two of the underlying strategic tenets recommended by the World Commission on Dams are 'gaining public acceptance' and 'recognizing entitlements and sharing benefits' [10.15]. For Sudan, this would require the revision of top-down approaches by which the decision to construct a dam is made by decree. Information-sharing and an open and transparent public and multi-stakeholder consultation process need to be institutionalized in Sudan's dam sector. This also implies that dams should not be regarded as an end in their own right, but rather be evaluated and discussed within the context of defined water and energy needs and the full range of available options to meet those demands.

Sedimentation of traditional small dams and water-harvesting structures

The small traditional dams inspected by UNEP did not have any of the environmental impacts of larger dams, but did have a number of performance problems. In addition, they provided clear examples of how local conflict over scarce natural resources can arise.

Traditional dugouts fed by rainwater and run-off (called *hafirs*) have played a critical role for centuries – in Darfur and Kordofan in particular – in supplying water for domestic use in villages and to pastoralists in remote areas vulnerable to erratic rainfall variations. However, increasing siltation from topsoil erosion and drifting sands as well as poor maintenance have led either to a serious decline in the water storage capacity or to the outright loss of many *hafirs*.

Due to increasing competition over limited water supplies, many *hafirs* have become 'flashpoints' between pastoralists and farmers. The situation has been compounded by the development of horticultural schemes around *hafirs*, as witnessed in Southern Kordofan [10.16].

Lack of investment and maintenance during the conflict years led to complete or partial loss of many hafirs, such as this one at El Tooj, near Talodi in Southern Kordofan. Constructed in 1972 as part of a national campaign to eradicate thirst, the water treatment facility was targeted during the conflict and local communities have been drinking untreated water ever since

A small dam complex in Darfur, with a banked catchment area, storage dams and associated small-scale irrigated agriculture

10.5 Sustainable use and conservation of wetlands

An important national resource under pressure

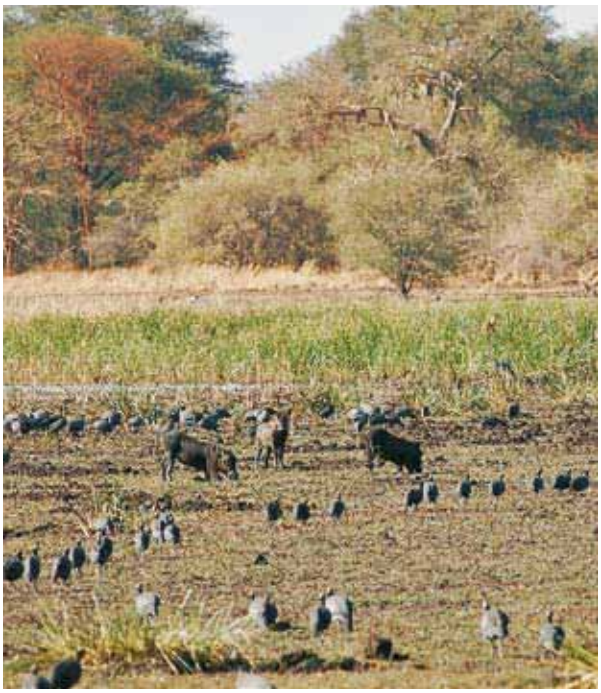
UNEP has found that most of Sudan's major wetlands are currently facing significant conservation threats.

During the long north-south conflict, wetlands in the south were adversely affected by uncontrolled hunting and poaching. With peace, the country's wetlands in all areas are under mounting pressure from development plans. The most significant issues are major infrastructure projects such as oilfields, dams and water engineering projects, roads, housing schemes, conversion for agriculture and settlement, as well as resource over-exploitation by a growing population. Other emerging threats include invasive alien species, namely water hyacinth and mesquite. This all points to the necessity of developing strategic action plans and building national capacity aimed at the wise use of wetlands.

Issues related to the Sudd are covered in Case Study 10.3, while the remaining mangrove wetlands – which are in steep decline and in urgent need of protection – are discussed in Chapter 12. The Machar marshes are very remote and were not visited by UNEP, but the Governor of Upper Nile state reported that the construction of roads for oil exploration constituted a major risk for the marshes. As for the Bahr el Arab wetlands, the principle threat is considered to be habitat degradation by land clearance for agriculture, overgrazing and fires.

Degradation of the Blue Nile wetlands

The *maya* ecosystems of the Blue Nile are badly degraded and in continuing decline. UNEP visited seven *maya*s (swamps dominated by *Acacia nilotica*) along the Blue Nile and found them all to be degraded by accelerated siltation. Several, such as Um Sunut and Kab in Gezira state and El Azaza in Sennar state, were effectively disconnected from the main river. The main causes of this decline are upstream dam construction and catchment changes. Other issues include extensive felling of riverine forests, damage from overgrazing and wildlife poaching.



Mayas like this one in Dinder National Park play a critical role in supporting wildlife populations during the dry season

Table 20. Status of the six most significant wetlands in Sudan [10.2, 10.17, 10.18, 10.19. 10.20]

Wetland	State(s)	Approximate size	Ecosystem integrity
Sudd	Jonglei, Unity, Upper Nile	57,000 km^2	Generally in very good condition
Machar marshes	Upper Nile	6,500 km^2	Status unknown
Blue Nile mayas, including Dinder	Blue Nile, Sennar	Discontinuous (< 1,000 km^2)	Moderately to heavily degraded
Bahr el Arab	Northern Bahr el Ghazal, Warrab, Unity	Discontinuous	Status unknown
Lake Abiad	Southern Kordofan	5,000 km^2	Moderately degraded
Red Sea mangroves	Red Sea state	Linear and discontinuous (< 100 km^2)	Badly degraded and shrinking

The plant biota of the Sudd range from submerged and floating vegetation in the open water to swamps dominated by papyrus. Over 350 plant species have been identified in the wetland

CS 10.3 The Sudd wetlands

Sudan has some of the most extensive wetlands in all of Africa and until recently, only a small percentage of this important habitat had any legal protection. In June 2006, however, the Sudd wetlands were listed as a site under the Ramsar Convention.

The Sudd is the second largest wetland in Africa, and the ecosystem services it provides are of immense economic and biological importance for the entire region. In the rainy season, the White Nile and its tributaries overflow to swell the Sudd swamps situated between the towns of Bor in the south and Malakal in the north. The swamp habitats themselves cover more than 30,000 km^2, while peripheral ecosystems such as seasonally inundated woodlands and grasslands cover a total area some 600 km long and a similar distance wide. The flooded area varies seasonally and from year to year, due to variations in rainfall and river flows. Its greatest extent is usually in September, shrinking in the dry season.

The plant biota of the Sudd range from submerged and floating vegetation in the open waters to swamps dominated by *Cyperus papyrus*. In addition, there are extensive phragmites and typha swamps behind the papyrus stands. Seasonal floodplain grasslands up to 25 km wide are dominated by wild rice *Oryza longistaminata* and *Echinochloa pyramidalis*. Over 350 plant species have been identified, including the endemic *Suddia sagitifolia*, a swamp grass [10.17].

The swamps, floodplains and rain-fed grasslands of the Sudd also support a rich animal diversity, counting over 100 species of fish, a wide range of amphibians and reptiles (including a large crocodile population) and 470 bird species [10.17]. The swamps host the largest population of shoebill (*Balaeniceps rex*) in the world: aerial surveys in 1979-1982 counted a maximum of 6,407 individuals. Hundreds of thousands of birds also use the Sudd as a stopover during migration; migratory species include the black-crowned crane (*Balearica pavonina*), the endangered white pelican (*Pelecanus onocrotalus*) and the white stork (*Ciconia ciconia*).

In addition, more than 100 mammal species have been recorded. Large mammals have always been hunted by local communities as an important food source. Given the present widespread availability of modern weaponry, however, the current status of large mammals, including elephants, needs to be reassessed urgently. Historically, the most abundant large mammals have been the white-eared kob (*Kobus kob leucotis*), the tiang (*Damaliscus lunatus tiang*) and the Mongalla gazelle (*Gazella rufifrons albonotata*), which use the floodplain grasslands in the dry season [10.21]. The endemic Nile lechwe (*Kobus megaceros*) and the sitatunga (*Tragelaphus spekii*) are resident, and it is anticipated that there are still significant populations of hippopotami (*Hippopotamus amphibius*).

The ecosystem services performed by this immense wetland, which extend far downstream, include flood and water quality control. Other services within the ecosystem itself are year-round grazing for livestock and wildlife, fisheries, and the provision of building materials, among many others. The Sudd is inhabited principally by Nuer, Dinka and Shilluk peoples, who ultimately depend on these ecosystem services for their survival. The central and southern parts of the Sudd have small widely scattered fishing communities. Up to a million livestock (cattle, sheep and goats) are kept in the area, herded by the pastoralists to their permanent settlements in the highlands at the beginning of the rains in May-June and down to intermediate elevations during the dry season. Crops include sorghum, maize, cowpeas, groundnuts, sesame, pumpkins, okra and tobacco.

There are three protected areas in the Sudd: Shambe National Park, and the Fanyikang and Zeraf game reserves. In June 2006, an area totaling 57,000 km^2 was declared Africa's second largest Ramsar site [10.17].

The Sudd and its wildlife are currently at risk from multiple threats, including oil exploration and extraction, wildlife poaching, pastoralist-induced burning and overgrazing, and clearance for crops. The resumption of the Jonglei canal project would also put the wetland at significant risk. Listing the Sudd as a protected site under the Ramsar Convention is an important but mainly symbolic initiative that now needs to be consolidated with practical measures to help conserve this critical natural asset.

10.6 Invasive plant species

Infestations on land and water

The watercourses of Sudan are afflicted with two invasive species: water hyacinth, which threatens the Nile basin watercourses, and mesquite, which has infested many of the seasonal *khors* and canals of northern Sudan. Mesquite is covered in detail in Chapter 8.

Water hyacinth

The most problematic aquatic weed in Sudan is water hyacinth (*Eichhornia crassipes*), a native plant of South America that was officially declared an invasive pest in 1958 [10.22]. Water hyacinth forms dense plant mats which degrade water quality by lowering light penetration and dissolved oxygen levels, with direct consequences for primary aquatic life. The weed also leads to increased water loss through evapotranspiration, interferes with navigation and fishing activities, and provides a breeding ground for disease vectors such as mosquitoes and the vector snails of schistosomiasis.

Water hyacinth (Eichhornia crassipes) grows rapidly; until recently, it had invaded the entire stretch of the White Nile from Juba to Jebel Aulia

Workshops of the Ministry of Agriculture's Water Hyacinth Control Division at Jebel Aulia lie idle as funding from donor agencies has dried up. The northern limit of hyacinth infestation is now reportedly between Kosti and Duweim, although its presence was cited in the Jebel Aulia dam reservoir in June 2006, for the first time in seven years

The Jebel Aulia dam has served as a barrier to the spread of the invasive water hyacinth

A 1,750 km stretch of the White Nile, from its upper reaches near Juba to Duweim (some 70 km south of Khartoum), is infested. The hyacinth spread used to extend to the Jebel Aulia dam, but a causeway at Duweim is apparently acting as a precarious barrier to downstream propagation. In Sudan, control measures initially relied on large-scale applications of chemicals. An estimated 500 tonnes of the herbicide 2, 4-D were applied to the White Nile annually [10.22]. This practice has now ceased, but it may have had significant long-term impacts on aquatic life and human health; these have not yet been assessed. Mechanical and biological control methods have also been used in Sudan, though a comprehensive evaluation of the success of these efforts has not been carried out to date.

Hyacinth control measures were hampered during the conflict years; as a result, efforts focused on sensitive locations such as near the Jebel Aulia dam. Today, there are no control operations underway at all. The role of the Plant Protection Department of the Ministry of Agriculture, which is responsible for hyacinth control, is currently limited to monitoring infestations, and it has no capacity to respond to the spread.

In the south, the impact of water hyacinth on the Sudd is completely unknown, although it is anticipated to be considerable, given that these wetlands comprise a large number of oxbow lakes and slow-moving channels which are ideal conditions for weed growth. The scale of infestation can be gauged every wet season, when up to 100 metre-long rafts of detached weed float down the White Nile downstream of the Sudd.

10.7 Water pollution

A major but largely unquantified issue

While water pollution is clearly a significant issue in Sudan, it has not been adequately quantified. Indeed, the sector is characterized by a lack of historical data and investment. Systematic surface water quality monitoring programmes in Sudan are limited to three sites: the main Nile at Dongola, the Blue Nile at Soba (near Khartoum), and the White Nile at Malakal. Other sites and groundwater are tested on an ad hoc basis. Monitoring data is publicly available but limited in scope.

This lack of information makes it difficult to adequately assess water quality and the likely changes that may take place in the future. With this in mind, UNEP noted three principal water quality issues:

- diffuse pollution from agrochemicals and sewage;
- point source industrial pollution; and
- high levels of suspended sediments.

Biological water pollution

Biological water pollution from sewage and waterborne infectious agents is the most serious threat to human health in Sudan. The limited monitoring that has occurred so far has confirmed bacteriological contamination of the Nile and shallow groundwater aquifers in Khartoum state and elsewhere in northern Sudan. There is very limited laboratory data for Southern Sudan but the waterborne disease statistics clearly show that it is a major problem. This is discussed in more detail in Chapter 6.

Given that fertilizer usage in Sudan is minimal by world standards, laboratory analysis of Nile waters only detected very low levels of nitrates. However, high nitrate levels were recorded at individual wells near concentrations of livestock [10.2].

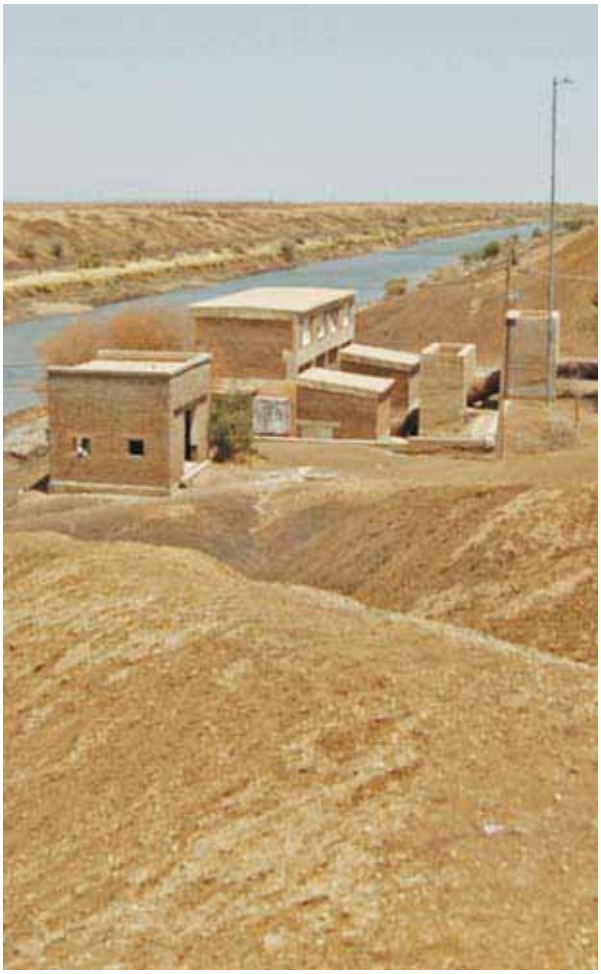
Pesticide pollution

Non-point source pollution is a cause for serious concern in the major irrigated schemes, particularly in Gezira and its Managil extension, Rahad and the country's five major sugar estates, where large-scale agrochemical applications continue despite overall declining usage trends. Various studies (mainly university graduate theses) have found serious pesticide contamination

The lack of a storm water drainage system in Khartoum causes major flooding, as observed here in August 2006. As the flood waters recede, pools of stagnant water increase the risk of spreading waterborne diseases, particularly in crowded areas like IDP camps

A local resident collects drinking water from the Nile. Biological water pollution from sewage and waterborne infectious agents is the most serious threat to human health in Sudan

The fast-growing cities of Southern Sudan are in desperate need of sewage systems



Pumping stations supply drinking water from irrigation canals that are susceptible to contamination from aerial pesticide application, such as this one in Deim el Masheihk on the Managil extension of the Gezira scheme

in the Gezira canals, as well as in boreholes in the Qurashi (Hasahesa) area and the Kassala horticulture zone. Accidental aerial spraying and pesticide drift reportedly lead to frequent fish kills in irrigation canals; these fish are sometimes collected for consumption [10.2].

Derelict and inadequate pesticide storage facilities and disposal measures, as observed in warehouse schemes at Hasahesa, Barakat and El Fao, as well as in stores of the Plant Protection offices in Gedaref, also pose a serious water pollution hazard. Complaints about the strong smell and contaminated spill during the rainy season have been received from Gedaref University, located downstream of the pesticide warehouse.

There is also a growing trend to apply pesticides in rain-fed mechanized agriculture schemes, which may lead to widespread contamination of both surface and groundwater, including the water points used by nomads. For example, herbicide application (mainly the persistent organochlorine 2, 4-D) in mechanized schemes is standard practice in Gedaref state [10.23] and is expanding in Dali and Mazmum in Sennar state, as well as in Habila in Southern Kordofan. Given the persistent nature of many pesticides and their biological magnification in the food-chain, long-term monitoring of surface and groundwater should be implemented, particularly in the states of Gezira, Sennar, White Nile and Gedaref, which host the main irrigated schemes.

Industrial effluent

Water pollution from industry is mostly limited to specific 'hot spots' such as North Khartoum, Port Sudan and Wad Medani. Given the current boom in industrial investment, however, it is an issue of growing concern. The majority of industrial facilities do not have dedicated water treatment facilities. Effluent is typically released either into the domestic sewage system (where one exists), or directly into watercourses or onto land.

For example, wastewater from the industrial area of North Khartoum (Bahri) flows untreated into the sewage treatment plant of Haj Yousif. Release of untreated industrial wastewater into watercourses or onto land is common practice, as was observed by the UNEP team in the Bagair industrial area, and at Assalaya and Sennar sugar factories, which dispose of their wastewater directly into the White and Blue Nile respectively. A major fish kill was reported in the Blue Nile in March 2006, following an accidental spill of molasses from the north-west Sennar sugar factory [10.2].

There are some positive developments, however, as a few large enterprises, such as the Kenana Sugar Company and some oil companies, have installed or are in the process of installing wastewater treatment plants [10.24]. This is a particularly critical issue for the oil industry, which is expected to generate large and increasing amounts of wastewater as the oilfields mature.

Suspended solids from eroded catchments

The heaviest water pollution load in Sudan is probably caused by suspended sediment. Recorded levels of suspended solids in rivers and reservoirs in the wet season range from 3,000 ppm to over 6,000 ppm, which corresponds to highly turbid/muddy conditions. While many of Sudan's rivers and streams are naturally turbid, the problem has been amplified by the high rates of soil erosion due to deforestation and vegetation clearance, overgrazing, dams, haphazard disposal of construction materials, and mining.

High levels of suspended sediment have adverse impacts on drinking water quality as well as on aquatic life, and in Sudan, have led to considerable economic losses due to the siltation of dams and irrigation canals. The impact is particularly visible in the Atbara river and the Blue Nile, whose catchments are seriously degraded by poor land management practices. In 2000, government sources estimated the total sediment load of the Blue Nile to be 140 million tonnes per annum [10.2].

Locals collect polluted effluent from the north-west Sennar sugar factory, for use in brick-making. The untreated effluent flows directly into the Blue Nile. This led to significant fish kills in the summer of 2006

Poor management of an experimental well drawing on fossil water from the NSAS has led to the creation of a wetland in the desert

10.8 Groundwater exploitation

A largely untapped but also unmanaged resource

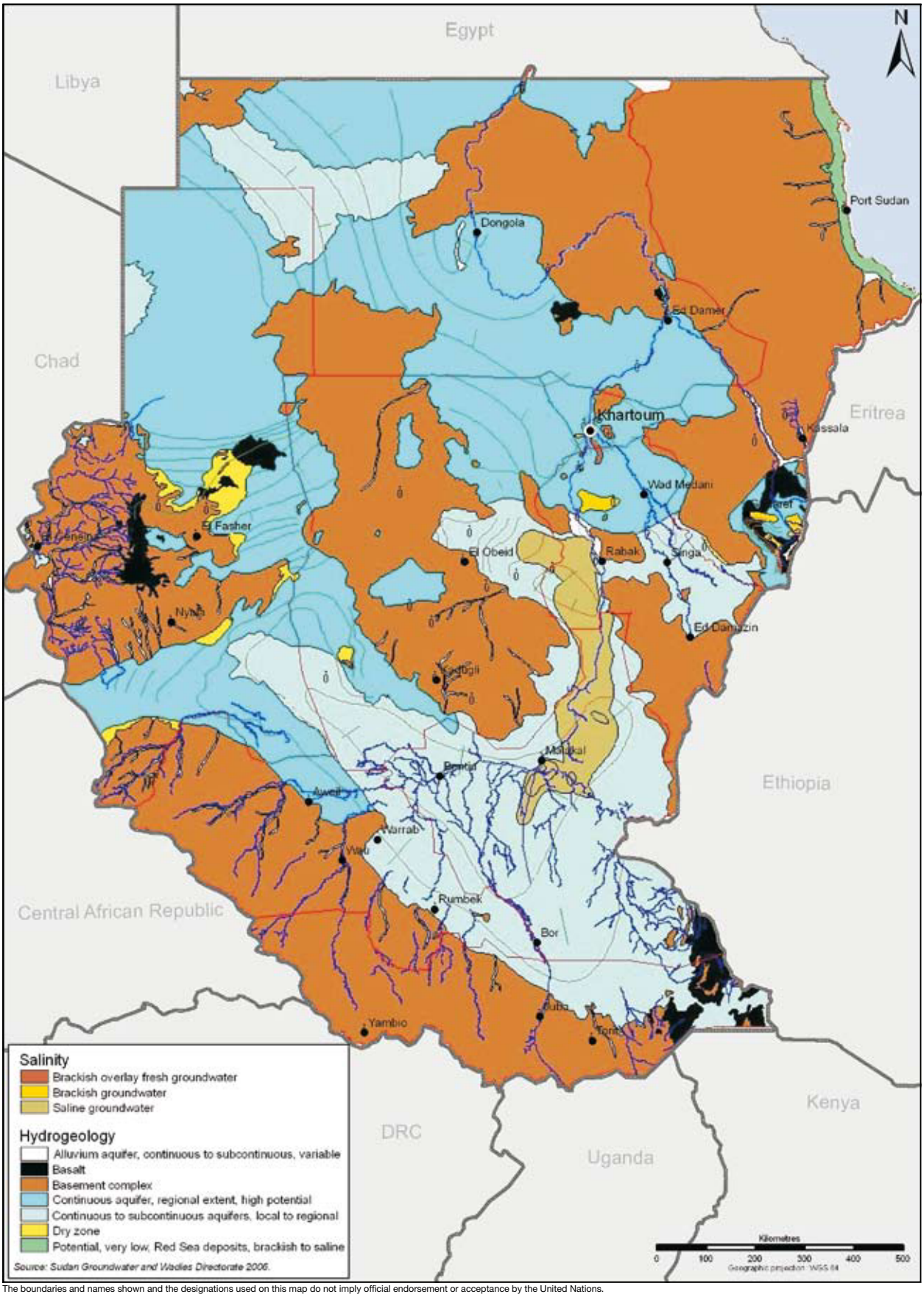
On a national scale, Sudan makes limited use of its groundwater, but it is a critical resource at the local level, particularly in the northern and central regions, and in Darfur. Data on the use and quality of groundwater, however, is rarely collected and extraction is generally completely unmanaged. There is anecdotal evidence of unsustainable extraction rates, but in the absence of monitoring data, the situation only becomes apparent when the wells run dry.

UNEP has focused on three examples of this general problem:

- the exploitation of the Nubian aquifer (discussed in the following section on transboundary issues);
- the use of upper terrace and other shallow aquifer systems; and
- the use of groundwater in the humanitarian aid community in Darfur.

The richness of groundwater resources in Sudan was recently evidenced in a piezometric survey at Gaab el Sawani, which showed the static water level to range from 1 to 6 m above ground level

Figure 10.4 Groundwater resources of Sudan



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

Use of upper terrace and other shallow aquifer systems

There is little published data available on Sudan's shallow groundwater resources such as the Umm Rawaba formation, which is reportedly an excellent source of near-surface groundwater. Overall, however, there is growing investment and reliance on groundwater resources in Sudan, particularly on the use of *mataras* (irrigation wells) in the Nile floodplain and adjoining upper terraces, as well as in the *wadis*. There are reports of falling aquifer levels in Wadi Nyala and Kassala, and of seawater incursion in the shallow groundwater of the Red Sea coastal zone [10.2].

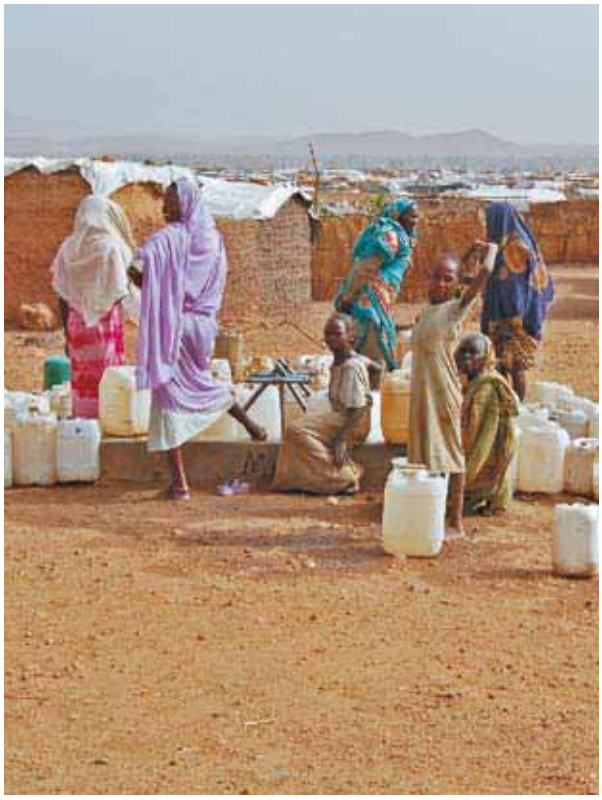
The sustainability of *mataras* in the upper terraces and *wadis* is questionable, and there are many anecdotal reports of declining groundwater levels that require scientific verification [10.2, 10.25]. For example, in Lewere in the Nuba mountains, groundwater levels have allegedly dropped from 3 to 70 metres, while in Atmoor, levels were said to have fallen by up to 10 metres.

Groundwater use in the humanitarian relief effort in Darfur

The humanitarian aid effort in Darfur has led to the drilling and establishment of hundreds of wells and water points since 2003. Many of these deep boreholes are located in or near displaced persons camps, and have high flow pumps installed to service populations of several thousand. These camps are commonly established in arid regions where groundwater is the only reliable source of water for up to ten months of the year. Given that the camps may stay in place for many more years, there is a clear need to ensure that groundwater extraction rates are sustainable. As of mid-2006, however, no organized groundwater level monitoring was taking place in camps in Darfur (see Chapter 5).

A recent groundwater vulnerability study of four large camps in Darfur indicated that camp wells extracting water solely from the basement complex aquifer were probably unsustainable in the medium term (two years) and that alternatives were needed [10.26].

The rapid expansion of shallow irrigation wells, locally known as mataras, in the Nile upper terraces needs to be sustainably managed to avert aquifer depletion



It is critically important that the water supply wells drilled in IDP and refugee camps do not run dry. Groundwater level monitoring should commence to allow the calculation of sustainable yields

10.9 Transboundary and regional issues

A need for cooperation over shared resources

Careful management and a high level of awareness are required for a number of transboundary and regional issues in the water sector in Sudan to avoid project failure or worse, catalysing regional disputes or even conflict.

Water projects and the CPA

In the Comprehensive Peace Agreement and subsequent Interim Constitution, the federal government (Government of National Unity) was granted specific sole authority over the management of Nile waters and Nile basin water resources. The Government of Southern Sudan and state governments were given separate powers related to water supply projects. GONU thus clearly has the mandate for any new major water project.

Given that the White Nile borders or flows through five of the ten states of Southern Sudan, northern state water projects may affect the southern states and vice versa. Therefore, it is considered critical that the GONU and GOSS conduct open and regular dialogue on Nile waters and development issues in order to not undermine the CPA. As of mid-2006, this was reported to be occurring, though not on a formal or regular basis.

Upstream watershed conditions, climate change and future projects in Sudan

The quantity, timing and quality of most of the Nile, Gash and Atbara river waters flowing through Sudan depend not on Sudan but on upstream countries, principally Ethiopia (Blue Nile, Atbara, Gash), Uganda (White Nile), and Tanzania and Kenya which border Lake Victoria (White Nile). These four countries all face a range of environmental problems including large-scale deforestation and land degradation. In addition, Uganda has recently increased water extraction from Lake Victoria for hydroelectric power, contributing to a significant drop in the lake's level. As a result, the currently observed changes in Nile flow rates (levels appear to be declining overall but variability is increasing) and turbidity are expected to increase over time.

Climate change will also affect the performance of the existing and planned major water resource management projects in Sudan. Both rainfall and river flows are expected to be affected within the next thirty years, and some impacts may already be occurring (see Chapter 3).

Large-scale water development demands a high level of flow predictability to ensure confidence for the large capital investment required. Accordingly, Sudan needs to better understand upstream catchment environmental issues and the likely impacts of climate change, and adjust its plans to suit.

Management of the shared Nubian Sandstone Aquifer System

The vast Nubian Sandstone Aquifer System (NSAS) represents the largest volume of freshwater in the world. It is estimated at 150,000 km^3 or nearly 200 years of average Nile flow. This deep artesian aquifer underlies approximately 376,000 km^2 of north-west Sudan (17 percent of the NSAS total area of 2.2 million km^2). It is shared with Chad, Egypt and Libya, and is primarily comprised of non-renewable or 'fossil' water some 20,000 years old [10.27]. A smaller basin of the NSAS, which is known as the Nubian Nile aquifer, receives recharge from the Nile river. The direction of groundwater flow in the NSAS is generally from south-east to north-east. Hence, Sudan and Chad are in an upstream position providing minor recharge to Egypt and Libya downstream.

The aquifer remains largely untapped in both Sudan and Chad. In contrast Libya and Egypt, through the Great Man-Made River and the South Valley Development projects respectively, are now actively pumping water for ambitious agricultural schemes [10.27, 10.28]. Large-scale irrigated agriculture with fossil water in a hyper-arid environment is a controversial issue due not only to potential wastefulness but also to the risk of soil salinization. Despite increasing pressure to mine the NSAS to meet the demands of a growing population, the need for wise and sustainable use of this precious resource, based on sound scientific knowledge and a regionally agreed strategy, cannot be overstated.

A catch from the White Nile. At present, the freshwater fisheries of Southern Sudan are only lightly exploited

To this end, a GEF project involving the four basin countries was launched in 2005. Its primary objective is to develop an NSAS water resource database and to promote technical exchange of information and expertise, as well as provide capacity-building for local staff. The project also aims to create a framework for a legal convention and institutional mechanism for shared management of the Nubian Aquifer System [10.29].

10.10 Freshwater fisheries: an unbalanced but promising resource

The freshwater fisheries of Sudan are an important source of sustenance for millions of riverine dwellers, and support a small informal commercial sector.

In the northern states near the major cities, resources are reportedly fished to saturation, with stable or dropping catches [10.20]. In the absence of hard water quality monitoring data, the reason for such catch reductions cannot be accurately determined, but localized overfishing and sedimentation are likely causes.

While there is no catch data for the freshwater fisheries of Southern Sudan, field observations and discussions with fisheries experts working on the White Nile indicated that the resource is clearly under-exploited, principally due to a lack of capacity in the local fishing sector.

As with any natural resource extraction, the sustainability of fisheries will only be achieved through good management, starting with data collection to assess the scale and health of the resource.

10.11 Water sector environmental governance

The ministerial-level structure for water governance is straightforward, as both the Government of National Unity and the Government of Southern Sudan have ministries for water resources management. In practice, however, governance is more complex, as water is a cross-cutting sector with other major ministries.

Laying nets in the White Nile at Bor, Jonglei state. The challenge for fishermen in this region is not catching enough fish, but preserving the catch so that it can be transported and sold outside of the area

CS 10.4 Development of fisheries in Southern Sudan

The Muntai Fisheries Training Centre based in Padak in Jonglei state is a positive example of sustainable development tied to better use of natural resources. The centre, which focuses on the transfer of skills to local artisanal fisherman, is part of an agricultural development project funded by USAID. A particular focus is placed on obtaining better value for fish catches and reducing wastage through the use of preservation techniques such as smoking and drying.

The wide variety of species and the large size of many fish indicate that the fishery potential of the White Nile is probably underexploited. The centre proposes to conduct catch surveys and commence development of fishery policies and by-laws in parallel with the capacity-building process.

Officials reported that the fishing community was actually only a small percentage of the local Dinka community, but that this minority was in some respects significantly better off than the majority of pastoralists, as they had both food security and a reliable source of income. The Dinka people are still food aid recipients, depend heavily on cattle-rearing and are expecting an influx of returnees to significantly increase local population density. In this context, sustainable initiatives to broaden the food base and promote rural business are most welcome.

This is particularly the case for major GONU projects such as the Merowe dam, for which a special dams unit was developed that overlays the responsibilities of the ministries for water resources, agriculture, energy, industry and environment. In Southern Sudan, the GOSS ministry is currently in the institution-building phase, and issues such as inter-ministerial mandates on cross-cutting issues have yet to be fully addressed.

The most significant governance issue for the water sector is considered to be its culture of development through mega-projects rather than sustainable development principles. At the working level, the water sector suffers from a lack of enforceable working regulations, standards or enforcement capacity, with particular gaps noted for water pollution and groundwater.

An irrigation canal headman. Pilot projects to establish water user associations in the Gezira scheme have shown reduced operational costs and more efficient on-farm water management

The introduction of improved smoking methods has raised the income of fishermen in the Bor region by expanding the market and increasing the price of fish

10.12 Conclusions and recommendations

Conclusion

At present, the national approach to water resources management in Sudan is based largely on resource exploitation and biased towards mega-projects. The water resources sector currently also faces a range of serious environmental challenges, which will require innovative management approaches as well as significant investments to rehabilitate degraded systems and strengthen technical capacity. In light of Sudan's ambitious dam-building programme, perhaps the most challenging task will be to develop a new decision-making framework for water projects that is based on equity, public participation and accountability.

Background to the recommendations

Substantial development of the water resources of Sudan is anticipated in the next decade. Such development should not be discouraged, but should be designed, constructed and operated in a more sustainable manner.

The two key themes of the recommendations are to strengthen national capacity for water resources management, and to introduce the philosophy and practical aspects of Integrated Water Resource Management (IWRM) to Sudan.

As the investment for most new and major water schemes will come from or be controlled by the Government of National Unity, the GONU Ministry of Irrigation and Water Resources is considered the appropriate counterpart for most of the capacity-building and advocacy proposed here, though some effort should be placed with equivalents in the Government of Southern Sudan and at the state level. Assistance to the Darfur states is a particular priority as substantial investments in this sector are anticipated as soon as the security situation allows.

Recommendations for the Government of National Unity

R10.1 Strengthen technical capacity in sustainable water resource management. This will entail significant investment in training and equipment for data collection, analysis and corrective action planning. All existing dam operations would be covered, as well as project planning for dams, groundwater and irrigation schemes. Priority targets for assistance would be the Dams Implementation Unit and the Ministry of Irrigation and Water Resources.

CA: CB; PB: MIWR and DIU; UNP: UNEP; CE: 2M; DU: 2 years

R10.2 Develop integrated water resources management (IWRM) plans for degraded basins. Priority should be given to the Blue Nile and Atbara river basins, Darfur, Khor Abu Habil in Northern Kordofan, and the Nuba mountains in Southern Kordofan. One of the key targets of these plans should be to propose integrated measures aimed at reducing river siltation levels and downstream riverbank erosion.

CA: GROL; PB: MIWR and DIU; UNP: UNEP; CE: 1M; DU: 2 years

R10.3 Develop and embed guidelines on dams in environmental law. The guidelines should include public consultations, and options and ecosystem integrity assessments. A legislative mandate prohibiting the initiation of any dam construction activities prior to the issuance of an EIA permit, and stipulating public participation throughout the dam project cycle as well as disclosure and timely distribution of all environmental information about the dam should be developed.

CA: GROL; PB: MIWR and DIU; UNP: UNEP; CE: 0.1M; DU: 2 years

R10.4 Conduct an additional environmental assessment of the Merowe dam project and develop specific mitigation measures for the operation of the facility. Key issues include the analysis and mitigation of downstream impacts and absorbing environmental lessons learnt from existing dams and irrigation schemes.

CA: AS: PB: MIWR and DIU; UNP: UNEP; CE: 0.5M; DU: 2 years

R10.5 Establish a national water quality monitoring programme for both surface and groundwater to include key physical, chemical and biological parameters. Include a tailor-made water quality monitoring programme for pesticide

residues in the large-scale irrigation schemes. Inventory and assess water pollution 'hot spots'.

CA: AS; PB: MIWR and DIU; UNP: UNEP; CE: 5M; DU: 2 years

R10.6 Develop a capacity-building programme and implement pilot projects on water conservation and management aimed at local user groups including water use associations. Priority should be given to the main irrigation schemes.

CA: CB; PB: MIWR and DIU; UNP: UNEP; CE: 2M; DU: 2 years

R10.7 Strengthen the capacity of regulatory authorities in groundwater data collection and management. This entails the development of a robust licensing system.

CA: CB; PB: MIWR and DIU; IP: UNEP; CE: 1M; DU: 2 years

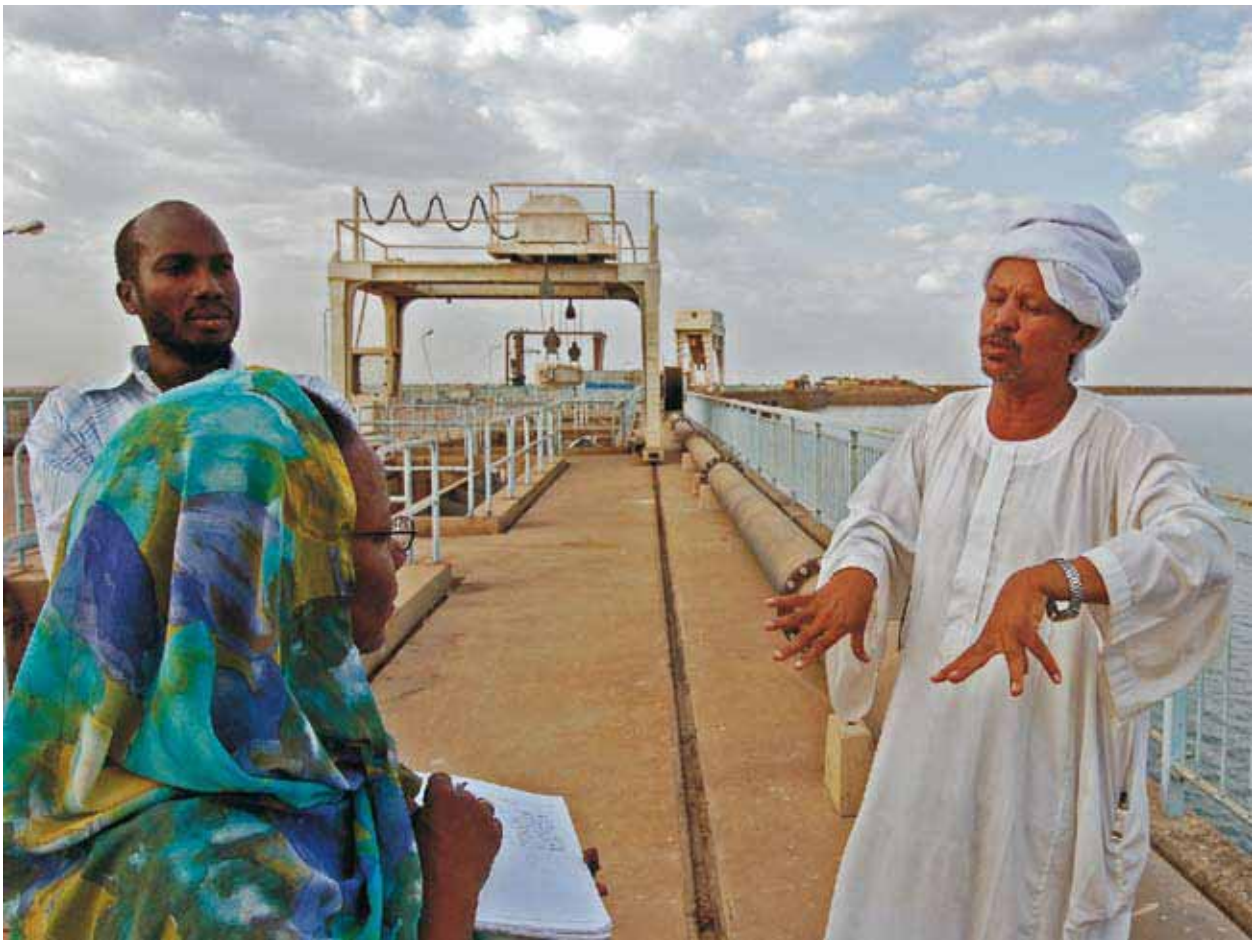
Recommendations for the Government of Southern Sudan

R10.8 Build capacity for sustainable water resource management, using IWRM as a founding philosophy. Capacity-building should include groundwork to assist the establishment of the ministry itself, and should initially focus on impact assessment and mitigation for planned water supply and power generation projects in the ten southern states.

CA: CB; PB: MWRI; UNP: UNEP; CE: 1M; DU: 2 years

R10.9 Develop and implement an integrated management plan for the Sudd wetlands. The cost estimate covers plan development and the first two years of implementation.

CA: GROL; PB: MWRI; UNP: UNEP/Ramsar Convention; CE: 1M; DU: 2 years



The Assistant Director of the Roseires dam explains the challenges of operating a facility that is of national significance for both power generation and irrigation

Wildlife and Protected Area Management

Birds of prey settle for the night on the flood plains of the White Nile in Jonglei state. While the past few decades have witnessed a major decline in wildlife in Sudan, remaining populations can still be considered internationally significant.
© Nick Wise

Wildlife and protected area management

11.1 Introduction and assessment activities

Introduction

As late as 1970, Sudan boasted some of the most unspoilt and isolated wilderness in east Africa, and its wildlife populations were world-renowned. While the past few decades have witnessed a major assault on both wildlife and their habitats, what remains is both internationally significant and an important resource opportunity for Sudan.

Ecosystems, issues, and the institutional structures to manage wildlife and protected areas differ markedly between north and south in Sudan. In the north, the greatest damage has been inflicted by habitat degradation, while in the south, it is uncontrolled hunting that has decimated wildlife populations. Many of the issues in the following sections are hence addressed separately for the two areas of the country. It should be noted that the most important remaining wildlife and protected areas in northern Sudan are on the coastline or in the Red Sea; these are covered in Chapter 12.

This chapter focuses on wildlife and protected areas as a specific sector. It is acknowledged that the larger topic of biodiversity has not been adequately addressed in this assessment. While the importance of conserving biodiversity is unquestionable, a significant difficulty for action on this front – in Sudan as elsewhere – is the lack of government ownership: no single ministry is responsible for this topic. As a result, the observed implementation of recommendations under the label of biodiversity is poor.

Although it has not been included as a specific sector in this assessment, the biodiversity of Sudan was studied and reported on in 2003 by a programme funded by the Global Environment Facility (GEF) under the auspices of the Convention on Biological Diversity (CBD) [11.1].

White-eared kob and zebra migrating through Boma National Park in 1983

Lion tracks in Padak county, Jonglei state. In the absence of formal survey data for much of the country, the evidence for wildlife populations is often anecdotal and qualitative

Assessment activities

The investigation of issues related to wildlife and protected areas in Sudan was conducted as part of the overall assessment. Two commissioned desk studies – one by the Boma Wildlife Training Centre, the other by the Sudanese Environment Conservation Society (SECS) – summarized the extent of existing knowledge for the south and north respectively [11.2, 11.3]. UNEP was able to visit one major site in the north (Dinder National Park), as well as a number of smaller reserves. The protected areas of Southern Sudan and Darfur were inaccessible due to security and logistical constraints. However, information was obtained from interviews and other sources in the course of general fieldwork in Southern Sudan.

Due to historical and ongoing conflicts, the available data on wildlife is highly skewed, with most recent information limited to northern and central states. This lack of up to date field data is a core problem for Southern Sudan's protected areas, but major studies by the Wildlife Conservation Society are underway in 2007 to correct this.

11.2 Overview of the wildlife and habitats of Sudan

The arid and semi-arid habitats of northern Sudan have always had limited wildlife populations. In the north, protected areas are mainly linked to the Nile and its tributaries, and to the Red Sea coast, where there are larger concentrations of wildlife. In contrast, the savannah woodlands and flooded grasslands of Southern Sudan have historically been home to vast populations of mammals and birds, especially migratory waterfowl. This abundance of wildlife has led to the creation of numerous national parks and game reserves by both British colonial and independent Sudanese authorities.

There is a large volume of literature on the wildlife of Sudan as recorded by casual observers who travelled through or lived in Sudan during the 19th and first half of the 20th centuries. A 1940s account, for instance, describes large populations of elephant, giraffe, giant eland, and both white and black rhino across a wide belt of Southern Sudan. Because of the civil war, however, few scientific studies of Sudan's wildlife have been conducted, and coverage of the south has always been very limited.

The migration of white-eared kob across the flood plains of Southern Sudan is one of the least known but most spectacular wildlife wonders of the world. Hundreds of thousands of animals move in a seasonal search for dry ground, new pasture and water (inset). Kob are perfectly adapted to the floodplain environment of Southern Sudan and have been hunted by local people for centuries

CS 11.1 The management of migratory wildlife outside of protected areas: the white-eared kob

One of the distinctive features of the wildlife population of Southern Sudan is that much of it is found outside of protected areas. This presents a range of challenges for conservation and management, as illustrated by the case of the white-eared kob antelope.

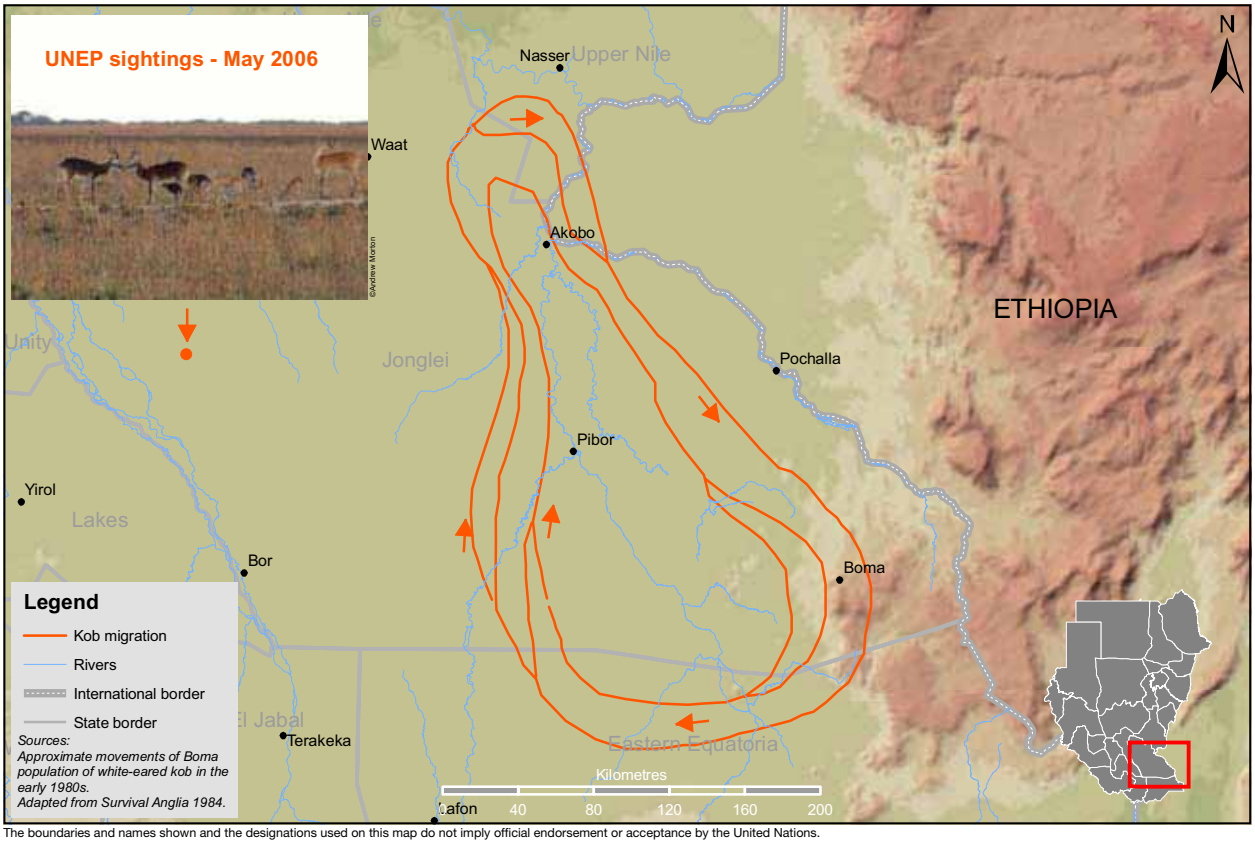
White-eared kob (*Kobus kob leucotis*) are largely restricted to Southern Sudan, east of the Nile, and to south-west Ethiopia [11.19, 11.20]. These antelope are dependent on a plentiful supply of lush vegetation and their splayed hooves enable them to utilize seasonally inundated grasslands. The spectacular migration of immense herds of white-eared kob in search of grazing and water has been compared to that of the ungulates in the Serengeti.

Substantial populations of white-eared kob occur in Boma National Park, the Jonglei area and in Badingilo National Park [11.20]. The paths of their migration vary from year to year, depending on distribution of rainfall and floods (see Figure 11.1). A survey and documentary film made in the early 1980s followed the herds of the Boma ecosystem as they moved between their dry and wet season strongholds that year, and found that the herds moved up to 1,600 km per year, facing a range of threats as they migrated through the different seasons, ecosystems and tribal regions [11.5].

The principle threats to the kob are seasonal drought, excessive hunting pressure and now the development of a new aid-funded rural road network cutting across their migration routes. The sustainable solution to excessive hunting is considered to be its containment and formalization rather than its outright prohibition, a measure which is both unachievable and unenforceable. White-eared kob represent an ideal opportunity for sustainable harvesting: they have a vast habitat, are fast breeders and are far better adapted to the harsh environment of the clay plains and wetlands than cattle. The spectacular nature of the kob migration may support some wildlife tourism in future but it is unrealistic to expect tourism revenue to provide an acceptable substitute for all of the livelihoods currently supported by hunting.

Minimizing the impact of the new road network will require some innovative thinking to integrate animal behaviour considerations into road design and development controls. Dedicated wildlife-crossing corridors, culverting and underpasses are all options that could reduce road accident-related animal deaths, while banning hunting within set distances of the new roads may help to control vehicle-assisted poaching.

Figure 11.1 Kob migration



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

As a result of this lack of technical fieldwork, virtually all up to date evidence of wildlife distribution in Southern Sudan outside of a few protected areas is anecdotal and cannot be easily substantiated. Nonetheless, this type of information is considered to warrant reporting in order to assess priorities for more substantive assessments. Key information from 2005 and 2006 includes the sightings of elephants in the northern part of the Sudd wetlands, and the sighting of very large herds of tiang and white-eared kob in Jonglei state. It is of note that both of these sightings took place outside of legally protected areas (see Case Study 11.1).

The only other recent data available on Southern Sudan is from ground surveys of Nimule, Boma and Southern National Park, carried out by the New Sudan Wildlife Conservation Organization (NSWCO) in 2001. The results of these surveys and other information provided to UNEP by the Boma Wildlife Training Centre indicate that many protected areas, in Southern Sudan at least, have remnant populations of most species.

Tiang, Bokor reedbuck and white-eared kob near the main road in Mabior, Jonglei state. Wildlife in Southern Sudan are found as much outside as inside protected areas

Wildlife habitats and occurrence by region

The regional environments of Sudan defined in Chapter 2 can be used as a basis for the description of current wildlife habitats and populations:

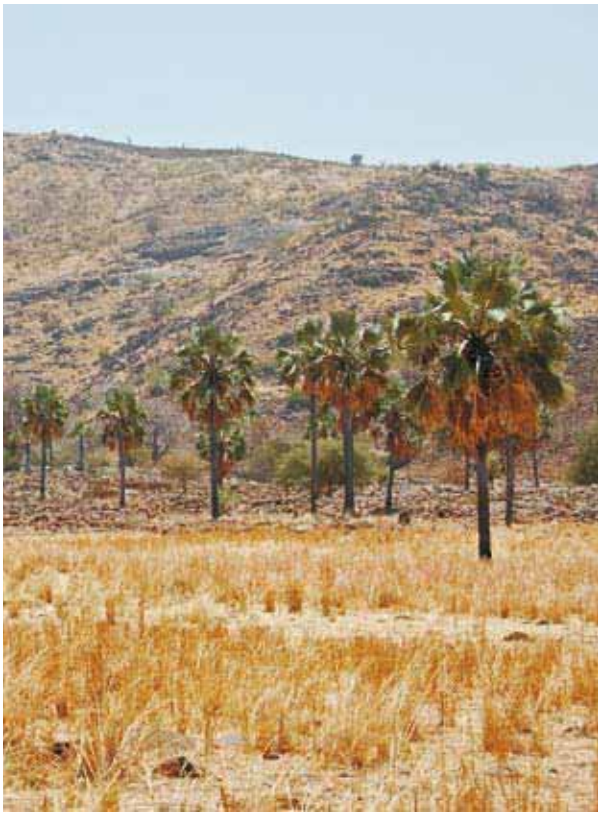
- arid regions (coastal and arid region mountain ranges, coastal plain, stony plains and dune fields);
- the Nile riverine strip;
- the Sahel belt, including the central dryland agricultural belt;
- the Marra plateau;
- the Nuba mountains;
- savannah;
- wetlands and floodplains;
- subtropical lowlands;
- the Imatong and Jebel Gumbiri mountain ranges; and
- subtidal coastline and islands – covered in Chapter 12.

The delimitations of the various areas in which wildlife are present are derived from a combination of ecological, socio-economic, historical and political factors. It should be noted, however, that the boundaries between certain regions are ill-defined, and that many animals migrate freely across them.

Arid regions. The mountains bordering the Red Sea, as well as those on the Ethiopian border and in Northern Darfur, are host to isolated low density populations of Nubian ibex, wild sheep and several species of gazelle [11.3]. Larger predators are limited to jackal and leopard. Due to the lack of water, wildlife in the desert plains are extremely limited, consisting principally of Dorcas gazelle and smaller animals. Life centres on *wadis* and oases, which are commonly occupied by nomadic pastoralists and their livestock.

The Nile riverine strip. The Nile riverine strip is heavily populated and as such only supports birdlife and smaller animals (including bats).

The Sahel belt, including the central dryland agricultural belt. In the Sahel belt, the combination of agricultural development and roving pastoralists effectively excludes large wildlife, although the region does host migratory birds, particularly in the seasonal wetlands and irrigated areas. With the important exception of Dinder National Park, the expansion of mechanized agriculture has eliminated much of the wild habitat in the Sahel belt.



Empty landscapes: the UNEP team travelled through the Nuba mountains without seeing or hearing any reports of remaining wildlife

The Marra plateau. The forests of Jebel Marra historically hosted significant populations of wildlife, including lion and greater kudu [11.3]. Limited surveys in 1998 (the latest available) reported high levels of poaching at that time. Due to the conflict in Darfur, there is only negligible information on the current status of wildlife in this region.

The Nuba mountains. The wooded highlands of the Nuba mountains historically held large populations of wildlife, but all recent reports indicate that the civil war led to a massive decline in numbers and diversity, even though forest cover is still substantial. The UNEP team travelled extensively through the Nuba mountains without any sightings or reports of wildlife.

Savannah. The bulk of the remaining wildlife of Sudan is found in the savannah of central and south Sudan, though the data on wildlife density in these regions is negligible.

Historical reports include large-scale populations of white and black rhino, zebra, numerous antelope species, lion, and leopard. In addition, aerial surveys carried out in the woodland savannah of Southern National Park in November 1980 revealed sizeable population estimates of elephant (15,404), buffalo (75,826), hartebeest (14,906) and giraffe (2,097) [11.4]. The number of white rhino in Southern National Park was estimated to be 168, which then represented a small but significant remnant population of an extremely endangered subspecies of rhino. In 1980, aerial surveys carried out in Boma (mixed savannah and floodplain habitats) indicated that the park was used by large populations of a wide variety of species as a dry season refuge, with the exception of the tiang, whose numbers increased considerably during the wet season [11.5].

Wetlands and floodplains. The vast wetlands and floodplains of south Sudan, which include the Sudd and the Machar marshes, are an internationally significant wildlife haven, particularly for migratory waterfowl. These unique habitats also support many species not seen or found in large numbers outside of Sudan, such as the Nile lechwe antelope, the shoebill stork and the white-eared kob.

Subtropical lowlands. The subtropical lowlands form the northern and western limits of the central African rainforest belt and thus host many subtropical closed forest species, such as the chimpanzee.

The Imatong and Jebel Gumbiri mountain ranges. The wetter microclimates of these isolated mountains in the far south of Southern Sudan support thick montane forest. There is only negligible information available on wildlife occurrences in these important ecosystems.

The flooded grasslands of Southern Sudan support very large bird populations, including black-crowned cranes (Balearica pavonina) (top left), pink-backed pelicans (Pelecanus rufescens) (top right), cattle egrets (Bubulcus ibis) (bottom left), and saddle-billed storks (Ephippiorhynchus senegalensis) (bottom right), seen near Padak in Jonglei state

Globally important and endangered species in Sudan

Sudan harbours a number of globally important and endangered species of mammals, birds, reptiles and plants, as well as endemic species.

In addition, there are a number of species listed as vulnerable by IUCN, including sixteen species of mammals, birds and reptiles: hippopotamus (*Hippopotamus amphibius*); cheetah (*Acinonyx jubatus*); African lion (*Panthera leo*); Barbary sheep (*Ammotragus lervia*); Dorcas gazelle (*Gazella dorcas*); red-fronted gazelle (*Gazella rufifrons*); Soemmerring's gazelle (*Gazella soemmerringei*); African elephant (*Loxodonta africana*); Trevor's free-tailed bat (*Mops trevori*); horn-skinned bat (*Eptesicus floweri*); greater spotted eagle (*Aquila clanga*); imperial eagle (*Aquila heliaca*); houbara bustard (*Chlamydotis undulata*); lesser kestrel (*Falco naumanni*); lappet-faced vulture (*Torgos tracheliotos*); and African spurred tortoise (*Geochelone sulcata*) [11.12].

The Mongalla gazelle is not endangered but has a relatively small habitat. Rangeland burning such as has recently occurred here is favourable to this species, as it thrives on short new grass

Table 21. Globally endangered Species occurring in Sudan [11.6, 11.7, 11.8, 11.9, 11.10, 11.11, 11.12]

Common name	Scientific name	Red List category
Mammals		
Addax*	*Addax maculatus*	CR A2cd
African ass	*Equus africanus*	CR A1b
Dama gazelle	*Gazella dama*	CR A2cd
Nubian ibex	*Capra nubiana*	EN C2a
Grevy's zebra*	*Equus grevyi*	EN A1a+2c
Rhim gazelle	*Gazella leptoceros*	EN C1+2a
African wild dog	*Lycaon pictus*	EN C2a(i)
Chimpanzee	*Pan troglodytes*	EN A3cd
Birds		
Northern bald ibis	*Geronticus eremita*	CR C2a(ii)
Sociable lapwing	*Vanellus gregarius*	CR A3bc
Basra reed warbler	*Acrocephalus griseldis*	EN A2bc+3bc
Saker falcon	*Falco cherrug*	EN A2bcd+3b
Spotted ground-thrush	*Zoothera guttata*	EN C2a(i)
Reptiles		
Hawksbill turtle	*Eretmochelys imbricata*	CR A1bd
Green turtle	*Chelonia mydas*	EN A2bd
Plants		
Medemia argun	*Medemia argun*	CR B1+2c
Nubian dragon tree	*Dracaena ombet*	EN A1cd

CR = critically endangered; EN = endangered; * questionable occurrence in Sudan

11.3 Overview of protected areas

Variable protection

A significant number of areas throughout Sudan have been gazetted or listed as having some form of legal protection by the British colonial or the independent Sudanese authorities. In practice, however, the level of protection afforded to these areas has ranged from slight to negligible, and many exist only on paper today. Moreover, many of the previously protected or important areas are located in regions affected by conflict and have hence suffered from a long-term absence of the rule of law.

Protected areas of northern Sudan

According to the information available to UNEP, northern Sudan has six actual or proposed marine protected sites [11.13], with a total area of approximately 1,900 km², and twenty-six actual or proposed terrestrial and freshwater protected sites, with a total area of approximately 157,000 km² [11.1, 11.2, 11.14, 11.15, 11.16, 11.17].

Table 22. Protected areas of northern Sudan (including marine areas)

Map reference	Protected area (* proposed)	Type (* proposed)	Km²	Habitat(s)	Key species
Marine protected areas					
30 53	Dongonab Bay	National park/ Ramsar site*/ Important bird area	3,000	Marine/tidal	Dugong, marine turtles, white-eyed gull
32	Sanganeb	National park/ Ramsar site*	260	Marine	Coral, marine fish
42	Suakin Archipelago*	National park/ Important bird area/ Ramsar site*	1,500	Marine	Marine turtles, crested tern
	Khor Kilab	National park*	2	Marine	Coral
	Abu Hashish	National park*	2	Marine	Coral
	Shuab Rumi	National park*	4	Marine	Coral
Terrestrial protected areas					
39 59	Radom	National park/ MAB reserve/ Important bird area	12,500	Savannah woodland	Buffalo, giant eland, leopard, hartebeest
35 52 58	Dinder	National park/ MAB reserve/ Ramsar site/ Important bird area	10,000	Savannah woodlands and flooded grasslands (mayas)	Reedbuck, oribi, buffalo, roan antelope, red-fronted gazelle
36	Jebel Hassania*	National park	10,000	Semi-desert	
43	Wadi Howar*	National park	100,000	Desert	
19	Jebel Gurgei Massif*	Game reserve	100		
	Rahad*	Game reserve	3,500		
26	Red Sea Hills*	Game reserve	150		
27	Sabaloka	Game reserve	1,160	Semi-desert	
28	Tokor	Game reserve	6,300	Semi-desert	
49	Erkawit Sinkat	Wildlife sanctuary	120	Semi-desert	
50	Erkawit	Wildlife sanctuary	820	Semi-desert	
3	Jebel Bawzer (Sunut) Forest	Bird sanctuary/ Ramsar site*	13	Semi-desert	
8	Lake Nubia	Bird sanctuary	100	Freshwater lake	Pharaoh eagle owl, crowned sandgrouse
2	Jebel Aulia Dam*	Bird sanctuary	1,000	Freshwater lake	
7	Lake Kundi*	Bird sanctuary	20	Freshwater lake	
6	Lake Keilak*	Bird sanctuary	30	Freshwater lake	
1	El Roseires Dam*	Bird sanctuary	700	Freshwater lake	
4	Khashm el Girba Dam*	Bird sanctuary	100	Freshwater lake	
9	Sennar Dam*	Bird sanctuary	80	Freshwater lake	
45	Jebel Elba*	Nature conservation area	4,800		
46	Jebel Marra Massif*	Nature conservation area/ Important bird area	1,500	Savannah grassland and woodland	Greater kudu, red-fronted gazelle
5	Lake Abiad	Bird sanctuary	5,000	Freshwater lake	Ruff, black-crowned crane

Figure 11.2 Protected areas of Sudan

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

Protected Areas

- Bird sanctuary (proposed)
- Game reserve (designated, proposed)
- Marine national park (designated, proposed)
- National park (designated, proposed)
- Nature conservation area (proposed)
- Wildlife sanctuary
- Wetlands of International Importance (Ramsar) (designated, proposed)
- World Heritage Convention
- UNESCO-MAB Biosphere Reserve

Square areas are drawn to scale.

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

Sources:
World database on protected areas (WDPA), UNEP-WCMC; SIM (Sudan Interagency Mapping); vmaplv0, NIMA; UN Cartographic Section; various other sources.

UNEP/DEWA/GRID-Europe 2006

Index to Protected Areas map

National designations

Site number, Site name ([p]Proposed,[u]Unknown location), Area (ha)

Bird sanctuary:

1. El Roseireis Dam[p]	70'000	5. Lake Abiad[p]	500'000	8. Lake Nubia[p]	10'000
2. Jebel Aulia Dam[p]	100'000	6. Lake Keilak[p]	3'000	9. Sennar Dam[p]	8'000
3. Jebel Bawzer Forest (Sunut Forest)[p]	1'234	7. Lake Kundi[p]	2'000		
4. Khashm El-Girba Dam[p]	10'000				

Game reserve:

10. Abroch[p u]	150'000	17. Ez Zeraf	970'000	24. Mongalla	7'500
11. Ashana	90'000	18. Fanikang	48'000	25. Numatina	210'000
12. Barizunga[p u]	200'000	19. Jebel Gurgei Massif	10'000	26. Red Sea Hills	15'000
13. Bengangai	17'000	20. Juba	20'000	27. Sabaloka	116'000
14. Bire Kpatuos	500'000	21. Kidepo	120'000	28. Tokor	630'000
15. Boro[p]	150'000	22. Mashra[p]	450'000	29. Wadi Howar[p]	400'000
16. Chelkou	550'000	23. Mbarizunga	1'000		

Marine national park:

30. Dongonab Bay	300'000
31. Port Sudan[p]	100'000
32. Sanganeb	26'000

National park:

33. Badinglo	1'650'000	37. Lantoto[p]	76'000	41. Southern	2'300'000
34. Boma	2'280'000	38. Nimule	41'000	42. Suakin Archipelago[p]	150'000
35. Dinder	1'000'000	39. Radom	1'250'000	43. Wadi Howar[p]	10'000'000
36. Jebel Hassania[p]	1'000'000	40. Shambe	62'000		

Nature conservation area:

44. Imatong Mountains[p]	100'000	46. Jebel Marra massif[p]	150'000	48. Lake No[p]	100'000
45. Jebel Elba[p]	480'000	47. Lake Ambadi[p]	150'000		

Wildlife sanctuary:

49. Erkawit Sinkat	12'000
50. Erkawit	82'000
51. Khartoum	1'500

International conventions and programmes

Site number, Site name, Area (ha)

Wetlands of International Importance (Ramsar):

52. Dinder National Park	1'000'000
53. Dongonab Bay-Marsa Waiai[p]	280'000
54. Jebel Bawzer Forest (Sunut Forest)[p]	1'234
55. Suakin-Gulf of Agig[p]	1'125'000
56. Sudd	5'700'000

World Heritage Convention:

57. Gebel Barkal and the Sites of the Napatan Region

UNESCO-MAB Biosphere Reserve:

58. Dinder National Park	1'000'000
59. Radom National Park	1'250'000

A baboon in Dinder National Park, Sennar state. The level of actual protection is highly variable but generally weak throughout Sudan. Poaching is a problem in all major parks

Nominally protected areas thus cover approximately ten percent of northern Sudan, with three sites – Wadi Howar, Dinder and Radon – accounting for a large portion of this figure. While this is significant and worthy of support, the actual level of protection provided and ecosystem integrity are more important than sheer size.

Wildlife authorities interviewed by UNEP in northern Sudan reported consistent problems with protected area management, ranging from poaching to livestock encroachment and land degradation. Many sites were so degraded from their original condition as to potentially warrant de-listing. The UNEP investigation of Dinder National Park, for example, found that this major site was not only badly damaged and under severe stress, but was also being starved of the requisite funds for proper management (see Case Study 11.2).

Overall, terrestrial and freshwater sites in northern Sudan were found to be very degraded and on a continuing decline. Marine protected areas were generally in better condition due to a low level of development pressure.

Protected areas of Southern Sudan

Given that the legally protected areas of Southern Sudan were in a conflict zone for over two decades, they have not been managed or effectively protected. During the war, the presence of the military gave some areas under SPLA control a measure of protection, but these were also used to supply bushmeat.

With the recent addition of the Sudd wetlands – which were listed as a site under the Ramsar Convention in 2006 – Southern Sudan comprises twenty-three sites, for a total area of 143,000 km² or approximately 15 percent of the territory. Again, this large figure is positive, but the condition of these areas and the level of actual protection are of more import.

The level of actual protection provided to these twenty-three sites is considered by UNEP to be negligible but rising as the GOSS wildlife forces start to build capacity and mobilize. The condition of the areas is more difficult to gauge, but all available evidence points to a massive drop in the numbers of large wildlife due to poaching.

The most reliable evidence comes from Boma National Park, which was surveyed three times,

Table 23. Protected areas of Southern Sudan

Map reference	Protected area (* proposed)	Type (* proposed)	Km²	Habitat(s)	Key species
33	Badingilo (incl. Mongalla game reserve)*	National park/ Important bird area	8,400	Flooded grasslands and woodlands	Elephant, buffalo, giraffe
34	Boma	National park/ Important bird area	22,800	Savannah woodlands, grasslands, swamps	White-eared kob, tiang, reedbuck
37	Lantoto*	National park	760	Tropical forest	Chimpanzee, elephant
38	Nimule	National park/ Important bird area	410	Savannah and riverine woodlands	Elephant, cheetah
40	Shambe	National park (within Ramsar site)	620	Flooded savannah and riverine forest	Nile lechwe, buffalo
41	Southern	National park/ Important bird area	23,000	Savannah woodland	Giant eland, elephant, rhino
11	Ashana	Game reserve/ Important bird area	900	Savannah woodland	Elephant, giant eland
13	Bengangai	Game reserve/ Important bird area	170	Tropical forest	Elephant, bongo, buffalo
14	Bire Kpatuos	Game reserve	5,000	Tropical forest	Bongo, yellow-backed duiker
15	Boro*	Game reserve	1,500	Savannah woodland	Elephant
16	Chelkou	Game Reserve	5,500	Savannah woodland	Elephant, giant eland, buffalo
17	Ez Zeraf	Game reserve (within Ramsar site)	9,700	Flooded grassland and woodland	Nile lechwe, sitatunga, hippo
18	Fanikang	Game reserve (within Ramsar site)	480	Flooded grassland and woodland	Nile lechwe
20	Juba	Game reserve/ Important bird area	200	Savannah grassland and woodland	Heuglin's francolin, Arabian bustard
21	Kidepo	Game reserve/ Important bird area	1,200	Savannah grassland and woodland	Elephant, heuglin's francolin
22	Mashra*	Game reserve	4,500	Flooded grassland	Elephant
23	Mbarizunga	Game reserve	10	Tropical forest	Bongo, bushbuck, yellow-backed duiker
25	Numatina	Game reserve	2,100	Savannah woodland	Elephant, giant eland, roan antelope
7	Lake Kundi	Bird sanctuary	20	Freshwater lake	Yellow-billed stork, black-crowned crane
44	Imatong mountains	Important bird area/ Nature conservation area	1,000	Montane forest and woodland	Blue duiker, bushbuck
47	Lake Ambadi	Nature conservation area	1,500	Freshwater lake	
48	Lake No	Nature conservation area	1,000	Freshwater lake	
56	Sudd	Ramsar site/ Important bird area	57,000	Rivers, lakes, flooded grasslands and savannah	470 bird species, 100 mammal species and 100 fish species

Table 24. Comparison of population estimates of larger ungulates in the years 1980 and 2001 in Boma National Park [11.2]

Species	2001 Count (wet season)	1980 Count (wet season)	1980 Count (dry season)
White-eared kob	176,120	680,716	849,365
Lesser eland	21,000	2,612	7,839
Roan antelope	1,960	2,059	3,085
Mongalla gazelle	280	5,933	2,167
Tiang	Not seen	116,373	25,442
Lelwel hartebeeste	5,600	8,556	47,148
Zebra	Not seen	24,078	29,460
Buffalo	Not seen	2,965	11,179
Giraffe	Not seen	4,605	9,028
Waterbuck	Not seen	620	2,462
Grant's gazelle	Not seen	1,222	1,811
Elephant	Not seen	1,763	2,179
Lesser kudu	Not seen	654	170
Oryx	Not seen	1,534	396
Cattle	7,980	7,056	93,815

twice in 1980 (in the dry and wet seasons) and once in 2001 [11.2]. As shown in Table 24, the wildlife populations recorded in 2001 had dropped dramatically, but there were still significant numbers of most species, with the exception of elephant, giraffe, zebra and buffalo. In scientific terms, the two surveys are not directly comparable. Nonetheless, the fact that viable populations of several species of wildlife still existed in Boma in 2001 is important for the future of wildlife and protected areas in Sudan.

A key figure to note is the cattle count, which documents the extent of encroachment into the park by pastoralists.

11.4 Wildlife and protected area management issues

There are four issues facing the wildlife and protected area management sector, which are cumulative in effect:

- habitat destruction and fragmentation;
- park encroachment and degradation;
- commercial poaching and bushmeat; and
- wildlife tourism (or lack thereof).

Habitat destruction and fragmentation

Habitat destruction and fragmentation from farming and deforestation is the root cause of most biodiversity loss in northern and central Sudan. Vast areas of savannah and dryland pasture have been replaced with agricultural land, leaving only limited shelter belts or other forms of wildlife refuge. The intensity of mechanized agricultural development has forced pastoralists to use smaller grazing areas and less suitable land, leading to the degradation of the rangelands and increased competition between livestock and wildlife.

The net result is that larger wildlife have essentially disappeared from most of northern and central Sudan, and can only be found in the core of the protected areas and in very low numbers in remote desert regions.

In Southern Sudan, the lack of development has resulted in much less habitat destruction, but the intensification of shifting agriculture is causing large-scale land use changes across the region, particularly in the savannah. The floodplains are less affected, but the continued burning will negatively impact some species, while benefiting others, such as the antelope.

An additional important issue in Southern Sudan is the impact of ongoing and planned development like the creation or rehabilitation of rural trunk roads. This is a particular concern for Jonglei state, where the new road cuts directly across the migration route of the white-eared kob (see Case Study 11.1).

Park encroachment and degradation

Livestock is present in most of the legally protected terrestrial areas of Sudan, irrespective of their legal status. In some cases, pastoralists used the area long before the legal status came into effect; in others, the site has been invaded during the last thirty years. Pastoralists and their herds are now well entrenched in many major parks, creating competition for water and fodder, leading to land degradation through burning and overgrazing, and facilitating poaching. Encroachment has partly destroyed the integrity of Dinder National Park [11.3], and now represents a major challenge for the developing wildlife sector in Southern Sudan.

Habitat destruction and fragmentation is the root cause of biodiversity loss in northern and central Sudan. The expansion of mechanized agriculture has deforested large areas and removed the shelter belts that host wildlife populations

A particular risk for Southern Sudan is armed conflict in the parks, as the wildlife forces (over 7,300 men as of late 2006) mobilize and start to confront pastoralists and poachers. Modern non-confrontational approaches entailing community engagement will be required if the wildlife sector in Southern Sudan is to avoid damaging gun battles between locals and rangers. The semi-resident population of pastoralists and bushmeat hunters from the Murle tribe in Boma National Park – who have become accustomed to living in the park and are heavily armed – illustrates this problem.

Commercial poaching and bushmeat

The ready availability of firearms has been the most significant factor in the reduction of wildlife in Southern Sudan, and has also compounded the problems of habitat destruction in northern and central Sudan. Uncontrolled and unsustainable levels of hunting have devastated wildlife populations and caused the local eradication of many of the larger species including elephant, rhino, buffalo, giraffe, eland and zebra.

Tiang are extensively hunted in the floodplains of Southern Sudan