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

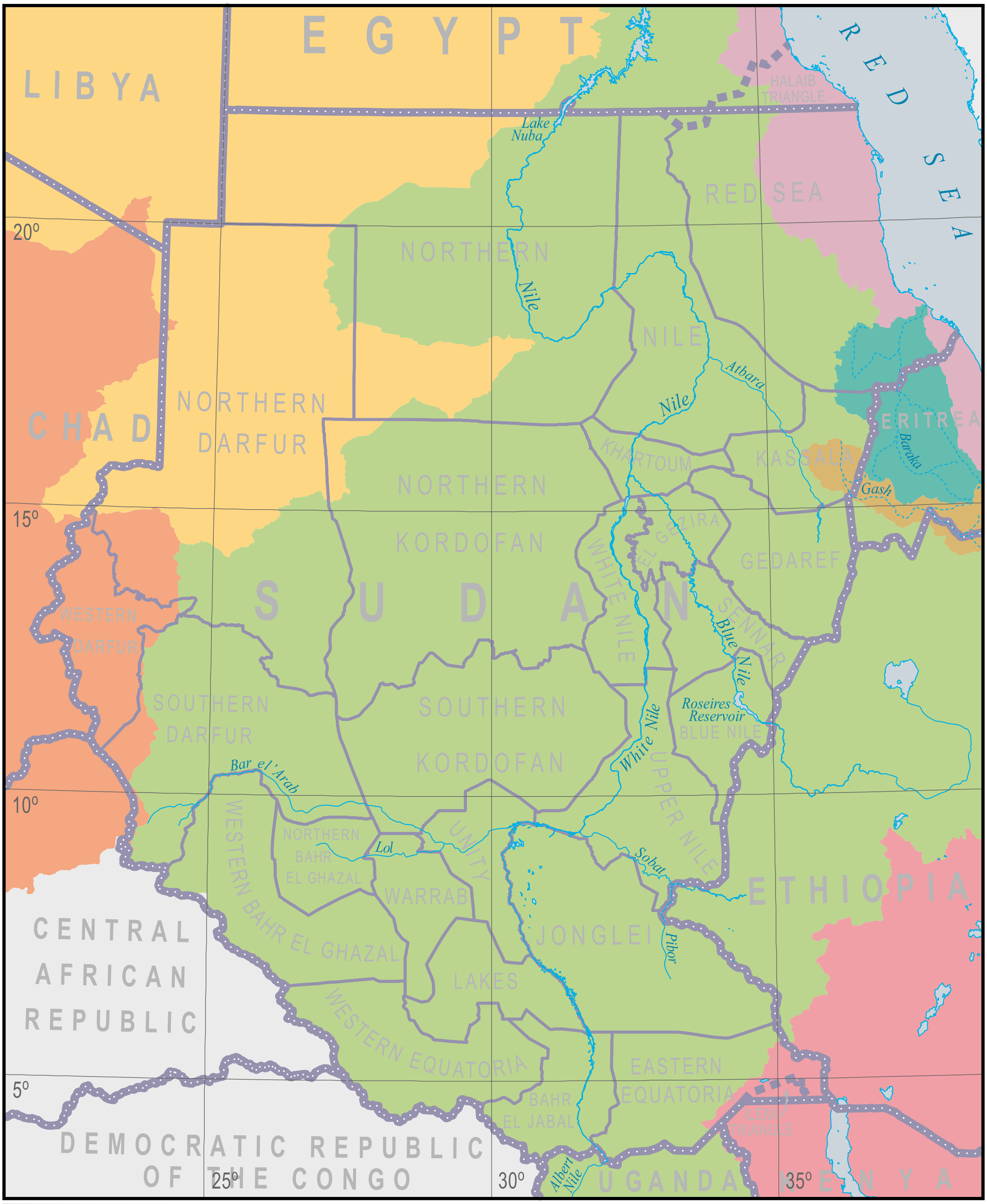
At the watershed level (the basic unit for integrated water resources management), Sudan comprises seven main basins:

- 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.

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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.

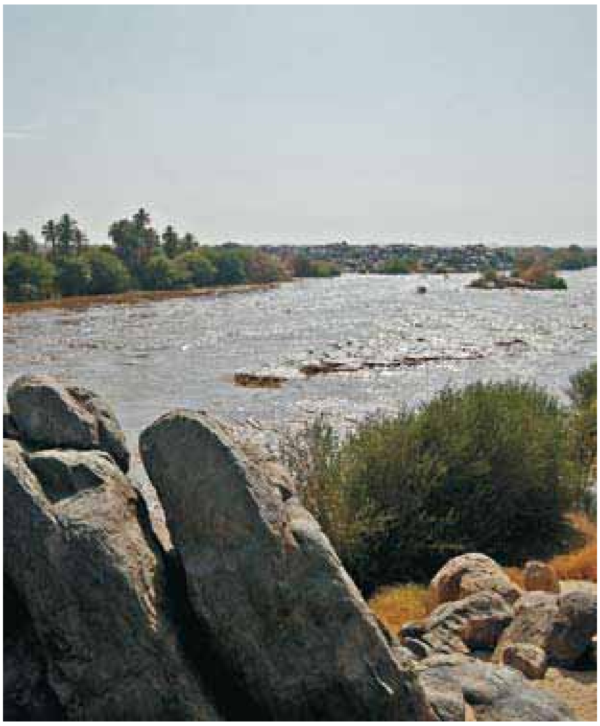
The root cause of the dams' performance problems is linked to upstream land degradation. The high rate of sedimentation in the Blue Nile and Atbara rivers is partly natural, and partly the end result of land degradation and soil erosion in the drainage basins of both Sudan and Ethiopia. Addressing the 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.

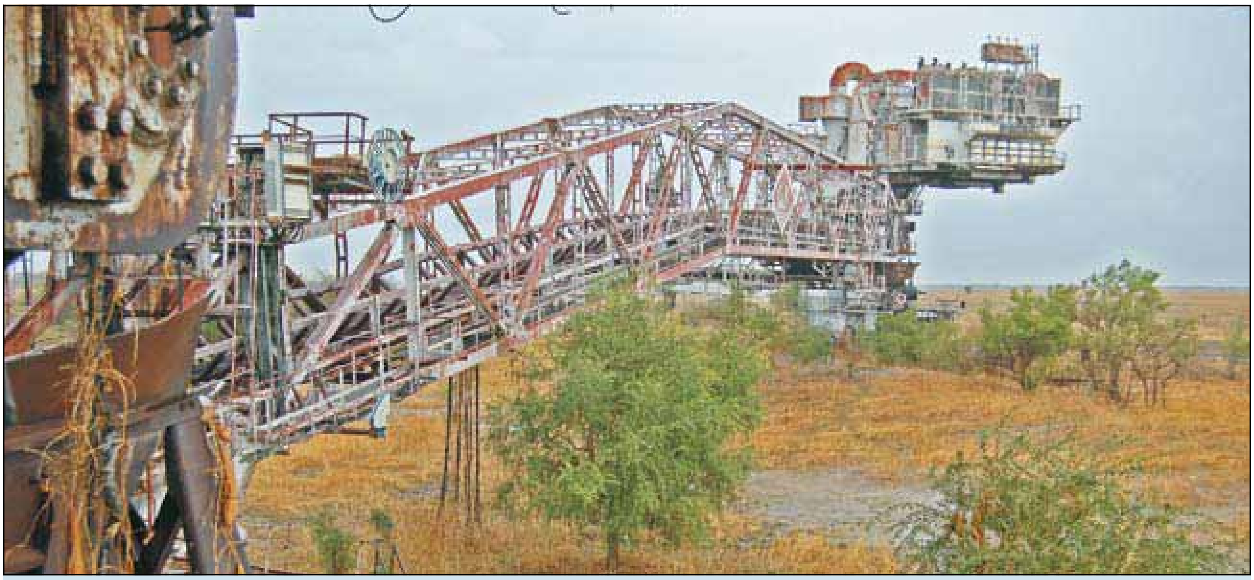
- **Blocking of fish migrations and the impact on locally endangered species** like the Nile crocodile. These issues were not addressed in the EIA.

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.

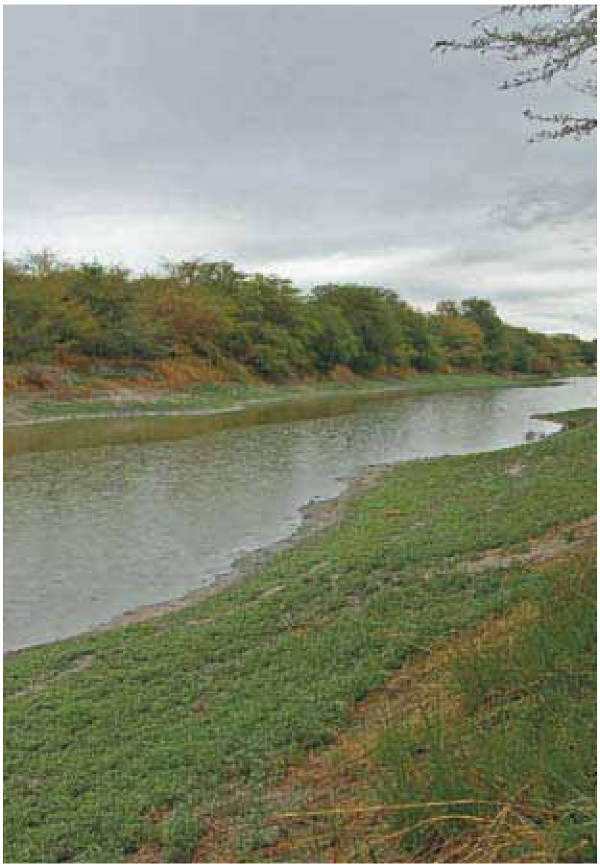
In its original design, the canal project would have had major negative environmental impacts on the Sudd wetlands [10.14]. The viability of the project is questionable on these grounds alone, irrespective of the numerous social, political and economic issues attached to any potential resumption of the 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

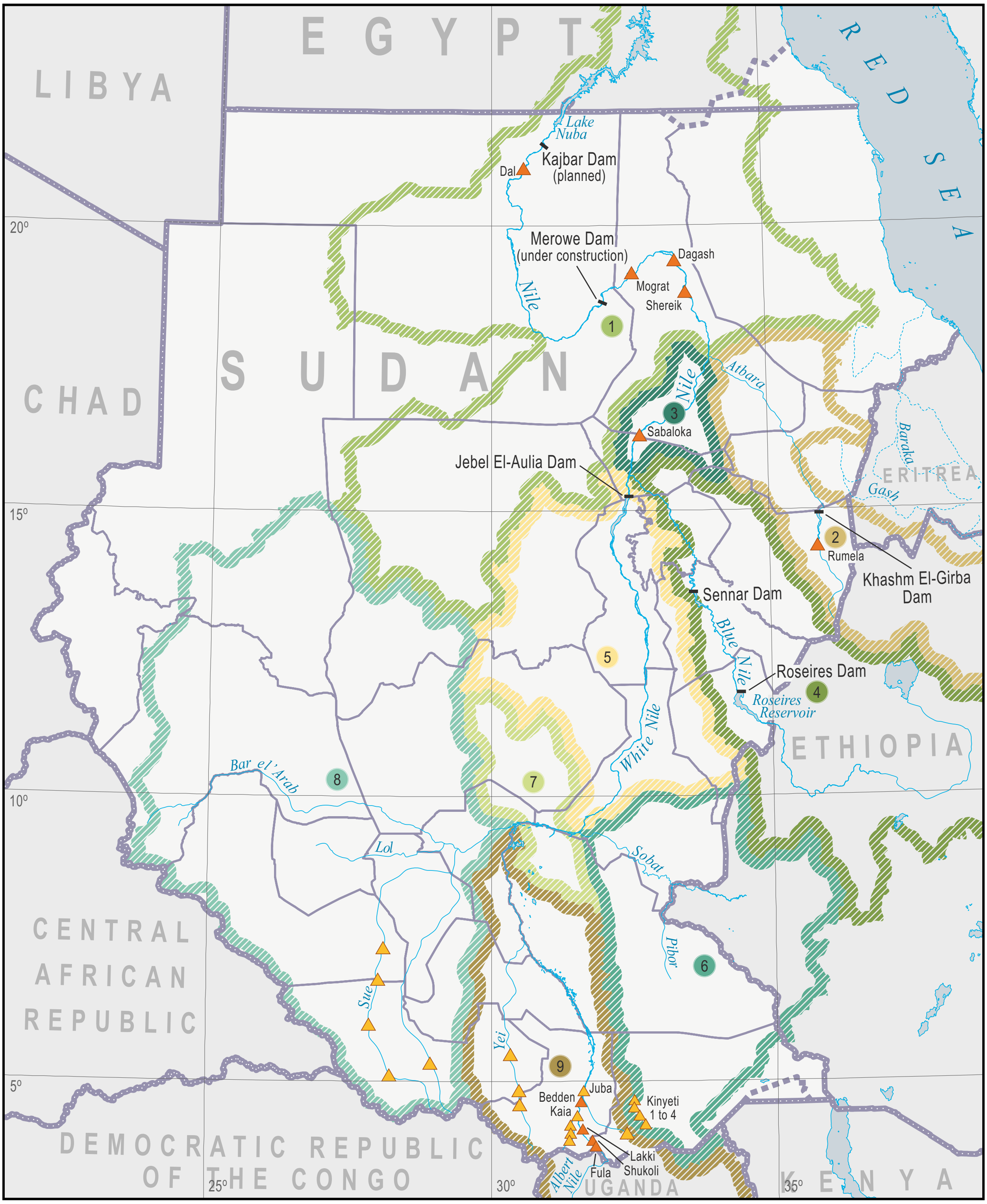
As of late 2006, the Government of National Unity is on the verge of launching a new and ambitious dams building programme (in addition to the Merowe dam). The importance conferred on dams is reflected in the September 2005 decision by Presidential Decree No. 217 to place the Dams Implementation Unit (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

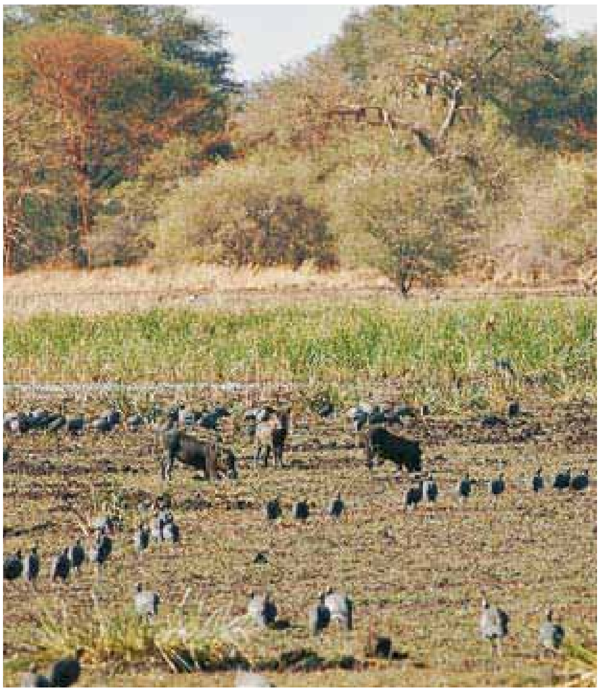
UNEP has found that most of Sudan's major wetlands are currently facing significant conservation threats.

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 *mayas* (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 km²	Generally in very good condition
Machar marshes	Upper Nile	6,500 km²	Status unknown
Blue Nile mayas, including Dinder	Blue Nile, Sennar	Discontinuous (< 1,000 km²)	Moderately to heavily degraded
Bahr el Arab	Northern Bahr el Ghazal, Warrab, Unity	Discontinuous	Status unknown
Lake Abiad	Southern Kordofan	5,000 km²	Moderately degraded
Red Sea mangroves	Red Sea state	Linear and discontinuous (< 100 km²)	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].

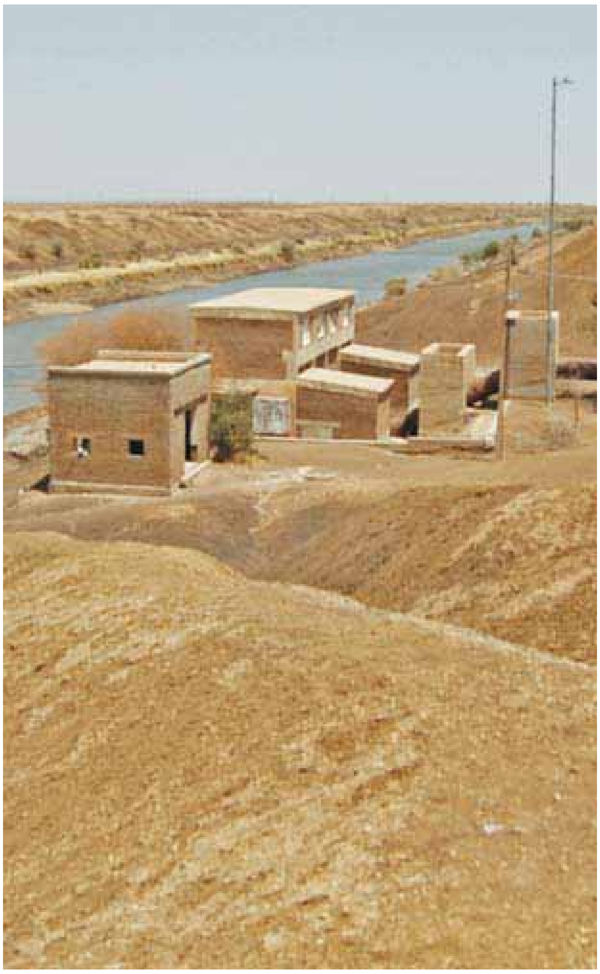
Pesticide pollution

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

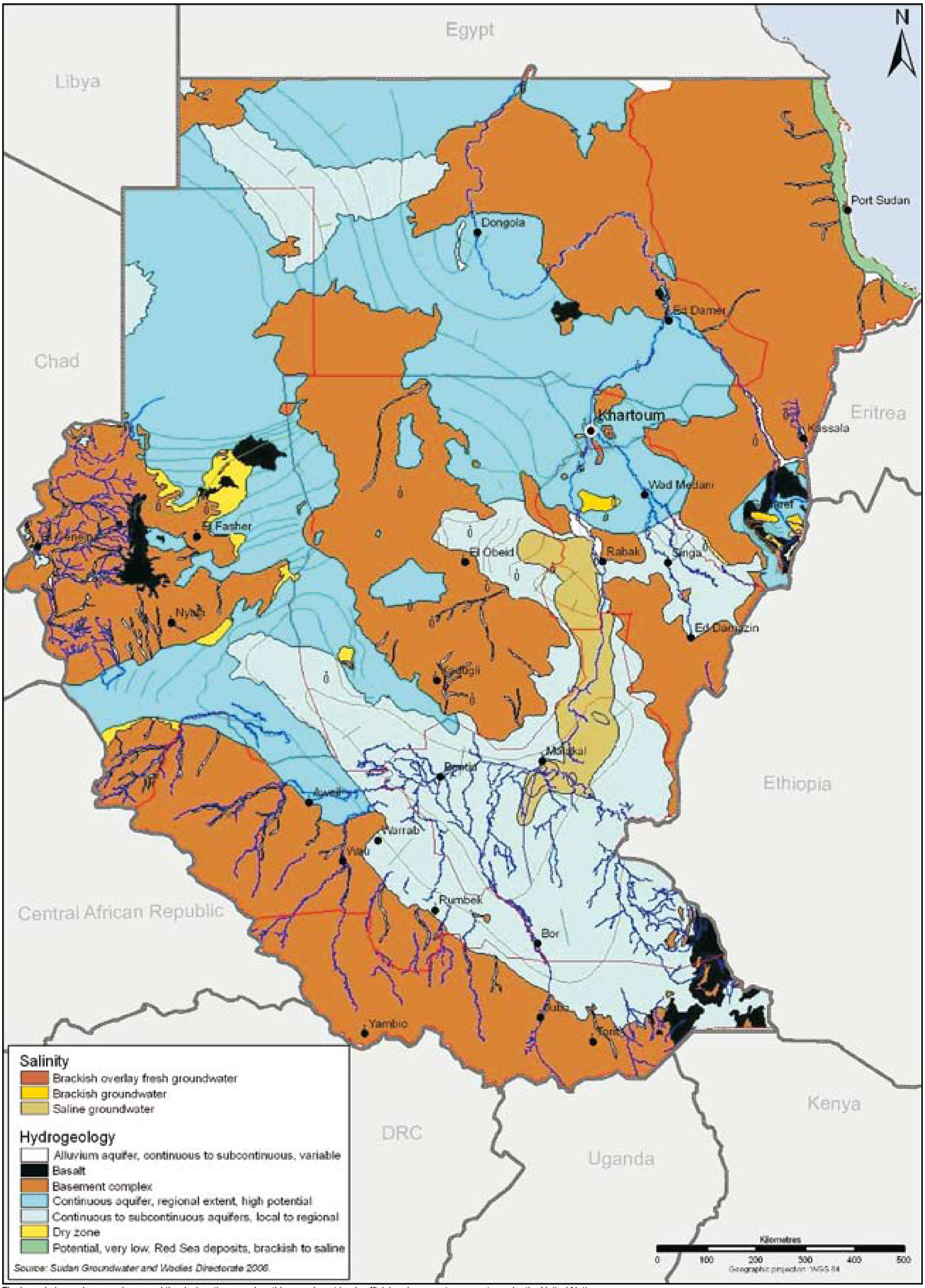
On a national scale, Sudan makes limited use of its groundwater, but it is a critical resource at the local level, particularly in the northern and central regions, and in Darfur. Data on the use and quality of groundwater, however, is rarely collected and extraction is generally completely unmanaged. 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].

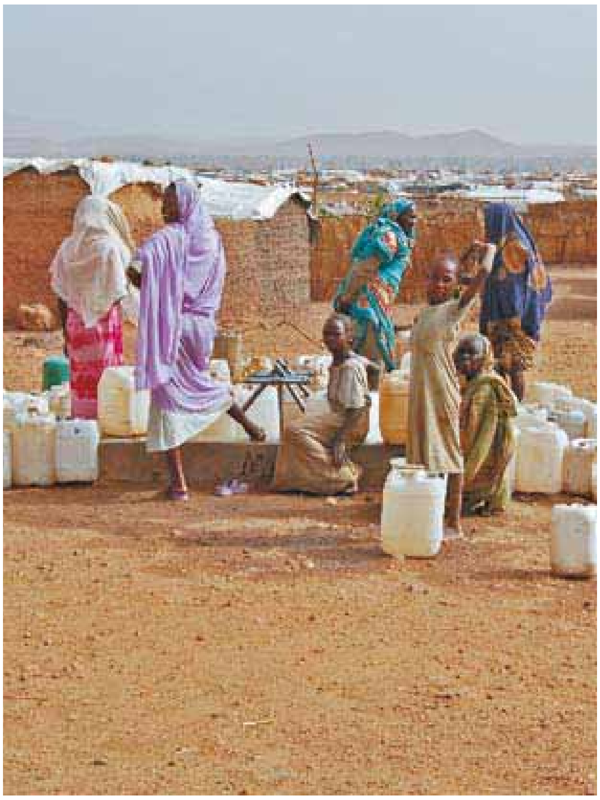
The sustainability of *mataras* in the upper terraces and *wadis* is questionable, and there are many anecdotal reports of declining groundwater levels that require scientific verification [10.2, 10.25]. For example, in Lewere in the Nuba mountains, groundwater levels have allegedly dropped from 3 to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

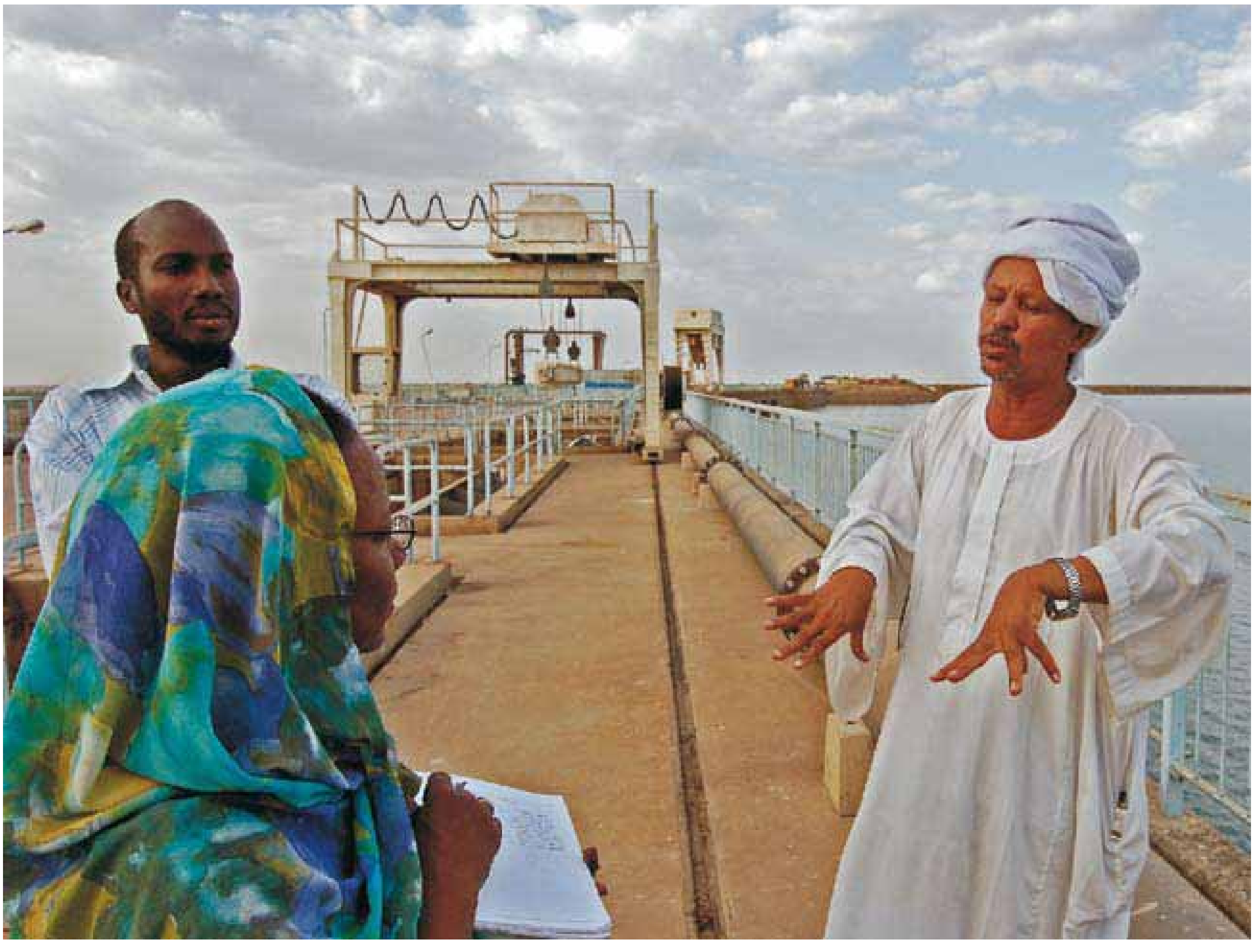
Recommendations for the Government of Southern Sudan

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