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Parched Ground: After the War, Can Sudan Sustainably Develop and Preserve Its Groundwater Resources?

Itzchak E. Kornfeld, Esquire*

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I. Introduction

The current ethnic strife and refugee quagmire in western Sudan's Darfur are both dreadful and problematic. The Darfuri tragedy has been described as a monumental problem.¹

The Arabic word for "problem" is *mushkilla*. In Sudan, the problems are as vast as they are numerous. The tragedy in Darfur [and the government's cheap] option of arming and lending air support to a militia composed of the [janjaweed] and other tribal enemies [of the Darfuree's], and encouraging them to murder, rape and rob the rebels' ethnic [targeting has resulted in some] 50,000 people killed, 1.2m forced to flee their huts, international outrage and a mammoth relief effort. But that is only one Sudanese *mushkilla*. Far to the east, the restive Beja and Rashaida tribes are threatening to cut the single paved road that links Sudan's vast interior to the sea. Big *mushkillas* plague the south, too. Following half a century of intermittent but savage warfare and perhaps 2m[illion] deaths, the government and the main southern rebel group have all but clinched a complex deal to share power and resources. Now, the impending return of some 3.5m displaced southerners to their ravaged homelands threatens a new type of trouble. Other chronic *mushkillas* include drought, locusts, disease [and] poverty. . . .²

These chronic environmental conundrums, are in many respects, augured by a more critical long term issue: Sudan's lack of effort in the sustainable development of its groundwater resources.

It is this latter predicament that I address in this article; particularly, the *mushkilla* of the sustainability of Sudan's groundwater. Part I discusses Sudan's geography and climate. Part II addresses the worldwide groundwater problem. Part III focuses on Sudan's groundwater situation; while in Part IV I discuss Sudan's groundwater resources. In Part V I address the concept of sustainable development and Agenda 21. Part VI spotlights the formulation of strategic decisions in light of groundwater resources; and Part VII centers on the Precautionary Principle.

II. Sudan's Geography

Sudan is situated in the northeastern corner of Africa and is the largest country on the African continent.³ See Figure 1. It has a total

1. *Decision Time in Darfur*, THE ECONOMIST, Sept. 3, 2004, at 39.

2. *Id.*

3. Food and Agriculture Organization of the United Nations, Land and Water Development (Sudan), <http://www.fao.org/ag/agl/aglw/aquastat/countries/sudan/index.stm> (last visited Apr. 15, 2006) [hereinafter FAO].

area of 2.5 million square kilometers.⁴ The country extends from a desert environment in the north, gradually transforming to a sub-tropical climate in the southern portion of the country.⁵

The country's terrain is generally flat⁶ "while the northern third of the country is covered by a sandy desert with mobile and fixed sand dunes in the north-western part which is considered to be an extension of the eastern outskirts of the Great Desert."⁷

Only 7.03 percent of Sudan's total land area is arable,⁸ consisting of "7.6 million ha[hectares], which is 7% of the cultivable area [and o]nly about 3 % consists of permanent crops, the remaining area consisting of annual crops."⁹ In addition, the country is beset by natural hazards such as dust storms and periodic persistent droughts. Moreover, Sudan's current environmental issues include "inadequate supplies of potable water . . . soil erosion [and] desertification."¹⁰

The country's arid climate determines the amount of precipitation it receives. Rainfall varies from a meager 20 mm/year (0.79 inches/year) in the north and west—adjacent to the Libyan desert—to approximately 1600 mm/year (63.04 inches/year) in the far south. Annual rainfall averages 436 mm/year (17.2 inches/year), an amount befitting a desert. However, the rainfall is characterized by significant variations in spatial distribution, timing as well as in location.¹¹

This variation in rainfall is critical to the country's agricultural sector and pastoral lifestyles. Sudan's agricultural segment "is *the leading* economic sector, contributing 48% of the GDP [Gross Domestic Product], giving employment to 65% of the population and providing the country with about 80% of the export earnings, which were estimated at 600 million dollars in 1999."¹² Pastoral nomadism, the practice "where people are always on the move with their animals, wandering throughout

4. CIA—The World Factbook—Sudan, <http://www.cia.gov/cia/publications/factbook/geos/su.html> (last visited Apr. 15, 2006).

5. Embassy of Sudan in South Africa, Agriculture in Sudan, http://www.sudani.co.za/economy_agricul_sudan.htm (last visited Apr. 15, 2006) [hereinafter Agriculture in Sudan].

6. *Id.* at 3.

7. FAO, *supra* note 3, at 1.

8. *Id.*

9. *Id.* at 2. A hectare is equivalent to 2.471 acres.

10. Sudan Embassy in South Africa, Water Resources in Sudan, http://www.sudani.co.za/economy_agric_water.htm (last visited Apr. 15, 2006) [hereinafter Water Resources in Sudan]; on the issue of desertification, *see also*, PHILIPPE CULLET, UNIVERSITY OF LONDON, DESERTIFICATION, *available at* <http://ielrc.org/content/a0201.pdf>.

11. *Id.*

12. Agriculture in the Sudan, *supra* note 5 (emphasis added).

the year fetching water and pastures,”¹³ is quite prevalent in Sudan.

III. Of Enigmas and Groundwater

Groundwater is under continuous assault. Worldwide, it is most impacted by an ever-increasing population growth rate,¹⁴ as well as mounting industrialization and agricultural expansion. These forces give rise to a dangerous situation: progressively escalating demands on groundwater resources. Across the face of the African continent, from the Maghreb to the Sahel¹⁵ and to southern Africa, rural and urban populations have become critically dependent on groundwater. Historical evidence is not on the side of today's inhabitants. For example, “archaeological evidence suggests that much of the Sahara was once a green and pleasant land, until depletion of groundwater turned it into desert.”¹⁶ Today, desertification is an ongoing problem in Sudan.

Thus, it is no surprise that numerous water experts argue that “[t]he world faces severe and growing challenges to sustain water quality and meet the rapidly growing demand for water resources. New sources of water are increasingly expensive to exploit, limiting the potential for expansion of new water supplies.”¹⁷

13. UNITED NATIONS DEVELOPMENT PROGRAMME [UNDP], RESEARCH ON ROOTS OF CONFLICT AND TRADITIONAL CONFLICT TRANSFORMATION MECHANISMS: TRANSHUMANCE ROUTES IN NORTH DARFUR (2002), available at <http://www.sd.undp.org/publications/pub2/transhumance%20routes%20report2.htm>.

14. Ali Ahmed Rind, *Dawn of a Thirsty Century*, THE NEWS, Aug. 21, 2003, at 3, available at http://www.sdpi.org/help/articles_in_press/Aug2003articles_rind.htm [hereinafter *Thirsty Century*] (“water experts identify population growth not only [as] increas[ing] human water needs, it also aids to accelerate environmental disturbances of the water cycle”).

15. The Sahel is a narrow band of semi-arid land south of the Sahara culturally complex area. The Sahel is widely French-speaking, Islamic and takes its name (“shore”) from Arabic. But the region, one of the poorest and most environmentally damaged places on earth, has deep troubles. In the 1970s, the Sahel captured international attention when drought and famine killed nearly 200,000 people. Though conditions have since improved, it has yet to shake a vicious cycle of soil erosion, insufficient irrigation, deforestation, overpopulation, desertification and drought. Parts of the region—like Mali’s legendary Timbuktu—are now more Sahara than Sahel. As the environment has suffered, the scramble for income has intensified. Ethnic lines that divided many traditional occupations—herders and farmers—have blurred, often sparking bloodshed. Public Broadcasting System, Sahel, http://www.pbs.org/wnet/africa/explore/sahel/sahel_overview.html (last visited Apr. 15, 2006).

16. *Irrigate and Die*, THE ECONOMIST, July 17, 2003, available at http://www.economist.com/displaystory.cfm?story_id=1906914.

17. MARK W. ROSEGRANT ET AL., POLICIES AND INSTITUTIONS FOR SUSTAINABLE WATER RESOURCE MANAGEMENT: A RESEARCH AGENDA (2002), available at <http://www.waterforfood.org/pdf/Background%20paper%20theme%205.pdf>; see also Rind, *supra* note 14, at 1 (stating that of the 3% of the earth’s fresh water “some two thirds of the remaining fresh water being found in the ice caps, fresh groundwater comprises only 0.76% of the world’s water, and rivers only 0.0002%”).

Globally, groundwater reserves outstrip all of the supplies found in rivers, lakes and other surface freshwater by a factor of one hundred to one.¹⁸ Currently, groundwater use is growing at a rate of four to eight percent per annum.¹⁹ Combined with improvements in management technology, groundwater use has escalated from strictly a local resource to one that entire nations are tapping.²⁰

Moreover, in the arid countries of eastern Africa, the situation is extremely dire. For example, in the arid and semi-arid western and northwestern Sudan and in sub-Saharan Africa generally, the dearth and the quality of surface water have caused farmers and municipalities to expand the use of groundwater—often ignoring its overuse and minimal recharge levels. In fact, a recent United Nations Report notes that

Unless more is done . . . by 2050 up to 7 billion people—out of a projected world population of 9.3 billion—may be suffering in some way from water shortages. . . . Intensive farming has greatly increased the world's food supply but it is sucking up growing quantities of water. Of 170 countries surveyed by the UN, 20 are already using more than 40% of their renewable water supply for irrigation. By 2030, the Middle East and North Africa [Sudan included,] may be using more [than] 60% of theirs. Developing countries could continue expanding their farm output without endangering their water supply by using more treated waste water on their crops.²¹

Moreover, a United Nations official noted that

[i]n the developing world, more than 1 billion people do not have access to clean drinking water, and 1.7 billion people lack access to adequate sanitation facilities. The U[nited] N[atations] [notes] that dirty water causes 80 percent . . . of diseases in the developing world

18. Int'l Law Comm'n [ILC], *Seventh Report on the Law of the Non-Navigational Uses of International Watercourses*, ¶ 14, U.N. Doc. A/CN.4/436 (Mar. 15, 1991) (prepared by Stephen C. McCaffery), reprinted in [1991] 2 Y.B. Int'l Law Comm'n 45, U.N. Doc. A/CN.4/SER.A/1991/Add.1.

19. See e.g., Joseph W. Dellapenna, *The Evolving International Law of Transnational Aquifers*, in *MANAGEMENT OF SHARED GROUND WATER RESOURCES: AN ISRAELI-PALESTINIAN CASE WITH AN INTERNATIONAL PERSPECTIVE* (Eran Feitelson, & Marwan Haddad et al. eds., 2001) (noting that although the available quantity of groundwater has remained stable over the course of time, consumption of the resource has increased many-fold since 1900).

20. *Id.* at 212. For example, in Lithuania groundwater accounts for 100% of that nation's drinking water. See e.g., E. ALMASSY & Z. BUSÁS, *GUIDELINES ON TRANSBOUNDARY GROUND WATER MONITORING: INVENTORY OF TRANSBOUNDARY GROUND WATERS* 21 (1999), available at [http://www.iwac-riza.org/IWAC/IWACSite.nsf/7BAFC09E93A2EE9DC1256BB800476C12/\\$File/Task%20Force%20Vol%201.pdf](http://www.iwac-riza.org/IWAC/IWACSite.nsf/7BAFC09E93A2EE9DC1256BB800476C12/$File/Task%20Force%20Vol%201.pdf).

21. *Nor any Drop to Drink*, THE ECONOMIST, Mar. 5, 2003, available at http://www.economist.com/agenda/displaystory.cfm?story_id=1621254.

and kills 10 million people annually.²²

At present, only 10% of irrigated land in these countries use recycled water, which, the United Nations notes, can actually improve soil fertility if correctly treated.

Unlike other developing countries, Sudan has not utilized non-conventional sources of water, such as treated wastewater.²³ Given the growth of the country's population, these alternative sources of water are a critical factor in the country's water use equation. This is especially true considering that of the total of 37.3 km³ of water withdrawn in Sudan in the year 2000, 36 km³ or 96.7% was used for irrigation and livestock; domestic purposes used 2.6%, while industry used only 0.7% of the total water withdrawal.²⁴

As the country's population increases, these proportions will have to change, due to the demand of industry and domestic consumption. For instance, the development of the country's natural resources such as petroleum and hard minerals, including copper, chromium, silver and gold places a heavy demand on the country's groundwater supply.²⁵ This has been the case with irrigation in other countries. For example, Israel, one of the most prominent users of recycled water, long ago, was forced to confront the fact that its "domestic and industrial sectors have higher priority, the fresh water allocation to agriculture is declining but the allocation of brackish and treated sewerage waters is increasing. With relative water scarcity and high cost of fresh water for irrigation, the irrigation sector . . . is constantly substituting capital and technology for water."²⁶ Furthermore, according to commentators,

Sonoma County, in the heart of California's wine country, is reusing water to assure adequate supplies for drinking water, commercial and agricultural uses. The three million gallons per day (mgd) water reuse facility treats secondary effluent from partially aerated lagoon treatment plant near the county airport in Santa Rosa. The reused water will irrigate fields near the airport and some of the many

22. Steve Lonergan, *Forces of Change and the Conflict over Water in the Jordan River Basin*, in *WATER IN THE MIDDLE EAST: A GEOGRAPHY OF PEACE* 52-53 (Hussein A. Avery & Aaron T. Wolf eds., 2000).

23. FAO, *supra* note 3, at 6, tbl. 2.

24. *Id.*

25. *See e.g.*, CIA *supra* note 4, at 2.

26. MARIA SALETH & ARIEL DINAR, THE WORLD BANK GROUP, WATER CHALLENGE AND INSTITUTIONAL RESPONSE: A CROSS-COUNTRY PERSPECTIVE 7 (1999), available at <http://www.worldbank.org/html/dec/Publications/Workpapers/wps2000series/wps2045/wps2045.pdf>; *see also* Itzhak E. Kornfeld, *Groundwater Conservation: Conundrums and Solutions for the New Millennium*, 15 TUL. ENV'T L.J. 365, 368-371 (2002).

nearby vineyards.²⁷

In fact, Sudan's population has doubled "since 1970 to 34 million people."²⁸ In 2005 Sudan's population was estimated at 40.2 million people.²⁹ Furthermore, given that the country's annual growth rate is between 2.6% and 2.8%³⁰—as compared with an annual growth rate in the United States of 0.92%³¹—the population will once again double by 2030. Given such a sharp increase in the number of people, northern, central and western Sudan will become more and more populated, particularly once the ethnic strife in Darfur ends. It is a given that the Blue, White and main Nile Rivers, in the eastern portion of the country, will not be able to support such a large increase in population alone. Accordingly, for those communities and populations situated outside the Nile River watershed, life will be harsh indeed. Lack of water will restrict their opportunities, unless groundwater resources can be developed in a sustainable fashion.

Thus, one of the issues that will confront Sudan's government during the next twenty to thirty years—much like other nations in the region—is how to sustain its water resources, specifically its groundwater resources.³² That is the topic of the next section.

IV. Sudan's Groundwater

Sudan's dominant hydrological features are the Blue and White Nile Rivers and the Nile River System, which flow north into Egypt in the northeast. See Figure 2. These three rivers and their tributaries are located in the east/northeast and flow into the country from the Ethiopian Plateau, continuing north into Egypt. See Figure 2. Pursuant to the 1959

27. See Kornfeld, *supra* note 26, at 376 (citing Tom Wingfield & Jim Schaefer, *Making Water Work Harder*, ENVTL. PROT., Nov. 2001, at 30-31).

28. *Decision Time in Darfur*, *supra* note 1.

29. CIA—The World Factbook—Sudan, <http://www.cia.gov/cia/publications/factbook/geos/su.html> (last visited Apr. 15, 2006).

30. *Id.* The CIA estimates the growth rate at 2.6%. However, others calculate it at 2.8%. For example, an estimate in 2000 noted that "with a current population of 30 million in Sudan and an annual increase of 2.8%, water stress is at our door steps." Osman El-Tom Hamad & Seifeldin H. Abdalla, *The Country Paper for Sudan To the VIII Nile 2002 Conference Addis Ababa, Ethiopia* (June 2002), available at <http://www.telecom.net.et/~walta/profile/articles/article166.html> (last visited Jan. 17, 2006).

31. CIA—The World Factbook—Sudan, <http://www.cia.gov/cia/publications/factbook/geos/su.html> (last visited Apr. 15, 2006).

32. For example, The Middle East ran out of water in the 1970s. See generally, J.A. ALLAN, *THE MIDDLE EAST WATER QUESTION: HYDROPOLITICS AND THE GLOBAL ECONOMY* 5 (2002); see also, Itzhak E. Kornfeld, *A Water Solution for the Middle East Conflict*, 33 ENV'T L. REP. 10207 (Mar. 2003).

Nile Waters Treaty³³ between Egypt and Sudan, “Sudan is now utilizing about 14.6 [billion cubic meters] of its share of Nile water for irrigation, of which 9.5 [billion cubic meters] are from the Blue Nile, 1.7 [billion cubic meters] from Atbara River, 1.8 [billion cubic meters] from the White Nile and 1.6 [billion cubic meters] from the main Nile.”³⁴

However, Sudan’s “share of the Nile water which stands currently at 20.5 md. c.m. at Sennar, according to the Nile Water Agreement of 1959,”³⁵ means that the country has a surplus of 5.9 billion cubic meters of water to draw upon to fulfill its allotted allocation. Unless, of course, Egypt decides that its allotment of Nile River water is too low.³⁶ On the other hand, in the eastern and west-central portions of the country, groundwater is a more critical resource for drinking water, agriculture and industry.

A. *The Country’s Aquifers*

Sudan has three extensive aquifers that are estimated to yield nine billion cubic meters of water.³⁷ These three aquifers are the Nubian, the Um Rwaba and the Basement complex.³⁸ I address each of these below, in addition to addressing subsidiary aquifers. Please note that although I have attempted to be thorough, I am constrained by the available information, and information available in English is quite scarce. Additionally information in Arabic, Sudan’s official language, is not readily available.

1. The Nubian Aquifer

The Nubian Aquifer system underlies northern Sudan.³⁹ This

33. The treaty is more specifically known as the “United Arab Republic and Sudan Agreement (With Annexes) For The Full Utilization of the Nile Waters Signed at Cairo, on 8 November 1959; in force 12 December 1959 Registered by the United Arab Republic on 7 February 1963, 6519 U.N.T.S. 63.” On the Nile Waters Treaty *see generally*, A.H. Garreston, *The Nile Basin, in THE LAW OF INTERNATIONAL DRAINAGE BASINS* 291-92 (A.H. Garreston, R.D. Hayton & C.J. Olmstead, eds., 1967); Yosef Yacob, *Tough Talk over a Defunct Treaty: The Case of the 1929 Nile Waters Agreement* (2004), <http://www.tigray.org/News/Articles2004/TheNileByYacob.html>.

34. Water Resources in Sudan, *supra* note 10.

35. *Id.* “Md. C. M.” stands for milliard cubic meters, which translates to billion cubic meters.

36. “Every Treaty in force is binding upon the parties to it and must be performed by them in good faith.” *See* Vienna Convention on the Law of Treaties, arts. 26, 27, and 30, May 23, 1969, 1155 U.N.T.S. 331; 8 I.L.M. 679 (entered into force 1980).

37. Water Resources in Sudan, *supra* note 10.

38. *Id.*

39. Ulf Thorweihe & Manfred Heintz, *Groundwater Resources of the Nubian Aquifer System, NE-Africa* (2002), available at http://geosys.bg.tu-berlin.de/archiv/downloads/NAS_syn.pdf [hereinafter “Nubian Aquifer System”].

system extends south from the Libyan-Egyptian-Sudanese border, stretching south of the Sudanese city of Selima, west of Dongola and west and south of Nukheila to Wadi Howar.⁴⁰ The sandstone Nubian aquifer “covers 28.1% of the total area of the Sudan,”⁴¹ and attains a thickness of 3,500 to 4,000 meters (2.17 miles -2.5 miles) in the Libyan Desert region of northwestern Sudan.⁴² However, in the eastern portion of the country’s Nubian Desert, the aquifer “contain[s] comparatively small groundwater resources due to the low sediment thickness of a few hundred meters. . . . [T]he groundwater in the Nubian Aquifer System is fossil. In other words, it is a groundwater deposit that would be depleted through natural and artificial processes”⁴³ as it has a very low rate of recharge.⁴⁴ In the Nubian Desert, the sediments are composed of Upper Cretaceous (60-65 million years before present) silty sandstones overlain by Tertiary age (63 million—1.8 million years before present) sandstones and underlain by crystalline basement.⁴⁵ On the other hand, in the country’s western/northwestern region the sediments, which are also predominantly sandstone, are much older in age.

40. *Id.* “The Nubian Sandstone Aquifer System (NSAS) is a huge groundwater resource shared among four countries within the Eastern Sahara in North-East Africa. It . . . underl[ies] almost all the area of Egypt, Eastern Libya, Northern Sudan and Northern Chad. . . . The NSAS underlies an area in excess of 2.5 million km.” THE CENTRE FOR ENVIRONMENT AND DEVELOPMENT FOR THE ARAB REGION AND EUROPE [CEDARE], NUBIAN SYSTEM AQUIFER PROGRAMME (2001), available at <http://isu2.cedare.org.eg/nubian> and <http://isu2.cedare.org.eg/nubian/project/maps.htm>.

41. Water Resources in Sudan, *supra* note 10.

42. Nubian Aquifer System, *supra* note 39.

43. *Id.* at 3-4. Fossil groundwater or paleowaters is water that is buried in strata or rock which is stored from earlier periods of wetter climate(s). It is not replenished by recharge. Thus, once this groundwater is mined or abstracted these waters are depleted.

44. The term “recharge” is the process of replenishment to an aquifer due to the infiltration/percolation from rainfall. Recharge to groundwater may also occur from surface water bodies such as lakes and streams. Centre for Groundwater Studies, Definitions, <http://www.groundwater.com.au/> (last visited Apr. 15, 2006).

The term “recharge” can also mean “[t]he process by which external water is added to the zone of saturation of an aquifer, either directly into a formation or indirectly by way of another formation. European Environmental Agency, Information for Improving Europe’s Environment, http://glossary.eea.eu.int/EEAGlossary/G/groundwater_recharge (last visited Apr. 15, 2006).

The zone of saturation, also called the phreatic zone, “[i]s that portion of the lithosphere [the earth] in which the pore spaces are filled with water, that is, the region beneath the water table.” American Meteorological Society, Glossary of Meteorology, <http://amsglossary.allenpress.com/glossary/> (last visited Apr. 15, 2006).

45. Nubian Aquifer System, *supra* note 39, at 6. Crystalline Basement is what sedimentary rocks lie or sit on. In Sudan they are generally composed of metamorphic rocks.

2. The Um Rwaba and Basement Complex Aquifers

A second groundwater source is the large and extensive aquifer known as the “Um Rwaba series covering 20.5% of the total area and the basement complex which covers 9.1% of the total area. The preliminary surveys of the underground [water] reserve quote the figure of [9] [billion cubic meters].”⁴⁶

The regional groundwater flow direction is southwest to northeast toward Egypt’s Nile River Basin. The groundwater column in Sudan varies in thickness, from 500 meters in the west to a featheredge in northeastern Sudan.

3. The Wadi Nyala Aquifer

A third groundwater source is the Wadi⁴⁷ Nyala aquifer, located in southern Darfur, some 250 kilometers from Sudan’s border with Chad and the same distance from the eastern border with the Central African Republic.⁴⁸ According to Mustafa A. Rahim Yousif,

The upper limits of the wadi Nyala catchment area extends from North of Nyala town to the southern part Jebel Marra Mountain region. . . . Wadi Nyala is formed by two main rivers, wadi Kabris and wadi Domaia, they join and form the stream channel about 15km. West of Nyala town. The runoff of the wadi [sic] during rainy season is caused by rains in the northern part of the catchment area. The average rain fall is 373 mm [14.7 inches] per annum while the evaporation is 2550 mm.⁴⁹

The groundwater bearing strata of Wadi Nyala are composed predominantly of alluvial deposits, *i.e.*, riverine sediments, and have a catchment area of 1375 km².⁵⁰ These range in thickness from 10-20 meters (approximately 30-60 feet). Their primary “source of recharge is the infiltration from surface water runoff in the wadi.”⁵¹

46. Water Resources in Sudan, *supra* note 10. In order to convert one billion cubic meters to gallons, divide one billion cubic meters by 1.3815. Thus, one billion cubic meters = 1.307 billion cubic yards = 35.289 billion cubic feet = 263.96 billion gallons.

47. A wadi (pronounced “waadee”) is a dry river or stream bed “in southwestern Asia and northern Africa” that is dry except during times of heavy rain. WEBSTER’S NEW COLLEGIATE DICTIONARY 150TH ANNIVERSARY EDITION 1305 (1981).

48. MUSTAFA A. RAHIM YOUSIF, USE OF SPACE TECHNOLOGY IN EXPLORATION & ASSESSMENT OF GROUNDWATER RESOURCES IN BASEMENT COMPLEX IN SUDAN (*case, Wadi Nyala Catchment*), in Workshop on the Use of Space Technology for Natural Resources Management, Environmental Monitoring and Disaster Management 5 (2004), available at <http://www.unoosa.org/pdf/sap/2004/sudan/presentations/03-02.pdf>.

49. *Id.*

50. *Id.* at 7.

51. *Id.*

Unfortunately, due to the high rate of evaporation only 15,800,000 meters³ or 15.8 kilometers³ of water, are available for human consumption.

In this area of Darfur, the impact of desertification, as well as the war against the Dar and Fur tribes and other factors, has caused a significant increase in the population of Nyala Town,⁵² the regional capital of the Southern Darfur State. As the population increases, so does the demand on the area's water supplies "for domestic, industrial and agricultural purposes."⁵³ This population increase will result in a drastic water shortage, unless additional water resources are utilized⁵⁴ including a section of Wadi Nyala Aquifer known as the Basement complex.

4. The Omdurman and Gezira Formations

The Omdurman formation is composed of a "sequence of sandstone, conglomerate and mudstone[s], [which are] more than 400 m[eters] thick."⁵⁵ Alternatively, the "Gezira formation . . . consists of a sequence of unconsolidated interbedded clay, silt, sand and gravel layers . . . [and] covers the area between the Blue and White Nile, and small strip east of the Blue Nile. . . . [Its] thickness . . . ranges from [a] few meters to more than 80 m[eters]."⁵⁶ The Omdurman-Gezira aquifer system is recharged "exclusively from the Blue Nile, White Nile and Nile, direct precipitation and seasonal streams."⁵⁷

Although preliminary assessments of the volume of water contained in the country's aquifers have been conducted, one of the main problems that plagues the Sudan is the dearth of data and research regarding the country's total groundwater reserves and the rate of groundwater recharge or replenishment.⁵⁸ Currently, only 1.3 billion cubic meters of the total known groundwater reserves are being used. Approximately 450 million cubic meters, or 34.6%, of the total groundwater reserves are utilized for domestic purposes.⁵⁹ In addition, 850 million cubic meters, or 65.4% of the total, are employed for irrigation of some 67.2 thousand

52. *Id.* at 5. Nyala Town is located in Western Darfur, at 12° 03' N, 24° 53' E.

53. *Id.* at § 3.3.

54. *Id.* the Basement complex is composed of crumbling crystalline or metamorphic rocks.

55. Abdil Elkraïl et al., Hydrochemical Evaluation of Groundwater in Khartoum State, Sudan, ¶ 2, <http://www.gisdevelopment.net/application/environment/water/ma03054pf.htm> (last visited Apr. 15, 2006).

56. *Id.*

57. *Id.*

58. *Id.*

59. *Id.*

hectares (27,206 acres).⁶⁰

Given Sudan's arid and semi-arid climate and the fact that the country's farmers use open ditches and canals for irrigating their crops, a great deal of water simply evaporates into the atmosphere.⁶¹ Furthermore,

The Human Development Index ranks Sudan in 139th place among 177 countries. Poverty in the Sudan is massive, deeply entrenched and predominantly a rural phenomenon. Over two-thirds of the population, and under the most favourable assumptions still around 50-70 percent, are estimated to live on less than US \$1/day. In recognition of the severity of poverty in general, and of rural poverty in particular, the Government started to prepare a draft Poverty Reduction Strategy Paper (PRSP) and launched a pilot poverty-reduction programme in 2001 to improve long-neglected rural social services. The programme is financing basic education, primary health care, malaria prevention and drinking-water supply.⁶²

Once the country's economy begins to grow, its per-capita water use will soar. Nevertheless, the water use figures cited above do not reflect any attempt to engage in a sustainable use of Sudan's groundwater resources. That subject is addressed below.

V. Sustainable Development and Agenda 21

According to the preamble to the UN's Rio Declaration on Environment and Development:

Humanity stands at a defining moment in history. We are confronted with a perpetuation of disparities between and within nations, a worsening of poverty, hunger, ill health and illiteracy, and the continuing deterioration of the ecosystems on which we depend for our well-being. However, integration of environment and development concerns and greater attention to them will lead to the fulfillment of basic needs, improved living standards for all, better protected and managed ecosystems and a safer, more prosperous future. No nation can achieve this on its own; but together we can—in a global partnership for sustainable development.

60. *Id.* One hectare is equivalent to 2.74 acres.

61. *See e.g.*, "Potential annual evapotranspiration ranges from 3,000 mm in the north to 1,700 mm in the extreme south." Evapotranspiration is defined as "[a] process, either naturally occurring or mechanically induced, whereby water is changed from its liquid state into a vapor." The Photonics Directory, Evapotranspiration, <http://www.photonics.com/dictionary/lookup/XQ/ASP/url.lookup/entrynum.1739/letter.e/pu./QX/lookup.htm> (last visited Apr. 15, 2006); *see also* AllRefer.com, Hydrology in Sudan, <http://reference.allrefer.com/country-guide-study/sudan/sudan43.html> ("evaporation takes most of the water from the slow-moving streams").

62. FAO, *supra* note 3.

This global partnership must build on the premises of [the U.N.'s] General Assembly resolution 44/228 of 22 December 1989, which was adopted when the nations of the world called for the United Nations Conference on Environment and Development, and on the acceptance of the need to take a balanced and integrated approach to environment and development questions.⁶³

Agenda 21 identified the need for a more robust administration of international law, coupled with sustainable development. It states,

Governments committed to the "further development of international law on sustainable development, giving special attention to the delicate balance between environmental and developmental concerns." Governments also recognised the "need to clarify and strengthen the relationship between existing international instruments or agreements in the field of environment and relevant social and economic agreements or instruments, taking into account the special needs of the developing countries."⁶⁴

However, the term "sustainable development" is vague. Some have argued that the notion of a collision between rich and poor peoples is inherent in the term.⁶⁵ Nevertheless, the International Law Association

63. U.N. Dep't of Econ. & Soc. Affairs, *Rio Declaration on Environment and Development*, Preamble ¶¶ 1.1, 1.2, available at <http://www.un.org/esa/sustdev/documents/agenda21/english/agenda21chapter1.htm>.

Agenda 21, is a 300-page plan for achieving sustainable development in the 21st century. The United Nations Commission on Sustainable Development (CSD) was created in December 1992 to ensure effective follow-up of UNCED; to monitor and report on implementation of the Earth Summit agreements at the local, national, regional and international levels. The CSD is a functional commission of the UN Economic and Social Council (ECOSOC), with 53 members. A five-year review of Earth Summit progress took place in 1997 by the United Nations General Assembly meeting in special session, followed in 2002 by a ten-year review by the World Summit on Sustainable Development.

U.N. Dep't of Econ. & Soc. Dev., Division of Sustainable Development, http://www.un.org/esa/sustdev/csd/about_csd.htm (last visited Apr. 15, 2006). About the Commission on Sustainable Development:

In 1992, more than 100 heads of state met in Rio de Janeiro, Brazil for the United Nations Conference on Environment and Development (UNCED). The Earth Summit, as UNCED was also known, was convened to address urgent problems of environmental protection and socio-economic development. The assembled leaders signed the Framework Convention on Climate Change and the Convention on Biological Diversity; endorsed the Rio Declaration and the Forest Principles; and adopted Agenda 21.

Id.

64. CTR. FOR INT'L SUSTAINABLE DEV. LAW, *INTERNATIONAL SUSTAINABLE DEVELOPMENT LAW: PRINCIPLES, PRACTICE & PROSPECTS* 1-2 (citing Agenda 21, 1992 Report of the UNCED, I (1992) UN Doc. A/Conf.151/26/Rev. 1, (1992), 31 I.L.M. 874 at Ch. 38), available at http://www.cisd.org/pdf/what_is_isdl.pdf.

65. Christopher D. Stone, *Deciphering "Sustainable Development,"* 69 CHI.-KENT

("ILA") recently illustrated Sustainable Development's impact on and incorporation into the current legal framework. In an April 6, 2002, report the ILA's Committee on the Legal Aspects of Sustainable Development observed the following:

The phrase "sustainable development" as launched in the Rio Declaration has found recognition in international legal instruments remarkably soon. Various environmental treaties incorporate it, for example the Climate Change Convention, the Convention on Biological Diversity and the Anti-Desertification Convention. It also features in the World Fisheries/Straddling Stocks Convention as well as in the preamble of the 1995 Agreement on the Establishment of the World Trade Organization. . . . Reference may also be made to the prominent place of sustainable development as an objective in the law of the European Union. For example, the Treaty on European Union, as amended through the 1997 Treaty of Amsterdam, includes objectives such as "economic and social progress and a high level of employment and to achieve balanced and sustainable development" (Art. 2). Sustainable development is also elevated as a general objective in Article 2 of the revised EC Treaty, albeit in not entirely identical terms.⁶⁶

Moreover, the Committee established a number of general principles, set forth as follows: (1) the rule of law in international relations, including economic relations, which imposes a duty upon States, as well as international organizations to "abstain from measures of economic policy that are incompatible with their international obligations and which are detrimental to the sustainable development opportunities of third countries and peoples";⁶⁷ and (2) the Duty upon States to cooperate with each other, which among other provisions states that "[i]t applies at the global, regional and bilateral levels and often requires prior information,

L. REV. 977, 978 (1994). ("The term sustainable Development . . . functions to gloss over not only failed consensus, but a latent collision course. The chasm is less a failure of language . . . than a poignant tussle between, roughly rich and poor.")

66. Committee on Legal Aspects of Sustainable Development, International Law Association, Searching for the Contours of International Law in the Field of Sustainable Development (2002), available at http://www.ila-hq.org/html/layout_committee.htm.

67. *Id.* at 6-7, providing as follows:

1. *General principles*

Obviously, a first general principle is the *rule of law in international relations, including international economic relations*. This entails a duty incumbent on States (and on international institutions and other main actors in international economic relations as well) to abstain from measures of economic policy that are incompatible with their international obligations and which are detrimental to the sustainable development opportunities of third countries and peoples. Treaties and binding decisions by international institutions have to be observed and fulfilled in good faith by all parties concerned. . . .

consultation and negotiation.”⁶⁸ The International Law Association adds:

This brings us to the principle of the *duty to co-operate* towards global sustainable development and protection of the global environment. The duty to co-operate is well-established in international law, as exemplified by Chapter IX on International Economic and Social Co-operation of the UN Charter and Principle 4 of the 1970 Declaration on Friendly Relations. It applies at the global, regional and bilateral levels and often requires prior information, consultation and negotiation. It is also embodied in Principle 27 of the Rio Declaration, where it provides: “States and peoples shall co-operate in good faith and in a spirit of partnership in the fulfillment of the principles embodied in this Declaration and in the further development of international law in the field of sustainable development.” Similarly, Rio Principle 7 states that “States shall co-operate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth’s ecosystem . . . , while its Preamble refers to the goal of establishing a new and equitable global partnership through the creation of new levels of co-operation among States, key sectors and people.” Indeed, in today’s world this principle does no longer exclusively relate to States, but also applies to international institutions, civil society and the business community as contracted in this mission by UN Secretary-General Kofi Annan through his Global Compact to promote sustainable growth and good citizenship through committed and creative leadership. Calling to observe nine universal principles in the areas of human rights, labour standards and the environment, it brings together companies with business organizations, UN organizations, international trade unions, non-governmental organizations and other parties to foster partnerships and build a more inclusive and equitable global marketplace. . . .⁶⁹

These duties require people—especially those who reside in the richer nations of the world—not only to advance institutional management, technologies and the law, so that they may share this progress with their poorer kin on all points of the globe, but also to use common sense in how *they* utilize their groundwater resources. In the following section I discuss the topic of Sudan’s groundwater resources.

VI. Groundwater Resources and Strategic Decisions

[W]ater resources are a strategic component for social, economic development and political stability. . . . It is not only the availability and accessibility of water, which is important . . . [but t]he ongoing

68. *Id.*

69. *Id.*

degradation of these resources and the landscape as a whole, that is, the quality aspects, represents a major threat to the livelihood of millions of people.⁷⁰

In the context of water resources and water scarcity, and in particular when dealing with the regulation, management and conservation of such resources, there appears to be a serious misunderstanding within the political and legal communities of the nature of ground-water and surface water and the interrelationship between the two. It is this misunderstanding which lies at the heart of the misgivings of the scientists I spoke with, and which all too often has resulted in policies, laws, and court decisions that are inadequate and ineffective in dealing with modern water problems.⁷¹

The long term availability of water resources is one of the critical issues facing the Sudan and other African States, as well as international organizations, such as the United Nations Food and Agriculture Organization.⁷² Given that a significant portion of the precipitation that lands on arid portions of the earth's surface is lost primarily due to evaporation, especially in northern and western Sudan,⁷³ a number of experts have posited that "[c]limate change may affect the amount of water available in rivers, lakes and below ground. But in the short run, the resource flow is fairly constant, albeit subject to considerable variations over seasons and geographically."⁷⁴

Professor Jan Lundqvist, an expert on international water resources recently noted, with regards to Southeast Asia that

Demographic trends and human aspirations represent a contrast. An increase in basic human needs for water is inevitable since survival is impossible without a minimum amount to cater for drinking and household requirements. Similarly, the production of food and fibre for a reasonable diet, shelter, etc. is also necessary for which huge volumes of water are necessary. In addition to requirements related to basic human needs, a much larger set of human wants is

70. JAN LUNDQVIST, LINKÖPING UNIVERSITY, FINITE WATER AND GROWING NEEDS AND WANTS: OPPORTUNITIES AND CHALLENGES FOR INTERDISCIPLINARY RESEARCH NETWORKING 4 (2001), available at <http://www.sasnet.lu.se/lundqvist.pdf>.

71. GABRIEL ECKSTEIN, AMERICAN UNIVERSITY CENTER FOR THE GLOBAL SOUTH, HYDROLOGIC REALITY: INTERNATIONAL WATER LAW AND TRANSBOUNDARY GROUND-WATER RESOURCES (1998), available at <http://www.internationalwaterlaw.org/Articles/GlobalSouth.htm>.

72. For example, one report on Sudan's hydrology, specifically related to the Blue Nile and the White Nile, notes that much of the water from these rivers "is lost to evaporation." AllRefer.com, Hydrology in Sudan, <http://reference.allrefer.com/country-guide-study/sudan/sudan43.html>.

73. *Id.*

74. Lundqvist, *supra* note 70.

determining the total, aggregate demand for water. Purchasing power, political position and what is deemed socially and culturally desirable are among the factors that will influence the “wants” in society. . . .⁷⁵

The same issue plagues the Sudan and is compounded by the return of at least 2.5 million Sudanese who sought refuge in Chad, the Central African Republic and neighboring countries and will soon be returning to their homes and villages in Sudan.

Nevertheless, “[g]roundwater is emerging as a formidable poverty reduction tool. However, developing and managing this resource in a sustainable way poses many challenges.”⁷⁶ Indeed, sustainable development requires government to impress upon its institutions and inhabitants an ethos of nourishing the environment so that development does not, like a tornado, destroy all that is in its path. However, before one can put the notion of sustainability into gear, one must know what to sustain. This requires an inventory of the resources to be preserved. It is not clear that Sudan has undertaken a full accounting of its groundwater resources.

Another problem in utilizing Sudan’s groundwater resources is that water used within country’s borders derives almost exclusively from surface water resources, as groundwater is used in only very limited areas and mainly for domestic water supply. There are large areas in Sudan where development cost hampers the exploitation of groundwater, as the water table is very deep.⁷⁷

Nevertheless, sustainable development also requires consideration of two other variables: performing a cost-benefit analysis in exploiting groundwater resources, and using the best available technology to extract groundwater from its subterranean depths. Whether the Sudanese government has attempted to employ the two foregoing methodologies is not at all clear.

Moreover, given the fact that the Nubian aquifer extends north into Libya and Egypt, under international law, Sudan has a duty to cooperate⁷⁸ with these two neighbors. This duty includes insuring that Sudan’s use of the land overlying the aquifers does not negatively impact

75. *Id.*

76. International Water Management Institute, Overview—Sustainable Groundwater Management Theme, <http://www.iwmi.cgiar.org/groundwater/index.htm> (last visited Apr. 15, 2006).

77. FAO, *supra* note 3, at 1.

78. *See generally* Declaration on Principles of International Law Concerning Friendly Relations and Co-operation Among States in Accordance with the Charter of the United Nations, G.A. Res. 2625, Annex, ¶ 121, 25 U.N. GAOR, Supp. (No. 28), U.N. Doc. A/5217 (1970).

Libya and Egypt. What's more, Sudan, under the doctrine of Sustainable Development and its implicit duty to cooperate, must not only control its withdrawal of groundwater, but it must also maximize the amount of recharge into its aquifers.

Currently, the country's amount of renewable water resources exceeds its total withdrawal. The water surplusage is evident when the per capita renewable water resources—both surface and subsurface—are compared to the per capita water withdrawal: $1,879 \cdot 10^3$ m/year versus $1,187 \cdot 10^3$ m/year or a $692 \cdot 10^3$ m/year affirmative variance. Despite this surplus, with close to three million refugees waiting to return from Chad and the Central African Republic, Sudan's water resources will certainly be taxed, and its surplus will be tested.

Table I shows the amount of renewable water resources, water withdrawal levels and aquifer recharge in the Sudan.

Table 1: Water: Sources and Use⁷⁹

<u>Renewable Water Resources</u>	
• Average precipitation	416 mm/yr or 1,042 billion cubic meters/year for the entire country
• Internal renewable water resources	30.0 billion cubic meters/year
• Total actual renewable water resources	64.5 billion cu m/yr
• Total actual renewable water resources per inhabitant - (as of 2004)	1,879 10 ³ m/yr
<u>Water withdrawal</u>	
Total water withdrawal (as of 2000) –	37.3 billion cu m/yr
• irrigation + livestock (as of 2000)	36.1 billion cu m/yr
• domestic (as of 2000)	0.987 billion cu m/yr
• industry (as of 2000)	0.258 billion cu m/yr
• per inhabitant (as of 2000)	1,187 10 ³ m/yr
• as % of total actual renewable water resources (as of 2000)	58 %
<u>Groundwater recharge</u>	Average 7 km ³ /year—80% reliable 5 km ³ /year ⁸⁰

Of note, are the Sudanese government's previous successful efforts at modernizing its institutions. For instance, the UN's Food and Agriculture Organization has observed that

[s]ince independence in 1956, Sudan has established a well developed institutional infrastructure in an attempt to make its irrigation sector more efficient. At the top, the National Nile Waters Commission determines the allocation of water to each province. The Ministry of Irrigation and Water Resources (MOI&WR) is responsible for the delivery of irrigation water to the major canals and, jointly with the Agricultural Corporations (AC), for the operation of minor canals. MOI&WR is the sole authority for surface

79. *Id.*, modified from table 2.

80. *Id.* at table I. Elements in the water balance of Sudan are presented, based on information from the Ministry of Irrigation and Water Resources, and including an assessment of the 80%-probability figures.

water resources assessment and development in Sudan, whereas the Groundwater Corporation has the same responsibility regarding subterranean water resources. The Hydraulic Research Station (HRS) of MOI&WR deals with the development of theoretical and applied research concerning surface water resources. Regarding the domestic water supply, the responsibility for its management and development is divided between the Urban Waters Corporation and the Rural Waters Corporation.⁸¹

[Moreover, u]nder the reforming policies of the post-1989 government in Sudan, the development of irrigated agriculture has become crucial. There are ongoing studies for the expansion and rehabilitation of irrigation projects. Also, the construction of new hydraulic structures, such as dams and major irrigation canals, are an essential part of the planned development. Important projects include raising the height of the Roseires dam, the excavation of two major canals for water diversion from the Blue Nile, and the construction of the Merawi dam in the northern part of the country. Further irrigation development is limited by the amount of water allocated by the Nile Water Agreement with Egypt.⁸²

Thus, there is no reason to believe that if a current or subsequent government puts its efforts and resources into implementing policies that foster the sustainability of groundwater resources, such efforts would not be fruitful.

In fact, one example in the expansion of groundwater use is in Khartoum state, which is located in the arid region of Central Sudan.⁸³ "It has been intensively inhabited during the last decenniums"⁸⁴ leading to expansion of the residential areas away from the surface watercourses. Suitable quantity and quality of groundwater becomes a more crucial alternative resource to that of surface water, in order to meet the swelling increase in social, agricultural, and industrial development and to avoid the expected deterioration of groundwater quality due to heavy abstraction for miscellaneous uses.

Furthermore, in the current climate, "[m]ost development projects are now assessed upon the bases of at least economic viability, sustainability and environmental impact. [For example, s]hort-term aquifer tests may not be sufficient to determine the long-term sustainable yield of an aquifer."⁸⁵

In this vein, the estimation of recharge to sedimentary basin aquifers

81. *Id.* at 3.

82. *Id.* See also note 33 and accompanying text.

83. Elkraill et al., *supra* note 55.

84. *Id.*

85. *Id.*

is required if Sudan is to sustainably manage such aquifers. Although a number of methodologies are available to the government, their applicability to larger aquifer systems, such as Sudan's Nubian and Um Rwaba, has not been assessed.

One approach to setting a baseline for sustainable development is to estimate recharge rates.⁸⁶ However, either the national government or the various state governments must take the initiative to make that decision before it is too late.

A. The United Nations' Millennium Goals

In September 2000, the United Nations offered another choice to countries like Sudan. The international community, with the backing of the UN, developed a program for the sustainable development of natural resources, including water, called the Millennium Development Goals (*hereinafter* "MDGs"). There are eight MDGs.⁸⁷ The seventh of these,

86. CENTRE FOR GROUNDWATER STUDIES, CORPORATE REPORT, RECHARGE ESTIMATION (2003) <http://www.groundwater.com.au/publications/CGS-Corp-Report.pdf> ("using 'standard' methods, *i.e.*, 'concentration of chloride in soil water and groundwater to assess extent of rainfall; [as well as] hydrograph analysis of groundwater level response to rainfall'").

87. The eight goals are as follows:

Goal 1 Eradicate Extreme Poverty & Hunger

Global poverty rates are falling, led by Asia. But millions more people have sunk deep into poverty in sub-Saharan Africa, where the poor are getting poorer. Progress has been made against hunger, but slow growth of agricultural output and expanding populations have led to setbacks in some regions. Since 1990, millions more people are chronically hungry in sub-Saharan Africa and in Southern Asia, where half the children under age 5 are malnourished.

Goal 2 Achieve Universal Primary Education

Five developing regions are approaching universal enrolment. But in sub-Saharan Africa, fewer than two thirds of children are enrolled in primary school. Other regions, including Southern Asia and Oceania, also have a long way to go. In these regions and elsewhere, increased enrolment must be accompanied by efforts to ensure that all children remain in school and receive a high-quality education.

Goal 3 Promote Gender Equality & Empower Women

The gender gap is closing—albeit slowly—in primary school enrolment in the developing world. This is a first step towards easing long-standing inequalities between women and men. In almost all developing regions, women represent a smaller share of wage earners than men and are often relegated to insecure and poorly paid jobs. Though progress is being made, women still lack equal representation at the highest levels of government, holding only 16 per cent of parliamentary seats worldwide.

Goal 4 Reduce Child Mortality

Death rates in children under age 5 are dropping. But not fast enough. Eleven million children a year—30,000 a day—die from preventable or treatable causes. Most of these lives could be saved by expanding existing programmes that promote simple, low-cost solutions.

Goal 5 Improve Maternal Health

“ensuring environmental sustainability” seeks to

- Integrate the principles of sustainable development into country policies and programmes; reverse loss of environmental resources
- *Reduce by half* the proportion of people without sustainable access to safe drinking water [and]
- Achieve significant improvement in lives of at least 100 million slum dwellers, by 2020.⁸⁸

More than half a million women die each year during pregnancy or childbirth. Twenty times that number suffer serious injury or disability. Some progress has been made in reducing maternal deaths in developing regions, but not in the countries where giving birth is most risky.

Goal 6 Combat HIV/AIDS, Malaria & Other Diseases

AIDS has become the leading cause of premature death in sub-Saharan Africa and the fourth largest killer worldwide. In the European countries of the Commonwealth of Independent States (CIS) and parts of Asia, HIV is spreading at an alarming rate. Though new drug treatments prolong life, there is no cure for AIDS, and prevention efforts must be intensified in every region of the world if the target is to be reached. Malaria and tuberculosis together kill nearly as many people each year as AIDS, and represent a severe drain on national economies. Ninety per cent of malaria deaths occur in sub-Saharan Africa, where prevention and treatment efforts are being scaled up. Tuberculosis is on the rise, partly as a result of HIV/AIDS, though a new international protocol to detect and treat the disease is showing promise.

Goal 7 Ensure Environmental Sustainability

Most countries have committed to the principles of sustainable development. But this has not resulted in sufficient progress to reverse the loss of the world's environmental resources. Achieving the goal will require greater attention to the plight of the poor, whose day-to-day subsistence is often directly linked to the natural resources around them, and an unprecedented level of global cooperation. Action to prevent further deterioration of the ozone layer shows that progress is possible. Access to safe drinking water has increased, but half the developing world still lack toilets or other forms of basic sanitation. Nearly 1 billion people live in urban slums because the growth of the urban population is outpacing improvements in housing and the availability of productive jobs.

Goal 8 Develop a Global Partnership for Development

The United Nations Millennium Declaration represents a global social compact: developing countries will do more to ensure their own development, and developed countries will support them through aid, debt relief and better opportunities for trade. Progress in each of these areas has already begun to yield results. But developed countries have fallen short of targets they have set for themselves. To achieve the Millennium Development Goals, increased aid and debt relief must be accompanied by further opening of trade, accelerated transfer of technology and improved employment opportunities for the growing ranks of young people in the developing world.

UNITED NATIONS, THE MILLENNIUM DEVELOPMENT GOALS REPORT (2005), available at <http://unstats.un.org/unsd/mi/pdf/MDG%20Book.pdf>.

88. The United Nations, Millennium Goals, <http://www.un.org/>

The Millennium Development Goals are to be achieved by 2015.⁸⁹ The MDGs have been characterized as

the world's time-bound and quantified targets for addressing extreme poverty in its many dimensions—income[,] poverty, hunger, disease, lack of adequate shelter, and exclusion—while promoting gender equality, education, and *environmental sustainability*. They are also basic human rights. . . . [Additionally,] [M]ore than 500 million people will be lifted out of extreme poverty. . . . There's more. Achieving the Goals will mean safe drinking water for another 350 million people. . . .⁹⁰

With regards to the MDGs, the United Nations Secretary General, Kofi Anan, in 2002 commissioned the “Millennium Project [in order] to develop a concrete action plan for the world to reverse the grinding poverty, hunger and disease affecting billions of people.”⁹¹ A recent report detailing the progress of the Project noted that

Access to safe drinking water has increased, but half the developing world still lack toilets or other forms of basic sanitation. Nearly 1 billion people live in urban slums because the growth of the urban population is outpacing improvements in housing and the availability of productive jobs.⁹²

In this regard, the percentage of Sudan's population with access to improved water sources is as follows: in 1990 it was – 85% , dropping

millenniumgoals/index.asp# (last visited Apr. 15, 2006) (*Goal 7: Ensure Environmental Sustainability*); see also UNITED NATIONS, OFFICE OF THE SPECIAL ADVISOR ON AFRICA, THE MILLENNIUM DEVELOPMENT GOALS IN AFRICA: A GRAPHICAL ILLUSTRATION OF PROGRESS AND PROSPECTS (2005) (on file with the author).

89. United Nations, Millennium Project, <http://www.unmillenniumproject.org> (last visited Apr. 15, 2006) (“The Millennium Village” approach draws upon the leading science-based action plan to fight poverty in rural African and meet the Millennium Goals by 2015.).

90. JEFFREY D. SACHS, INVESTING IN DEVELOPMENT: PRACTICAL PLAN TO ACHIEVE THE MILLENNIUM DEVELOPMENT GOALS (2005), available at <http://www.unmillenniumproject.org/documents/overviewEngi-1LowRes.pdf>.

91. United Nations, About the UN Millennium Project, <http://www.unmillenniumproject.org/reports/index.htm> (last visited Apr. 15, 2006). Headed by Professor Jeffrey Sachs, the Millennium Project is an independent advisory body and presented its final recommendations, *Investing in Development: A Practical Plan to Achieve the Millennium Development Goals*, to the Secretary-General in January 2005. The Millennium Project has been asked to continue operating in an advisory capacity through the end of 2006.

The U.N. Millennium Project consists of ten task forces and a Secretariat, which are composed by a wide array of participants, including academics, governments, non-governmental organizations, U.N. agencies, international financial institutions, among others. SACHS, *supra* note 90, at x.

92. THE MILLENNIUM DEVELOPMENT GOALS REPORT, *supra* note 87, at 5.

to 78% in 2002,⁹³ most likely due to the wars in Darfur and the south. In contrast, in two of Sudan's neighbors, Chad and the Libya, the percentage of people who had access to improved or clean water were as follows:

	1990	2002
Chad	45%	40%
Libya	72%	72%. ⁹⁴

Note, that although the Sudan is ravaged by war, some would say genocide, its population as a whole, even with a drop of 7% over twelve years, has greater access to clean potable water than Chad, its neighbor to the west, and Libya, its neighbor to the northwest. Thus, if Sudan adopts the MDGs into its cache of development tools, the plight of its population on a per capita basis will certainly be better-off, than that of its next door neighbors.

B. The New Partnership for Africa's Development

Another program the United Nations initiated is the New Partnership for Africa's Development ("NEPAD").⁹⁵ In passing the NEPAD resolution, the General Assembly

recognized the importance of integration in welcoming "the commitment of African countries to integrate the priorities of the New Partnership for Africa's Development into their national policies and development planning frameworks, to maintain full ownership and leadership in developing and utilizing such policies and frameworks, and to mobilize domestic resources in support of the New Partnership."

NEPAD adopted and integrates the MGDs "as a core component of its goals, which, in part, indicates an appreciation of the linkage between the two development initiatives."⁹⁶

NEPAD's originating documents instituted a definite aim for the African initiative: to marshal the political and economic will in Africa

93. U.N. Statistics Division, Water, percentage of population with access to improved drinking water sources, urban (WHO-UNICEF), http://unstats.un.org/unsd/mi/mi_series_results.asp?rowID=666 (last visited Apr. 15, 2006).

94. *Id.*

95. U.N. G.A. 57/7, U.N. GAOR, 57th Sess., U.N. Doc. A/Res/57/7 (2002), available at <http://daccessdds.un.org/doc/UNDOC/GEN/N02/538/31/PDF/N0253831.pdf>.

96. UNITED NATIONS, OFFICE OF THE SPECIAL ADVISOR ON AFRICA, INTEGRATING THE PRIORITIES OF THE NEW PARTNERSHIP FOR AFRICA'S DEVELOPMENT (NEPAD) INTO THE NATIONAL DEVELOPMENT PROCESS: EXPERIENCES FROM SELECTED AFRICAN COUNTRIES (2004) (on file with the author).

and the international community.⁹⁷ However, the plan is based on the presumption that each African State is responsible for the welfare of its own people.⁹⁸ Consequently, “[t]he NEPAD priorities must therefore be integrated into the development process of African countries as a means of supporting and enhancing the existing potential of each country.”⁹⁹

One problem, however, is that many African States have a poor governance record. For example, “over the past two decades, Africa’s dismal economic performance has been partially attributable to weak or ineffective governance.”¹⁰⁰ Sudan is plagued by governance problems, which is defined as “civil or political governance”.¹⁰¹ a years long war. Moreover, Forbes Magazine recently identified the country as one of the 16 most corrupt nations in the world.¹⁰² Given these issues it is unclear whether the Sudanese Government will, in fact, implement the Millennium Development Goals.

C. *Are the Millennium Development Goals Attainable by 2015?*

Whether the MDGs can be met by the target date of 2015 is a serious question. However, even if the goals are not fully realized, the efforts are sure to alleviate some of the burden of poverty and lack of water and to promote sustainable development. Then again, so long as civil society does not exist in the Sudan, a government that is at war with its people will not promote the MDGs.

Nonetheless, the application of any solution to the groundwater problem will require the weighing of costs, benefits and risks. Any attempt or approach to solve these predicaments naturally leads to a discussion of the Precautionary Principle, which addresses risks within the environmental fabric.

VII. The Precautionary Principle

According to the Danish Ministry of Environment and Energy, “the precautionary principle emanates from the wish to protect Man and nature, even if there is no certain scientific evidence of the extent and

97. *Id.* at 7.

98. *Id.*

99. *Id.*

100. Ejeviome Eloho Otobo, *Contemporary External Influences on Corporate Governance: Coping with the Challenges*, in AFRICAN DEVELOPMENT AND GOVERNANCE STRATEGIES IN THE 21ST CENTURY: LOOKING BACK TO MOVE FORWARD 101 (Bade Onimode ed., 2004).

101. *Id.*

102. David A. Andelman, *A Stewpot of Corruption*, FORBES, Feb. 6, 2006, available at http://www.forbes.com/2006/02/03/corrupt-nations-world-cx_daa_0206caphosp.html.

cause of the environmental problem.”¹⁰³ The principle traces its origins to Germany where guidelines discussing the *Vorsorgeprinzip* were published by the federal government in 1986. It has been part of the environmental lexicon for the past two decades.¹⁰⁴ The precautionary principle has received both praise and censure. In short, the principle provides that:

In order to achieve sustainable development, policies must be based on [forethought]. . . . Environmental measures must anticipate, prevent and attack the causes of environmental degradation. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.¹⁰⁵

A. *The Aim of the Precautionary Principle*

There is no clear definition of the meaning of the precautionary principle. However, a review of the literature provides some general observations. The precautionary principle focuses on the degree of certainty needed before politicians and other authorities can decide to initiate action regarding possible environmental problems. Scientific uncertainty may prevail for a number of years, whether the problems carry a significant risk of environmental damage, or whether these problems are of a limited scope.¹⁰⁶

The critical issue, therefore, is when is action required? Is it required immediately, upon suspicion and indication of risks, or do policymakers wait until they are assured of 100% scientific certainty? Or is there a third approach?

When in concrete cases politicians have decided—at [the] national or international level - to adopt the precautionary principle, [*a fortiori*

103. Danish Ministry of Environment and Energy, Danish Environmental Protection Agency, The Precautionary Principle (Translation of “Faktuelt” No. 15), available at http://www.mem.dk/faktuelt/Artikler/fak15_eng.htm.

104. In 1992 the United Nations Conference on Environment and Development in Rio de Janeiro drafted a number of principles. In Principle 15 of the declaration, the participants, including numerous developing nations, agreed upon the use of the precautionary principle. Moreover, they held that the principle is to be widely applied by States according to their capabilities. The intention was to allow developing countries to apply the principle less rigorously. Nevertheless, it could be extended to include the fact that all countries have a limit to their capabilities. In addition, the environmental field and relevant social and economic agreements or instruments, may take into account the special needs of the developing countries.

105. Groundwater Protection in Selected Countries, The Precautionary Principle, Ch. 4, http://www.mst.dk/udgiv/Publications/2002/87-7972-025-0/html/kap04_eng.htm (last visited Apr. 15, 2006).

106. The Precautionary Principle, *supra* note 103, at 1.

that] means that action cannot await final scientific evidence.

The use of the precautionary principle may be compared with taking out insurance. You take initiatives which have direct economic implications or which limit your immediate scope of action. You do not know whether at a later moment you will need the insurance, because there may not be a problem at all. Broadly speaking, significant aspects of the precautionary principle are therefore the question of the economic implications, to society and to business, of using the principle, and a comparison with the possible implications of not using it.¹⁰⁷

The precautionary principle is, thus, rather a political norm than a concept which can be clearly defined. And as such, it forms the basis for decisions taken by authorities, politicians and business.¹⁰⁸

It has been said that the public's expectations regarding the utilization of the precautionary principle are often characterized by contradictions and dilemma.¹⁰⁹ For example, the "demand for caution is greater for contamination of groundwater with pesticides than for pollution of the air from traffic."¹¹⁰ Very often, we tolerate high risks in areas affected by our own way of life—for instance smoking and driving; however, we do not abide similar risks in areas of our lives in which we have little or no control ourselves, *e.g.*, intake of water and food.

Thus, if farmers in the Sudan contaminate their water, like many farmers across the world, they will tolerate that risk and throw caution to the wind, because they control their own actions. Conversely, depletion of groundwater reserves, droughts and desertification will be less tolerated, as they are seen as the work of an outside force, be it God or some other entity. Given the ups and downs of the climatic cycle—which controls the amount of rain and consequently the rate of recharge—the precautionary principle, pursuant to the thesis postulated above, should lead the Sudanese peoples to conserve water resources and to sustainably develop groundwater and, in so doing, their communal economy. Time will tell. But, only if groundwater exploitation and use are monitored and structured with forethought and planning.

107. *Id.* The use of the precautionary principle should be based to the extent possible on scientific evidence of a given problem. Scientific knowledge is a decisive element in the decision whether to adopt the principle or not. However, it is not possible to weigh or measure your way towards this decision, rather it must be based on an assessment which also involves economic, social and ethical aspects. *Id.*

108. *Id.*

109. *Id.*

110. *Id.*

VIII. Conclusion

For decades, the Sudanese people have been ravaged by war and cross-ethnic violence. Millions have been killed and even more have been injured and permanently disfigured. If and when this violence comes to an end, it will require a growing population—one that will double within a couple of decades—to settle the regions of the country that do not lie along the shores of the Blue Nile, White Nile and Nile River.

Rather, many will join those who currently live in villages in the northern, central and western regions of the country, and those who are in refugee camps, who previously lived in, and will return to, those areas. This growth of population and pull of citizens to towns and cities, will cause a demographic shift away from farming and pastoralism. The trend towards urbanization is escalating.

As in many other developing countries, Sudan's reallocation of labor will cause the sprawl that is unique to these nations, wherein the prospect of better jobs forces people to move to urban centers. However, "[m]igrants often find that their lives become more difficult. Growth is fastest in small cities, which often lack infrastructure, and in shanty towns and squatter settlements around many large cities. In Africa 37 percent of urban residents live in such 'informal' settlements. . . ." ¹¹¹ These new inhabitants will require water to stay alive.

At the same time, people are growing more and more food in urban areas. Worldwide, some 200 million city dwellers are growing food, providing about 1 billion people with at least part of their food supply. In Accra, Ghana, for example, urban gardens supply the city with 90 per cent of its vegetables. In Dar-es-Salaam, United Republic of Tanzania, one adult in every five grows fruits or vegetables. ¹¹²

This activity also requires large volumes of water, which in many cases for the Sudan, like its neighbors will mean groundwater.

In view of the fact that the regions surrounding and including the Nubian Desert, the Libyan Desert and the west central portion of Sudan are fed predominantly by groundwater bearing aquifers and intermittent streams or wadis, a new paradigm will be required. Government institutions, regardless of whether they are part of the central government in Khartoum or in the country's various states, must focus their efforts on sustainable development of their water resources. These institutions

111. United Nations Population Fund, *The State of World Population 2001*, <http://www.unfpa.org/swp/2001/english/ch03.html> (visited last Apr. 15, 2006).

112. *Id.*

must also employ the Precautionary Principle, making decisions with an eye toward the future. Otherwise, Sudan will find itself in the conundrum that many nations in the Middle East and on the African continent face: severe water shortages.

Finally, a country ravaged by war can sustainably develop and preserve its groundwater resources, but, only if that country's government grasps the enormity of the predicament it faces if it does not act. Only when a nation recognizes the consequences of inaction will it use its groundwater resources well.

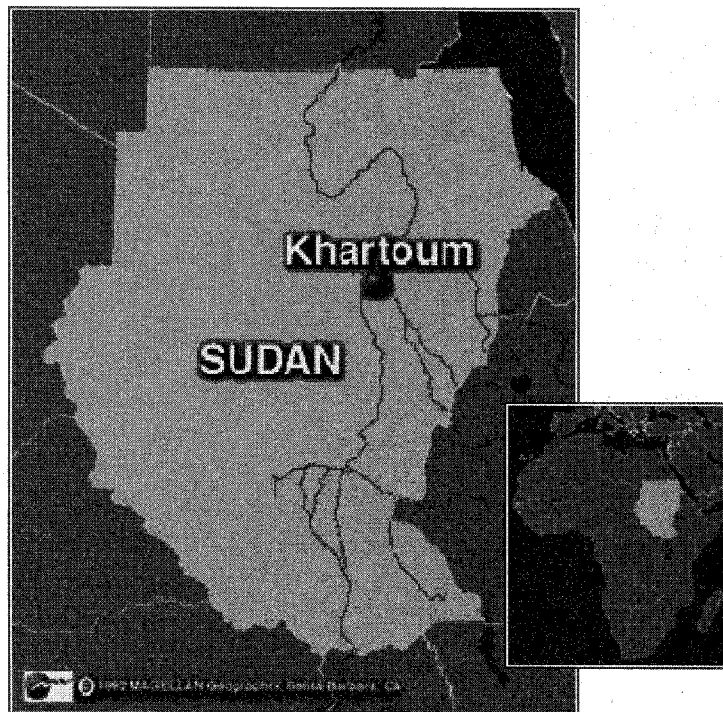


Figure 1: Sudan's Location in Africa

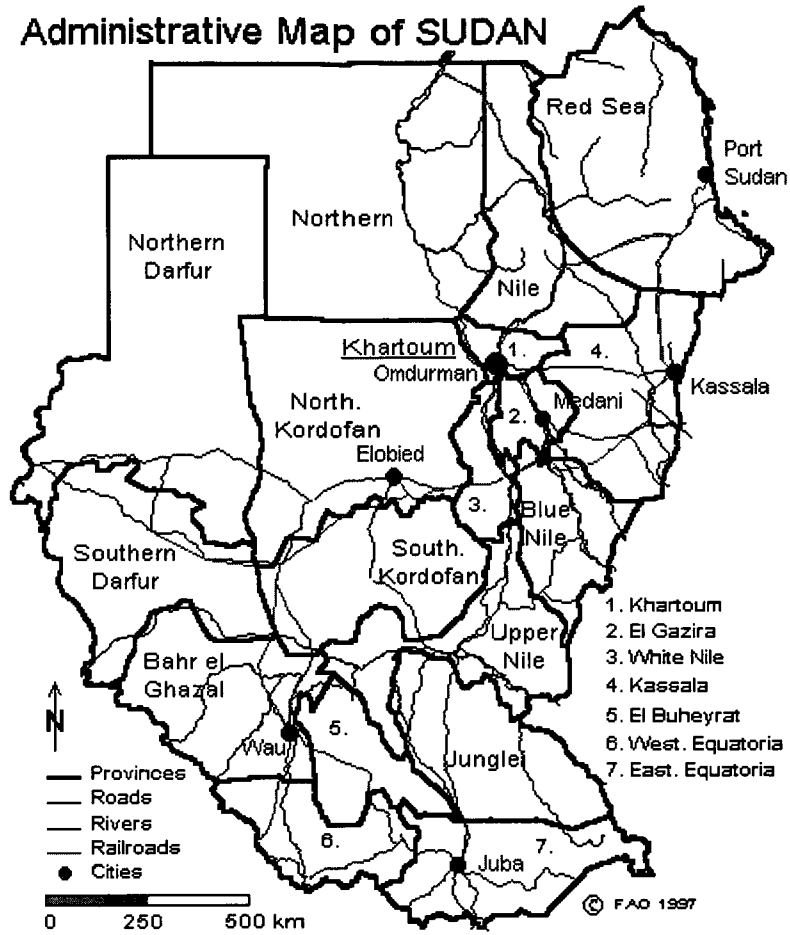


Figure 2: Administrative Map of Sudan