RIVERAINS AND LACUSTRINES:
TOWARD INTERNATIONAL COOPERATION IN THE NILE BASIN

by

John Waterbury
Princeton University

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Acknowledgments

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Forward

This discussion paper is intended to be just that. It takes off from earlier research I have published in The Hydropolitics of the Nile Valley (1979) without attempting to reproduce all the detail that is contained in that book. It raises many questions that I hope will be at once worthy of discussion by informed observers and experts and an agenda for my own future research. The earlier study focused on two of the nine riparian states in the Nile Basin: Egypt and Sudan. The logic of that choice was and is compelling. Those two are the only countries in the basin that make significant use of the Nile waters. Egypt alone draws on about 65 percent of the mean annual discharge of the Nile as measured at Aswan while the Sudan uses about 22 percent. These waters are employed overwhelmingly in agriculture, and for Egypt there is no alternative source.

It has been clear for at least half a century that full utilization of the Nile waters could not be engineered by Egypt and the Sudan alone but would depend upon the cooperation of the seven co-riparians of the upper basins. For some time the essential proposition was to construct a complicated and interdependent series of upstream storage and delivery facilities of which Egypt and the Sudan would have been the only direct beneficiaries. Now, in the 1980s, it is equally clear that the seven upper basin co-riparians will inevitably make claims of their own upon the water in the system. Thus the challenge is two-fold: to continue to meet Egypt's and the Sudan's
growing demands for water, and to accommodate these with the, as-yet, potential demands of the upstream states (Morrice, H.A.W. & Allan, W.N.: 1960).

The kinds of demands and pressures upon water supply that have become manifest in the Nile basin are reflected with greater or lesser intensity in several other international river basins. The pressures are particularly severe in the developing countries where a major effort is being made to reduce the vagaries of rain-fed agriculture and to increase agricultural production. Many of these rivers traverse arid or semi-arid regions which, under conditions of flood irrigation or inadequate and highly variable rainfall, cannot sustain growing human and non-human populations, no less yield an agricultural surplus for urban consumption or export. Large scale irrigation, with all its attendant ecological hazards and managerial challenges offers, so it is believed, a way out. How well-founded this belief may be is beyond the scope of this paper. The goal is simply taken as a given.

The major river systems in semi-arid regions that face challenges similar to those of the Nile are the Senegal, the Niger, the Kagera, and the Chad Lake Basin in Africa; the Euphrates in the Middle East; the Indes, Ganges and Brahmaputra in South Asia. But the problems are not altogether different for river systems in regions with much higher rainfall: the Plate and Amazon in Latin America and the Mekong, which in its riparian complexity most resembles the Nile, in Southeast Asia. It is my hope that my previous book and this study will help clarify a range of legal, managerial, technical and political questions that bear upon all the river systems mentioned above.
The expression "the struggle for fresh water" may be a good deal more than a rhetorical device. Fresh water has been fought over and fought for in the past. Insofar as potentially irreconcilable demands affect food production the most vital national and social issues imaginable are at stake. Final decisions regarding the use of these water resources remain more or less firmly within the framework of the nation state and national sovereignty. Yet there is unquestionably a move away from these strictures in both legal and organizational terms. There is a growing awareness that for certain resources that are unavoidably shared by all of humankind -- air, the seas, and fresh water -- only some form of multi-lateral, supra-national management can protect the vital interests involved and strike some equitable balance in the exploitation of the resource. What can be learned in the context of international river basins should have general applicability to other transnational resources.
I.
The General Context and General Propositions

The unity of the Nile basin is a geographer's construct; it bears no resemblance to social, cultural or economic reality. Over the four thousand mile course of the White and Main Niles and the 1000 mile course of the Blue Nile to where it joins the White at Khartoum in the Sudan, it is the river's water itself that constitutes the only common denominator in the basin. The topography and ecology of the basin are as varied as the people who inhabit it (A. Ibrahim, 1981; J. Waterbury, 1979: 12-42; H.E. Hurst; 1957). There could be nothing more culturally different, it seems to me, than the peasant of the Ethiopian highlands and the fellah of the Nile Delta. Yet they represent the only true peasantries in the entire basin, peasantries that can boast millenia of experience, sophisticated if traditional technology (ox-crawn plows for example) and the occasional production of a marketable surplus. The inhabitants of the Dongola region of the northern Sudan may lay claim to the same kind of history, but aside from them, and until the 20th century, the Nile Basin has been a land without farmers. For the rest of the basin's population there is virtually nothing in their history, language, religion, attitudes toward power, cultivating practices, agricultural conditions, etc. that could bind them together. In some measure one can say the same of most international river basins, and to the extent basin-wide cooperation ever becomes a reality, it will be the creation of elite decisions not popular sentiment.
Beyond the water itself, however, there are a few frail ties that bind. Most are objective but at least one is subjective. With respect to the latter, one can conceive of the basin as falling into four geographic and social parts. There is Egypt, an old and self-contained practitioner of irrigated agriculture. It is at once the biggest society in the basin, conceivably the most militarily powerful, and the most vulnerable so far as water supply is concerned. At the antipodes are the two up-stream parts. On the upper Blue Nile is Ethiopia, a near rival to Egypt in terms of population and military strength but not level of development. But Ethiopia has the water, about 80% of whatever finally discharges into the lake behind the High Aswan Dam. The other upstream entity consists of the states of the Lake Victoria/Lake Albert* catchment area: Uganda, Kenya, Zaire, Tanzania, Rwanda, and Burundi. They have access to more water than Ethiopia but so far little of it ever gets beyond the southern Sudan and into the White Nile. These states are relatively small in population and militarily weak.

The fourth part, the Sudan, is the only one that links the other three geographically and that could provide a cultural bridge from Egypt to the up-stream parts. Sudan is the middle-stream state, distributing, without controlling their sources, the waters of the Blue and White Niles. Population movements from the largely Christian

* Now officially known as Lake Mobutu Sese Seko
Ethiopian highlands, the Muslim parts of Eritrea, the animist regions of the southern Sudan and southwest Ethiopia, the Nilotic, Hamitic, Animist, Christian, Muslim societies of the equatorial lakes have all filtered through the Sudan. The country's Muslim core and its recent history binds it to Egypt. A somewhat inexplicable cultural affinity, given their long and bloody history of confrontation, links the Sudan to Ethiopia, and the black Nilotic populations of the southern Sudan link it to its equatorial neighbors (A. Ammay, 1947; Yusuf Eadl Hassan, 1971). Thus, the Sudan, tenuously integrated itself, lends what little coherence there exists, to the Nile basin.

We may identify a common set of social and economic characteristics among the nine co-riparians. These are summarized in Table 1. The Nile Basin states together comprise a population totalling ca. 175 million. That proportion estimated to be living in the basin itself, that is in the catchment or drainage area, is ca. 100 million, although this figure contains a significant margin of error. All in all it is a sizeable piece of humanity, sharing not only the river but, as well, agriculture and animal husbandry as a way of life and poverty as its conditioning factor.

All are predominantly agricultural societies. The proportion of the active population engaged in agriculture ranges from a low of 51% in Egypt to highs of 90% or more in several other states. The contribution of agriculture to GDP ranges from 24% in Egypt to 50% in Burundi, reflecting the low per cap. productivity of the rural populations. All of these countries rely upon agricultural
The estimates for the population in the basin are those of the author and contain a large margin of error. They should be taken only as indicating gross magnitudes. The estimates for the population in the basin are those of the author and contain a large margin of error. They should be taken only as indicating gross magnitudes.

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Table I

Social Economic Indicators of the Nile Basin States
exports to generate foreign exchange, and when these fail, either because of production shortages or unfavorable world market prices, the entire economy is disrupted. Every state in the basin has experienced more or less chronic balance of payments crises, and only those with other valuable primary exports (oil for Egypt and on occasion copper for Zaire) have been able to weather these crises. For several riparians, however, simply maintaining production has proved an elusive target: Tanzania, Uganda, Ethiopia, and the Sudan are the most conspicuous in this respect, but no riparian can boast unalloyed agricultural success. All import substantial quantities of food grains destined to feed, above all, their urban populations. One state, Egypt, has no hope of being self-sufficient in grain production and currently wades into world markets for upwards of five million tons of grain per year. But all feel the weight of food imports upon their balance of payments.

For some -- Ethiopia, Kenya, and Tanzania -- irrigated agriculture seemingly offers a way to high steady production; for two others -- Egypt and the Sudan -- it already is the backbone of their rural economies.

It must be kept in mind, however, that for all its water resources, the African continent boasts very little irrigated agriculture. In 1975 of Africa's 150 million cultivated hectares (ha.) only 8 million were irrigated. Of these, 6 million were in Egypt,
the Sudan, and Madagascar. Something like 2 million hectares are to be brought under irrigation by the turn of the century, of which 1.2 million hectares are planned for Egypt, the Sudan, and Madagascar (Sadik Toksoz, 1981 and Peter Oram, 1979). As we shall see in sections dealing with each of the riparians these planned figures should be revised upwards as nearly all the basin states have set ambitious targets for irrigated agriculture.

It is worth noting here that those areas proximate to water from the Nile system and enjoying highly fertile soils (resulting from igneous, calcareous rock and alluvium) are:

1. the region lying between the White and Blue Niles in the Sudan
2. smaller areas around Lake Tana and the Baro salient in Ethiopia
3. the area east of Lake Kyoga in Uganda
4. north central Tanzania.

Much of upper Egypt and the Nile Delta enjoy such soils, but they are already fully irrigated (H.R.J. Davies, 1973: 8-9).

All the basin states have been victimized by the "oil shocks" of the 1970s that gravely exacerbated their already difficult balance of payments situation. Here, as with agricultural production, the Nile waters may provide part of the way out. To the extent that harnessing the Nile can help meet growing energy demands through hydroelectric power, the importation of fossil fuels can be reduced or at least held steady.
It gives one pause to realize that among these nine societies, Egypt offers the greatest relative prosperity (or the least pronounced poverty) and the least fragile economy. The Nile Basin, whatever its future may hold, is a region of extreme poverty shared by states in various stages of economic crisis. For two of them, Uganda and the Sudan, it is not too much to speak of economic collapse.

This fact alone could explain why Nile basin cooperation does not haunt the minds of the leaders of the Nile states. There is simply too much competition from other more immediate and more tangible crises. Working my way upstream, I will mention those that held center stage at the time the research for this study was undertaken.

Egypt: October 6, 1981, President Anwar Sadat was assassinated and his successor, Husni Mubarak, tried to consolidate his own position, deal with the extremist Muslim movements in Egypt, assure Israeli withdrawal from the Sinai in April 1982, and cope with declining revenues from oil sales in a glutted world market. However, the first Arab country he visited as President was the Sudan, in early May 1982.

The Sudan: aptly called an "African calliope" by Edward Hoagland because of its extreme ethnic and lingual diversity and vast territorial extent. Despite the ingredients for a bright agricultural future the Sudan found itself saddled with an enormous trade deficit rooted in declining cotton exports and soaring oil imports. Sudan was unable in the fall of 1981 to honor some of its international obligations. Its creditors including Saudi Arabia were no longer willing to finance Sudan's modest self-indulgence. Belt-tightening measures in conformity with IMF recommendations led to riots in the winter of 1982. Underneath all this were the perennial problems of regional dissidence in the south and the west, and the possibility of foreign intervention to unseat the regime from Libya and Ethiopia. Khartoum's wags had it that so long as he was away on one of his frequent trips abroad, President Numeiry would welcome a coup d'etat. However, there were no takers.
In most respects there was nothing unusual about the period in which this research was carried out. It contained a 'normal' quota of political and economic malaise and on occasion crisis. If basin-wide cooperation is inevitably to be the creation of the leaders of the basin states, it has to be recognized that that cooperation will be fairly low on the list of policy priorities for any particular head of state. Given its vulnerability to all that transpires upstream, it is understandable that Egypt's leaders have typically been far more cognizant of the possible benefits of basin-wide cooperation than those of any of the other eight states. If cooperative institutions are to be born they will have to slip in amongst the more pressing issues of regime survival and maintaining standards of living. Those who will have to catch the ear of their leaders are the region's technocrats, the hydraulic engineers, agronomists, meteorologists, geologists, and planners who will be thrust into political roles for which their technical training gives them little preparation.

The agenda for negotiations among co-riparians has gone through two distinct phases and has now entered a third. The first, beginning in 1920 and petering out after the Second World War, consisted in negotiating an accord for the apportionment of the annual flow of the Sudano-Egyptian Nile. The negotiations were bi-lateral, between the Kingdom of Egypt and Great Britain, acting on behalf of the Sudan. Thus only two riparians were affected, and the water apportioned was
Ethiopia: By the fall of 1981 the regime of the Dergue had entered into a phase of relative internal and external stability. The conflict with Somalia had subsided, but the joint military manoeuvres among Egypt, the Sudan, the U.S. and Somalia fed fears that Washington sought to topple the regime in Addis Ababa. At the same time Colonel Mengistu was preparing a major offensive against the Eritrean liberation fronts for the spring of 1982. The province of Tigre remained the arena of frequent violent clashes between government troops and Tigrenia insurrectionaries.

The Lacustrines: Uganda, the pearl of Britain's east African empire, has become synonymous with ethnic fratricide and economic neglect. Milton Obote's return to power under a Tanzanian military umbrella allowed the first and so far unsuccessful steps to be taken toward the restoration of some semblance of public order. But the violence and economic collapse have persisted, and Obote's chances for survival must be regarded as slim. It is only against this standard that Rwanda and Burundi can inspire any hope. Their incumbent military regimes have established some order in societies that have indulged in orgies of Hutu-Tutsi massacres, bordering in 1972 in Burundi upon genocide. Whatever calm prevails they remain totally landlocked, dependent upon coffee exports for foreign exchange, and desperately poor. Of the two other major lake states to be considered here, Kenya and Tanzania, both were dealing with severe economic crises, built once again on the vicious triangle of stagnant agricultural production, declining world market prices for coffee, tea, sisal, and cotton, and growing energy imports. Both were confronted with the need to implement stabilization plans to satisfy the IMF and other international creditors. While Julius Nyerere denounced these pressures, he also admitted that the last decade had brought no economic progress to Tanzania. For his part, President Daniel Arap Moi was caught up as President of the OAU in coping with the civil war in Chad and the intractable problem of Morocco's conflict with the RASD in the western Sahara. He was directly challenged by an air force putsch in August 1982.
that could be stored seasonally at Sennar and Jebel Aulia in the Sudan and at Aswan in Egypt or that, used in flood irrigation.

The second phase again involved Egypt and the Sudan, this time as sovereign states, and lasted from 1955 to 1959. Because of the proposed construction of the High Aswan Dam, capable of capturing and storing as much as two consecutive floods, the issue was to find a formula for apportionment that took "over-year" storage into account.

The final phase has as its goal increasing the amount of utilizable water throughout the catchment area. The total amount of water in the basin remains, of course, a function of natural rainfall, but through integrated engineering works a much greater proportion of the total supply could be captured for agricultural, hydroelectric and municipal/industrial use. The origins of some of the projects under discussion lie in the Century Water Storage Scheme, first mooted in the 1930s, briefly resuscitated after the Second World War, and then shelved as various riparians gained their independence and Egypt promoted the High Dam project. The issue became live once again when, in the early 1970s, Egypt and the Sudan agreed to implement the Jonglei project to excavate a canal through the Sudd swamps in the southern Sudan (C.O. Okidi, 1979; J. Waterbury, 1979: 65-116; A.H. Garretson, 1967: 256-97; M. Barbour, 1957: 319-30).
This paper is concerned mainly with the third phase, by far the most complex because it necessarily must include most of the co-riparians and because the relative benefits to be drawn by individual states are highly unequal. The negotiations, if they ever begin in earnest, will be conditioned by the following factors. First, the hydrology of the basin and the performance in terms of run-off and discharge of many of its components, are not yet fully known. Consistent time-series data on the upper basin are not yet available nor do several riparians have sufficient technical personnel to analyse them even if they were available. The Hydromet Project, which we shall look at in some detail further on, is remedying this situation.

This being the case it is difficult to make good estimates of the financial costs involved in any one or combination of projects. It is likewise difficult to assess relative benefits and costs, apportioning financial contributions, and arranging for compensation for disruptions caused to any particular riparian.

What is sure is that Egypt and the Sudan will be the primary beneficiaries. They also have a corner on most of the reliable data and expert personnel in the basin. Moreover all the upstream riparians know Egypt regards the general issue of water supply as one of national survival and phase III as crucial to its future economic prosperity. Thus while benefits of future projects may accrue very unevenly to the states in the basin, what one among them would want to hold Egypt demonstrably by the throat? Cooperation, no matter how small the immediate pay-off, may look attractive over the long haul.
II.
Dimensions of the Water Balance

At the time research was completed in the mid-1970s for Hydropolitics of the Nile Valley there was considerable evidence that if the two principal water consumers, Egypt and the Sudan, pursued their national development plans with any success there would not be by 1985 or 1990 sufficient water available to meet the rising demands. This judgement was founded on the rather heady prognostications surrounding Sudan's vast agricultural potential at the time and the apparent availability of external, mainly Arab, financing for large scale development. It was also sustained by Egypt's proclaimed intention to carry on with massive reclamation of desert land. For the detailed albeit crude calculations and projections I made at that time see J. Waterbury, 1979: 210-41.

There was nothing inevitable about the predicted crisis, and I wrote (1979:241):

"Two situations could obviate the otherwise looming water shortage: 1) a technological miracle of some sort (rapid, cheap implementation of the Upper Nile projects, drastic reductions in evapo-transpiration through plant genetics, etc); or 2) the stagnation of the Sudanese and Egyptian economies, both of which are carried by their agricultural sectors. The first situation is unlikely and the second undesirable."

The undesirable, at least so far as Sudan is concerned, has come to pass. It is not easy to explain the country's economic plight, but in no small measure the Sudan has paid the price of supporting
encroachment onto agricultural land has not been stemmed. The net
loss of agricultural land means a net reduction in water demand.

The last general point to be made here is that the mean annual
discharge of the Nile appears to be somewhat above what was used
as the mean in negotiating the 1959 Agreement between Egypt and the
Sudan on the Full Utilization of the Nile Waters. A mean discharge of
84 billion $M^3$, based on the period of 1900-1959, was used as the
basis for allocating water between Egypt and the Sudan. That mean,
as it turns out, looks too modest when compared to the data for an
entire century. In Table 2 it becomes clear that the period 1900-1959
comprised a series of fairly low floods, and that since 1960 there is
some, very weak, evidence of a new rise. A century of readings does
not give one much to go on when dealing with the Nile, but the mean
for the century up to 1980 is 89.7 billion $M^3$, or, on average, 6 billion
$M^3$ more per annum than was provided for in the 1959 Agreement. Thus
the crisis in conflicting demands may be delayed because there is
more water available than was commonly believed.

IIa.

Egypt: Supply, Demand and Development

Each of the national consumers of Nile water presents unique
characteristics in the shaping of its real or potential demands. In
Egypt demand is and will be conditioned primarily by three basic
Table 2  
Decennial Mean Discharges of the Nile  
in billions of M$^3$ as measured at Aswan  
1880/81 - 1979/80

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<th>Decade</th>
<th>billion M$^3$</th>
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<tr>
<td>1890/91-1899/1900</td>
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<tr>
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<td>82.9</td>
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<td>87.0</td>
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<tr>
<td>1880-1980</td>
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</table>

Source: For the period 1880-1970/71 year-by-year natural yield figures published in J. Waterbury, 1979:253 from unpublished statistics of the Nile Control Department, Ministry of Irrigation (Egypt). The figures for 1971/72 to 1979/80 are from the PJTC headquarters, Khartoum. The latter do not correspond to those I published in 1979 up to 1975. I cannot explain the discrepancy. The trend is the same but the figures for individual years vary significantly.
factors: the rate and type of land reclamation, the re-utilization of drainage water, and the intensity of cropping on cultivated land. Before examining these factors, however, it should be stressed that in treating Egypt and the states further upstream as separate entities, I am merely conforming to the effective units in which policy is made and implemented, and which international donors such as the World Bank accept as the unit for planning. In other words, although there are nine co-riparians in the basin that could be regarded as parts of a large basin-wide unit for water resource planning, few steps have been taken in that direction.

It can legitimately be countered that the state of our knowledge is such that any basin-wide planning exercise would be premature. But there is, to my mind, a more fundamental reason: so far it has been in the interests of none of the major actors to try to see the system as a whole. Rather what I have called the "fragmented view" has been more convenient for it is sustained by an underlying assumption of abundant water supply. No one wants to call that assumption into question yet; not until each national actor knows fairly exactly where its interests lie and what cards it has to play the day that conflicting demands become extremely difficult to reconcile.

As far as Egypt is concerned the sanguine outlook of the middle 1970s, when international bodies of aid and technical assistance such as the FAO or USAID foresaw no possible water supply constraints before the year 2000 (J. Waterbury, 1979: 210-211), has given way to more
cautious and more detailed assessments that look to the 1990s as a period of possibly conflicting demands (IBRD, 1981 "Irrigation Subsector Report"; AREF, MOI, 1981 "Master Water Plan - Main Report").

This caution has not yet seeped into official pronouncements, and the same perceptions of abundance that led an Egyptian MP some years ago to advocate selling Egypt's "surplus" Nile water to Saudi Arabia\(^1\) probably lent credibility to the more recent declaration of Hasbollah Kafrawi, Minister of Housing and the Development of New Lands. He announced to the National Congress of the National Democratic Party (al-Ahram, 9/30/81) that "the Ministry had prepared its major plan for the reclamation of 2.8 million feddans and shown it to various specialists and consulting firms after it had been confirmed that there was sufficient water for such projects until the year 2000".

Perhaps it all depends on what estimates of basic parameters are used. In that respect it is well to keep in mind the summary statement of the IBRD Irrigation Sub-Sector Report (1981:3):

"Unfortunately, recorded data on water diverted for irrigation, areas irrigated, changes in level of water tables and return flows, on-farm losses, and on irrigated areas being occupied for non-agricultural purposes are either lacking or at best only approximate, so that detailed computations of actual water use on a command area basis cannot be made, even on a national basis."

That being the case, the report concludes that water consumption can be assessed only through "simulation inflow-outflow methodology" as
developed by the Master Water Plan whose estimates the IBRD accepts.

The Egyptian Master Water Plan (EMWP) undertaken by the Ministry of Irrigation in collaboration with the IBRD and UNDP, consists of 17 volumes containing detailed analyses of each of the variables affecting water supply and demand in Egypt. It is an impressive effort, and it is still underway. I want to stress that while in general I find the reports sound in their analysis and conclusions, there are problems in the definition of certain parameters that are either unexplained or stem from assumptions that border on acts of faith. It is worth exploring some of these problems with the caveat that given the quality of the data available the margin of error involved is considerable.

Under the terms of the 1959 Agreement with the Sudan Egypt is entitled to release 55.5 billion m$^3$ of water each year through the sluice gates and turbines of the High Aswan Dam. For some years Egypt has been using even more than this amount, but no one disputes that an enormous amount of waste is involved. How to measure that waste, to ascertain what are real needs as opposed to actual consumption, and therefore what would become available for productive use if waste were reduced, are challenges of crucial importance. Because according to how one measures the waste and makes assumptions about recovering it directly determines estimates of the overall national water balance.
Of Egypt's 55.5 bn M³ we may crudely schematise average use, say for the late 1970s, as follows:

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<td>Total available</td>
<td>55.5 bn M³</td>
</tr>
<tr>
<td>1. crop needs</td>
<td>30.0</td>
</tr>
<tr>
<td>2. crop use</td>
<td>45.0</td>
</tr>
<tr>
<td>3. drainage (2-1)</td>
<td>15.0</td>
</tr>
<tr>
<td>4. conveyance losses</td>
<td>6.7</td>
</tr>
<tr>
<td>5. Navigation and power release</td>
<td>2.5</td>
</tr>
<tr>
<td>6. Industrial and domestic</td>
<td>1.3</td>
</tr>
<tr>
<td>Total 2+4+5+6</td>
<td>55.5 bn M³</td>
</tr>
</tbody>
</table>

So far this is an artificial accounting exercise to give orders of magnitude. In fact Egypt's water use is higher than its allotted share because of three factors:

a) Egypt was able to borrow 1.5 billion M³ annually from the Sudan because the latter was unable to utilize its full share. It is not clear if these "loans" persist, but they had the effect of raising Egypt's total share to 57 bn M³.

b) The return flow of drainage water into the Nile between Aswan and Cairo may average 3-4 bn M³ annually.

c) About 2.5 bn M³ of drainage water in the Delta is being reused in agriculture annually.

These sources thus raised water available by 7-8bn M³ annually or to a total of 62-63 bn M³. As we shall see further on this additional water found its way into industrial and domestic consumption at levels much higher than most estimates, as well as into land reclamation and higher plant consumption.

But the essential point here is agricultural waste. Over the period 1964-72, the first eight years of the so-called High Dam era, the effective crop use of irrigation water grew from 27 bn M³ to 33 bn M³. All of this increase could have been accounted for by
expanded rice cultivation made possible by the water stored at Aswan. At the same time the amount of drainage water grew from 14bnM$^3$ to 16bnM$^3$. The crop use of irrigation water thus became somewhat more efficient rising from 48% to around 50 or 51% (el-Gendi and el-Ghomri 1977:5). Figures for the last decade, estimated by the Master Water Plan, are somewhat different.

There is neither space nor justification for reproducing all the tabular material the EMWP advances in projecting three scenarios of water balances assuming different rates of land reclamation. In Table 3, I have reproduced the basic parameters for the medium-growth scenario, assuming land reclamation at an average rate of 100,000 feddans per year, for the period 1980-2000.

Table 3

EMWP Water Demand High Growth Scenario, Land Reclamation at 100,000 Feddans per year, 1980-2000 billions of M$^3$

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>old lands</td>
<td>29.4</td>
<td>29.4</td>
<td>29.4</td>
<td>29.4</td>
</tr>
<tr>
<td>reclaimed lands</td>
<td>----</td>
<td>4.8</td>
<td>8.5</td>
<td>11.5</td>
</tr>
<tr>
<td>Municipal, net consmp.</td>
<td>1.8</td>
<td>1.9</td>
<td>2.2</td>
<td>3.5</td>
</tr>
<tr>
<td>Industrial, net consmp.</td>
<td>.5</td>
<td>.5</td>
<td>.8</td>
<td>1.4</td>
</tr>
<tr>
<td>Navigation and spills</td>
<td>3.8</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Evaporation</td>
<td>2.0</td>
<td>2.1</td>
<td>2.1</td>
<td>2.2</td>
</tr>
<tr>
<td>Unaccounted</td>
<td>.7</td>
<td>.3</td>
<td>.1</td>
<td>.1</td>
</tr>
<tr>
<td>Drainage</td>
<td>16.0</td>
<td>15.7</td>
<td>14.2</td>
<td>13.4</td>
</tr>
<tr>
<td>Total Demand</td>
<td>54.0</td>
<td>56.3</td>
<td>58.9</td>
<td>63.1</td>
</tr>
</tbody>
</table>
Let us proceed seriatim through the demand sources to see the underlying assumptions. First, the one source of demand that is changeless is that of the old lands at 29.4 bnM³ for the entire twenty year period. It is not altogether clear from the MWP reports how this figure was obtained. It is assumed that in 1978 the cultivated acreage in Egypt totalled 5.8 million feddans, and, with a multiple-cropping intensity (MCI) of 1.9* the cropped surface was equivalent to 11.1 million feddans. Average water consumption then works out to 5,068 M³ per cultivated feddan and 2,648 M³ per cropped feddan. These figures must be based on certain notions of crop consumption that are not made explicit. They do not represent much greater efficiency in water use because, as table 3 shows, over the period drainage is lowered only from 16bnM³ to 13.4bnM³. They do not square at all with estimates by I.Z. Kinawy (February 1976 as presented in J. Waterbury, 1979:221). These, on the basis of an MCI of 1.6 in the early 1970s, yield water consumption of 6,088 M³ per cultivated feddan and 3833 M³ per cropped feddan (cf M.I. Eid et.al., 1966 Abou al-Atta, 1976). Moreover the MWP presents tabular material for only eight crops and does not include the acreage devoted to each (see Main Report and Technical Reports 2 and 17).

The consumptive use estimates thus appear too low by perhaps as much as 3 to 4 billion M³ per year. It is as if the report had to make its figures sum correctly so as not to exceed the supposed supply limit of 55.5 billion M³. But the MWP, like the IBRD Subsector

*This simply means that for every acre cultivated an average 1.9 harvests were obtained per year.
Report, does not for 1980, take 2 billion $M^3$ in reused drainage water into account on the supply side (although on p. 76 of the Main Report they mention 2.5bn$M^3$ in reused drainage water), nor does it include 5bn$M^3$ of drainage water returned to the Nile in Upper Egypt. That figure is put forth in Technical Report 4 on groundwater (p. 25), and is higher than earlier estimates (Kemal Hefny, 1977:4), but these sources ease the supply constraint somewhat.

Crop consumption of water is probably higher than estimated by the MWP. The IBRD Subsector Report estimates annual consumption at 31bn$M^3$ (for ex. Table 12) explaining the difference in a cryptic note to the effect "Subsector Review includes water consumption unallocated by WMP." In an equally mysterious comment the same report (p. 12) states:

"When WMP crop specific water use values are compared with estimates of potential crop consumption under ideal conditions, these were found to give figures averaging between 15 and 20 percent higher than the former values except for rice and sugar cane. This difference is believed to reflect the field situation where factors other than water available are likely to be limiting crop yields. As improvements in agricultural practices, drainage, and water management take place, actual consumptive use is expected to increase as a concomitant of the resulting improvements in crop response." (emphasis supplied)

What these factors are is not explained. Not specifically mentioned is the likelihood that cropping intensity is going to increase substantially. Fitch and Abdel Aziz (1980) put the case convincingly.
They chart the increase to the mid-1970s and make an estimate

<table>
<thead>
<tr>
<th>Year</th>
<th>MCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1952</td>
<td>1.6</td>
</tr>
<tr>
<td>1962</td>
<td>1.76</td>
</tr>
<tr>
<td>1974</td>
<td>1.86</td>
</tr>
<tr>
<td>1985-90</td>
<td>2.1 -2.45</td>
</tr>
</tbody>
</table>

The authors note that if sugar cane is netted out (because its maturation
takes about eleven months) the MCI of Upper Egypt is already 2.12.
Moreover, the MCI is highest on small farms, below 10 feddans, using
family labor. Much of the Egyptian countryside has moved toward
that kind of farm unit (Ilya Harik, 1980). As it is likely that cotton
acreage will be reduced (a crop that ties up acreage for about nine
months and which the MWP regards along with sugar cane and citrus
as a "permanent crop"), vegetable acreage increased, and tile
drains replacing open field drains, cropping intensity will increase
as indicated above. If, for example, 5.7 million feddans are
cultivated in 1990 with an MCI of 2.3 cropped acreage would be 13.1
million feddans, and crop water consumption might be as high as 35.8 bnM^3
with 14bnM^3 allotted to drainage.

One factor needs mention here; loss of agricultural land to
urban, industrial, and village encroachment. The EMWP estimates
the loss of old agricultural land at 15,000 feddans per year (Technical
Report 2, p. 12), or 300,000 feddans between 1980 and the year 2000.
Although that estimate appears low, the loss would just about offset
the expected increase in cultivated acreage resulting from the full implementation of the tile drainage program. Cultivated acreage would thus remain about 5.7-5.8 million feddans.

Egypt's demand for water may increase dramatically as a result of land reclamation. The will and some of the infrastructure are already there. Herein lies another anomaly in the EMWP's data presentation. Note that in Table 5 for the year 1980 no water is assumed to be used on new lands. Yet it is something more than common knowledge that a gross area of 912,000 feddans had been reclaimed between 1960 and 1972, of which about 600,000 were actually under cultivation (J. Waterbury, 1979: 136-43). This acreage is in addition to the 5.8 million feddans of old land, and water use upon it has been very high, around 10,000 M$^3$ per feddan per year depending upon the stage of reclamation that it is in. If the 600,000 feddans use on average 7,000 M$^3$ each year, 4.2 billion M$^3$ would be consumed. That figure for what one might call the 'old new lands' should remain fairly constant for the entire twenty-year period.

The EMWP assumes water use in all future reclamation projects at a rate of 5,400 M$^3$ per feddan per year, a figure that in its modesty bears no resemblance to Egypt's performance on the 'old new lands'. Even this figure is not used consistently in the MWP. On p. 89 of the Main Report the figure of 5,400 M$^3$/feddan/year is given while on p. 32 Technical Report 2 a figure of 4,200 M$^3$/feddan/year is offered as the norm, based on the cropping pattern of 1978. The IBRD Subsector Report is far more realistic in its estimate of "a command area diversion
requirement of 9,200 $M^3$/feddan." However in Table 4.2 of this Report the figure used is 8,300 $M^3$/feddan/year although perhaps the discrepancy stems from the difference between net and gross feddans.

These varying assumptions can take on truly staggering proportions according to the rate and total amounts of land reclamation. Egypt, under Sadat, proclaimed reclamation of 2.8 million feddans as its goal by the year 2000, and while President Mubarak has changed the officials involved, he has not renounced the target. Indeed great emphasis has been placed upon land reclamation and settlement in the Sinai peninsula. The partially completed al-Salam Canal in the eastern Delta, with an estimated capacity of 4.4 billion $M^3$ per year is to irrigate 185,000 feddans west of the Suez Canal and 400,000 in the Sinai.

There has been considerable skepticism among international donors regarding the rate of return to this and other reclamation projects. The poor quality of the soils outside the old lands (the latter consisting mainly in relatively rich alluvial deposits), their distance from major consuming centers, the high cost of efficient water delivery systems (for ex. sprinkler irrigation) and energy for pumping, cast into doubt the ability of the new lands to pay for themselves. At an estimated average cost of over $5000 per feddan in 1981 prices, the Egyptian target would cost $14 billion.

Both the EMWP and IBRD Subsector Report calculate water demand according to varying rates of land reclamation: a range of 50,000 - 180,000 feddans per year to the year 2000. The figures in Table 3 assume an average rate of reclamation over 20 years of about 100,000
feddans per year at 5400 M$^3$ per feddan. If the Subsector Report estimated average of 9000 M$^3$ per feddan were used, the gross water use for the new lands would look like this:

<table>
<thead>
<tr>
<th></th>
<th>EMWP</th>
<th>Subsector Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>4.8 bnM$^3$</td>
<td>8.3 bnM$^3$</td>
</tr>
<tr>
<td>1990</td>
<td>8.5 bnM$^3$</td>
<td>14.4 bnM$^3$</td>
</tr>
<tr>
<td>2000</td>
<td>11.5 bnM$^3$</td>
<td>19.2 bnM$^3$</td>
</tr>
</tbody>
</table>

These differences are enormous. That for 1985 alone, nearly 4bnM$^3$ is about twice what Egypt expects to gain from the Jonglei Canal project. The difference for the year 2000 is the equivalent of all that Egypt stands to gain from all the proposed Upper Nile projects. These will be looked at in detail in subsequent sections, but the point here is that the margin for error in the assumptions we make cannot be very wide. Misestimating crop water duties, return flow of drainage water, water demand on reclaimed land, etc. has serious consequences for the measurement of water constraints that become tighter with each passing year. It used to be that Egypt and the Sudan made allocation decisions "give or take 5 billion M$^3$". Now it is a case of give or take half or a quarter billion M$^3$.

The estimates of the EMWP for municipal water consumption need to be examined (see esp. Technical Report No. 9). It rightly assumes a per capita rate of consumption for Egypt's urban population that is well above standard estimates for other LDCs. In other parts of Africa, for example, urban consumption is frequently estimated at 150 liters per capita per day: LCD (ROK, MWD, TAMS, 1979). Egyptians, however, have long historical habits of profligate water use in their homes, constrained only by the difficulties in transporting it.
Increasingly the major cities are served by house connections or nearby stand pipes. A visitor to Cairo cannot fail to notice the myriads of gushing or leaking faucets in public buildings and the broken mains that flood entire streets. By 1980 Cairo's average LCD was probably on the order of 480. Other cities have somewhat lower rates, but one must remember that Egypt's population in 1976 was 45% urban, and the authors of the EMWP expect it to be 55% urban in the year 2000 (Report 2), or perhaps 36 million people. It is assumed that their consumption will average about 350 LCD.

This seems reasonable. What is harder to accept is the proportion of total potable water delivered that the EMWP believes will be returned to the Nile as waste water and hence become available for agricultural use. The proportions range from 50 percent waste water in 1980 to 61 percent in the year 2000 (Report 2:37). Further on in the same report (p.47) the proportions remain the same but the total potable water delivered is considerably higher.

Table 4

<table>
<thead>
<tr>
<th></th>
<th>Estimate 1*</th>
<th>Estimate 2*</th>
<th>Estimate 3*</th>
</tr>
</thead>
<tbody>
<tr>
<td>t. Potable Water</td>
<td>2.25  2.42  4.62</td>
<td>6.1  6.6  12.6</td>
<td>6.  6.6  12.6</td>
</tr>
<tr>
<td>Net loss</td>
<td>1.78  1.87  3.47</td>
<td>3    2.9  4.9</td>
<td>4.8  5.1  9.5</td>
</tr>
</tbody>
</table>

*The first estimate is the standard one, from Table 10, p.66 of the Main Report and is reproduced in all other aggregate tables. Estimate 2 and 3 are from p.47 of Report 2.
The discrepancy between estimates 1 and 2 regarding the net loss over time involve on average about 1 billion M³. More interesting are the differences between estimates 2 and 3. Estimate 2 assumes that municipal sewage will be treated and returned to the system and that much of the waste water of Cairo, Alexandria, and the northern Delta cities that is currently pumped into the northern lakes or the sea will be recovered. Estimate 3 shows what might happen if the capital outlays necessary for capturing the waste water are not made. It is, moreover, difficult to imagine how the municipal waste water of Alexandria, Rosetta, Danietta, and Mersa Matrah along the northern coast; of Port Said, Ismailia, and Suez along the Suez Canal, and the new cities being built in the desert can, at reasonable cost, return their waste water to the Nile. According to how this problem is or is not addressed, water consumption figures may vary upwards by as much as 3 billion M³ per year.

One point of lesser significance: it is only in Report 9 that any estimate of rural consumption of potable water is made. Generally in poor countries rural rates of consumption are no more than a fifth of urban rates, but in Egypt, because of the proximity of the Nile, they are higher than in other LDCs. One should estimate the water consumption of animals as well. Egypt's animal population in the mid-1970s was 9 million including over 2 million water buffalo. My own estimate is that total rural consumption, animals and humans alike,
was about 850 mm $M^3$ in 1980 and will rise to about 1.4 bn $M^3$ in the year 2000.

The EMWP's estimates of industrial water consumption hinge on a few crucial assumptions. The first is that all future thermal-electric power plants will be located near the sea so as to use seawater for cooling, and second, that all industrial waste water returned to the system will be suitable for re-use (Main Report 66-67 and Report 10). On those assumptions the authors see industrial water demand rising from 2.9 bn $M^3$ in 1980 to 6.4 bn $M^3$ in the year 2000. Wastewater production will rise from 2.8 bn $M^3$ in the first year to 6 bn $M^3$ in the last so that there is very little net loss to the system.

Are these assumptions reasonable? One should note first that Report 10 acknowledges that most of the waste water produced in 1980 is unsuitable for agricultural use without treatment. Either 2 bn $M^3$ or so should be entered in Table 3 as part of industrial net consumption or that water is being treated, or it is being reused untreated. A second point is that, as pointed out in the Main Report (p. 66) siting power plants on the coasts may stimulate coastal urban and industrial growth, thereby increasing the amounts of municipal and industrial waste water discharged directly into the sea.

Given these caveats, the possibility that power plant location may be determined by factors other than the nature of coolants (for ex. regional development, proximity to raw materials), and the high costs of waste water treatment, it is probably more prudent to assume high levels of net water loss through industrial use.
Returning to Table 3 we come to navigation and spills, that is the amount of water used in the system to keep up minimal navigation requirements. Some of this water, about 3.8 bn $M^3$, is lost to the system and flushed out to sea. It is the reasonable expectation of the EMWP that in the future over half of these spills can be captured for use in irrigation. For example, 200 mn $M^3$ that are currently used at Faraskur to flush out the Damietta branch of the Nile will in the future be flushed directly into the al-Salam Canal offtake.

There is no single estimated variable in the EMWP that differs more from my own in the mid 1970s than that of evaporation and conveyance losses. The EMWP puts these at 2 bn $M^3$ in 1980 rising minimally to 2.2 by the year 2000. The slight increase will be brought about by the extension of the irrigation grid to the new lands, causing an increase in evaporation and seepage from the canals. In essence what we are talking about here is evaporation and seepage on the 1200 km stretch of the Nile from Aswan to the Mediterranean and in the 42,000 kms of irrigation canals and drains (Radwan, 1974:36). The EMWP estimates the surface of the first at 725km$^2$ and the second at 380km$^2$ (irrigation canals only) for a total of 1105km$^2$. There is some consensus now that surface evaporation rates at the High Dam reservoir are on the order of 2.7 to 2.9 meters per year (M.H.Omar and M.M. El-Bakry, 1970, EMWP, Report 14:108). It is reasonable to expect similar or higher rates on the downstream networks, above all because of the multiplier effect of aquatic weeds,
Nile hyacinth, shallow canal depth, etc. So evaporation alone should claim at least 3 bn $M^3$ annually. Yet the EMWP allows for only 2 bn $M^3$ for all conveyance losses.

Egypt's canals are unlined so that seepage is a major factor of loss. It must be the assumption of the EMWP that all water lost through seepage is returned to the Nile or at least to the aquifer adjacent to or underlying agricultural land. In part this is certainly true, but some proportion of this water drains away from the Nile Valley, especially on the west side. On the east the massive seepage from the Ismailia Canal and presumably from the al-Salam canal drains eastward. Seepage water that does drain toward the Nile tends to raise the water table in low lying areas in the northern and central delta, thereby increasing water logging and the need for drainage. It is not absorbed by the system but rather needs to be rejected.

It is safe to estimate conveyance losses in a system such as Egypt's at about 15% of total supply delivered -- at a minimum 30 bn $M^3$ for agricultural consumption plus 15 bn $M^3$ per year for drainage. Conveyance losses would thus total about 6.7 bn $M^3$ per year instead of the 2-2.2 bn $M^3$ put forth by the EMWP.

The remaining variables in Table 3 require little comment. The small reduction in drainage water may be somewhat conservative, but if we take drainage water as a proportion of total water delivered to old and new lands, it declines from 46% in 1985 to 32% in the year 2000.

The question of water supply requires analysis of fewer variables, but the magnitude of the unknowns is if anything greater. Supply
depends on:

1. the 1959 Agreement allocation: 55.5 bn $M^3$ + 1.5 bn $M^3$ on loan
2. actual discharge at the High Dam Reservoir
3. return flow of drainage water in Upper Egypt
4. re-utilization of drainage water in lower Egypt
5. implementation of Upper Nile projects.

I have, for the sake of argument, chosen two years to calculate a water balance for the Egyptian Nile, using EMWP figures and estimates of my own that are plausible. I hasten to add that I could have put forth other sets of figures for other scenarios which would likewise have been plausible. So too could have the EMWP. In addition I had to manipulate 1980 supply figures so that what I calculate as real Egyptian demand was in fact covered. The point is that my estimates can be sustained with as much conviction as those of the EMWP and when we arrive at the balances for 1990 the differences are very large (cf. Haynes and Whittington, 1981b). If, over a decade, such differences could plausibly materialize means the Egyptian planners and outside experts should err on the side of caution.

Some comment on my estimates is clearly needed. On the demand side I assume higher crop water duties and a higher MCI than the EMWP. The estimates for new lands assume 600,000 feddans under reclamation in 1980 and 1.6 million in 1990. The rate of water use is put at 8000 $M^3$ per feddan in 1980 and 7000 $M^3$ in 1990 -- probably an under estimate. I have already gone over the need to revise upwards municipal, industrial and conveyance losses. Finally I assume somewhat greater efficiency in water use than the MWP.

On the supply side for 1980 I have assumed the Sudanese loan of 1.5 bn $M^3$ to be in effect, in addition to which another 3 billion $M^3$ to have found its way downstream from the High Dam. This is due to discharge above the conventional average. In 1978, for
Table 5
EMWP and JW Estimates of Water
Demand and Supply in Egypt: 1980 and 1990
billions of M^3

<table>
<thead>
<tr>
<th>Demand</th>
<th>EMWP</th>
<th>JW</th>
<th>EMWP</th>
<th>JW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old Lands</td>
<td>29.4</td>
<td>32.4</td>
<td>29.4</td>
<td>33.0</td>
</tr>
<tr>
<td>New Lands</td>
<td>--</td>
<td>4.8</td>
<td>8.5</td>
<td>11.2</td>
</tr>
<tr>
<td>Munic. Net Loss</td>
<td>1.8</td>
<td>3.0</td>
<td>2.2</td>
<td>4.0</td>
</tr>
<tr>
<td>Ind. Net Loss</td>
<td>.3</td>
<td>1.0</td>
<td>.8</td>
<td>2.0</td>
</tr>
<tr>
<td>Navigation</td>
<td>3.8</td>
<td>2.5</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Unaccount. &amp;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaporation</td>
<td>2.7</td>
<td>6.7</td>
<td>2.2</td>
<td>7.0</td>
</tr>
<tr>
<td>Drainage</td>
<td>15.0</td>
<td>15.0</td>
<td>14.2</td>
<td>14.2</td>
</tr>
<tr>
<td>Demand Total</td>
<td>54.0</td>
<td>65.4</td>
<td>58.9</td>
<td>73.0</td>
</tr>
</tbody>
</table>

| Supply           |      |    |      |    |
| At Aswan         | 57.5 | 60.0 | 61.7 | 58.9 |
| Drainage Re-use  | --   | 2.5 | 3.4  | 6.0 |
| Drainage Return Flow | -- | 4.0 | --   | 4.0 |
| Supply Total     | 57.5 | 66.5 | 67.1 | 68.9 |
| Balance          | +3.5 | +1.1 | +8.2 | -4.1 |
instance, the IBRD Subsector Report (p.14) records discharge at Gaafra, 20 kks downstream of the High Dam, of 62 bn M\(^3\). My figure is admittedly a guess. In 1990 I assume the Sudanese loan to have disappeared, but that the first phase of the Jonglei Project will bring a net increase of 1.9bnM\(^3\) for Egypt, in addition to which discharges will continue above the averages for the first half of the century. Unlike the EMWP I do not believe any of the other Upper Nile projects will be implemented by 1990, if ever. That explains the difference between the two estimates for supply at Aswan: 61.7bnM\(^3\) vs. 58.9bnM\(^3\).

The Upper Nile projects are best left for discussion in the next section that deals with the Sudan. However it is important to note at this point what appears to be a major overestimate of the potential water benefit Egypt stands to gain from these projects.

Table 6

<table>
<thead>
<tr>
<th>Project</th>
<th>Expected Completion Date</th>
<th>Total Water Benefit</th>
<th>Egyptian Benefit 50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jonglei I</td>
<td>1985</td>
<td>4.81 bnM(^3)</td>
<td>2.4 bnM(^3)</td>
</tr>
<tr>
<td>Machar Marshes</td>
<td>1990</td>
<td>4.41</td>
<td>2.2</td>
</tr>
<tr>
<td>Jonglei II</td>
<td>1995</td>
<td>4.78</td>
<td>2.4</td>
</tr>
<tr>
<td>Bahr al-Ghazal</td>
<td>2000</td>
<td>5.1</td>
<td>2.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>19.1 bnM(^3)</td>
<td>9.5 bnM(^3)</td>
</tr>
</tbody>
</table>


Leaving aside for the moment whether or not it is realistic to expect all of these projects to be implemented by the year 2000, there is a
fundamental error in calculating Egypt's benefit. According to the 1959 Agreement Egypt is to receive 50% of any water increase resulting from joint projects between Egypt and the Sudan, as measured at Aswan. Egyptian and Sudanese hydrologists have always assumed that between Malakal at the tail of the Jonglei canal and Aswan, the water lost in conveyance is about 19% of its total volume (there is, inter alia, a very high rate of evaporation at the Jebel Aulia reservoir downstream of Malakal). The total benefit is measured at Malakal. Egypt's real benefit at Aswan would then be 7.7bnM³ rather than 9.5 bnM³. The benefit from Jonglei I would be 1.9bnM³ rather than the 2.4bnM³ used by the EMWP.

Finally some comment on the re-utilization of drainage water is required. If, as the Ministry of Irrigation claimed in 1976 (Abu al-Atta, 1976) up to 12 bn M³ of Egypt's drainage could be captured for further use, then Egypt would indeed find itself in a comfortable supply position. But the Ministry has subsequently revised its targets downwards, setting an objective of 7-8bnM³ by the year 2000 (Main Report, p.76). The EMWP concedes no more than 5.4bnM³ by that time (given in detail in Table 15,p.77). At an estimated cost of LE 1 per 1000M³, reutilization of drainage water is about the cheapest method available for increasing water supply. Of the 15 billion M³ or so available in any given year, some must be wasted to maintain overall water and salt balances in the Delta, and another portion is available only at unsuitable locations or altitudes
(IBRD Subsector Report:13). The main problem however is the level of dissolved solids in the drainage water. Report 3 of the EMWF suggests that in general total dissolved solids should not exceed 750 parts per million:ppm (the Nile at Cairo, for example, has 200-250 ppm). The Subsector Review, in Table 9, gives a detailed breakdown of the salinity ranges for the main Delta drains. In general the range is 500-4700 ppm, with most of the water above the salinity level of 750 ppm. Re-use will require mixing with irrigation water, but ever with such mixing in the al-Salam canal, total dissolved solids will be about 800 ppm. Consequently, while re-used drainage water offers some hope in easing Egypt's supply constraints, greater efficiency in delivery and on-field use would have a greater long-term payoff.

The EMWF has undoubtedly advanced our knowledge of the basic variables affecting water supply and demand in Egypt. Still it appears to have some important shortcomings. These are, on the demand side:

a) an underestimation of the likely MCI and crop water duties on the old lands
b) an underestimation of water requirements for the new lands
c) an optimistic assumption as to the amounts of municipal and industrial waste water that will be re-utilized
d) an underestimation of conveyance losses.
On the supply side, the shortcomings are:

a) an overestimation of the likely yield of the Upper Nile projects  
b) an underestimation of return flows of drainage water in Upper Egypt.

Only the last is an error that reduces estimated supply. All the others either reduce demand or increase supply. If these turn out to be real errors, planning that takes place in light of them will be seriously faulted.

Egypt must pursue two strategies simultaneously. The first is to reduce demand in relative terms (it will go up in absolute terms with more intensive cropping, land reclamation, urbanization and industrialization) by bringing about greater efficiency in water use. The second is to pursue, diplomatically, those accords and agreements with the upper Nile riparians that will permit implementation of the Upper Nile projects. It may well be that over the next 15-20 years the first strategy will be more within Egypt's reach than the second.
II.b

The Sudan: Money on the Blue or the White Nile?

Egypt, let us recall, has no significant agriculture other than that which is irrigated. The Sudan, by contrast, has about 4 million feddans under irrigation and another 14 million cultivated under rain-fed conditions. It is the long term objective of the Sudan to raise the irrigated surface to about 10 million feddans and the rain-fed to about 60 million (A. Ibrahim, "Environmental Impact" p.3). The irrigated acreage would be developed mainly in the rich plains between the Blue and White Niles (as would a good deal of the rain fed), but it is certain that nowhere near all the Sudan's land suitable for irrigation will ever be developed. Water is the limiting factor.

There are two fundamental strategy choices confronting the Sudan. The first is whether to emphasize hydraulic development on the Blue Nile or the White Nile. The former would be in the medium term interest of the Sudan; the latter in the medium term interest of Egypt. The second choice is whether to place primary emphasis upon hydraulic development for agricultural purposes or for power generation. Both these choices are conditioned by the severe balance of payments and external indebtedness crises that the Sudan is experiencing. The Sudan can borrow very little investment capital for any projects and thus must decide on absolute priorities. If capital could be mobilized for, say, one major project where would it be?: on the Upper Nile where Egypt might share financing but would also reap half the benefits?;
or on the Blue Nile where the Sudan would have to proceed alone but where agricultural and power pay-offs would be more immediate?

The same balance of payments crisis has made projects whose major benefit would be hydroelectric power generation far more attractive. Such projects could lessen Sudanese dependence upon imported fossil fuels and lead to some improvement in its foreign exchange position. Again, if one could muster capital for one project, would it go to a big hydroelectric unit at the 4th Cataract, to heightening the Roseires Dam, or to building a dam for mainly agricultural purposes at Remela on the Setit? Both sets of strategic options have major implications for Sudano-Ethiopian relations, and, of course, for Sudano-Egyptian relations.

There was a time only five or six years ago when it appeared that the Sudan would not have to make such difficult choices. The Sudan had been identified as the last great untapped source of agricultural expansion on the African continent. With its proximity to oil-rich but food-poor Arab neighbors, it looked as though investment capital would be no problem. Rather all that stood between the Sudan and an agricultural bonanza were political instability, poor infrastructure, and meagre local investment resources. If the Arabs and the West provided the capital, the first two problems might take care of themselves.

The capital was not forthcoming. Sudan's support for Egypt in its signing of the Camp David Accords reduced, although it did not stop, the flow of Arab funds into the Sudan. The AAAID maintained
its headquarters in Khartoum but was for months paralysed by its inability to replace its first Egyptian director. With Arab investors staying away, Western investors, interested mainly in selling technology and expertise, were not eager to take on the Sudan alone.

At this critical juncture, with its energy import bill soaring, cotton production and cotton exports began to decline. The Sudan had to turn to the IMF for balance of payments support. The price in 1979 was a devaluation of the Sudanese pound (LS) and the implementation of a stabilization program. The IMF, going beyond its conventional writ, argued that part of the trade imbalance stemmed directly from the management of the 2 million-feddan Gezira-Managil cotton scheme. The IMF convinced the Sudanese government to stimulate cotton production there by doing away with the export levy and the development tax on the tenants while offering them production bonuses (Andrew Lydett 1981:38).

The decline, however, continued. The Iraq-Iran war drove petroleum prices further upwards, while rehabilitation of the Gezira scheme proved itself to be a long-term proposition. The discovery of oil by Chevron in Bahr al-Ghazal Province offered only a distant respite, and the sugar schemes of the mid-1970s that were to transform Sudan into a net exporter, saw their cost estimates double and treble. By the fall of 1981 Sudan had begun to default on its external obligations. In November the cabinet was dismissed and a new austerity
program, in compliance with IMF recommendations, announced. Against
credits worth $220 million to be used to reschedule its most pressing
debts, the Sudan once again devalued the LS (by 12.5%) and pledged
to end all internal subsidies on petroleum products, to withdraw over
eighteen months all subsidies on wheat and sugar, to increase the
excise duty on imported luxury goods, to regulate public sector
borrowing, and to cut the government deficit by LS20 million

Compounding the economic crisis were the Sudan's perennial
political crises. Leaving aside the dubious alarm sounded of a
Libyan invasion of the Sudan through neighboring Chad, there were
more deep-rooted crises. The South, which had been devastated by civil
war between 1955 and 1971, showed renewed signs of tension. On October 5,
1981 Nameiry dissolved the Southern Regional Assembly and replaced
the Region's President and a long-time client of Numeiry, Abel Allier (A
Dinka and a nominal Christian) by General Gasmallah Abdullah Rassas,
who, although a southerner, is a Muslim.\(^3\) Part of the restlessness in
the south resulted from resentment of Dinka domination of the regional
executive. There were non-Dinkas, led by the former guerrilla fighter
Joseph Lagu, that advocated subdividing the southern region so as to
give greater weight to other tribes. At the same time the continued
influx of refugees and armed bands from Uganda, the alleged Ethiopian
support for the "Imatong Liberation Front" (Jeune Afrique Jan. 20, 1982:18
Sudanow, Oct. 1981) and Khartoum's decision to locate the refinery to
handle "southern" oil in the northern city of Kosti, all kept the pot boiling.

1982 initially brought no relief. In January riots broke out in protest of the austerity measures adopted earlier. Once the situation was in hand, Nimeiry fired the top leadership of the Sudanese Socialist Union. Simultaneously he arrested 21 southern leaders who had formed an alliance in opposition to the subdivision of the southern region. These snippets may seem of only distant relevance to the matter at hand. But the simple fact is that Jonglei I is currently underway in the southern region, and all other Upper Nile projects will likewise be sited there.

The false comfort one can draw from the Sudan's continued economic and political malaise is that it has set back projects that would have made significant demands upon Nile water. Two projects started in the mid-1970s have been partially completed: the Rahhad scheme for cotton and groundnuts, and the Kenana sugar project. A number of other projects, especially involving sugar cane cultivation, have been temporarily shelved. It may even be the case that the Sudan's net cultivated irrigated acreage has declined in recent years.

As one proceeds upstream in the Nile Basin statistical measurements become less and less comprehensive and occasionally less reliable. Thus we find a very broad range of estimates of current and potential agricultural water use, including, as in Egypt, avoidable inconsistencies and errors in data presentation. Again as in Egypt there have been in
recent years a number of baseline studies of Sudan's water resources. The studies that I shall rely upon in this section are IBRD, Sudan Agricultural Sector Survey, 1979, especially Volume II (henceforth IBRD AgSector); Ministry of Irrigation, Nile Waters Study, 1979, especially Volume I, The Main Report, Volume 2, Report II, Agriculture and Agricultural Economics and Volume 3, Report IV, Irrigation (henceforth MOI, Nile Study); and Ministry of Irrigation, Blue Nile Waters Study, 1978, especially The Main Report, and supporting Report IV, Irrigation (henceforth MOI, Blue Nile Study). Both the latter surveys were carried out by the private consulting and engineering firms of Coyne & Bellier, Sir Alexander Gibb, Sir M. Macdonald, and Hunting Technical Services.

The IBRD AgSector report (Vol.II, p. 114) gives out the same bad news for the Sudan as for Egypt: "Crucial elements of irrigation policy such as transmission losses, supply-demand balance, on-farm water management, irrigation efficiency remain after 50 years only theoretical estimates." In the spirit of that assessment, it is small wonder that estimates of those same parameters are at considerable variance. The same report suggests, for example, that water supply on the old established cotton schemes of Gezira-Managil, was and is about 12% below crop requirements at crucial points in the growth cycle. At the same time it was posited that large amounts of water were wasted on-field or through transmission losses (see Table 7). The
MOI Nile Study (Main Report: 47) by contrast has this to say:

"The present efficiency of irrigation water use in the Sudan is generally very high...(F)ield irrigation efficiencies are high and canal transit losses low. Waste of water due to spillage and escapage is generally small. In recent years the Gezira Research Station has made a comparison of theoretical water requirements and actual divisions for the Gezira Managil scheme. In 1976/77 this comparison showed that total diversions were some 5% less than theoretical requirements and in 1977/78 divisions were some 2% more than theoretical requirements."

How much irrigation water was being used as of, say, 1980? Estimates range from 13 bn M$^3$ per year to 18 bn M$^3$, the difference being far from trivial. Part of the problem lies in estimating the portion of the command area actually under cultivation. Here the range is from 2.7 million feddans for 1978/79 (MOA, Current Agricultural Statistics, 1979) to about 3.2 million feddans for 1977 (MOI, Blue Nile: Vol. 3, Report IV, Table 2.8 and Table 7). It is not impossible that the combination of the deteriorating irrigation grid at Gezira-Mangil and the Sudan’s deepening economic crisis actually led to a decline in the cropped area.

Aside from the area under cultivation, estimates of water use depend upon crop water requirements. As was the case with Egypt, the values assigned by different sources to different crops can be quite confusing. These are sometimes calculated according to the Penman E$^o$ crop factor method which yields estimates of theoretic plant requirements that are much lower than actual use (see IBRD AgSector, Vol. II: 150 and MOI, Nile Study, Vol. 1, 78-87 and Doorenbos, 1977). We
<table>
<thead>
<tr>
<th>Water</th>
<th>Crops</th>
<th>Water</th>
<th>Water</th>
<th>Rainfall</th>
<th>Cropping</th>
<th>Intensity</th>
<th>Fadams</th>
<th>Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Unutilized</td>
<td>% Used</td>
<td>M³/FYR</td>
<td>M³/FYR</td>
<td>000 Fadams</td>
<td>Crop Area</td>
<td>Crop Water</td>
<td>Rainfall</td>
<td>Net Command</td>
</tr>
</tbody>
</table>

Table 7
can compare theoretic requirements and actual use for certain crops as follows.

Table 8
Different Estimates of Crop Water Requirements

<table>
<thead>
<tr>
<th>Crop</th>
<th>Penman Eo *</th>
<th>Actual Use: SENNAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long-staple cotton</td>
<td>4369 M³/yr/fed</td>
<td>5318 M³/yr/fed</td>
</tr>
<tr>
<td>Med.-staple cotton</td>
<td>3257</td>
<td>4234</td>
</tr>
<tr>
<td>peanuts</td>
<td>2359</td>
<td>3921-4337</td>
</tr>
<tr>
<td>rice</td>
<td>4493</td>
<td>6365</td>
</tr>
<tr>
<td>wheat</td>
<td>2755</td>
<td>2864</td>
</tr>
<tr>
<td>sorghum</td>
<td>3275</td>
<td>2899</td>
</tr>
<tr>
<td>sugar cane</td>
<td>9025</td>
<td>11274</td>
</tr>
<tr>
<td>vegetables</td>
<td>3923</td>
<td>9661</td>
</tr>
</tbody>
</table>

Both estimates are exclusive of rainfall. For a technical explanation of the Penman method see Doorenbos, 1977, "Crop Water Requirements".

Theoretic requirements are of little use as a guide to actual consumption. In large irrigation schemes it is impracticable to deliver water in precisely the quantities needed by crops; when they need it and where they need it. And of course it is rather much to expect peasant tenants to respect theoretic norms in water use, although the water charges being introduced in the Gezira scheme may push the cultivators in that direction. In fact at Gezira-Managil, Khashm al-Girba and other large, state-run irrigation projects average water deliveries to the command areas are 4100 M³/fed/yr or 5300 M³ to each cultivated feddan. With the cropped area probably fluctuating between 2.7 and 3.2 million feddans, water use ranges from 14.3 bn M³ to 16.6 bn M³ per year.
Demand at that level seemingly gives the Sudan a good deal of leeway in developing new irrigated agricultural schemes/while remaining within the 20.5 bn M$^3$ per year allotted to it under the 1959 Agreement. Five or six years ago that might not have been the case. Former Minister of Irrigation, Saghayroun al-Zein*, put Sudan’s real crop use at 18.2 bn M$^3$ in 1975 (al-Zein, 1975 as cited in J. Waterbury, 1979:233), on the basis of 4168 M$^3$ per feddan of the command area. Similar figures were put out by the Ministry of Irrigation (Control and Use of the Nile Waters, 1975) as well as by the Gezira Research Station (Mehdi al-Bashir, 1981). If one adds in industrial and domestic water consumption, it can be seen that the Sudan was approaching the full utilization of its share. Moreover several large sugar cane schemes were on the drawing boards. Sugar cane consumes great amounts of water, 12000-17000 M$^3$ per year/feddan. New sources of water supply, either through the Upper Nile projects and/or more efficient on-field use were seen as urgent requirements. In fact only the 80,000 feddan Kenana sugar scheme has become operational. While I have not seen figures on actual water use there, I find in general that the reports cited in the preceding pages seriously underestimate real water use in cane cultivation (see for instance IBRD, AgSector, Vol.II:136).

The most that one can say at this point in 1982 is that agricultural water use is about 17 billion M$^3$ per year. That figure

*Re-appointed as Minister of State for Irrigation in November 1981 when President Numeiri took over both the Ministry of Irrigation and of Agriculture.
presumably includes conveyance losses but not evaporation at reservoirs.
What can we expect if and when the Sudan emerges from its spell of
agricultural stagnation? The MOI Nile Waters study (Vol. 1: 4-13) and
the IBRD AgSector Report (Vol. II: 136) contend that the Sudan's existing
command area of 4 million feddans can be raised to over 5 million with
a total water requirement of 20.5-21.8 bn M$^3$ per year. According to
the Nile Waters Study a command area of 7.5 million feddans could be
cultivated with 30 billion M$^3$ per year.

What these estimates mean is that the rate of water use per
command area feddan remains 4000 M$^3$ and that cropping intensity
remains around .75. This assumption is flawed. In other sections of
these same reports it is clearly stated that at Rahhad the MCI is
close to 1 and that rehabilitation of the Gezira-Managil complex should
bring the MCI up to 1 there. Private pumping schemes should achieve
an MCI of 1.5. Let us then make a simple adjustment. Taking the
1977 command area we come up with:

4,047,000 feddans x MCI/1 x 5300 M$^3$ per cropped feddan = 21.4 bn M$^3$

In addition a little over three million feddans in new irrigated projects
have been targeted for development. Of these the highest priority is
attached to 1.6 million feddans in the following projects:

<table>
<thead>
<tr>
<th>Project</th>
<th>Feddans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rahad II</td>
<td>300,000</td>
</tr>
<tr>
<td>Gezira Intensification</td>
<td>270,000</td>
</tr>
<tr>
<td>Kenana II</td>
<td>300,000</td>
</tr>
<tr>
<td>Kenana III</td>
<td>300,000</td>
</tr>
<tr>
<td>Jibil-el-Renk</td>
<td>182,000</td>
</tr>
<tr>
<td>Ken-Kelhak</td>
<td>231,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,583,000</strong></td>
</tr>
</tbody>
</table>
A somewhat more distant hope is a 600,000 feddan project on the Upper Atbara. Let us assume an MCI of 1 for this acreage as well:

\[
1,583,000 \text{ feddans} \times \text{MCI/1} \times 5300 \text{ m}^3/\text{per cropped feddan} = 8.4 \text{ bn m}^3
\]

The grand total would then be:

- Existing schemes: 4,047,000 feddans - 21.4 bn m\(^3\)
- Priority projects: 1,583,000 feddans - 8.4 bn m\(^3\)

Total 5,968,000 feddans - 29.8 bn m\(^3\)

Leaving aside for the moment whether or not the Sudan will find financing for its priority projects, the water demand estimates are not excessive. They do not, for instance, make any allowance for the heavy demands of new sugar cane schemes. There are currently 207,000 feddans under sugar cane using at a minimum 2.1 bn m\(^3\) per year. Nor do these figures include about 2.5 bn m\(^3\) in likely evaporation losses at reservoir sites. If the Upper Atbara project were to be implemented these figures would have to be adjusted upwards by about 3.5 bn m\(^3\) per year. Sudan's agricultural water use would be equivalent or superior to that of Egypt. It is important to remember that in the Sudan very little drainage water finds its way back into the Nile because the water table is generally about 30 meters below the surface and the heavy cotton clay soils are virtually impermeable.

If all the Upper Nile projects to increase usable discharge are brought into being by the turn of the century, the Sudan would have
a little less than 30 billion $M^3$ per year to meet a demand of upwards of 32 billion $M^3$. The latter figure does not include industrial and domestic use. As I will argue further on, the possibility that those projects will be implemented is very remote. What could and most likely will keep supply and demand in equilibrium is the Sudan's financial inability to bring off new agricultural schemes as well as its managerial incapacity to increase the intensity of cultivation on existing acreage. Those are scarcely glad tidings.

There is little doubt that the Sudan will make a major effort to seek funding for one project; the heightening of the Roseires Dam on the Blue Nile. As early as 1978 the MOI Blue Nile study warned "... it is imperative that the fullest use should be made of the Roseires site and no option should be contemplated that precludes ultimately raising the reservoir to 490 meters, this being the highest level which would not create adverse effects in Ethiopia" (due to reservoir backwater). The Nile Water Study (Main Report:15), carried out by the same consultants, unsurprisingly came to the same conclusion.

What is involved is raising the original dam, completed in 1966, by ten meters at a cost in 1979 prices of about $248 million. The consultants contended the increased hydropower generation at the dam site would alone pay for project costs. The project is urgent because the rapid silting-up of the Roseires reservoir is diminishing its capacity to generate electricity and to deliver irrigation water to Managil and Rahad. The live storage capacity of the reservoir has
been reduced from an initial 2.7 bn M$^3$ to about 2.3 bn M$^3$ in the early 1980s. Raising the Dam would increase live storage capacity to 7 bn M$^3$ and thus permit the development of new irrigation schemes at Rahad and Kenana. The Sennar reservoir, downstream of Roseires on the Blue Nile, is also experiencing severe siltation problems, but the most acute case is that of the reservoir of the Khashm al-Girba Dam on the Atbara. A dam upstream of Khashm al-Girba may have to be built to protect the original dam from siltation.

At one point two dams were envisaged on the Atbara, one at Burdana an the other at Rumela. The Burdana dam would have acted primarily as a silt trap, and eventually only the Rumela project was retained. Rumela is 14 kms upstream of the confluence of the Siteit and Atbara rivers. A dam there would create a reservoir of 1.6 bn M$^3$ in live storage capacity and about 400 mn M$^3$ in dead storage for silt deposit. It would allow the Khashm al-Girba dam and irrigation scheme (originally developed to accommodate Nubians displaced by the Egyptian High Dam reservoir) to function more efficiently. In conjunction with the Girba power station it would be able to generate between 66,000 and 84,000 mwh/year.

The new dam would permit irrigation of an additional 450,000 feddans (MOI, Upper Atbara Feasibility Study, 1981), in what I have referred to as the Upper Atbara project. It is significant to note the range of cost estimates associated with this project. The 1979 Nile
Water Study put construction costs in 1978 prices at LS100 million or about $200 million. The 1981 feasibility study put the costs for the dam, the main canal, power and transmission lines and the irrigation grid at LS912 million in 1980 prices, or nearly $2 billion. With the 1981 devaluation of the Sudanese pound coupled with world inflation the price must be around $2.5 to $3 billion. I would simply suggest that the reader take cost estimates with a grain of salt and that it be assumed that such estimates drawn up by consultants who have an interest in seeing the project implemented, seldom cover full project costs and underestimate inflation rates.

While the Upper Atbara project itself is not of top priority in agricultural terms, its ability to "save" the existing Khashm al-Girba irrigation and power scheme from rapid degradation may oblige the Sudanese government to pursue it despite its prodigious costs.

There have been a number of sites suggested for dams on the Main Nile, downstream of its confluence with the Atbara.
The one that seems to be under the most serious consideration is the Merowe Dam or dams on the 4th cataract. Two variants are under study: a single dam and 10 bn $M^3$ reservoir (with very high surface evaporation rates) or two smaller dams on either side of Shirri Island which would create less storage capacity and less hydroelectric head, but also less evaporation. The different projects would have installed generating capacity of 450 to 750 MW. The 1979 costs were put at a minimum of
LS428 ($856 million) to a high of LS638 ($1.276 bn). I leave it to the reader to apply the cost adjustments I suggested earlier.  

The Sudanese Ministry of Energy, or at any rate its Minister Dr. Sharif al-Tuhamy, ranks the Merowe project as the country's top priority in hydraulic engineering. It would, in his view, be operated as a "run of the river" project with minimal water storage involved. He is convinced that the returns to projects that have as their primary purpose generating hydropower are far higher than those whose primary goal is agricultural expansion. Concomitantly he would like to see existing hydroelectric projects run to maximize power generation rather than to adjust water release in conformity with agricultural demand.

Dr. al-Tuhamy does not therefore share the stress placed by others on heightening the Roseires Dam. He sees the central clay plains between the two Niles, the Atbara-Khartoum axis to the north, and the Kessala-Gadaref region to the east as ready for economic takeoff. Whatever the Sudan's modest potential in petroleum production, it should be used for thermal power generation in the west and on the east coast, areas too far to make efficient use of the existing hydro-electric grid. He envisages the eastern grid at Khashm al-Girba-Rumusa eventually linking into the western grid from Roseires to form an ellipse with Merowe at its northern end.
None of the irrigation schemes or hydropower projects mentioned above would involve Egyptian participation under the terms of the 1959 Agreement as none would provide any water benefit for Egypt. The Sudan would have to take on alone the daunting task of finding external assistance. Dr. al-Tuhamy had some hope that Egypt might share costs for the Merowe project. Merowe, he believed, could act as a flood control reservoir, holding water in those years when the High Dam reservoir is already at maximum storage levels. The snag in this vision, and it is a major one, is that Egypt has constructed a spill-way at Tushka, about midway along the left bank of the reservoir, to siphon off excess flood waters. I cite this situation because it is an example of the nonexploration by co-riparians of the possibility of joint projects leading, possibly, to two costly national projects where one bi-lateral project might have sufficed. I am in no position to argue that Merowe would have been a step toward optimal use for both countries (it was part of the original Century Water Scheme as outlined by H.E. Hurst, Y. Simaika, et. al.), but, despite their cooperation in the Upper Nile projects, Egypt and the Sudan did not explore its potential benefits.

From all the above discussion, two points emerge with some clarity. It is in the basic long term interests of the Sudan to emphasize development of the Blue Nile (including Dinder and Rahad) and Atbara (including Siteit) systems. Storage sites on these systems are proximate to existing agricultural schemes and major urban concentrations. But, most important, irrigation water from Blue Nile storage sites can be delivered in part by gravity flow whereas any scheme upstream of Khartoum depending on White Nile water would
require very expensive, fuel-costly, pumping arrangements. The original
Kenana sugar scheme was first designed to draw on Blue Nile water from
Roseires, but Ministry of Irrigation officials belatedly concluded that
there was not sufficient water stored there to accommodate the project.
The first great leap in project costs thus stemmed from the need to
redesign it to pump water from the White Nile to a level 42 meters
above the river. The Sudan has little desire to replicate this kind
of experience. In the short term Blue Nile-Atbara development is
imperative to protect existing schemes at Khashm al-Girba, Gezira-Managil,
Rahad, etc.

The second point is that there is now a strong "energy
lobby" in Khartoum that wants to break with the traditional agro-
centric view of the Ministry of Irrigation, a view rooted in the
construction of the Sennar Dam in 1925 and the development of the
Gezira cotton scheme. Its representatives will argue that priority
should be given to projects with large hydroelectric capacity in order
to ease the country's fuel import bill. They will urge that sites
be selected with their priorities in mind and that the projects be
managed to maximize power generation even if that means a non-optimal
pattern of water release for any associated agricultural schemes.
Finally, as the Power Master Plan pointed out in 1978, hydroelectric
projects may involve large losses due to evaporation that, in aggregate,
will reduce the amount of water available for agriculture.
While it is the case that the Sudan's most pressing agricultural and power needs would dictate development of the Blue Nile and Atbara rivers, the only major hydraulic engineering underway is on the Bahr al-Jebel stretch of the White Nile. The project is the Jonglei Canal, Phase I, or, more simply, Jonglei I, and it merits detailed consideration because, in several respects, it recapitulates many of the themes central to this paper: cooperation between two co-riparians, costs of engineering, estimates of water benefits, environmental impact. In a general sense the Jonglei project demonstrates the longevity of project proposals in this and other river systems. Projects may disappear for decades at a time only to reappear much later under radically altered circumstances.

From the turn of the century it was evident that tremendous quantities of water were lost each year in the swamps of the southern Sudan (W.E. Garstin, 1904; W. Willcocks, 1908; R. Tignor, 1966: 224-25). The area of permanent swamp is 5000-6000 Km², but the annual flood can easily quadruple this area. The permanent swamp is choked with heavy vegetation -- papyrus, cattails, and more recently Nile hyacinth -- that increase the rate of evapo-transpiration. The seasonal swamp spreads in a thin layer across the flat grazing areas of the south, seeping into the soil and evaporating rapidly as soon as the rains cease.

Once the Gezira scheme became reality and the extent of Sudanese agricultural potential was gauged, it was judged necessary to reduce the losses due to evaporation, perhaps 15 bn M³ per year,
so that the water needs of both Egypt and the Sudan could be accommodated. The first formal project presentation was drawn up in 1936 as an integral part of the Century Water Scheme. The Second World War put an end to any steps toward implementation. After the War, discussion of reviving the project resumed, the World Bank was approached for evaluation and funding, and, as we shall see, thorough engineering and environmental studies were undertaken. But by the time these steps were taken Nasser had come to power in Egypt in 1952 and the Sudan was on its way to full independence in 1956 (see H.E. Hurst, et.al. 1947 and Mahdi El-Beshir, 1981). Britain was no longer in a position to promote Jonglei or any other component of the Century Water scheme, and Egypt and the Sudan were not convinced of their necessity.

Thus it was not until September 1969 that Jonglei I was dusted off and offered up for a new round of discussions. A subcommittee of The Permanent Joint Technical Commission (PJTC) between Egypt and the Sudan, set up under the terms of the 1959 Agreement, drew up the broad outlines of a revised Jonglei project. The report underwent discussion in the PJTC, and in December 1971 a draft proposal was submitted to both governments. It languished for two years, until, in February 1974, Presidents Sadat and Numeiri launched a new era of Egypto-Sudanese cooperation. As part of a number of joint projects, Jonglei I was given formal approval by
both governments in April 1974. It was then a question of tendering project bids and beginning construction.

The original Jonglei project stimulated one of the first environmental impact studies ever undertaken. In four volumes, the Jonglei Investigation Team (1947-1954) presented a thorough survey of the population and resources of the area and an assessment of the impact of the project as it was then conceived. The crucial point here is that the High Dam at Aswan, with its over-year storage capacity, was not yet beyond the preliminary discussion phase. The assumption of the Investigation Team was that there would be no over-year storage facilities downstream of Malakal at the tail of the swamps. The objective was then to excavate a canal, running along the eastern side of the swamps on a fairly straight line from Jonglei in the south to a point on the Sobat in the north (Hillet Doleib) just before it enters the White Nile upstream of Malakal (see MAP 2).

The canal would capture flood water at its off-take at Jonglei, that would otherwise be lost in the swamps, and deliver it to the White Nile where it would proceed downstream to Egypt. The capacity of the canal was set at 55 mm M$^3$ per day, and it would carry that amount during the so-called timely period, roughly December 20 - June 20, when Egypt most needed irrigation water and when the seasonal storage capacity at Aswan would be exhausted. This
period corresponds, of course, to the planting and maturation of the cotton and rice crops, and it was believed that any extension of these crops would depend upon Jonglei in particular and the Upper Nile projects in general.

Something on the order of 7 bn M$^3$ per year would have been "saved", but at tremendous social and environmental cost. The swamps would have been deprived of replenishment during their dry season. Some 200,000 cattle-transhumants (Dinka, Nuer, and Shilluk) with twice as many animals would have found their flood-irrigated pasturage (toich) seriously diminished. Large areas of the permanent swamp would have been drained disrupting local fisheries. The canal itself would have lain along a ridge raised above the flood plain and swamps, upon which the tribes have built their permanent villages. It would have interrupted in a major way the seasonal movements of herds from the west to the east of the ridge and back.*

*Seasonal Population Movements and Grazing among the Dinka

February: herds in west toich areas; some animals left in ridge villages to provide milk for the young and aged.
March: continued exploitation of dry-season toich grazing
April: toich begins to deteriorate; village animal enclosures (luaks) repaired on ridge; first herdsmen return to villages to prepare land for cultivation.
May: Rains have started; herds move to intermediate grazing closer to ridge. First crop of red sorghum is sown. Maize is planted around luaks, as well as some beans.
June: herds move through villages to eastern intermediate zones; tobacco transplanting takes place.
July: cattle camps break up and animals are brought back to village luaks; white sorghum is sown.
August: Animals remain in luaks.
September: Animals remain in luaks but grazing becomes scarce with the end of the rains. First crop of sorghum is harvested; it may be ratooned.
October: cattle remain in luaks.
November: cattle stay out of luaks at night, grazing further and further from the villages. First harvest of white sorghum takes place.
December: cattle camps form again and intermediate Khor zones are invaded for remaining pasturage.

From M. Ahmed Abdel Ghaffar
Finally, Lake Victoria or Lake Albert would have been used as reservoirs to hold water in August and September at a time when Egypt receives all the water it needs from the Blue Nile flood. It was, in short, a formula for maximum environmental disruption.

The Sudanese were well aware of this fact, and it was the task of the Jonglei Investigation Team to suggest alternate means to minimize the damage. It recommended abandoning one part of the original project that called for embanking the Bahr al-Jebel to reduce its flood spill. In addition it suggested a canal discharge schedule that would conform better with the natural regime of the swamps as well as a major reduction in the discharge itself. The publication of the report coincided with Egypt's commitment to the High Dam project, so that Jonglei and the Upper Nile projects lapsed into temporary obsolescence. Nonetheless the report remains an invaluable base-line survey of the entire southern region.*

When Jonglei was revived in 1969, the circumstances had changed completely, and for the better. The construction of the High Dam erased the need of any consideration of water delivery during the timely season. This, not incidentally, is one of the major benefits of the High Dam, and it is one that is almost never taken into account either by friends or critics. The over-year storage capacity at Aswan liberated the Sudan from having to adapt its agriculture and hydraulic development to seasonal water requirements.

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* A year after its publication the outbreak of civil war in the south precluded any subsequent attempts to follow up on this survey.
in Egypt. With regard to Jonglei, it meant the project could be redesigned so that discharge through the canal could be minimized during the local dry season, October through April, and the total annual discharge nearly halved, so that flood pasturage and permanent swamp would be better protected.

Nonetheless, in an era in which environmental concerns had become much more salient, there was and is considerable concern that even the revised project may have major negative consequences. To deal with these issues, and to undertake planning for the affected region, the Sudanese government set up a special commission for the Jonglei region in 1975. It has subsequently been renamed the Executive Organ of the National Council for the Development of the Jonglei Canal Area. Under its aegis several studies have been carried out to measure social and environmental impact. One of them (Executive Organ, July 1979) contributed to a major design modification in the canal, and in that respect may be one of the first social impact analyses in an LDC to change the basic character of a large civil engineering project. The study was carried by a group of sociologists and anthropologists who concluded that the former direct line canal from Jonglei to Hillet Duleib would, in its southern half lead to substantial disruption in the movement of herds in their seasonal west-east movements in search of toich pasturage. As a result of the team's investigation, it was recommended that the canal alignment
be shifted eastward in its southern half, thereby increasing the total length of the canal from 280 to 360 kms. This shift would reduce the need for crossing points from 26 to 16 for the entire length of the canal. In practical terms this means minimizing the operations that entail swimming large cattle herds across the canal with likely damage to the canal embankments especially in that the landing point cannot be exactly known given varying rates of flow through the canal. The eastern alignment will give free access to the intermediate grazing zones to the west of the settled ridge. Moreover it may reduce the movements toward the east, which are motivated more by the search for water than for pasturage, because the canal will provide a year-round source of water.

The zone that will benefit most from the new alignment is inhabited by the Bor Athooc and Twi Dinka, involving some 117,000 people and over 200,000 cattle. The entire canal area and the settled ridge comprises some 260,000 people and 450,000 cattle.7

It was not solely as a result of this report that the alignment was shifted, adding 80 kms to the canal's length and increasing excavation time by at least one third. As Abdullahi Ibrahim, the first Jonglei Commissioner, pointed out, the original canal off-take on the Atcm tributary to the Bahr al-Jebel near Jonglei had, since the preliminary engineering studies of the early 1950s, become subject to permanent flooding with shifting channels and dense concentrations of hyacinth that would have made construction
of the off-take extremely difficult. An off-take at Bor, further upstream, became far more attractive. No barrage at the new site would be required to facilitate the off-take, so at least on that score some savings would result from the new alignment. These considerations aside, Ibrahim concludes: "The alignment finally adopted for the extension of the Jonglei Canal to Bor, is the result of integrated studies, in which the interest of the population was the decisive factor." (p. 11)

This modification in favor of the local populations is extremely important. When the Jonglei project first became known in the Southern Sudan in late October 1974, large scale rioting broke out at Juba as rumors flew that hordes of Egyptian peasants or even northern Sudanese troops would find their way back into the autonomous southern region. The regional chairman, Mr. Abel Alier had to quell these fears in a major public relations effort and perhaps in an act of faith.

Subsequently the National Council for the Development of the Jonglei Canal Area, with its seat in Khartoum, become something of a bastion of southern interests and led the lobbying for canal realignment. The Ministry of Irrigation and the PJTC were initially opposed, arguing that the technical problems at the Atem-Jonglei off-take could be mastered. Eventually the matter went all the way to President Numeiri, and in August 1979, after excavation of the canal at its northern and had actually begun, the decision was taken to realign and lengthen the canal to Bor.
There remain, however, questions of the environmental and social impact of the project that are partially or wholly unanswered. There has been considerable concern that the partial drainage of the swamp will reduce local rainfall, impede the recharge of the aquifer in its presumed northerly movement, and disrupt swamp fish reproduction (inter alia, Oscar Mann, 1977 and C.E. Gischler, 1975).

In order to get some grasp on the magnitudes involved, let us assume that Jonglei I will reduce spillage into the swamps by 8 bn M^3 per year. If this amount of water were spread over flat land at a depth of one meter, it would cover 8000 Km^2, i.e. one third to one fifth of the temporary swamp area. Over a year's time average surface evaporation on 8000 Km^2 would be over 2 meters, or ca. 18 bn M^3. Of course real evaporation varies seasonally leading to total drying out of large areas of the swamp. Just as obviously spillage occurs at varying depths. It is just such uneveness that creates toich grazing, islands of vegetation in a rapidly dessicating landscape.

The fears about rainfall do not appear well-founded. The surface evaporation that could produce precipitation is at its maximum at a time when most of northeast Africa receives no rainfall at all, i.e. roughly October-April. Second, during the 1960's when the size of the swamps increased substantially, and hence surface
evaporation as well, there was no major increase in precipitation in the Jonglei region. As regards seepage, Abdullahi Ibrahim (1981b) has this to say: "It appears that the Sudd basin is a closed one, which is not in hydraulic conductivity with the surrounding Nubian basin, but with the Baggera and Eastern Kordofan basins, at larger distances. Although the data are few, they all point to the fact that groundwater is flowing from all directions towards the central part of the Sudd basin, not the other way round."

The whole point of the project is to reduce the 15 bn M$^3$ or thereafter lost annually in the swamps to evaporation and seepage. The reduction will have an inevitable impact on the size of the swamp. Most of the change will occur in reducing spills over the left bank of the Bahr al-Jebel between Mongalla and Bor.

By one estimate (Asim al-Maghrabi, Environmental Studies Center, Khartoum University) the current size of the swamps will be reduced by 10-15%. But because their extent was so enlarged during the 1960s, a point to which we shall return in looking at the Equatorial lakes states, even the reduced swamp will be larger than the 'normal', pre-1962 area. Indeed this reduction will be of direct benefit to local populations that, for nearly two decades, have lost land to the expanded swamps. While warning of the dangers of prediction, Abdullahi Ibrahim (1981b) notes that if present trends continue, Lake Victoria water levels and rainfall may return to normal sometime in the 1990s which would mean that in combination with the Jonglei
canal the Sudd swamps would recede to a size comparable to that of the
pre-1962 period.

There are differing views on what this might mean in
terms of the swamp's fisheries and wildlife. There is little question
that the migratory routes of several species of animal (primarily the
kob antelope) will be disrupted. Abdullahi Ibrahim dismisses the
fish potential of the swamps, noting that they are "not very rich"
and becoming less so as Nile hyacinth spreads leading to increased
deoxygenation. An expert of the UNDP (UNDP, 1976) believes by
contrast that the potential fish yield of the swamps is 50 kg per hectare
or up to 120,000 tons per year. He warns "The flood cycle is vital
to the continued survival of fish species and any alterations in the
water regime can produce important changes in the fish population" (p.11).
The Jonglei Executive Organ is determined to protect this potential
for the benefit of the region's population (Executive Organ, 1978).

One of the most important and immediate benefits that the local
populations will draw from the canal once it is completed is a year-
round source of water close to their villages. While water demand
will be small, probably no more than 150 mn M³ per year, it will
allow intensification of agriculture near or on the ridge and ease the
problem of watering cattle in the dry season (UNDP, 1977).

Initial hopes for extensive agricultural development in the
region appear less well-founded. The most ambitious project was
for a large, 200,000 acre-mechanized farm on the Pengko plains southeast
of the canal. Irrigation would be used to supplement rainfall. It was judged that the total potential cultivable area in this region is 3.7 million feddans. A Dutch firm, ILACO, found that the project was impracticable. The original Jonglei Investigation Team suggested as much in 1954. While acknowledging that the heavy clay soils of the area are in theory suitable for agriculture, in practice they cannot be worked during the dry season as the clay and minerals in them "cement", and in the wet season they are so sticky and plastic that they are likewise unworkable (Jonglei Investigation Team, Vol.1, 107-08).

The principal beneficiaries of the canal, of course, are to be Egypt and, somewhat indirectly, the Sudan. In fact Egypt will probably absorb the entire net increment in White Nile discharge, reducing its demands proportionately on Blue Nile/Atbara discharge and thereby allowing the Sudan to increase its utilization of those sources. The High Dam has made Blue and White Nile water savings "fungible."

How is the Jonglei water benefit calculated? The impact of the Sudd swamps upon the regime of the White Nile is such that no matter how much water discharges into the swamps about the same amount of water finds its way downstream to the junction of the Bahr al-Jebel with the Sobat. Prior to the high flood years of the 1960s and 1970s, discharge into the swamps as measured at Mongalla averaged about 24 bn M³. But the higher discharges of the last two decades
have been offset by higher evaporation rates (see PJTC, 1976).

Table 9
Rates of Water Loss in Sudd Swamps

<table>
<thead>
<tr>
<th>Discharge rate MN M³/Day</th>
<th>Annual Loss in Swamp bn M³</th>
<th>Loss/Discharge %</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>10.9</td>
<td>17</td>
</tr>
<tr>
<td>75</td>
<td>27.4</td>
<td>50</td>
</tr>
<tr>
<td>120</td>
<td>43.8</td>
<td>62</td>
</tr>
</tbody>
</table>

Jonglei I is designed to draw off at Bor an average of 25 mm M³ per day (Min. 15 mm M³ per day, Max. 30 mm M³/day) or 9.1 bn M³ per year. Using the high discharge rates at Mongalla of the last two decades, we come up with the following calculation:*

1. average annual discharge at Mongalla: 29.0 bn M³
2. draw off into Jonglei Canal 9.1
3. losses in canal 1.0
4. canal discharge at tail (2-3) 8.1
5. discharge into Bahr al-Jebel and swamps (1-2) 19.9
6. losses in swamps @ 45% 8.8
7. Bahr al-Jebel discharge (5-6) 11.1
8. "Normal" discharge (losses at 50% of #1) 14.5
9. Bahr al-Jebel discharge and canal discharge (4+7) 19.2
10. Net gain (9-8) 4.7
11. Egypt's and Sudan's share (50/50) 2.35
12. Egyptian share at Aswan (19% conveyance loss) 1.9

*The figures represent my own calculations. Published figures generally reflect pre-1962 discharge at Mongalla of ca. 24 bn M³ per year, measured off-take at Jonglei rather than Bor, and use an average canal discharge of 20 mm M³/day rather than 25 mm M³/day.
These figures are, of course, but an approximation of what will inevitably be a water benefit varying annually with total discharge upstream. It is to regulate and increase that discharge that Jonglei II would be implemented, but before turning to that and other Upper Nile projects, let us look at the cost estimates for Jonglei I.

The cost of Jonglei I and the other Upper Nile projects have been estimated by the PJTC and then taken uncritically by others to generate their own estimates of incremental water costs and rates of return on other projects. The least that one can say is that these figures must be treated with skepticism and that they are no more than crude guesses. Let us begin by a look at the Egyptian Master Water Plan cost accounting for all Upper Nile projects (EMWP, Main Report; 74)

Table 10
Costs and Water Benefits of Upper Nile Projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Total Capital Cost LE mn</th>
<th>Annual Water Benefits</th>
<th>Cost per 1000 M^3/LE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jonglei I</td>
<td>89.1</td>
<td>4.8</td>
<td>1.91</td>
</tr>
<tr>
<td>Jonglei II</td>
<td>117.6</td>
<td>4.8</td>
<td>2.33</td>
</tr>
<tr>
<td>Machar Marsh</td>
<td>160.1</td>
<td>4.4</td>
<td>3.46</td>
</tr>
<tr>
<td>Bahr al-Ghazal so.</td>
<td>23.7</td>
<td>.7</td>
<td>3.4</td>
</tr>
<tr>
<td>Bahr al-Ghazal no.</td>
<td>210.7</td>
<td>4.4</td>
<td>4.7</td>
</tr>
</tbody>
</table>
As in other sources the costs are cited in local currencies, although much of the outlays will be in foreign exchange. It is my guess that the figures above reflect 1978 conversion rates, and both the Sudanese and Egyptian pounds have devalued considerably against major hard currencies since 1978. Second, the figures reflect for the most part engineering costs but not the attendant costs of regional development.

Presumably cost estimates for Jonglei I are somewhat firmer inasmuch as the project has been underway since 1979 (see PJTC, 1981). The total cost in 1978 was put at LS 92 mn, with LS42 million for the excavation of the canal itself. The French firm, Compagnie des Constructions Internationales, won the contract in 1976 and brought on site from Pakistan a bucket-wheel excavator with an effective capacity of moving 3400 $M^3$ of earth per hour. For the entire canal this would work out to about 50 Sudanese pence per $M^3$. The Sudanese decided to eliminate the canal tail regulator to reduce engineering costs.

However, since 1978 costs have risen rapidly. The Sudanese pound has been devalued twice or by nearly 100% against the dollar. Initially the excavator had to be recalibrated and "re-toothed" to deal with the heavy abrasive clay soils along the canal route. Then, more recently fuel shortages hit the excavator. This machine consumes more petroleum than the regional southern capital of Juba. Fuel shortages have led to periodic shut downs in the excavator's operations.
With about a third of the canal dug, it is estimated that Egypt and the Sudan have already sunk $100 million in the project (The Economist, May 22, 1982:91). It seems safe to assume that Jonglei I will cost between three and four times initial estimates. It would be prudent to assume a similar cost inflation for the other Upper Nile projects. To that extent studies such as the EMWP that calculate internal rates of return for land reclamation on the basis of unrealistically low incremental water cost estimates, need thorough revision.  

Three other projects have been proposed for the Upper Nile and Equatorial lakes that in combination could yield an additional 14 bn M$^3$ annually downstream of Malakal. The Machar Marsh project, if financing could be found, would be next after Jonglei I. In general, however, the three projects have been only cursorily studied from both an engineering and a social impact point of view and costs are only being guessed at. Indeed, in most respects it is still the work of H.E. Hurst, et al. (Vol. VIII) and the Jonglei Investigation Team that constitute the baseline studies.

The Machar Marshes occupy an area of about 6500 km$^2$ in the southeastern Sudan, and are fed by flood spills from the Baro river downstream of Gambella in Ethiopia, by drainage of Ethiopian torrents, and by direct rainfall. Most of the spillage occurs on the stretch of the Baro before it is joined by the Pibor to form the Sobat river. The area is inhabited by the Thiang Nuer in its northern part
and by the Garjoba Nuer in the south (see Jonglei Investigation Team, Vol.III).

The flow of the Baro, Pibor and Sobat reveals great seasonal variations. The latter, for instance, has shown extremes of 66 mm $M^3$ per day in November to 8 mm $M^3$ per day in April. It should be remembered that these waters are coming from the Ethiopian watershed so that the timing of the annual flood is different from that of the Bahr al-Jebel. Nonetheless, the flood discharge of the Sobat has normally overwhelmed that of the Bahr al-Jebel at their junction near Malakal, creating a backwater effect on the latter that reaches as far as Buffalo Cape. During the Sobat flood it is likely that the backwater effect combined with the additional discharge of the Jonglei canal will cause increased water loss of some 400 mm $M^3$ between July and December, but will reduce water loss between January and June by 320 mm $M^3$ (see PJTC, 1976), nearly an even trade.

There are essentially two ways in which water losses in the Machar Marshes could be reduced. The first, the oldest proposition and perhaps the best from an engineering point of view, would be to construct a seasonal storage facility on the Baro across the Ethiopian border at Gambela. The reservoir would be used to even out the Baro-Sobat discharge to ca. 37 mm $M^3$/day (or 13.5 bn $M^3$/year). This would reduce spillage on the Baro by some 3.8 bn $M^3$ per year. The second project would include embanking the Baro at the point of maximum spill and excavating a diversion canal of at least 400 km
running from Khor Machar northwest to the White Nile at Melut. The latter scheme has the advantages of being entirely within the Sudan and of increasing the White Nile yield by about 4.4 bn M$^3$ per year (as in Table 10) through reduced spillage and a reduced backwater effect at Malakal. But the engineering challenge, and, I would guess, the costs dwarf the Jonglei canal. H.E.Hurst, in 1950, considered the latter alternative and took note of its drawbacks (Vol.VII:28) "It is clear that some of this loss could be prevented and the water made available for cultivation by embanking the Baro and part of the Sobat. There is, however, the difficulty, which was discussed in Vol. VII, that in low years the losses are much reduced and the economy which can be made is also reduced perhaps to the point of vanishing altogether." The best solution, Hurst argued, would be a dam on the Baro with a reservoir of 25 bn M$^3$ capacity in order to even the flow of the river at Gambella.

Once the Machar Marsh project has been implemented, the Egyptians and Sudanese would then turn to the vast area west and southwest of The Jonglei canal to undertake the Bahr al-Ghazal project. The Bahr al-Ghazal river is fed by a myriad of torrents that arise along the watershed forming the Sudan's border with Zaire and the Central African Republic. The principal streams, are the Bahr al-Arab, the Lol and the Jur which come together along the western edge of the Sudd swamp to form the Bahr al-Ghazal which then flows
into Lake No. At that point it joins the Bahr al-Jebel. As can be seen in Map _, the entire drainage area is much larger than that of the Baro, Pibor and Sobat to the east. Over the last 40 years the average aggregate discharge of the Bahr al-Ghazal's major tributaries has been 13.5 bn M$^3$ per year. Virtually all this discharge is lost in the swamps (PJTC, 1981 b).

What is being proposed is to construct a canal, 425 km in length, beginning on the River Jur, cutting northwest to the Lol, and then following a dog-leg that cuts across to the north of the Bahr al-Ghazal to run east to the junction of the Bahr al-Ghazal and Bahr al-Jebel at Lake No. This canal would save about 7 bn M$^3$ of the waters of the Jur, Pongo, and Lol that are normally lost in the swamps. However, that canal alone might be relatively useless as the much stronger flow of the Bahr al-Jebel, and, on a seasonal basis, of the Sobat, blocks the Bahr al-Jebel from discharging into Lake No. To overcome this blocking effect, it is proposed to excavate a second canal of 225 kms from Lake No to the White Nile at Melut.

A glance at Table 10 will show the estimated costs for the two canals. The names of the projects were taken directly from the EMWP, and I suspect that the cost estimates for Bahr al-Ghazal south (the 445 km canal) and Bahr al-Ghazal north (the 225 km canal) were reversed. Reversed or not, they are grossly underestimated as
are those for the Machar Marshes. If the real costs of Jonglei I
are approaching $1 million per km of excavated canal, the cost of the
Machar and Bahr al-Ghazal canals in 1981 prices would be about
$1.3 billion. That would not include any head or tail regulators,
locks, or regional development schemes. That amount is somewhat
higher than the total cost estimates put forth by the EMWP for
all the Upper Nile projects, including Jonglei I and II.

Jonglei II would be the last of the major Upper Nile
projects to be implemented. Because it would ideally involve
Uganda and Zaire, we shall have more to say about it when we look
at the lacustrine states. Suffice for the moment to note that
Jonglei II would double the capacity and discharge of Jonglei I,
either by widening the canal presently under excavation or by digging
a second canal parallel to it.

To assure the amount of water necessary to channel 50 mn M$^3$/day
through the Sudd swamps would require utilizing Lake Mobutu
(Lake Albert) as an over-year storage facility. That in turn would
require regulating the discharge from the lake and raising the lake
level considerably (Hurst, et.al. Vol. VII: 68-73). Before the
levels of all the Equatorial lakes rose abruptly in the 1960s as a
result, it is believed, of heavy rainfall, it was assumed that coffer
dams and head regulators would have to be built to increase the
storage capacity and the discharge of Lakes Victoria and Kyoga. However,
for nearly two decades lake levels have been very high. As long as
SIMULATED MEAN MONTHLY FLOWS AT MALAKAL FOR PRE- AND POST-PROJECT CONDITIONS

JONGLEI TWO + MACHAR MARSHES
+GAZEL CANALS

JONGLEI TWO + MACHAR MARSHES

JONGLEI-ONE

PRE - PROJECTS

Mean Monthly Flow in MCM per day

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Max. Pre-project monthly flow
that situation prevails, Jonglei II could be supplied by additional water stored at Lake Mobutu alone. Releases would be timed to even out seasonal variations and to minimize the back water effect at the junction of the Sobat, Bahr al-Jebel, and Bahr al-Ghazal.

This project would be the last of the Upper Nile efforts to increase discharge on the While Nile. The cost estimate in Table 10 does not include any works outside the Sudan; that is it covers only the cost of doubling the capacity of the Jonglei canal. Even then the estimate cannot be taken seriously. The costs of Jonglei I have been substantially underestimated themselves. To suggest that Jonglei II would cost only 30% more than Jonglei I with something like ten to twenty years separating the two projects borders on the absurd.\(^9\)

There is a little discussed problem that is likely to make itself felt if any Upper Nile projects beyond Jonglei I are implemented. The stretch of the White Nile between Malakal and Renk has very little slope. If something like an additional 19 bn M\(^3\) per year is delivered downstream of Malakal a considerable amount of spillage will be unavoidable (see Figure ___). Therefore, that stretch will have to be dredged, or embanked, or both. The cost is estimated by the PJTC in 1978 prices at about Ls40 million.

There are important conclusions that may be cautiously drawn from the discussion of the Upper Nile Projects. The first and major conclusion is that, Jonglei I aside, none of them are likely to be
implemented in the next twenty years if ever. Let us look at the reasons.

The first two reasons are closely interlinked. The Sudan must carefully husband its meagre foreign exchange investment funds. For some time Sudan is likely to be seen as a poor credit risk, and even if it shares costs with Egypt, it may be extremely difficult to borrow the funds necessary for these mamouth projects.\(^{10}\) Second, what funds the Sudan is able to borrow in all logic will go to development on the Blue Nile, first of all to raise the Roseires dam. Whatever the Sudan’s economic situation, development of the water resources of the Blue Nile will remain its first priority.

The 1959 Agreement provides for situations in which one party is unable to assume the costs of its share of projects that both parties deem as desireable. In other words, Egypt could, in theory, proceed unilaterally to pay for and implement the Upper Nile projects. Such an eventuality seems unlikely on two counts. Egypt's economy is not strong enough to absorb the costs of the international borrowing needed to pay for the projects. (I am assuming something on the order of $2 billion in project costs with at least half that is foreign exchange.) Second, the Sudan is not likely to accept that arrangement.

The explanation for that judgement is rooted in the southern region of the Sudan. The Southern populations have gradually come
round to see the regional benefits of Jonglei I. It will reduce flooding in formally inhabited areas around Zeraf island that have been under water for twenty years. It will facilitate the movement of goods and people in and out of this inaccessible region by a navigable canal and an all-weather road along its embankment. It will provide a year round source of water for animals and agriculture close to the villages of the major tribes. By contrast Jonglei II will bring no new benefits. The road and navigable canal will already be in place. The additional carrying capacity will be irrelevant to local water demand which will be met by Jonglei I. On the other hand, abstracting 50 mn M$^3$/day will not simply produce double the effect of Jonglei I on swamp drainage and dessication but some multiple thereof. The ecological impact is likely to be far more severe than that of Jonglei I. Likewise, the ecological and social consequences of the Machar Marsh and Bahr al-Ghazal projects have received no study to date aside from the somewhat cursory and dated treatment of the Jonglei Investigation Team.

The southern populations and their leaders will therefore probably insist that before proceeding to any of the other three projects the consequences of Jonglei I be carefully monitored for some years, and that intensive surveys be carried out to forecast the impact of the other projects. If Jonglei I is completed in 1986, it may not be until 1996 that the evidence of its operation has been analysed. The other projects cannot reasonably be undertaken until 2000 or after. Downstream planning, especially in Egypt, that assumes otherwise will not be worth much. And the government in
SLOPES OF THE WHITE, BLUE, AND MAIN NILES

SOURCE: GIULIANO FERRIERI, ET AL.
IL NILO, NOVARA, 1978, pg. 14
Khartoum will have little incentive to confront the southern region over this issue inasmuch as Egypt stands to gain the most from White Nile development. Indeed such planning should take as given only 1.9 bn M$^3$ per year in additional water by 1987, but at a cost per M$^3$ at least twice that conventionally used.

The final obstacle to medium-term implementation of the projects lies in the need to seek accords with other riparians. Probably the least expensive and most efficient variant of the Machar Marsh scheme would require construction of a dam on the Baro at Gambela in Ethiopia. Likewise utilization of Lake Mobutu/Albert to regulate discharge in the Jonglei II project would require the cooperation of Uganda and Zaire. Political rivalry and suspicion in the first instance, and political chaos or indifference in the second, make any such accords an insurmountable obstacle. We shall have a good deal more to say about this problem in Section V intra-basin cooperation.

III

Ethiopia: The Great Unknown

Ethiopia has been rightly described as Africa's water tower (Wolde-Mariam, 1972)\textsuperscript{11}. Eleven rivers arising in the Ethiopian highlands flow across its borders to Somalia and the Sudan (see Map). Each year these rivers discharge about 100 bn M$^3$ to Ethiopia's neighbors. By far the largest river is the Blue Nile (known as the
Abbey in Ethiopia) which on average delivers about 50 bn m$^3$ to the Sudan each year, or about 60% of the total discharge of the main Nile. In addition, in the southwest the Baro and Pibor rivers that form the Sobat river, and in the northwest the tributaries of the Atbara supply respectively 14 percent and 13 percent of the Main Nile's discharge.

Table 11

Contribution of Main Nile Sources

<table>
<thead>
<tr>
<th>Tributary</th>
<th>12-Month Water Year %</th>
<th>Flood Period %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethiopian Sources</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blue Nile</td>
<td>59</td>
<td>68</td>
</tr>
<tr>
<td>Sobat</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>Atbara</td>
<td>13</td>
<td>22</td>
</tr>
<tr>
<td>Sub-total</td>
<td>86</td>
<td>95</td>
</tr>
<tr>
<td>Equatorial Lakes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bahr al-Jebel</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Adapted from Michael Field, 1973 as in Waterbury, 1979: 23.

It is no exaggeration to say that Ethiopia holds both Egypt and the Sudan by the jugular. It is alleged (Jones & Monroe 1970: 117) that Abyssinia's Christian King, Takla Haymanot warned Egypt's Muslim Pasha
around 1680:

"the Nile would be sufficient to punish you, since God hath put into our power His fountain, His outlet and increase, and that we can dispose of the same to do you harm."

As irrigated agriculture has become the mainstay of the downstream economies the geographical reality that Haymanot evoked has taken on tremendous geopolitical weight.

Despite the fact that most of Ethiopia is semi-arid, vast quantities of water are precipitated over its mountains during the rainy season. Average rainfall over the highlands is 1000 to 1400 mm per year. The southwest, where the Baro finds its source, receives the highest rainfall ranging from 1400 - 2200 mm (see map and Gamachu, 1979: 14-26).

If we take the Blue Nile catchment area, variously estimated at 174,000 km\(^2\) (Hurst, et.al., Vol. VIII) and 204,000 km\(^2\) (Bureau of Reclamation, 1964) total annual run-off may be on the order of 208 to 244 bn M\(^3\). On average only a fifth to a quarter of that run-off (i.e. ca. 50 bn M\(^3\)) is captured annually by the river itself and delivered downstream to Roseires in the Sudan. It is one of the peculiarities of the Blue Nile that its source, Lake Tana, provides less than 10 percent of its total discharge while the major tributaries downstream of Tana -- especially the Didessa, the Dabus, the Fincha, and the Balas -- provide most of the rest.
Not only does Ethiopia export water but, as well, the rich soils that have made the fortune of Sudanese and Egyptian agriculture. The price has been the profound and irremediable erosion of the Ethiopian highlands. It has been estimated that something like 2000 tons of solid materials per km$^2$ are washed away annually in the highlands (Wolde-Mariam, 1972: 78). These soils, over the millenia, have been deposited on the broad flat plain between the White and Blue Niles upstream of Khartoum and in the Delta in Egypt. More recently billions of M$^3$ of silt have been deposited in the reservoirs at Roseires, Sennar, Khashm al-Girba, and at Aswan.

The severe erosion of the highlands is a function of the very steep slope of the westward flowing rivers and of centuries of deforestation. For example, the Blue Nile, in its 900 km course from Lake Tana to the Sudanese border, drops 1786 meters. However, the very steepness of the rivers in the Blue Nile and Taccaze (upper Atbara) systems means that Ethiopia has enormous hydroelectric potential. Ethiopia could be to hydroelectric power what Saudi Arabia is to fossil fuels.
Table 12

<table>
<thead>
<tr>
<th>Country</th>
<th>Installed Capacity MW</th>
<th>% of Total</th>
<th>Potential MW</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethiopia</td>
<td>100</td>
<td>4</td>
<td>8380</td>
<td>53</td>
</tr>
<tr>
<td>Uganda</td>
<td>150</td>
<td>5</td>
<td>2500</td>
<td>16</td>
</tr>
<tr>
<td>Sudan</td>
<td>178</td>
<td>6</td>
<td>2348</td>
<td>15</td>
</tr>
<tr>
<td>Egypt</td>
<td>2445</td>
<td>85</td>
<td>2445</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>2873</td>
<td>100</td>
<td>15,673</td>
<td>100</td>
</tr>
</tbody>
</table>

Source:
How real that potential may be is another matter. Storing water on the Upper Blue Nile for hydroelectric projects or irrigation is very difficult because of the rapid siltation that takes place in the reservoirs. So-called run-of-the-river hydroelectric schemes, involving no or very little storage, would be poorly suited to most of Ethiopia's rivers that are highly seasonal in their discharge. Further, the best dam sites are at considerable distance from major energy-consuming areas such as Addis Ababa and Harar. Eighty percent of Ethiopia's population lives in scattered rural communities. Their problem is not electricity but fuel for cooking and keeping warm (cf. per cap energy consumption Figures in Table 1).

It seems, however, to be merely a question of time before Ethiopia turns its attention to harnessing the resources of its western watershed. How and when it will proceed to do so are questions of vital import to its downstream neighbors. Since the first propositions on Century Water storage were put forth after the turn of the century, various schemes have been drawn up to use Lake Tana as an over-year storage facility. But the interest of the Ethiopian government was never more than lukewarm. Its regard was always resolutely eastwards, toward Somalia and Djibouti, towards the Red Sea and the Indian ocean. If Ethiopia has a soft underbelly, it lies along its eastern frontiers, and it was from the east and northeast that the Arabs, and then the French and the Italians penetrated the highlands.
In that same vein, what little water management and irrigated agriculture has occurred in Ethiopia has been concentrated east of Addis Ababa, above all in the Awash valley.

Nonetheless, as Ethiopia's population continues to grow and highland agricultural conditions to deteriorate, the thrust of development will be increasingly toward the west along Ethiopia's 2200 km border with the Sudan. As that shift takes shape, the Ethiopians will be able to draw upon a number of studies carried out since the turn of the century (C.E. Dupuis, 1904). H.E. Hurst (Vol. IX, 1959: 22) argued that Lake Tana should be used for over-year storage even with the High Dam at Aswan so that maximum head could be maintained at the turbines of the power station. He believed that by raising the level and regulating the discharge of Lake Tana, Egypt and the Sudan could share an additional 3.5 bn $M^3$ annually. He also noted that a tunnel of no more than 8 km in the northwest corner of Lake Tana could channel water to an escarpment with a 500 metre drop into the Balas River. Even if the level of Lake Tana were to fluctuate by a metre or more each year the head available at the Balas site would provide tremendous hydroelectric potential.

In the inter-war years the Ethiopian government and the country's King, Hailie Selassie, showed some interest in Lake Tana development. J.C. White Engineering Corp of New York was awarded, apparently in 1927, a concession to carry out feasibility studies
and to construct a dam at the outlet of the lake. Between 1930 and 1934 the basic engineering studies were completed, but in the interim the world depression in general and the crisis in world cotton markets in particular, cooled interest in the project. In May 1935, Ethiopia formally proposed the project to the U.K., Egypt and the Sudan, but the U.K. opposed it, so it is claimed, in order not to antagonize Italy (A. Ibrahim, 1981a and Jones & Monroe, 1970: 166). The Egyptians, for their part, were sufficiently interested in the project to set aside £21 million in their public works budget toward its implementation.

As was the case with the projects on the Upper White Nile the depression and World War II cast Lake Tana and Blue Nile development schemes into limbo. They were not to be revived until the middle 1950s. The revival occurred at a time in which the U.S. had for all intents and purposes replaced Great Britain as the dominant external power in Ethiopia. With Kagnaw airbase near Asmara, Ethiopia became a watching and listening post for the US and NATO for all the Red Sea-Indian Ocean zone.

In 1952 Gamal Abdul Nasser came to power in Egypt, and early in the regime's life plans were laid to proceed with construction of the High Dam at Aswan. In 1955 the USSR, through the intermediary of Czechoslavakia, sold Egypt about $200 million in sophisticated armaments. The deal represented the first introduction of Soviet weaponry into the Arab Middle East and one of the first major arms sales to any Third World country. The United States was duly discomfited, and as part of the fall-out of the arms deal, Western funding committed
to the construction of the High Dam was withdrawn. By 1958 the Soviet Union had agreed to take on itself the financing and the construction of the High Dam. From then on the High Dam became something of a symbol of great power confrontation (see Waterbury, 1979: 87-115).

It is hard to accept as mere coincidence the U.S. concern for Blue Nile development in Ethiopia that emerged during those same years. The beginnings may have been innocent enough. In 1952, Tom Clark of the Bureau of Reclamation, carried out a preliminary reconnaissance report of the water resources of the Blue Nile. It was, however, in August 1957 that the Bureau of Reclamation entered into a formal contract with the Ethiopian government to undertake a detailed survey. This in turn was begun in 1958 and completed in June 1963, resulting in 17 volumes of findings including identification and preliminary engineering studies of several hydraulic projects (USDI, 1964; Min. of Information "Power and Irrigation in Ethiopia" 1969: 79).

The five years of the study coincided with a period of growing tension between Washington and Cairo. Nasser had entered into close economic and military relations with the Soviet Union, and had embroiled the Egyptian armed forces in the civil war raging in North Yemen. The Bureau of Reclamation study was a thinly-veiled warning and reminder to Egypt of its geopolitical vulnerability. The High Dam could do little to protect Egypt against any determined policy on the part of Ethiopia to abstract significant amounts of water from the Blue Nile. I have no direct evidence that the Blue Nile survey was intended to convey that message, but those Egyptians who knew of its existence
certainly took it in that spirit.

The Bureau of Reclamation studied the location of 26 dams and reservoirs that would provide water for both irrigation and hydroelectric power. As we can see in Table 13 between 371,000 and 433,000 hectares were identified as suitable for irrigation. Power projects theoretically capable of generating 38 billion Kwh were examined as well (USDI, 1964 Vol. I: 97). In all the survey estimated that if all 26 projects were implemented the annual water requirements for irrigation and storage losses would reduce the discharge of the Blue Nile at the Sudanese border by 5.4 bn M$^3$ (USDI, 1964, Vol.1: 41). Even in the early 1960s that would have meant a major reduction in the supply available to Egypt and the Sudan. Today such a reduction would be near catastrophic.

Ethiopia, both before and since the overthrow of Hailie Selassie in 1974, has done little to implement any of these projects. A run-of-the river power station, known as Tis Issat, was built on the Blue Nile 25 kms downstream of its outlet from Lake Tana, the Fincha River project, involving a large irrigated perimeter and a 100 mw power station was completed in the mid-1970s. Only the latter project has involved any draw-down in the Blue Nile discharge.

Nonetheless, the revolutionary Ethiopian regime, led by Mengistu Meriam, indicated as early as 1977 that it had big plans for the Blue Nile and the Sobat. At the UN Water Conference at Mar del Plata, Argentina, in March 1977, the Ethiopian country paper (Ethiopia, 1977)
<table>
<thead>
<tr>
<th>Area and Project</th>
<th>Class 1</th>
<th>Class 2</th>
<th>Class 3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lake Tana Area (incl. Gilgel Abbey)</td>
<td>3,388</td>
<td>1,570</td>
<td>46,142</td>
<td>115,490</td>
</tr>
<tr>
<td>Lake Tana Area (excl. Gilgel Abbey)</td>
<td>(3,818)</td>
<td>-</td>
<td>(3,122)</td>
<td>(6,940)</td>
</tr>
<tr>
<td>Megech Gravity</td>
<td>-</td>
<td>-</td>
<td>(15,270)</td>
<td>(15,270)</td>
</tr>
<tr>
<td>Ribb River</td>
<td>-</td>
<td>-</td>
<td>(9,780)</td>
<td>(12,920)</td>
</tr>
<tr>
<td>Gumara River</td>
<td>(1,570)</td>
<td>(1,570)</td>
<td>-</td>
<td>(12,920)</td>
</tr>
<tr>
<td>East Megech Pump</td>
<td>-</td>
<td>-</td>
<td>(5,890)</td>
<td>(5,890)</td>
</tr>
<tr>
<td>West Megech Pump</td>
<td>-</td>
<td>-</td>
<td>(7,080)</td>
<td>(7,080)</td>
</tr>
<tr>
<td>Northeast Tana Pump</td>
<td>-</td>
<td>-</td>
<td>(5,000)</td>
<td>(5,000)</td>
</tr>
<tr>
<td>Gilgel Abbey (German Team)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(62,390)</td>
</tr>
<tr>
<td>Beles River Area</td>
<td>3,200</td>
<td>19,600</td>
<td>40,400</td>
<td>63,200</td>
</tr>
<tr>
<td>Beles</td>
<td>(3,200)</td>
<td>(19,600)</td>
<td>(40,400)</td>
<td>(63,200)</td>
</tr>
<tr>
<td>Birr River Area</td>
<td>16,264</td>
<td>2,560</td>
<td>16,550</td>
<td>35,374</td>
</tr>
<tr>
<td>Upper Birr</td>
<td>(12,500)</td>
<td>(1,600)</td>
<td>(10,250)</td>
<td>(24,350)</td>
</tr>
<tr>
<td>Debohila</td>
<td>(3,240)</td>
<td>(960)</td>
<td>-</td>
<td>(4,200)</td>
</tr>
<tr>
<td>Lower Birr</td>
<td>(300)</td>
<td>-</td>
<td>(6,300)</td>
<td>(6,600)</td>
</tr>
<tr>
<td>Jiga Spring Pilot</td>
<td>(224)</td>
<td>-</td>
<td>-</td>
<td>(224)</td>
</tr>
<tr>
<td>Guder River Area</td>
<td>240</td>
<td>1,160</td>
<td>3,700</td>
<td>5,100</td>
</tr>
<tr>
<td>Upper Guder</td>
<td>(240)</td>
<td>(1,160)</td>
<td>(3,700)</td>
<td>(5,100)</td>
</tr>
<tr>
<td>Finchaa River Area</td>
<td>-</td>
<td>15,771</td>
<td>7,719</td>
<td>23,490</td>
</tr>
<tr>
<td>Finchaa</td>
<td>-</td>
<td>(10,000)</td>
<td>(5,000)</td>
<td>(15,000)</td>
</tr>
<tr>
<td>Amartti-Neshe</td>
<td>-</td>
<td>(5,771)</td>
<td>(2,719)</td>
<td>(8,490)</td>
</tr>
<tr>
<td>Diddessa River Area</td>
<td>870</td>
<td>28,270</td>
<td>23,960</td>
<td>53,100</td>
</tr>
<tr>
<td>Arjo-Diddessa</td>
<td>-</td>
<td>-</td>
<td>(16,800)</td>
<td>(16,800)</td>
</tr>
<tr>
<td>Debana</td>
<td>-</td>
<td>(4,700)</td>
<td>(1,400)</td>
<td>(6,100)</td>
</tr>
<tr>
<td>Angar</td>
<td>(870)</td>
<td>(23,570)</td>
<td>(5,760)</td>
<td>(30,200)</td>
</tr>
<tr>
<td>Dabus River Area</td>
<td>900</td>
<td>9,900</td>
<td>4,200</td>
<td>15,000</td>
</tr>
<tr>
<td>Dabus</td>
<td>(900)</td>
<td>(9,900)</td>
<td>(4,200)</td>
<td>(15,000)</td>
</tr>
<tr>
<td>Dindir-Rahad Area</td>
<td>-</td>
<td>12,900</td>
<td>110,100</td>
<td>123,000</td>
</tr>
<tr>
<td>Rahad</td>
<td>-</td>
<td>(5,000)</td>
<td>(48,100)</td>
<td>(53,100)</td>
</tr>
<tr>
<td>Galegu</td>
<td>-</td>
<td>-</td>
<td>(11,600)</td>
<td>(11,600)</td>
</tr>
<tr>
<td>Dindir</td>
<td>-</td>
<td>(7,900)</td>
<td>(50,400)</td>
<td>(58,300)</td>
</tr>
<tr>
<td>Total (including Gilgel Abbey)</td>
<td>26,862</td>
<td>91,731</td>
<td>252,771</td>
<td>433,375</td>
</tr>
<tr>
<td>Total (excluding Gilgel Abbey)</td>
<td>26,862</td>
<td>91,731</td>
<td>252,771</td>
<td>371,364</td>
</tr>
</tbody>
</table>
announced that over the short term as many as 225,000 acres in the Blue Nile basin, and 70,000 in the Baro, would be brought under irrigation. Over the medium term, the total water abstraction might reach 4 bn m$^3$ per year. There is little doubt that the regime relied upon the Bureau of Reclamation survey, carried out for the benefit of Hailie Selassie, as the basis for its planning.

In 1981 at the UN Conference on the Least Developed Countries, Ethiopia presented a summary of its ten-year investment program (UNCLDC, 1981). It listed some fifty irrigation projects for the entire country, comprising up to 704,000 hectares, of which 381,000 are in the Blue Nile basin and 15,000 in the Baro-Akobo basin. Among these projects top priority is to be given to twenty covering 337,000 hectares. Few of these, however, appear to involve the Blue Nile or the Sobat. There will be two hydroelectric projects at Fincha and Lake Tana, and two irrigation projects, one in the Dabus covering 15,000 hectares and the other at Ribb-Gomera covering 12,000 hectares. These are scheduled for implementation between 1981 and 1985. Between 1986 and 1990 only two relevant projects are planned. The East and West Megech irrigation perimeters, covering 11,600 hectares and utilizing water pumped from Lake Tana, and the Upper Balas hydroelectric project. Thus despite ambitious long-term goals, the next ten years will see only a handful of modest water control projects on the Blue Nile.

Ethiopia's population is expected to grow from 31,000,000 in
1979 to 41,100,000 in 1989. A move out of the over-populated, over-
farmed highlands is already underway. It began first with the
development of the Awash Valley. Then, more surprisingly it developed
in the alluvial plain around Homera along the Sudanese border.
Necessity is transforming behavior that Hurst took as given after
the Second World War (H.E. Hurst, et.al. Vol. IX: 24):

"The Ethiopians avoid the low country, which they
consider unhealthy. They never camp by the river in
the course of their journeys from the plateau on one
side to that on the other, although it may mean a very
long day's march down to the river and up the opposite
bank."

By the late 1960s this picture had been considerably altered. Private
commercial farmers opened up the hot agricultural plains of Beghender
Province, watered by the Seteit and Amgharib Rivers. Nearly 200,000
hectares of land were brought under mainly rain-fed agriculture
to produce sorghum, sesame, and cotton. The activity attracted worker
migrants from Beghender and from Tigre provinces. "The region that only
about five years ago was nearly uninhabited is now teeming with
hundreds of thousands" (Wolde-Mariam, 1972: 116). The revolutionary
regime took over the farms as well as much private trucking with the
result that production has declined sharply and marketing has been
disrupted. Many of the original migrants have returned home.

The setback is only temporary. There is too much good
alluvial soil and water in this region to be ignored. It will
inevitably be developed. Geographically and hydrologically
it is part of the heavy cotton clay zone that extends all the way
to Khartoum and it is watered by the same rivers: the Blue Nile,
the Rahad, the Dinder and the Seteit-Atbara. Just as inevitably the southwest Baro region, with high rainfall and good soils, will also be developed. Currently it is inhabited by the Annuak tribe, but the region has been singled out as a growth pole for northern populations. In short Ethiopia's eastern fixation is likely to give way in the next decade to much greater concern for the west and southwest. How that concern will become manifest is of great interest. As the Ethiopians declared at Mar del Plata, they would welcome an accord on the utilization of the Nile with its downstream neighbors, but in the absence of such an accord they reserved the sovereign right to carry out their projects unilaterally.

However ominous that threat, it is clearly not of immediate import. The projects Ethiopia is contemplating over the next 10-15 years will have very little impact on Blue Nile-Atbara water supply. If the western donor community is invited to participate in those projects, it is likely that they would urge Ethiopia to seek formal accords with Egypt and the Sudan (although the IBRD, which helped fund Fincha I, required no such accord). It is the longer haul, beyond the scope of this study, that the great Ethiopian unknown will become relevant. But, and this must be part of an Egyptian nightmare, when Ethiopia gets around to its western lowlands, there will be the makings, if not the motivation, for the Sudan and Ethiopia to strike a deal on the Blue Nile at the expense of Egypt. C.E. Dupuis saw the logic of the situation eighty years ago (C.E. Dupuis, 1904: 23):

"As a reservoir for the Blue Nile feeding canals irrigating
the Gezira and the rich lands to the east of that river in the Soudan, the suitability of Lake Tsana is so great and obvious that it seems almost inevitable that sooner or later in the world's history some solution of the political difficulties must be found, and advantage taken of it."

That the political difficulties still persist testifies to the difficulties that inhere in such cooperation.
IV
The Lacustrine States

Three Equatorial lakes -- Victoria, Albert/Mobutu, and Kyoga -- could all figure in long-term, over-year storage schemes to deliver an additional 4-5 bn M$^3$ downstream to the Bahr al-Jebel. In 1974 over 200 possible storage combinations were being readied for computer analysis (Hydromet, 1974: vol. I: 903). Any one of them will require the accord and cooperation of six states: Kenya, Uganda, Tanzania, Zaire, Rwanda and Burundi. Of these Uganda, with control over portions of Lakes Victoria and Albert and total sovereignty over Lake Kyoga, would be the most directly affected. There is a certain irony in the fact that all this potential modeling, engineering, and diplomatic maneuvering would at best yield an amount of water that is less than one fifth of one percent of Lake Victoria's average volume (2700 KM$^2$). It is the simple fact, however, that the Sudd swamps and the existence of fairly flat stretches along the Albert and White Niles preclude more ambitious water targets. Likewise there are no alternative storage sites to the Lakes further downstream.

The obstacles to achieving even this modest target are legion. We have already examined the possible objections that would be raised in the southern Sudan itself to implementation of Jonglei II. Beyond this, the lake states stand to gain very little from cooperating with Egypt and the Sudan. There could be some intangibles in the form of goodwill, but material advantage would be served only through increased
hydropower generation and perhaps a flow of external funds that any regional development scheme might attract. Consequently the Lake states are suspicious of downstream efforts, particularly on the part of the Egyptians, to promote basin-wide cooperation and to move closer to implementing the Upper Nile projects. While in principle all basin states see cooperation as a good thing, they will not allow themselves to be bullied or cajoled into formal arrangements before they better understand their own interests.

Even if they bring together the information and expertise to assess their interests, the tortured political relations among those states may impede any concerted action in light of them (cf. Norman Miller, 1980).

Nonetheless, the formation of regional groupings for economic cooperation, consecrated in the 1980 Lagos Plan of Action of the OAU, is very much in vogue. Indeed there has been such a proliferation of these groupings that one wonders how they can be effectively coordinated, no less financed. The recent tractations among the states of East Africa are typical of the unevenness with which cooperation is pursued. In late 1981 Tanzania entered into negotiations with Uganda and Kenya to liquidate the assets of the defunct East African Community. The negotiations stalled over determining Kenya's debt, variously estimated at $225 million. Simultaneously Tanzania, and eight other states, refused to sign a preferential trade agreement within the framework of the 19 member Preferential Trade Area of East and Southern Africa. Tanzania pleaded that it needed more time to
study the implications of the agreement, especially to determine if adherence would be compatible with obligations under the ten-nation Southern African Development Conference. It was believed that in fact Tanzania feared that Kenya would be the major beneficiary of the trade agreement and that if it were ratified Tanzania would have to re-open its border with Kenya, closed since 1977.

By contrast, there have been some effective steps toward regional cooperation within the framework of the Kagera River Basin Organization. This grouping, comprising Tanzania, Rwanda, Burundi, and Uganda, is particularly important for this study because it involves the Kagera River which is Lake Victoria's single largest source of inflow, and because it has set a precedent for water management among four states of the Nile Basin. Moreover, the intent of the Organization is to promote regional development in agriculture, transportation, communications, training, and energy. In thus broadening its terms of reference beyond issues of hydraulic development, the Kagera Organization has become something of a model for what the Egyptians are proposing for the entire Nile Basin. We shall take up this question in Section V.

The Kagera river is formed by the confluence of the Nyvarongo and Ruvuvu rivers and over its 500 km course drains an area of 58,370 km² distributed as follows:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Burundi</td>
<td>13,060</td>
<td>km²</td>
</tr>
<tr>
<td>Rwanda</td>
<td>20,550</td>
<td></td>
</tr>
<tr>
<td>Tanzania</td>
<td>20,240</td>
<td></td>
</tr>
<tr>
<td>Uganda</td>
<td>4,520</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>58,370</td>
<td></td>
</tr>
</tbody>
</table>
Each year on average it discharges 9 bn m$^3$ into Lake Victoria. There are several sites along its course that are suitable for hydroelectric development, especially at Kyansoro Falls, Kakono, and Rusumu Falls. Irrigated agriculture is not as attractive because the region is characterized by fairly high and dependable rainfall (Hydromet, 1974, Vol. IV: 15).

In July 1969 the four member states took the first steps toward establishing the organization. A technical committee was founded and seven potential projects identified. Modest support to begin feasibility studies was obtained from the UNDP in 1971. The principal consultants were Norconsult (Norway) and Electrowatt (Switzerland), and in May 1977 they produced a 13-volume study, the final volume of which served as an indicative plan for the entire basin.

On the strength of this plan the heads of state of Tanzania, Burundi, and Rwanda signed the "Rusumu Agreement" of August 24, 1977. This gave birth to the Organization for the Management and Development of the Kagera River Basin that was formally proclaimed on February 5, 1978. Uganda, after 1971, ceased to participate in the steps leading up to the creation of the organization, but Idi Amin having fled Uganda and Milton Obote having been restored to power, Uganda rejoined the organization in May 1981 (Gasarasi, 1981).

To date the member states have concentrated on negotiating the terms for construction of a dam and hydroelectric power station at Rusuma Falls. Tanzania had originally urged a large dam and power station capable of generating 129 megawatts, but which would have flooded 18,000 hectares and led to the displacement of 22,000 families, primarily in
PROPOSED PLANS OF DEVELOPMENT IN THE KAGERA RIVER BASIN
Rwanda. A scaled-down version, providing for an 80 megawatt installation and a reservoir that will flood only 3700 hectares, was finally approved at Bujumbura in May 1981. Rwanda noted that it was prepared to accept this sacrifice against compensation and against access to the sea through Tanzania. One of the other projects under examination is in fact a rail link to all four countries ("Kajera Union counts its blessings", AFRICA, N.123, Nov. 1981)

Another example of regional cooperation has been the Hydromet project which started up in 1967. In that year all the Nile co-riparians, with the exceptions of Ethiopia and Zaire, finalized an agreement with the UNDP and the WMO to carry out a detailed survey of the rainfall patterns and water resources of the Upper White Nile basin. In the first phase, which lasted from 1967 to 1974, thirty-six individual catchments were monitored and time series data gathered on each. Initially the survey covered the catchments of Lakes of Victoria, Kyoga and Mobutu. Upon the request of Rwanda and Burundi the survey was extended to the Kagera Basin in 1972. In 1971 Ethiopia joined the project as an observer. Zaire likewise enjoyed observer status until 1976 when it requested that the survey be extended to include the catchment area of the Semliki River, 70% of which lies in Zaire and whose waters discharge into Lake Mobutu. The request was approved in 1978.

By that time the second phase of the project was well underway. It involved continued monitoring and data gathering, and the development of a mathematical model of the water balance of the entire Upper White Nile Basin, an area covering some 410,000 km² (Hydromet, 1974 and 1981).
The project has a fairly long and very important history. Some experts see it as an Egypto-Sudanese stratagem to tap into data that they will then use for their own planning purposes. These experts rightly point out that no part of the territory of either state -- not even the Sudd swamps -- falls within the survey area. Moreover Egypt's quest for this kind of data is long-standing. In 1950, in an exchange of notes with the UK acting on behalf of Uganda, Egypt requested access to data then being gathered on the Equatorial lakes. As Charles Odidi Okidi pointed out (1979:141) "...Egypt was well set to use the hydrological and meteorological data of the East African Lakes ahead of the countries within the catchment area." (cf. Caponera, 1959).

The immediate stimulus to the current Hydromet Project was, however, an abrupt rise of two and a half meters in the level of Lake Victoria between October 1959 and May 1964. When one considers that such a rise represents about 180 bn m$^3$ of water, then the concern of the lacustrine states is readily understandable. Low-lying areas around Lake Victoria, especially in Kenya's Kavirondo Gulf and Kisumu port areas, were flooded, infrastructure had to be moved, agricultural land was lost and populations displaced. What caused this sudden rise, and was it likely to endure? It was to answer these questions that in 1963 Uganda, Tanzania, and Kenya, because they were directly concerned, joined with Egypt and the Sudan to request support for the survey that eventually got under way in 1967.

As the years have gone by, what may once have been a hidden agenda for Hydromet became openly exposed. The Hydromet recommendations
(1981: XII-XIII) are straightforward:

"The participating governments should assign trained staff to the Hydromet Project and should use the Project to plan the conservation and development of the water resources of the Upper Nile Basin. Such planning should include investigation of individual water resources projects..., as well as river-basin development schemes and regulations of equatorial lakes."

"At the same time consideration should be given to setting up an organization for water resources studies of the entire River Nile Basin. Only in this way will it be possible to ensure that future developments will be optimum for the basin as a whole."

That reads like an Egyptian clause, and so far it has not been given any practical effect. It is nonetheless significant that in Hydromet Egypt and the Suwan have identified a set of objectives and have found an organizational vehicle that are acceptable to the Lake states. It is precisely in seeking such instrumentalities that deal with real and immediate needs while servicing potentially divergent interests among the riparians that meaningful progress toward basin-wide cooperation can be made.

Having said that, we must turn to the vexed question of rising lake levels and the controversy that surrounds the search for an explanation. Hydromet 1981 came to this conclusion:

"During the period 1961-64, the level of Lake Victoria rose by around 2.5 meters and [after a drop between 1968 and 1976:JW] over the period 1977-80 rose by around 1.5 meters."

"The most part of the observed rises in lake level must therefore be due to natural causes. However, neither a simple water balance nor use of the model have been able to pinpoint the exact cause. This is believed to be because of the inaccuracy of the data on over-lake precipitation and evaporation."
In other words, the conventional argument is that a sudden increase in rain fall in the early 1960s accounts for the rise. This thesis is sustained by the fact that higher rainfall was recorded throughout East Africa in those years, and levels of other lakes, such as Tanganyika, Edward, George, Naivasha, etc. rose dramatically as well. More far-fetched are suggestions that increased sedimentation or tectonic tilting may have caused the rise. The first could not produce an abrupt rise in lake level, and the second would surely have produced major tremors throughout the region.

There is another explanation, however, and it rests on the operation of the Owen Falls dam at Jinja in Uganda. This dam controls the outlet of Lake Victoria into the Victoria Nile. Its construction was arranged by the UK, on behalf of Uganda, and Egypt whose consent was needed as stipulated in the 1929 Nile Waters agreement. For the UK the objective was to develop a major source of hydroelectric power to supply both Uganda and Kenya. For Egypt, in the pre-High Dam era, the objective was to raise the level of Lake Victoria so that additional water could be stored there awaiting the day Jonglei I would become a reality.

The project was drawn up and approved between May and December 1947. The dam was begun in 1948 and completed in 1954. Along with the Jebel Aulia barrage in the Sudan it represented the only projects implemented within the framework of the Century Water scheme.
<table>
<thead>
<tr>
<th>Component</th>
<th>Victoria</th>
<th>Estimated Magnitude $10^9$ M$^3$</th>
<th>Kyoga</th>
<th>Mobutu</th>
<th>Entire Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td>land runoff</td>
<td>18.8</td>
<td></td>
<td>2.9</td>
<td>7.3</td>
<td>29.0</td>
</tr>
<tr>
<td>rainfall on lakes</td>
<td>114.3</td>
<td></td>
<td>5.5</td>
<td>3.8</td>
<td>123.6</td>
</tr>
<tr>
<td>evaporation</td>
<td>99.6</td>
<td></td>
<td>6.9</td>
<td>8.3</td>
<td>114.8</td>
</tr>
<tr>
<td>inflow from Nile</td>
<td>--</td>
<td></td>
<td>28.8</td>
<td>30.0</td>
<td>--</td>
</tr>
<tr>
<td>outflow to Nile</td>
<td>28.8</td>
<td></td>
<td>30.0</td>
<td>32.6</td>
<td>32.6</td>
</tr>
<tr>
<td>change in storage</td>
<td>- 4.7</td>
<td></td>
<td>- .3</td>
<td>- .2</td>
<td>- 5.2</td>
</tr>
</tbody>
</table>

Table 14b
National Shares of Major International
Equatorial Lake Basins in KM²

<table>
<thead>
<tr>
<th>Lake/River</th>
<th>Land Area</th>
<th>Lake Area</th>
<th>Total Area</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Victoria</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kenya</td>
<td>44,000</td>
<td>3,900</td>
<td>47,900</td>
</tr>
<tr>
<td>Tanzania</td>
<td>54,200</td>
<td>36,3800</td>
<td>120,580</td>
</tr>
<tr>
<td>Uganda</td>
<td>32,100</td>
<td>29,980</td>
<td>62,080</td>
</tr>
<tr>
<td>Rwanda-Burundi</td>
<td>33,600</td>
<td>--</td>
<td>33,600</td>
</tr>
<tr>
<td>Total</td>
<td>153,900</td>
<td>70,260</td>
<td>264,160</td>
</tr>
<tr>
<td><strong>Mobutu/Albert</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uganda</td>
<td>13,662</td>
<td>3,570</td>
<td>17,232</td>
</tr>
<tr>
<td>Zaire</td>
<td>2,849</td>
<td>2,548</td>
<td>5,397</td>
</tr>
<tr>
<td>Total</td>
<td>16,511</td>
<td>6,118</td>
<td>22,629</td>
</tr>
<tr>
<td><strong>Semliki</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uganda</td>
<td>2,642</td>
<td>--</td>
<td>2,642</td>
</tr>
<tr>
<td>Zaire</td>
<td>7,110</td>
<td>--</td>
<td>7,110</td>
</tr>
<tr>
<td>Total</td>
<td>9,752</td>
<td>--</td>
<td>9,752</td>
</tr>
</tbody>
</table>

The power station had an installed capacity of 150 megawatts (by 1960 Kenya was taking nearly half of all power generated), and the dam was built at 27 meters, one meter higher than necessary for power generation. The additional meter allowed the dam to control a lake level two or more meters above the average levels of the first half of the century. Discharge through the turbines was to be restricted below optimal levels for power generation especially during the timely season. Egypt paid for the additional construction and made a once-and-for all compensation payment to Uganda for lost power of £980,000 (Wilson, 1967 and Elkin; Wilson, 1968).

In 1958 Egypt obtained funding for the construction of the Aswan High Dam from the Soviet Union, and excavation began shortly thereafter. It was known that the first earthen works across the Nile at Aswan would be completed in 1964 and the High Dam reservoir would begin to fill. There are informed observers who suspect that the Egyptians, who by treaty supervise water release at Owen Falls, forced the level of Lake Victoria above 'normal' levels so that additional water could be delivered downstream to fill the reservoir.

This argument is frankly implausible. The High Dam reservoir has an optional storage level of about 130 bn M$^3$ and a maximum capacity of 162 bn M$^3$. Normal discharge on the main Nile, which depends largely on the Blue Nile flood, may have been around 86 bn M$^3$ per annum in the early 1960s. Let us subtract from that 12 bn M$^3$ per annum as average Sudanese use for those same years, and another 7 bn M$^3$ as average seepage and evaporation at the reservoir site. That leaves 67 bn M$^3$. 
If Egypt used its full share of 55.5 bn M$^3$, there would be an average annual net gain to storage of 11.5 bn M$^3$. In ten years the reservoir would reach a stored level of 115 bn M$^3$ and in 12 years the optimal amount of 130 bn M$^3$. In fact in 1975 the actual amount stored was 125 bn M$^3$, after the large 1974 flood, and in 1977 the level topped 131 bn M$^3$. Thus, filling the reservoir was brought about by unmanipulated savings based on above average Blue Nile floods, low levels of Sudanese consumption, and low levels of seepage and evaporation at the reservoir site.

The argument is implausible on another count. We have already noted that the effect of spillage in the Sudd swamps is to reduce large discharges into the swamps to a nearly invariable discharge out of the swamps. In other words, in the absence of either Jonglei I or II, it would have gained the Egyptians very little to store and release large amounts of water at Owen Falls, for most of it would have evaporated in the swamps. In October 1961 representatives of Uganda, Kenya and Tanganyika met with Sudanese and Egyptian members of the Permanent Joint Technical Commission for Nile Water, set up between the latter two countries by the 1959 Agreement. All parties agreed that a temporary regulation of releases at Owen Falls was necessary to diminish the abnormally high lake levels (A. Ibrahim, 1981b:26). In fact, as shown in Table 15, releases at Owen Falls did increase substantially beginning in 1962 with the major result that large areas of the Sudd, especially around Zeraf island, became part of the permanent swamp.
However valid the counter argument presented above, it is still the case that Egypt's motives and actions are viewed with suspicion. G.S. Ongweny (1979:76) implied that Egyptian operation of Owen Falls had caused the high lake levels, and some years earlier, in 1973, Tanzanian and Kenyan members of the East African Assembly voiced the same suspicions.

Since the late 1960s the trend has been toward more normal discharges at Jinja of about 30 bn M$^3$ annually, although between 1977 and 1979 there was a new rise in the lake's level. Several experts associated with Hydromet believe that the freakish period of the 1960s is now over. Still, it would be foolhardy to undertake any comprehensive planning for the Lake basin before the rainfall, run-off, and evaporation patterns are better understood. This should be the major objective of the Hydromet project in stage III. At the same time, the rise in Lake Victoria's level has shown what can be expected if the lake is used for over-year storage -- none of the countries around the Lake found the adjustments they had to make to the rising waters insurmountable.

There is some question whether or not in the future the inevitable resort on the part of the Lake states to waters that normally run-off into Victoria will gradually reduce the amount of water stored there. In the October 1961 meetings between representatives of the three Lake Victoria states and Egyptian and Sudanese members of the PJTC, the East Africans put their future needs at 5 bn M$^3$ (existing needs were put at 700 mn M$^3$), a figure the PJTC rejected for lack
Table 15
Annual Discharge at Jinja and Lake Kyoga, 1946-70, bn M³

<table>
<thead>
<tr>
<th>Year</th>
<th>Jinja</th>
<th>Kyoga</th>
</tr>
</thead>
<tbody>
<tr>
<td>1946</td>
<td>15.3</td>
<td>--</td>
</tr>
<tr>
<td>47</td>
<td>23.0</td>
<td>--</td>
</tr>
<tr>
<td>48</td>
<td>23.0</td>
<td>22.0</td>
</tr>
<tr>
<td>49</td>
<td>18.3</td>
<td>17.6</td>
</tr>
<tr>
<td>50</td>
<td>16.7</td>
<td>14.5</td>
</tr>
<tr>
<td>51</td>
<td>17.5</td>
<td>16.0</td>
</tr>
<tr>
<td>52</td>
<td>26.2</td>
<td>21.6</td>
</tr>
<tr>
<td>53</td>
<td>22.0</td>
<td>16.6</td>
</tr>
<tr>
<td>54 (construction of Owen Falls finished)</td>
<td>20.5</td>
<td>17.7</td>
</tr>
<tr>
<td>55</td>
<td>18.0</td>
<td>18.2</td>
</tr>
<tr>
<td>56</td>
<td>19.5</td>
<td>19.0</td>
</tr>
<tr>
<td>57</td>
<td>21.2</td>
<td>20.6</td>
</tr>
<tr>
<td>58</td>
<td>20.4</td>
<td>17.6</td>
</tr>
<tr>
<td>59</td>
<td>17.7</td>
<td>17.6</td>
</tr>
<tr>
<td>60</td>
<td>20.4</td>
<td>23.3</td>
</tr>
<tr>
<td>61 (rise in Lake level)</td>
<td>20.6</td>
<td>24.2</td>
</tr>
<tr>
<td>62</td>
<td>38.6</td>
<td>41.8</td>
</tr>
<tr>
<td>63</td>
<td>44.8</td>
<td>48.7</td>
</tr>
<tr>
<td>64</td>
<td>50.5</td>
<td>54.5</td>
</tr>
<tr>
<td>65</td>
<td>46.8</td>
<td>50.3</td>
</tr>
<tr>
<td>66</td>
<td>42.9</td>
<td>45.4</td>
</tr>
<tr>
<td>67</td>
<td>37.7</td>
<td>40.6</td>
</tr>
<tr>
<td>68</td>
<td>43.3</td>
<td>46.8</td>
</tr>
<tr>
<td>69</td>
<td>46.0</td>
<td>48.1</td>
</tr>
<tr>
<td>70</td>
<td>44.2</td>
<td>40.1</td>
</tr>
</tbody>
</table>

*Source: Hydromet, 1974, vol. I: 593*
of supporting data. It is quite conceivable, however, that Tanzania, Uganda, and Kenya will bring two to three million acres under irrigation by the year 2000, and that the on-field use and losses in storage of the irrigation water will reduce flows into Lake Victoria by 6-7 bn M$^3$ per year.\textsuperscript{13} That represents only about 5% of precipitation over the lake and less than one fifth of one percent of lake volume. Nonetheless even this small amount could gradually drop the lake's level by a few centimeters each year, all other factors being equal. Moreover, as agriculture develops around the lake shore, there will be an incentive to keep the lake level low in order to promote proper drainage. An off-setting factor, however, will be that as swampy areas in the lake catchment are drained, evaporation will be reduced and run-off into the lake increased. All in all Egypt and the Sudan will have to consider financial compensation to the lake states for keeping the lakes' (including Mobutu's) levels higher than would locally be desirable. Given the value of additional water to the agriculture and hydropower of the downstream states, such compensation should be manageable.

As we have stated, this eventuality will arise only if Egypt and the Sudan decide to proceed with Jonglei II and seek increased storage in the Equatorial lakes. Such an eventuality appears remote, but were it to come to pass the best site for increased storage would be at Lake Albert/Mobutu. It is moot whether or not Albert would have to be operated in tandem with Victoria. Although the possible
combinations are numerous, it is estimated that the gross amounts of water that would have to be stored to assure annual discharges of 26 to 44 bn M³ at Mongalla would fall in the ranges represented in Table 16.

Table 16
Ranges of Storage Capacity at Victoria and Albert Needed to Assure Indicated Discharges at Mongalla

<table>
<thead>
<tr>
<th>Combined Storage at Victoria &amp; Albert bnM³</th>
<th>Regulated Discharge at Mongalla bnM³/day</th>
<th>Jonglei II Drawoff mmM³/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>26.3</td>
<td>72</td>
</tr>
<tr>
<td>100-200</td>
<td>27.7</td>
<td>76</td>
</tr>
<tr>
<td>200-240</td>
<td>38.4</td>
<td>105</td>
</tr>
<tr>
<td>240+</td>
<td>43.8</td>
<td>120</td>
</tr>
</tbody>
</table>

*adapted from Hydromet, 1974, v.I, pt. II: 903

It is possible and probably most desirable that all storage be confined to Lake Albert. There are two basic reasons for this: first, the lake shores are very sparsely inhabited, and, second, because the surrounding slopes are so steep raising the lake's level will increase volume far more rapidly than surface area. Until 1960 the average level of the lake was 620.4 meters above sea level or 10.6 meters as measured on the Butiaba gauge. At that level the volume of the lake is 155 bn M³ and its surface area 5700 km². With the heavy
rains of the early 1960s the level reached 624 meters a.s.l. in June 1963. That increased volume to 181 bn $M^3$ and surface area to 6100 $km^2$. It might be necessary to raise the lake level to 640 meters a.s.l., or 30 meters on the Butiaba gauge, in order to assure discharges at Mongalla of 38 bn $M^3$. At that level the volume of the lake would be 280 bn $M^3$ and its surface area 6880 $km^2$. In other words, its volume would have doubled over pre-1960 means while its surface would have increased by only 25 percent. This enormous gain in storage could thus be brought about with minimal disruption to existing populations and land-use and with little increase in surface evaporation.\(^\text{14}\)

In addition to increasing the annual discharges at Mongalla, there might be further benefits from operating the Albert Reservoir in tandem with the High Dam Reservoir. Haynes and Whittington (1981) have suggested that in years of a high Blue Nile flood, releases from Albert could be curtailed and storage volume built up there. This would tend to reduce the amount of water stored at Aswan, but the authors have calculated that on average hydropower generation would drop by only 15% while up to 6 bn $M^3$ could be saved through reductions in surface evaporation. This savings would then be made available to agriculture. In turn higher levels of Lake Albert would permit increased hydropower generation at its outlet regulator. This is an intriguing argument, but because the authors do not present figures on the amounts of water reaching the White Nile under varying levels of Blue Nile
flooding, it is hard to know if the proposal is solid. Moreover, they make no estimates of the impact upon the Sudd swamps of restricted discharges from Lake Albert.

Before there are any serious negotiations with the Sudanese and Egyptians regarding the Lake Albert or any other Equatorial lake project, the lacustrine states will insist upon identifying their own national needs and possibilities. This identification will depend upon completion of Hydromet III and analysis of the data flowing therefrom. It will also depend upon national master water plans that look at all water resources within and without the Nile catchment area. Kenya has moved far along with such studies, as have the countries sharing the Kagera basin. But internal turbulence may well prevent Uganda from developing an overview of all its water resources.

In December 1978, President Daniel Moi of Kenya officially inaugurated the Lake Victoria Basin Authority to supervise planning for Kenya's portion of the Victoria basin. In a study of the context in which the authority was to operate (Odidi Okidi, 1979) the editor pointed out that at a minimum Kenya would have to have assurances from its lake neighbors that certain levels of the lake would be mutually agreed upon, especially from Uganda that controls the outlet at Jinja. Moreover, he suggests, it would be important to know the total contribution of each state to Victoria's water balance so that the impact upon discharge at Jinja of abstractions by any riparian can be calculated (p. 103). The editor concluded:

"...that the establishment of the Authority and its operations might be the first step in efforts to deal with the Lake Victoria basin as a hydrological unit and to ensure balanced management of its water resources" (p. 34)
In short, while and until national and regional plans for water management are laboriously put together, Egypt and the Sudan will have to be patient in their lobbying for a basin-wide accord.

V
Legal Precedents and the Prospects for Basin-Wide Cooperation

It has been nearly a century since the first legal instruments were negotiated to secure access to water in the Nile Basin. Because of Egypt's total reliance upon irrigation water from the Nile, the emphasis has been squarely upon access to and use of water, not merely navigation which had been a central concern of legal arrangements for Europe's international rivers. I suspect that in this respect the Nile Basin has been the subject of some pioneering legal work. Our task here is, then, to review briefly those legal instruments affecting water management, to assess their continued validity, and to see in what measure the precedents they have set may serve to promote basin-wide cooperation. It is the case that engineering projects carried out by any one state and that impinge upon the flow of the Nile or its tributaries will continue to require formal accords from other states in the basin. In that view the Egypto-Sudanese agreement of 1959 will be of particular importance in what follows.

Until after the Second World War many of the accords affecting the Nile were drawn up by European powers controlling parts of the catchment area. Only Egypt and Ethiopia on occasion laid claim to a tenuous sort of sovereignty. An important issue resulting from this legal history is whether or not the now-independent states of the basin
are bound by legal instruments negotiated and signed in their name by imperial powers. We shall return to this point further on.

The first accord to be considered is the Treaty of Ucciali signed between the Italian government and King Menelik of Ethiopia in 1889. It was interpreted by the Italians as a delegation of responsibility for all Ethiopia's external relations to Italy. By contrast, Menelik recognized only the Amharic text which stated that Ethiopia could make such a delegation. European powers accepted the Italian version and considered Ethiopia to be, de facto, a protectorate.

In that spirit England and Italy negotiated a Protocol, signed on April 15, 1891, delineating their spheres of influence in East Africa. In that Protocol, Italy pledged to do nothing to impede the flow of the Atbara, the only tributary of the Nile that arose on territory then under its control. In 1896, however, Ethiopian forces led by King Menelik, defeated the Italians at Adawa in Eritrea. Italy recognized Ethiopia's full sovereignty and, in October, annulled the Treaty of Ucciali.

With the eclipse of Italy, France discerned an opportunity to form an alliance with the triumphant Menelik and to establish itself at the headwaters of the Blue Nile. In 1898, Ethiopian and French forces planned to meet in the southeast of the Sudan to confront the British, but the rendez-vous never came off. Instead Col. Marchand and his small French force were isolated at Fashoda, near Malakal, and forced to withdraw in the face of Kitchener's superior force.
This assertion of British influence led to two new accords. On May 15, 1902, the Anglo-Ethiopian Accord defining the border between Ethiopia and the Sudan, was signed. In article IV, Menelik II undertook "not to construct, or allow to be constructed, any work across the Blue Nile, Lake Tana, or the Sobat (Baro) which would arrest the flow of their waters into the Nile except in agreement with his Britannic Majesty's Government and the Government of the Sudan" (quoted in Wolde-Mariam, 1972: 26). According to Caponera, this accord was never ratified by Ethiopia (Caponera, 1959:60). Nonetheless, the principle of non-obstruction of the flow of the Sobat, Atbara and Blue Nile was recognized by Italy and France in the 1906 Tripartite Treaty with Britain. With its signing the last vestiges of the Fashoda incident were effaced (Jones & Monroe: 1970: 150).

In the same year, 1906, a British agreement with the Belgian Congo stipulated that the Congo would do nothing to alter the flows of the Semiliki and Isango rivers in such a manner as to reduce the level of Lake Albert. Nine years later Britain and Belgium signed an agreement (February 3, 1915) establishing the boundaries on rivers and lakes of their respective colonies.

More colonial horse-trading took place through the exchange of notes between Britain and Italy in December 1925. These implicitly ignored the abrogation of the Treaty of Ucciali and suggested that Italy was still responsible for Ethiopia's external affairs. The exchange recognized Italy's economic sphere of influence in Eritrea.
as well as its right to build a railroad from Eritrea to Somalia. For their part the Italians pledged to use their good offices to convince the Ethiopian government to grant Great Britain a concession to build a barrage at the Lake Tana outlet of the Blue Nile. Italy further recognized the "prior hydraulic rights" of Egypt and the Sudan and, perhaps in anticipation of its takeover of Ethiopia a decade later, promised to do nothing to impede the flow of the Blue Nile or any of its tributaries. Ethiopia, then a member of the League of Nations, protested the accord: "We should never have suspected that the British government would come to an agreement with another government regarding our lake" (Jones & Monroe: 164, also Odidi Okidi, 1979).

Another exchange of notes, this time between Egyptian Prime Minister, Mohammed Mahmoud Pasha and British High Commissioner Lord Lloyd, acting on behalf of the Sudan, took place on May 7, 1929. This exchange became known as the 1929 Nile Waters Agreement. By its terms Egypt recognized the Sudan's right to water adequate for its own development, so long as Egypt's "natural and historic rights are protected". The Sudan recognized those rights, but the intriguing aspect is that the exchange itself did not define those rights in quantitative terms. It was accompanied by the 1920 Nile Projects Commission Report that suggested Egypt should be guaranteed water sufficient to irrigate the maximum acreage cultivated up to that time, i.e. five million feddans. It was on that basis that quantitative estimates were derived giving Egypt acquired rights to 48 bn M$^3$ and the Sudan to

Ethiopia did not recognize this agreement nor did it accept Egypt's claim to acquired or historic rights. Moreover, in 1935 when the UK recognized Italy's annexation of Ethiopia, a situation was created whereby Ethiopia could argue that all agreements to which the UK was a party and which required Ethiopian approval, were void.

In negotiating construction of the Owen Falls dam, acceptance of the principle of Egypt's acquired rights was explicitly extended to Uganda. The exchange of notes, May 30, 1949, between the UK, acting on behalf of Uganda, and Egypt further stipulated that while the Uganda Electricity Board would manage the dam, it "will regulate the discharges to be passed through the dam on the instructions of the Egyptian resident engineer" (as cited in Odidi Okidi, 1979: 136). A subsequent exchange of notes on July 16, 1952, provided for financial compensation to Uganda for raising the dam one meter above the level needed for hydropower generation. Egypt was to pay compensation for any environmental damage suffered by the lake states as a result of deliberate operation of the dam to raise lake levels. Thus the question of the causes of the rise in Lake Victoria's level in the early 1960s bears directly upon the question of compensation.

In this and in all the other accords mentioned above, the problem of state succession to treaty obligations is posed. It is not clearly established in international law whether or not newly-independent states must accept obligations assumed by treaty in their name by colonial
or imperial powers. The states of the Nile basin are certainly not of one mind in dealing with this problem. Indeed, depending upon the issue, Ethiopia might want to have it both ways. For instance, Ethiopia's claims to the Ogaden and its rejection of Somalia's claims, are rooted in the upholding of the principle of inherited obligations. Mesfin Wolde-Mariam contends that the Ethio-British agreement of December 1944 whereby Ethiopian sovereignty over the Ogaden was given explicit recognition must be considered as binding upon independent Somalia. He goes on to cite the proceedings of the Report of the International Law Commission in its 26th session (1975) to the effect that

"...the clean state principle does not, in any event, relieve a newly-independent state of the obligation to respect a boundary settlement and certain other situations of a territorial character established by treaty"

(Wolde-Mariam, 1977:48). One wonders if the author would extend that principle to the 1902 Accord, which is a boundary settlement, but which commits Ethiopia to refrain from any works that might impede the flow of the Blue Nile, Sobat, and Atbara, except in agreement with the Sudan. It is the case that in the early 1970s Ethiopia undertook construction of the Fincha dam without consulting the Sudan, although the dam impedes the flow and draws water from one of the tributaries of the Blue Nile. It is also the case that in 1977 the Government of Ethiopia, without mentioning the 1902 Accord, stated its policy as one of seeking international agreements on water use, but that their absence "does not in any way diminish the right of one basin state to go along, unilaterally, and develop the waters of international rivers within its territorial jurisdiction."
Other legal experts seem to believe that the clean slate principle prevails. M.A.H. Mutiti argues that "dispositive treaties", dealing with cessation, boundaries, navigation, delimitation, and neutralization, are not necessarily binding upon successor states (Mutiti, 1976: 14). All East African states either refused to sign devolution treaties with former colonial powers or extended the validity of existing treaties for a fixed period after which it was assumed they had expired. Few states, however, took explicit positions regarding the 1929 Agreement. Uganda considered it to have expired by the end of 1963, while Ethiopia never accepted it in the first place. The Sudan, having become independent in 1956, questioned its validity, and, in 1958, by undertaking to build a dam at Roseires unilaterally, effectively repudiated it.

On the other hand, the Owen Falls agreements appear to remain in effect. Uganda has not renounced them, and there is still a resident Egyptian engineer at Jinja. Derivatively, because the agreement is founded on the 1929 Agreement, one would have to assume that Uganda still recognizes the principle of Egypt's acquired rights. But with this exception one can say that there are no international accords negotiated before 1959 that are still unambiguously binding today. As for the 1959 agreement, to which we now turn, it obligates only Egypt and the Sudan.

It is important to grasp the legal principles that went into the 1929 Agreement and its successor the agreement on the Full Utilization of the Nile Waters, signed by Egypt and the Sudan on November 8,
1959. Whether or not a basin-wide accord is ever elaborated, it is
easily certain that the 1959 agreement will have to be renegotiated.

Egypt has always insisted upon the legal validity of the
principle of "acquired rights", or, as Gamal Badr has put it, the
principle of "first come, first served" (1959:97). Egypt claims
that because since "time immemorial" it has drawn upon the Nile to
sustain its agriculture, it has a historic droit acquis to or
"priority of appropriation" of the river's waters that all other
riparians must honor. In modern times that right corresponds to the
amount of water needed to irrigate the maximum surface cultivated prior
to the 1929 agreement. No riparian has explicitly challenged this
principle, but even if all accept it there still remain questions of
the efficiency with which Egypt uses its irrigation water and the
types of crops to which it is devoted. There seems to be no legal
reason why 48 bn M^3, or any other absolute amount of water, need be
accepted as Egypt's acquired right.

Badr's 1959 article was, however, dogmatic in its insistence
upon absolute quantities and somewhat contemptuous of any legal
arguments to the contrary. Two decades later, N.A. Hilmy, another
Egyptian specialist of international law, put the argument for acquired
rights in far more flexible terms (N.A. Hilmy, 1979:127)

"The Helsinki rules [of 1966; see below] in article 8 also
mention "an existing reasonable use may continue in
operation unless the factors justifying its continuance
are outweighed by other factors leading to the conclusion
that it be modified or terminated so as to accommodate a
competing incompatible use."
From this we can conclude that the preferences of uses of international river water may change at any time, a new utilization may appear and may take priority over the traditional utilizations.

It is, thus, surely the case that in any future negotiations on apportionment of Nile waters the principle of acquired rights will be interpreted in relative terms and that the determination of fixed shares will be considered as temporary and a function of changing agricultural practices and needs throughout the basin. Moreover acquired rights will have to be weighed against what Dante Caponera (1959:60) has called "natural rights":

"The fact of having supplied 6/7 of the waters of the Nile to the riverain states from time immemorial without any compensation does not automatically constitute a tacit renunciation on the part of Ethiopia of its own "natural right" to use at least a part of these waters arising on its own territory."

In light of this fact, Caponera argued that Ethiopia could not recognize the 1959 Agreement between Egypt and the Sudan without undermining, if not totally destroying, its own claims to natural rights to a portion of the Blue Nile, Atbara and Sobat (Caponera, 1959:62). Indeed Ethiopia never has recognized that Agreement and has reserved its rights to the Nile waters arising on its territory. Likewise, in August 1959, Great Britain acting on behalf of its East African colonies reserved their rights to negotiate for additional water should the need arise.

The 1929 agreement dealt only with Egypt's and the Sudan's acquired rights. The 1959 Agreement took up the issue of the
unutilized portion of the Nile's discharge or the so-called "reserved rights" of the two states. The negotiations of this agreement were long and sometimes acrimonious, but an important new principle was introduced in determining the final apportionment. Rather than extending the ratio of the 1929 Agreement (48:4 in favor of Egypt) to the 32 bn M$^3$ of unutilized discharge, the Sudan was able to assert its claims to immediate and potential needs for water. Thus of the 32 bn M$^3$ mentioned above, the Sudan received 14.5 bn M$^3$ and Egypt only 7.5 bn M$^3$. The remaining 10 bn M$^3$ was written off to evaporation and seepage. So, instead of the old ratio of 48:4 in favor of Egypt, the reserved rights were determined on the basis of a ratio of 2:1 in favor of the Sudan. Many Egyptians, including Gamal Badr (1959:109), were unhappy with this apportionment. The Sudanese, looking at an overall apportionment that gave Egypt 55.5 bn M$^3$ to their own 18:5 (ratio of 3:1 in Egypt's favor) felt that, given their agricultural potential, they had sold out too cheaply. Egypt did somewhat better in winning acceptance of the 50/50 principle for apportionment of all water saved through joint implementation of the upper Nile projects.\textsuperscript{15}

There are several points about which the Sudan is likely to press for greater advantage. One, already noted, is establishing that mean annual discharges of the Nile have actually been above the 84 bn M$^3$ mean assumed in the 1959 Agreement. Therefore the Sudan should be allowed to use up to 50\% of whatever new increment is agreed upon. Some Sudanese would like to see shares negotiated on a five-year basis, and that the Sudan be allowed in years of abundant rainfall when its demands for Nile water are reduced, to carry forward a credit to be used in years of low rainfall.
There are, as well, many Sudanese who feel that water benefits from Jonglei I and all other Upper Nile projects on Sudanese territory should be shared 75/25 in the Sudan's favor. This view is based on the fact that Blue Nile/Atbara development is more relevant to the Sudan's needs than works on the Sobat, Bahr al-Jebel, and Bahr al-Ghazal, and that the Sudan alone will bear the costs of social and ecological disruption in these regions.

Finally the Sudan may argue that storage should be decreased at Aswan in order to reduce evaporation losses and increased at Lake Albert. If Egypt were unwilling to do that, then the amount of evaporation that could be avoided through storage at Lake Albert should be deducted from Egypt's share of total discharge (Whittington & Haynes, 1981:b). Whatever the issues of future negotiations, one can be certain that assessments of the efficiency of actual and planned use will come into play. Negotiators will have to be versed not only in hydraulic engineering and international law, but, as well, in cost-benefit analysis, in the weighting of social and economic opportunity costs, and in the determination of comparative advantage.

Egyptian policy-makers must surely have sensed the mounting pressures toward renegotiation. One may surmise that in dealing with them, Egypt would prefer to broaden the scope of negotiations to include all the basin states. In this way the redefinition of the terms of the 1959 Agreement would simply be part of a much larger set of issues. In turn the 1959 Agreement obligates Egypt and the Sudan to adopt a common bargaining position vis à vis all other riparians
and to empower the Permanent Joint Technical Commission to carry out
the negotiations in their name. In short Egypt's strategy will be
to downplay any differences with the Sudan and to aim for a comprehensive
accord covering the entire basin. However, if Ethiopia remains aloof
from this process, Egypt, with its interest in the White Nile and
Equatorial Lakes, can afford to press ahead in that country's absence
more easily than the Sudan with its concerns over Blue Nile development.

Progress toward a comprehensive accord could have been achieved
more than twenty years ago, but then as now regional and great power
conflicts stood in the way. In August 1959, at the same time that
Imperial Ethiopia launched its Blue Nile survey with U.S. assistance,
Great Britain issued the following statement on behalf of Kenya,
Uganda, and Tanganyika:

"The territories of British East Africa will need for
their development more water than they at present use
and will wish their claims for more water to be recognized
by the other states concerned. Moreover, they will find it
difficult to press ahead with their own development until
they know what new works the downstream States will require
on the headwaters within British African territory. For
these reasons the United Kingdom Government would welcome
an early settlement of the whole Nile Waters question
[emphasis added]. A conference of all riparian states has
been suggested. In principle the United Kingdom Government
favor this idea but think that a conference is unlikely to
be successful until the Sudan and the United Arab Republic
have settled the difference between them." (Overseas Press

Egypt and Sudan did settle their differences in November 1959, but the
British suggestion was nonetheless doomed to failure. For the Egyptians
it looked too much like an attempt to ensnare Nasser in a complicated
series of negotiations that Britain could dominate and by which Nasser
could be punished for the affront of having nationalized the Suez Canal in 1956 (see D.C. Watt, 1968:124). Secondly, the East African territories were not eager themselves to be herded into commitments made by the UK in their name. For example they objected to Britain's 1959 estimate of their future water needs of 1.75 bn M³, and, as we saw, they put forth a figure of 5 bn M³ just two years later.

It was not until 1978 that proposals for a comprehensive accord resurfaced. Unsurprisingly it was Egyptian and Sudanese representing the PJTC on the Technical Committee of the Hydromet Project that put forth the proposals. They reflected the fact that since 1974 Egypt and the Sudan had been able to conclude an agreement and award contracts for the construction of the Jonglei canal, and that it had become clear to both countries that water would become a severe constraint to their agricultural development in the medium-term future. Thus the Egyptian and Sudanese PJTC representatives recommended the setting-up of a Nile Basin Commission "to be entrusted with the tasks of conducting hydrometeorological studies, establishing data banks, sponsoring studies pertinent to the conservation of the Nile Waters, sponsoring studies of the river control, preparation of working arrangements of dams, and standardization of hydrological equipment and methods of measurement" (A. Ibrahim, 1981b:28).

The protagonists were moving cautiously toward an organizational form that Odidi Okidi has termed a "community of co-riparian states". Communities of this sort are premised on the assumption that the river and/or lake basin constitutes an economic and geographic whole, whatever the nature of state boundaries within it. Examples of such "communities"
on the African continent include the Office de Mise en Valeur du Sénégal (OMVS, established in July 1963); the Niger River Basin Organization (Oct. 1963) the Lake Chad Basin organization (May 1922), and the 1978 Kagera River Basin organization, mentioned above. While sharing in the spirit of these arrangements, the 1959 Agreement between Egypt and the Sudan does not encompass the entire Nile catchment, but the 1978 proposal was aimed in that direction. The tasks of the Commission that would form its core amounted for the most part to data-gathering and technical analysis pertaining exclusively to water. These are the tasks characteristic of what Dante Caponera, in an unpublished study, has referred to as a "regulatory body". Within three years of the proposal, however, Egypt and the Sudan were lobbying for a far-more comprehensive arrangement that would plan for and implement projects for the over-all economic development of the Nile Basin.

Before looking at the later proposal, we should briefly consider the international law principles that have inspired this and other like bodies for the regulation and management of transboundary resources. It appears to be the opinion of many experts of international law that the principle of "equitable utilization" of such resources should supercede principles -- such as absolute territorial sovereignty, favoring upstream states, or sic utere tuo enjoining use of the resource so as to cause no harm to others who share it -- in order to promote coordinated exploitation of the resource for the greater good of the greatest number.
The most explicit formulation of the guidelines to equitable use have been set down in the Helsinki Rules, elaborated by the International Law Commission in 1966. The Rules suggest ten factors that must be taken into account in devising frameworks for water utilization:

1. the economic and social needs of each state and the comparative costs of satisfying them

2. the nature of conflicting needs

3. past and existing patterns of utilization of water

4. the population dependent upon the water

5. availability of other sources of water

6. avoidance of waste

7. practicability of compensation

8. geography of the basin

9. the hydrology of the basin

10. the climate

At best this list constitutes nothing more than an agenda for negotiations and an evocation of the cooperative spirit in which they ideally will be conducted. The guidelines themselves have no fixed
definitions, nor, if they did, would they be binding upon sovereign states. As Van Alstyne remarked (cited in Parnall and Utton, 1976:255) with respect to equitable utilization"...the same platitudinous quality which makes it so agreeable also makes it disturbingly vague and uncertain." Nonetheless, there are well over 300 international agreements dealing with lakes, rivers, and drainage areas, and nearly all reflect the principle of equitable utilization (Odidi Okidi, 1979).

Acceptance of guidelines even so vague as those of the Helsinki Rules may prove to be the lowest common denominator for an accord among the Nile riparians. All of the states concerned have acknowledged their worth. Egypt in particular invokes them with some regularity (Interregional Meeting, 1981). Moreover, since the original Nile Basin Commission proposal in 1978, Egypt, and perhaps the Sudan, has tried to promote an accord that would include far more than water.

The political background to the latest proposals warrants a brief review. In many ways Egypt could not have launched its campaign at a more inopportune time. After the Camp David accords of March 1979, Egypt found itself isolated in the Arab world. Of its neighbors only Gaafer Numeiri of the Sudan endorsed the accords. Libya, more and more closely allied to Ethiopia, vehemently condemned the accords. Sadat harped constantly upon this tacit alliance and the menace it posed for the lower Nile valley. The atmosphere was further charged by open discussion between Egypt and Israel of delivery up to 800 mn M³ of Nile water annually to Israel's Negev. These talks raised
intense protest from several of Egypt's neighbors. Not only was the proposal politically abhorrent to some, including Ethiopia, but it would involve an extra-basin transfer of Nile water, a matter over which Egypt should have no unilateral right of decision.  

Tensions between Egypt, Ethiopia, and Libya mounted sharply in the summer of 1981. In August, U.S. aircraft downed two Libyan aircraft over the Gulf of Sirte. Col. Qaddafi who was in South Yemen at the time, extracted from this humiliation a Tripartite Alliance with South Yemen and Ethiopia, signed on August 19. Just before his assassination, Sadat, as he had done in the past, warned the Ethiopians and Libyans in these terms (al-Ahram, October 1, 1981):

"Today, Qaddafi is playing a very dangerous game in that operation he has mounted with Ethiopia and South Yemen...I say to him so that he hears it well, any operation against the Sudan and we will be there in the next instant at the Sudan's side."

The sword brandishing scuttled, for a time at least, an effort that had been underway since the previous March to convene a meeting of the foreign ministers and hydrology experts of the Nile basin states. At a meeting in March 1981 in Khartoum of Ministers of Irrigation from these states, President Numeiri argued both for a top-level meeting and for a basin-wide accord. The Ethiopians, in their typically aloof fashion, sent only their ambassador to the March meeting, but the Sudanese were and are convinced that Ethiopia must be a willing partner in any basin-wide venture. With the endorsement
of those present, the PJTC was authorized to put together a small team to tour the capitals of the riparian countries to lobby for a high level meeting, either in Khartoum or Cairo. The date suggested was late September, and there is good evidence that the Ethiopians were more than mildly interested in attending. But with Sadat's bitter denunciation of the Tripartite Alliance, Ethiopia decided not to attend. Mainly because Sudan insisted on Ethiopian participation, the meeting was postponed. While the death of Sadat may have removed an obstacle to such a meeting, at the time of writing (8/82) it had not yet taken place.

If and when it does take place, Egypt will place before it an ambitious draft proposal for the creation of a Nile Basin Organization. It represents a shift from a regulatory body to a developmental body which would go far beyond data gathering, feasibility studies, and coordination. As stated in the draft proposal, the nine-member Organization "shall consider all joint projects, work, or programmes which are of an inter-state nature within the Nile Basin, particularly in the fields of:

1. development of water and hydropower resources
2. supply of water for drinking and for industrial and mining users
3. supply of water for agriculture, forestry, livestock and land reclamation
4. mineral exploration and exploitation
5. disease and pest control
6. transport and communications
7. trade
8. tourism
9. wildlife conservation and development
10. fisheries and aquaculture development
11. environmental protection
What the Egyptians have done in presenting such a broad mandate is to play down the saliency of water supply, which is of nearly unique and primordial concern to them, while playing up the common benefits to be drawn from integrated development throughout the basin in fields having little to do with water or water supply (points 4-11). If the authors of the proposal have a model in mind, it may be that of the Kagera River Basin. The Egyptian draft is studded with references to the OAU's Lagos Plan of Action and the need to promote regional development. It is probably the hope of the Egyptians that if such a broad accord were concluded, the international donor community in general, and the Arab oil rich in particular, might see it as a suitable conduit for substantial capital transfusions.

Here the record of the OMVS is of interest: by early 1982 it had attracted pledges of $780 million in external financing, $460 million of which comes from Arab sources. At a minimum, however, such a basin-wide accord would be the sine qua non for implementation of any projects involving the Equatorial lakes.

The Egyptian proposal is vague on the powers that would be attributed to the Organisation. It appears that what is envisaged is replicating the procedures and powers of the PJTC. The major innovation would lie not in an extension of these powers but rather in the fact that membership would be expanded to nine and the scope of work broadened.

The PJTC, as it exists now or how it would exist within the framework of the proposed Organization, falls short of being a regional
development authority (see Interregional Meeting, 1981b). It can advise member governments but cannot make decisions binding upon them. On the African continent only the Senegal River Basin Authority would appear to enjoy such powers. The PJTC and its proposed successor does share with the OMVS the power to accept and administer grants and to receive technical assistance. It is not clear, however, if the PJTC holds title to jointly financed projects or if it can borrow money in its own name. Indeed it would enhance the strength of the proposed Nile Basin Organization if it could commit its members to financial obligations and render such commitments binding upon members even if one or more should withdraw from the Organization. With such provisions, however difficult they may be to negotiate and apply, regional development could become something more than an appealing slogan. Parnall and Utton rightly insist upon the need to create Authorities (Parnall and Utton, 1976:256):

"Rather than speaking of equitable utilization, we should begin to argue for "optimal utilization". Rather than development which is "separate but equitable", we need development which is unified and optimal."

To honor such prescriptions would require the explicit delegation of certain sovereign rights inhering in member states to a supranational body. The prospects for delegation of that kind are not bright, but with time it may well become unavoidable.

It is certainly my belief that an accord that moved in the direction of an Authority with sufficient powers to commit its
members to certain developmental objectives is to be desired. At the same time, it must be abundantly clear from all the foregoing discussion that the odds against that or any other kind of basin-wide accord are very high. Let us note once again the principle obstacles:

1. The distribution of benefits from water conservation schemes would be highly unequal.

2. Those that would benefit most -- Egypt and the Sudan -- have little leverage with which to move those that stand to gain little more than goodwill.

3. Hydrological expertise is very unequally distributed. Until that inequality is overcome, the least expert will have good reason to avoid negotiations in which they might unknowingly trade away important interests.

4. Political differences between several of the riparians are acute, and the suspicions arising from them may preclude progress toward technical agreements of mutual benefit.

5. None of the riparians has a strong economy. The funding of ambitious water development projects will remain an important challenge.

Regional development efforts that involve states with very different political philosophies and regimes are extremely difficult to sustain. The East African Community is a case in point. It is hard to dismiss or overcome fears that multi-state projects serve to shore up or strengthen regimes that some member states would like to see fail. If some lowest common denominator of shared interests among the Nile riparians can be identified, then the challenge would be to move the parties gradually toward mutual, balanced, negotiated dependency.
What I have in mind are projects that involve important economic interests in two or more riparian states, but that have minimal political significance in terms of the ideological predilections of any one of them. No project is ever politically neutral, but some are less symbolically loaded than others. An existing example of what I have in mind is the Owen Falls hydropower station in Uganda, upon which Kenya depends for a third or more of its energy. Uganda in turn is dependent upon Kenya for an important source of revenues. There appear to be similar opportunities for joint power and water projects between the Sudan and Ethiopia on the Baro, Blue Nile, and Atbara rivers. They should be pursued, rather than avoided in the name of national self-sufficiency and antarky.

Roads and railroads, carrying vital traded goods among riparian states (fuel, fertilizers, grain, etc.) promote mutual dependency. Navigable stretches of rivers and lakes offer similar possibilities, and ports provide still more. Mombassa could serve the southern Sudan, southern Ethiopia, and Uganda. Dar as-Salaam could serve Rwanda and Burundi.

Finally, industries dependent upon cheap hydropower (nitrogenous fertilizers and aluminum smelters are examples) could be jointly financed on the territory of one riparian but designed to supply the markets of several.

None of this is particularly original, nor, as the history of
regional groupings since the Second World War attests, is it easy. There will be no groundswell of popular support for moves in this direction. There will not even be a ripple. The recognition of the mutual long term benefits to be drawn must come from technical and policy-making elites. These elites must be able to discount the dogma of national self-sufficiency and to see the potential gains that would flow from placing some modicum of their nation’s fate in the hands of their neighbors. Knowing the technical facts of the situations that they will be called upon to negotiate is absolutely essential. Knowing and understanding the political susceptibilities of their adversaries is equally necessary, and that knowledge, I believe, can come only through structured contact and exchange of views.

One major conclusion that can be drawn from these considerations is that Egypt has some very hard choices that it must make soon. While sometime in the next century the water conservation projects on the Upper Nile may become a reality, over the next few decades Egypt must set as its number one priority establishing the most efficient domestic patterns of water use and allocation possible. This will entail at a minimum reduction in land reclamation targets, careful selection of crops in terms of their water duties, substantial reduction in conveyance losses and on-field waste, and efforts to recuperate domestic and industrial waste water. While some may see my vision of the next two decades as overly pessimistic, there is no way that
Egypt can lose in following these prescriptions. If progress is made toward fulfilling them, and more water becomes available, Egypt will be in a position to use it to maximum advantage. If water does not become available, Egypt will be in a position to draw maximum advantage from resources already in hand.
NOTES

1. The gentleman had the germ of a plausible plan. Even if Egypt had to deprive its agriculture of water, it could, if conveyance problems could be overcome, deliver 500 million M$ per year to Saudi Arabia at, say, $1.00 per M$. That would be considerably less than costs of desalinization or the still-born project of towing icebergs and a good deal more than the 12¢ per M$ that was talked about as the price of Nile water that might be sold to Israel. Such transfers, however, are "extra-basin" and, as we shall in the section V, are subject to the approval of other riparians.

2. Table 2.4 of the IBRD Sub Sector Report (p.14) does not seem to take these sources into account nor do the aggregate tables in the Main Report of the EMWP.

3. I am taking for granted on the part of the reader a fair knowledge of the politics of the "non-Muslim" southern Sudan. Suffice it to say here that as of 1972 the thru southern provinces were granted substantial regional autonomy with a regional Chairman of the Southern Executive Committee. In 1981 the rest of the Sudan was divided into semi-autonomous regions as well.

4. Other sites on the Main Nile are being explored: Sabaloka 85 km.s north of Khartoum with a reservoir of half billion M$; the Shereik dam at the 5th cataract to be run as a hydro-electric project. The 1.5 bn M$ reservoir would risk very rapid siltation. A project on the scale of Merowe is being examined at Dal. Its major drawback is that the reservoir would lose up to 19% of its live storage capacity in evaporation each year. Finally on the Upper Nile Bahr al-Jebel two small hydroelectric power projects are under study: Fula Rapids near Nimule would supply the Juba region with electricity, and the Kinyeti River scheme to supply the Torit region. See MOI, Nile Waters, Vol.3, Report IV; and Hafslund Consulting Division (Oslo) Eastern Equatoria Hydro-electric Power Study: Feasibility Study, Aug.1981.

5. For reasons that were not made explicit, the IBRD officially refused access to any of the records regarding these post-war contacts. T.T. Thahane-E.A.Bayne; 26/6/81, personal correspondence.

6. Political changes may have dictated this chronology. Numeiri came to power through a coup d'etat on May 25, 1969 and immediately sought closer relations with Nasser's Egypt. This new Sudanese mood must have been felt within the PJTC. Nasser died in September 1970, his attentions still firmly fixed on Israel and the Sinai. Sadat's relatively successful military gambit of October 1973 allowed him to pay more attention to his immediate hinterland, and particularly to the Sudan. Hence the important meeting of the two heads of state on February 11, 1974 (see J. Waterbury, 1979: 60-61).
7. In the legitimate concern to protect local populations and their way of life critics of large projects such as Jonglei occasionally idealize patterns of group life and location that are presented as deeply rooted if not immutable. It is not to dismiss such concerns that I point out that the Sudd region in the last 200 years has been subject to far reaching social upheaval brought about by the local populations themselves. Before 1820, for example, the Nuer lived west of the Bahr al-Jobol. Then perhaps due to a combination of low floods and expanded human and cattle populations, they pushed east, driving the Dinka northwards and southwards until parts of the Dinka came up against the Annuak straddling what is now the Sudano-Ethiopian border.

8. The EMWP (Main Report: 27) implies in Table 8 that the value and range of crops grown on Egypt's old lands will be the same for the new lands. The table underestimates real crop/water demand and in general produces highly optimistic estimates of the economic return to water in Egyptian agriculture.

9. That the EMWP, compiled by reputable international experts, could take uncritically figures supplied by the PJTC (whose experts readily admit the guesswork involved) is a good example of what I referred to earlier as the convenience of the "fragmental view".

10. Difficult but not impossible. Arab oil-exporting states, principally Saudi Arabia, Kuwait, the United Arab Emirates, Oman, and Iraq, have taken on most of the funding of the hydraulic works in the development of the Senegal River Basin involving three very poor riparians: Senegal, Mauritania, and Mali. See Section V.

11. In West Africa the Fouta Djallon highlands of Guinea play the same role. The sources of the Niger, the Senegal, the Gambia and the Casamance rivers are all to be found in the Fouta Djallon watershed.

12. Somalia is in a similar position. Its only major rivers, the Shebele and the Juba, arise on Ethiopian territory.

13. Tanzania, for example, has sporadically considered drawing off large amounts of Lake Victoria water at Smith Sound and dropping it by gravity to a low-lying valley with considerable agricultural potential. So far the costs have apparently been prohibitive.

14. There is a potential problem related to increased discharges from Lake Albert that merits at least an endnote. The slope of the Albert Nile, flowing from Lake Albert to the Sudanese border, is very flat with significant swampy stretches. It is possible that some sort of channeling or embanking operations would be necessary to handle increased discharges.

16. It is instructive to note three of the guidelines Egypt has discerned in the Helsinki Rules as enunciated by the Minister of Irrigation in May 1981 (Interregional Meeting, 1981:9): 1) relative significance of actual requirements, 2) the degree of a country's reliance on the river, 3) availability of alternative water sources, 4) the population density of the country (emphasis added). These three would work to ensure Egypt's claims.

17. On the proposed transfer, see Mohammed Hassan, "Israel's Designs on Nile Waters", al-Ahram al-Iqtisadi, N.649 6/22/81; for a general assault on Egypt's position, Wondimneh Tilahun, 1979.
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Egypt

Sarwat Fahmy; Nile Control Department
Mohammed Muhammedin, Chairman PJTC
Boutros Boutros Ghali, Minister of State for Foreign Affairs
Ambassador Salah Basyouni, Ministry of Foreign Affairs
John Gerhart, Regional Representative, Ford Foundation

Sudan

Muhammed al-Amin PJTC, Senior Engineer
Tewfiq al-Aid, PJTC
Yahya Abd al-Maguid, former Minister of Irrigation
Sherif al-Tuhami, Minister of Energy
Abdullahi Ibrahim, former Jonglei Commissioner
Muhammed Omar Beshir, Director Institute for Asian & African Studies
James Ajith, Commissioner National Council for the Development of the
    Jonglei Canal Area
Daniel Deng Yong, Assistant Commissioner
Jonathan Janesse, Advisor to the National Council
Kemal Ali Mohammed, Director General Nile Water Department, MOI
Thayer Scudder, Division of Social Sciences, Caltech
Norman Singer, Representative, Ford Foundation/Sudan
Michael Bess, Consultant to Ministry of Energy
Abbas Hidayatullah, Senior Advisor, Ministry of Irrigation
Assim al-Maghrabi, Institute of Environmental Studies
Ahmad Abd al-Ghaffar, Economic and Social Research Council
Usman Samahoni, Director Department of African Affairs, Ministry of
    Foreign Affairs
Izzat Abd al-Latif, Egyptian Ambassador to the Sudan

Ethiopia

John Harbeson, USAID, Washington D.C.
Mesfin Wolde Meriam, Institute of Development Research
Duri Mohammed, Rector, University of Addis Ababa
Aleme Ishte, Department of Political Science, Addis Ababa
Negussie Ayele, Department of Political Science, Addis Ababa
Harold Marcus, Department of History, MSU
David and Marina Ottaway, Washington Post/Cairo
Roger McConick, UNDP/Addis Ababa
Robert Mabouché, IBRD/Addis Ababa
Robert Lilienthal, IBRD/Washington, D.C.
Kenya

Norman Miller, AUFS/East Africa
Goran Hyden, Representative, Ford Foundation/Nairobi
Charles Odidi Okidi, Institute for Development Studies
D.M. Kirori, Director Water Resources Department, Ministry of Water Development
Mrs. Kinyanjui, Africa Department, Ministry of Foreign Affairs
Carlos Munoz, UNEP
Peter Thatcher, UNEP
A.B. Abu al-Hoda, Director, Hydromet/Nairobi
Sadik Toksoz, HIID Group, Ministry of Agriculture/Nairobi
John Cohen, HIID Group, Ministry of Agriculture/Nairobi
Fahad al-Asqalani, Egyptian Ambassador to Kenya

General

Dante Caponera, Legal Division, FAO/Rome
Essam Muntasser, Director, IDEP/Dakar
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