Natural Resources Forum, Vol. 21, No. 1, pp. 13–22, 1997

0165-0203/97 $17.00 + 0.00
PII: S0165-0203(96)00004-9

Comparing theoretical and actual feasibility of transferring management of river lift irrigation systems in Sudan

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This article focuses on agricultural production in lift irrigation schemes along the White Nile in the Sudan. A comparison is drawn between the theoretical forecast and actual practical experience regarding the feasibility of transferring management from government-run parastatal organizations to private farmer organizations. Although the theoretical model indicates that farmers should be able to cover the cost of managing the river lift irrigation systems, field data show, however, that farmers growing wheat are barely able to break even. Even assuming a doubling of the present wheat yields, the cash surplus earned would only suffice for fuel to operate the pumps. Under these circumstances, it is not surprising that, contrary to government expectations, the private sector has been unenthusiastic about taking over management of White Nile river lift schemes. The lessons that emerge from this study indicate that unplanned and rapid withdrawal of state management can lead to negative results. The transfer of management responsibility for the river pumps does not appear to influence economic performance considerably, which depends on the wider context of the country's economic, political and institutional environment, within which the agricultural sector functions.

Key words: management transfer, lift irrigation, Sudan, self-sufficiency, maintenance, support system

Sudan has approximately 1.85 million ha of irrigated land and thus ranks 10th among developing countries in the world. Most of the irrigated land was developed over the past five decades by the Government of Sudan (GOS), although certain areas were originally developed by private individuals, mainly through pump schemes along the Nile and shallow wells. The Gezira scheme, with a command area of 900 000 ha, is the major irrigation scheme in the country. The remaining irrigated area is served by two gravity schemes, Rahad and New Halfa, as well as 60 river lift schemes on the Blue Nile, 174 schemes on the White Nile and 15 schemes in the northern part of the country on the main channel of the Nile (Samad and Dingle, 1995).

After the expiration of the 25 year lease in 1950, management responsibility for the Gezira Scheme reverted back to the GOS. Following this, in the late 1960s the government of Sudan committed itself to establishing a socialist form of administration. As a result, during the 1960s and early 1970s state involvement in irrigated agriculture rapidly expanded as the GOS nationalized many private sector enterprises. Public corporations were established to manage these nationalized firms. In addition, new policies were implemented that expanded government intervention into agricultural production. In the case of irrigated agriculture, there was a dual management structure with parastatal bodies managing agricultural production and the Ministry of Irrigation managing irrigation. State involvement in agriculture operated through sixteen parastatal firms that controlled all aspects of the agricultural sector.

Approximately 200 000 tenant farmers and their families earn a living in the irrigated areas. Cotton and wheat are the major crops, although other crops are also grown such as sorghum, groundnuts, fodder and various horticultural crops. From 1982 on, production has been organized as a three-way partnership where the government provides land and water, a parastatal organization provides supplies and services, while tenants provide labour. In return for their labour, tenants—

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through a personal account system — are entitled to keep the funds that remain after the parastatal organization has deducted the total of production costs plus charges for land and water from the gross returns.

Under this system farmers are supposed to be able to earn a profit, yet as reported by Deloitte *et al.* (1990) even in the Gezira scheme, where the farmers are recognized to be much better off, the accumulated debt of the farmers to the Gezira Board as of June 1989 was LS 476.5 million (or around US$1.15 million — based on an exchange rate of LS 425 = US$1).

Over the past decade overall cotton production has declined from 5.8 million tonnes in 1983 to 2.3 million tonnes in 1990. Per hectare yields of cotton are less than 60 percent of the yields obtained in Egypt. Declining production combined with low international cotton prices, a shortage of production inputs, hyper-inflation and a tax and levy policy on farmers that accounts for more than 20 percent of gross revenue have increased the poverty level of small farmers and agricultural tenants.

In view of the economic problems in the country, the GOS is now in the process of disengaging itself from direct involvement in many sectors, including agriculture. As part of the decentralization programme, the GOS has decided to transfer management responsibility for agricultural production in the irrigated area to the users and eliminate the parastatals. However, in contrast to other countries, such as Bangladesh, Sudan still maintains state control over the management of irrigation facilities and decision making with respect to water allocation.

The first objective of this article is to assess, in theory, the financial feasibility of transferring management of agricultural production to farmer organizations or local organizations in the pump irrigation systems along the White Nile. The theoretical analysis of this article focuses on the financial performance that can be expected under alternative forms of management, including independent farmer management relying on the market for services and inputs, and a private company contract. The theoretical options are based on the assumption that schemes would operate in the framework of a market economy, where goods and services are freely available, where normal prices prevail and where market information is readily accessible.

The second objective of this paper is to examine what has actually happened in the irrigation schemes that have been transferred to farmer groups and private companies, operating on a profit sharing basis. The impact of change is documented with data from existing pump schemes, where transfer to alternative organizational models has taken place. The final section discusses the differences between the theoretical model and the actual impact in the field resulting from the transfer, and examines the long-term sustainability of pump irrigation in Sudan in the light of these observed discrepancies.

Background — White Nile pump schemes

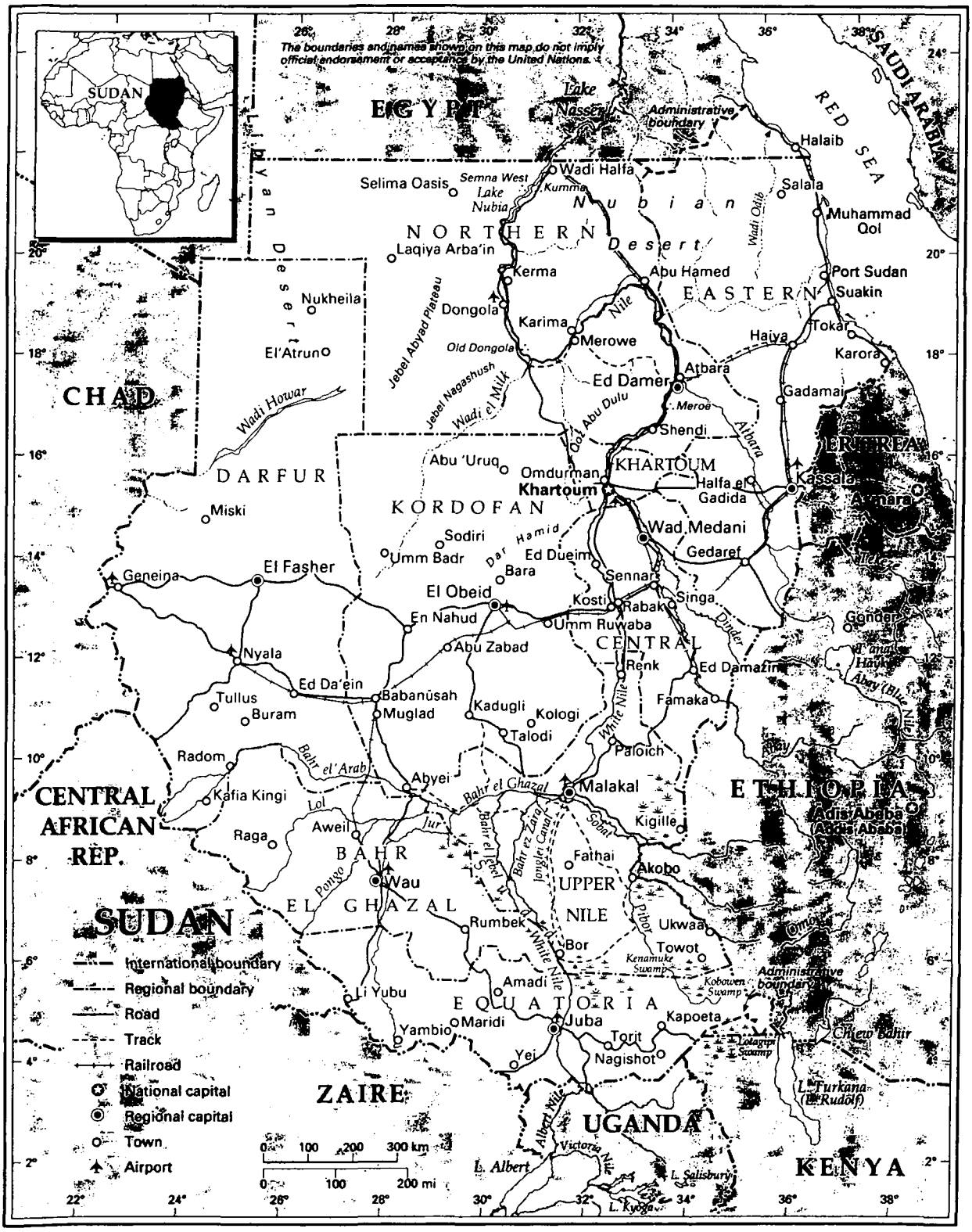
Starting in 1929 private investors installed pump lift irrigation schemes along the eastern and western banks of the White Nile (see Figure 1). After completion of the Jebel Aulia Dam downstream on the White Nile, the GOS resettled farmers who had lost their lands due to the impoundment of water behind the dam. During the 1950s, as a result of the Korean War and the requirements for cotton cloth, uniforms and bandages, cotton demand was extremely high. The increased demand led to a cotton price boom which in turn resulted in extensive private investment in private irrigation systems along the White Nile. After the Korean War, when cotton prices declined, the income of both growers and tenants declined rapidly. In order to reduce conflicts between owners and tenants, during the 1960s, the GOS placed most of the private schemes under public control.

In 1980 the GOS established the White Nile Agricultural Production Corporation (WNAPC) to manage the 174 schemes along the White Nile. The nominal command area was 210 000 ha with an original design capacity of 50% cropping intensity. However, by the mid-1980s the GOS realized that it was necessary to intervene in order to reverse the decline in cotton production; it was also necessary to address the problem of the debts accumulated by the government corporations managing agricultural production along the Blue and White Nile. As a result, on the White Nile WNAPC was eliminated and a new parastatal body, the White Nile Agricultural Schemes Administration (WNASA) was placed in charge of the pump lift irrigation schemes. However, as many of the staff were shifted over to the new organization, and the operational rules were not revised significantly, this change had limited impact.

Privatization policy

Due to many factors, including a costly civil war, deterioration in the terms of international trade and natural calamities, aggravated by inappropriate economic policies, the economy of Sudan has declined while the country's foreign debt has risen to more than $16 billion, or $600 per capita. During the past few years, Sudan's economy has suffered hyperinflation, declining access to foreign exchange and external assistance, shortage of many production inputs and a negative real growth rate. The GDP declined by 14% between 1992 and 1993 while inflation was 250% in 1993 (International Fund for Agricultural Development, 1993). Starting in 1991, in an effort to revive the economy, the GOS instituted a programme of decentralization, including the dismantling of many of the parastatals. This programme was part of a larger set of macro-economic policy reforms under the Economic Salvation Programme of 1990–93 designed to reduce the role of government and expand that of the private sector and the market in order to reach social and economic development targets.

These policy changes impacted directly on the WNASA which in 1991, was one of the first GOS parastatals to be selected for partial privatization. WNASA was chosen because it had stopped making any payment on its debts, already in excess of US$2



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JUNE 1993

Map of the Sudan.
Source: United Nations (1993).

million. The government could not afford further subsidies to the agency. Also, it was assumed that its 174 relatively small, self-contained irrigation schemes (ranging from 105 ha to 4 000 ha) would be easier to transfer to local management than the larger blocks of the gravity flow irrigation schemes. A further reason for WNASA's selection was that the tenant unions in the White Nile schemes were recognized to be weaker

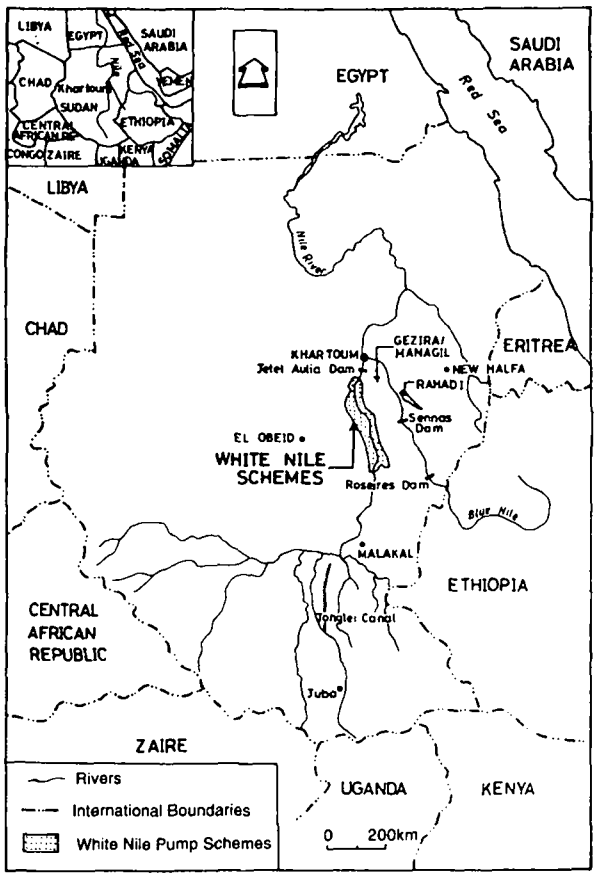

Figure 1 Location of White Nile lift irrigation schemes.

than their counterparts in the larger gravity flow schemes.

In 1991 more than 70% of the staff of the WNASA were released and its responsibility for managing lift irrigation schemes was reduced from 174 schemes to 38 schemes. It must be stressed that physical assets were not privatized but what was transferred to the farmers was the responsibility for the provision of agricultural services and inputs, previously held by the parastatal company. While the actual ownership of the infrastructure of the lift irrigation schemes remained with the government, it was expected that tenant-farmers would form their own water users associations to manage the systems or enter into management agreements with private sector firms.

After three years the resulting organizational arrangements have been far from satisfactory, however. In the majority of the 136 schemes in which farmers were given management responsibility, the tenants were not prepared to take over management or to arrange for an alternative management organization. In the first year, two companies took over five schemes, but abandoned the enterprise after a single year. Sixteen schemes have been taken over by the White Nile Holding Company and another 33 schemes in Dueim Province are operated by a management organization established by the provincial government. A large number of the other schemes have abandoned irrigated crops and are just growing rainfed crops, or the land has been left fallow (Samad and Dingle, 1995).

Opportunities and constraints for White Nile pumps

This section presents the main features of the physical, economic and financial environment in which the White Nile pump irrigation schemes operate.

Water

The average annual flow of the White Nile is 28,000 million m^3 while the river lift schemes extract less than 2 million m^3. Water is available in the river throughout the year, and normally the flow is adequate for meeting irrigation requirements; however, during part of the year the water level in the river is a constraint. The Jebel Aulia Dam passes the normal river flows downstream without impounding, until some time in July/August. After this date, the sluices are closed and water begins to accumulate in the reservoir. At many pumphouses on inlets, water reaches a level to permit pumping at this time, or a little earlier if flows have increased sufficiently.

Again, in February/March the sluices at the dam are opened to release water for downstream use, and reservoir level soon drops below the level which can sustain pumping at the schemes. As a result, most pump houses are dry by the middle of March. This window of feasible water levels makes it virtually impossible to grow two crops per year. Yet, there is no intrinsic difficulty in growing two crops a year if the government can find a means of maintaining the water level in the river and labour and/or machines are available for farm operations. As suggested below, installing booster pumps on the river so that the main pumps can lift river water even during the low flow season, is one alternative.

Pumping capacity

The Gibb study (1989) presents a comprehensive strategy for improving performance of the White Nile schemes. Its most important proposal was to group schemes, establish larger pumping stations with electric drives, and provide booster pump facilities on the river to enable the main pumps to run practically throughout the year. Booster pumps can also be provided at every scheme; Gibb considered both economy of size and feasibility of maintaining inlet channels clear of weeds in making its recommendation for grouping schemes.

However, even now at almost all schemes, the nominal pumping capacity provided is more than adequate for irrigation at 100% annual intensity. With rehabilitation, even with some pumps derated, pumping capacity, if maintained, will not be a constraint to increasing annual intensity to 100%. This can be contrasted to the present situation where most schemes are operating at 20 to 50% intensity due to deterioration of the infrastructure, lack of maintenance and low flow in the river.

Pump—maintenance and fuel

Maintaining pumps in working condition is a major problem. A major bottleneck is availability of spare parts, and any sustainable transfer will depend on a

strategy being found for resolving this constraint. The phased replacement of diesel engines by electric drives — whether following Gibb's grouping scheme or proceeding on a scheme-by-scheme basis — offers an alternative, avoiding much of the spare parts dilemma.

Availability of diesel fuel is another serious problem; it is uncertain whether farmer groups or a company servicing farmers will be able to obtain reliable supplies. Given the monopoly control over diesel fuel, and the widespread black market for fuel, progressive change over to electric drives is probably the long term solution to improving availability of energy for the pumping plants. It must also be remembered that diesel fuel is imported, and it is sold at an administered price. Due to this monopoly, and the artificial shortages it causes, much of the fuel is bought on the black market. During early 1995, in many locations, the black market rate for diesel was LS 700 (US$1.65) per (imperial) gallon, compared to the official price of LS 500 (US$1.18).

Water conveyance system

Design capacities of the water conveyance system are adequate to meet the requirements for 100% annual intensity with considerable flexibility in cropping pattern. The main question to be examined is whether a minor canal can serve all the water channels properly, i.e. maintain appropriate flow levels, if their requirements differ widely. To meet different water needs within an irrigation section requires well placed cross-regulators. With respect to the design of the canal system, the International Irrigation Management Institute (1994) reported, "The minor canals are designed to ensure full supply level between 20 and 40 cm above the adjacent land, by means of regulators at required intervals, each consisting of a sluice gate and a steel pipe embedded in an earthen dike across the channel." Apparently these regulators are in addition to the weir and sluice gate structures provided at intervals of 1 to 4 km to allow water storage during the night. It is expected that there will be larger operational losses in the system when farmers are allowed freer choice of crops, but this will not be a serious problem until cropping intensity increases significantly.

Water distribution

Water levels in the channels are normally scheduled to ensure irrigation of the entire section. Also, black cotton soils become waterlogged even with moderately excessive irrigation. This means that deliberate over-irrigation by head reach farmers at the expense of tail end farmers is not likely to happen. However, tail end problems are nevertheless reported, apparently due to the poor condition of the channels.

In addition, as farmers are tenants, there is a practice of rotating the situation of the land plots allocated to them, so that in one year the farmer gets a head end plot, in another a middle plot and so on. Under this arrangement, if the pump unit is maintained in reasonable condition, inequitable distribution among the sections is likely to arise only due to poor condition of the major and minor canals.

Land tenure

In spite of several studies, as well as aid donors, suggesting that a policy on land tenure be enunciated by GOS, no clear policy has been articulated. Farmers have informal rights as tenants, and are rarely deprived of tenancy. A large number of present tenants owned land before it was nationalized. They expect that if the tenant system is revised, they will get their old lands back, or at least equal areas. But such a policy would leave insufficient land available for distribution to the formerly landless and immigrants. This is reportedly one of the reasons why no clear signals are being given regarding a new land tenure policy.

Farm operations

One of the most striking features of farming practices in Sudan is the high level of mechanization. Mechanized rain-fed crop production, mainly operated by large companies, accounts for 15% of output of the agricultural sector, versus 33% by irrigated crop production (again with high mechanization). The remaining output is 20% by traditional rainfed crop production and 32% by animal husbandry. Rainfed farming in the northern areas is mostly traditional and land is owned by farmers, although the holdings are small. Some farmers own tractors, but generally traditional methods are used as the soil in the north is lighter and, consequently, easier to work.

In the White Nile schemes, while cotton is picked by hand, wheat is harvested with large combines. Weeding is done with imported herbicides rather than with hand labour. Plant protection chemicals are applied by aerial spraying, rather than with knapsack sprayers. At present, farmers depend on a corporation to bring labour, which they pay for with cash obtained through credit. If mechanized operations are not provided by the corporation or a private company participating under share-cropping arrangements, farmers will have to get these services from contractors, and pay for them with money obtained under the prevailing credit systems. All machines are imported, even small-scale threshers, and farmers have to pay a high price to compensate for the problems in maintaining and running them. Chemical fertilizers and pesticides are imported. It is reported that farmers are resorting to knapsack spraying to reduce the cost of applying pesticides, yet even so the import content of farm expenses is very high, reducing the value added from crop production within the country.

The formal credit system

The credit system to the private farmer offered by the formal sector is known as the *salam* contract system for cash credit, supplemented by a procedure (murabaha) of direct provision of inputs such as seed, fertilizer and pesticides. The Agricultural Bank of Sudan (ABS), and the Farmers' Bank, a relative newcomer, are the main institutions providing this system of credit.

Under the *salam* contract system, the Bank and the farmer enter into a contract, binding the Bank to advance a specified amount against repayment in kind

by the farmer after harvest. The quantity to be paid is determined from the *salam* price, which is negotiated, but is likely to be the same for all farmers in an area. There are variants which allow for providing the credit in two or three instalments, with the *salam* price revised each time. However, these alternatives are rarely used.

On harvest, the farmer delivers the agreed quantity of produce to the bank. IFAD-AR2 (1993) says that if the harvest price does not exceed the *salam* price by more than 33%, or fall below by more than 33%, no further adjustment is made. Thus, within this band the farmer is insulated against price change. Outside this range, the farmer receives the surplus above the upper margin, or has to make good the shortfall below the margin. In the present high inflation situation, the harvest price will invariably be more than 33% higher, and the Bank will stand to lose if the 33% band is strictly observed. However, the Banks do not follow this part of the system.

Banks trade in commodities (a major part of ABS's income is from trading), and provide seed, fertilizer and pesticides in kind. Farmers have to repay in cash with a service charge (interest) of 36% per year. In order to secure itself against loss, due to depreciation of the Sudanese pound, the Bank enters into forward contracts with the monopoly cotton procurement agency for cotton.[1] This lowers the price which the agency offers at harvest. Therefore, the Banks, while making their positions safe, adversely affect the possible financial returns to the farmers.

Theoretical model to assess impacts of state disengagement

Until recently, farmers in the White Nile schemes have not had any experience with independent management. In order to examine how farmers might perform in the future, Narayanamurthy (1995) developed a model to estimate the financial returns from crop production under two types of organization. The first model assumes independent management by a farmer, or group of farmers, in which the farmer/farmer group secures all necessary mechanized services from contractors, credit and commodity inputs from formal institutions, and procures labour from the market. This is designated as 'IF/FG'. The second option is a crop-sharing arrangement called *musharaka*, in which the farmer enters into joint venture with a company that provides, or arranges for, mechanized services, inputs, labour and necessary credit. When the harvest is sold, the expenses incurred by the company are first reimbursed, and the remaining amount is shared in the ratio of 54% for the farmer and 42% for the company, with 4% deposited in a social development fund of the local authority.

In this analysis, sorghum is assumed to be grown on 15% of a normal holding, which is 5 hectares (12 fedans) per farmer family in most of the irrigation schemes. Sorghum is grown for home consumption as a sustenance crop and therefore its gross margin is assumed zero. At present the irrigation facilities are owned and operated by the GOS. Charges for water paid by farmers reflect only a fraction of actual cost to the government of operating and maintaining the irrigation schemes. It is assumed that in turning over O&M to the farmers, the first step will be to transfer the responsibility for fuel charges relating to pumping. The actual cost of pumping is 2 to 4 times the present water and land charges. It should be possible, in the future, to achieve 95% cropping intensity with the present pumping facilities (rehabilitated) and canal systems, assuming that management options work properly and farmer confidence improves.

Rehabilitation

In determining the viability of the IFAD-funded project for rehabilitation, a committee made estimates of the cost of rehabilitation of the schemes (134 schemes covering 169 901 ha) to a state that would permit operation for a period of about 10 years. The cost estimates, which were applicable at the beginning of 1994, are classified into bands and presented in Table 1.

According to officials, the GOS will treat the present value of the schemes as a sunk cost, and seek to recover only rehabilitation costs. IFAD AR assumes that the schemes will be able to operate for 10 years after rehabilitation, by which time a long term improvement strategy, such as that suggested by Gibb (grouping and electrification), could be undertaken. At 10% interest, annual payments to amortize rehabilitation over a 10 year period will require payment of 16.3%. Cost estimates for electrification, presented in Table 2, were developed during the beginning of 1995.

Theoretical financial performance

The analysis underlying the conclusions of this article are summarized in Table 3. Some of the assumptions related to these tables are discussed below while more detailed information is included in the annex tables of the 1995 Sudan study by Narayanamurthy.

In the long term, electrification of the schemes and provision of booster pumps to give access to river flows over the entire year, would be the best strategy. Gibb had suggested grouping of schemes in order to take advantage of existing economies of scale and to organize the maintenance of the inlet channels better. The groups suggested by Gibb range in size from 470 to 28 615 ha. Using data in the Gibb volumes and electric motor-pump set costs, rough cost estimates were developed for schemes or groups of schemes of 425, 850 or 1 275 ha, which could be used as pilot schemes. Depending on pump size, configurations of 2 plus 1 spare or 3 plus 1 spare were selected.

Prospects for farmer takeover at these costs for electrification (Table 2) can be judged from the long term earning prospects shown in the lower panel of Table 3. If minimum useful life of 20 years is assumed, amortization over this period will require annual equated payment of about 12%. At an intensity of

[1] The former Government-owned Cotton Public Corporation of Sudan has been replaced by a private agency.

Table 1 Annual payment bands for rehabilitation and transfer

Capital cost band ($/ha)	No. of schemes	Area of schemes (ha)	Equated payment at band limits ($/ha)
276 to 331	2	245	45 to 54
221 to 276	3	794	36 to 45
166 to 221	9	3307	27 to 36
111 to 166	31	15583	18 to 27
83 to 111	33	23343	14 to 18
55 to 83	31	41680	9 to 14
28 to 55	19	53124	5 to 9
14 to 28	6	31825	2 to 5
	134	169901	

Source: Narayanamurthy (1995).

Table 2 Cost of electrification in zone

Area (ha)	Cost per ha in Zone		
	Duiem ($/ha)	Kosti ($/ha)	Renk ($/ha)
425	912	774	664
850	758	650	564
1275	664	580	509

Source: Narayanamurthy (1995),

76% and at optimistic yield levels, farmer earnings under IF/FG look adequate to expect farmers to take over some of the irrigation facilities. It should be kept in mind that farmers will be more confident of keeping the electric drives in good order, than the diesel drives. On the other hand, farmers will need assurance of a reliable power supply grid.

Based on assumptions about different cropping intensities and yield levels, Table 3 presents the expected range of returns to the farmer. The upper part presents the estimates for the short term, that is without any significant change to the pumping units, with cropping intensities of 50% and 76%. In the table, the gross margin represents the expected financial return before any recovery of the costs of operating the irrigation scheme, or of capital charges. The second column presents the gross margin minus fuel costs before O&M and capital recovery. The net return column is obtained by subtracting the O&M costs from the second column values. Any capital charges for rehabilitation — assumed to consist of interest on outstanding capital and the annual repayment instalments — must come out of the net return. Other extraordinary taxes must also be subtracted from the net return (Samad, 1996). Table 3 presents the estimated financial returns from modeling a holding following a rotation of wheat, sorghum and fallow, as this is the rotation followed in many pump irrigation schemes (Samad, 1996).

As can be seen in Table 3, based on an assumption of optimistic wheat yields (almost double the present levels), a 5 ha holding operated by independent farmers/farmer groups would be able to pay the costs of operating the lift system and still have a net return of $50 before any payments for rehabilitation. This is almost twice the net return from a *musharaka* mode of management. Increased net returns are also expected from increasing the cropping intensity to 76% and rehabilitating the systems along with adopting high yielding agricultural technology. In all cases, the theoretical model indicates that financial returns are superior under farmer management than under a crop-sharing type of arrangement.

Table 3 Total farm returns — 5 hectare holding for wheat crop 1993–94

		Independent F/FG $/farm			Musharaka $/farm		
		Gross margin	Margin less fuel	Net return	Gross margin	Margin less fuel	Net return
Returns in short term — 50% cropping intensity							
Wheat 1.7 ha	W-720	6.06	−52.57	−131.82	4.71	−30.58	−78.01
Sorghum 0.8 ha	W-1080	100.14	41.32	−37.74	57.59	22.30	−25.14
Fallow 2.5 ha	W-1440	187.50	128.46	49.62	110.47	75.18	25.74
Returns in short term — 76% cropping intensity							
Wheat 3.0 ha	W-720	10.69	−79.50	−200.01	8.32	−46.00	−118.10
Sorghum 0.8 ha	W-1080	176.71	86.18	−33.99	101.63	47.31	−24.79
Fallow 2.5 ha	W-1440	330.88	240.34	120.17	194.94	140.62	68.52
Returns in long term — after rehabilitation — high yields, 76% intensity							
Wheat 3.0 ha	W-1800	328.25	237.72	117.55	247.41	193.09	120.99
Sorghum 0.8 ha	W-2160	482.42	391.88	271.71	343.65	289.33	217.23
Fallow 2.5 ha	W-2440	589.15	498.61	378.44	407.81	353.49	281.39

Exchange rate: US$1.00 = 425 LS.
W-720 = wheat with 720 kg/ha yield; W-1080 = wheat with 1080 kg/ha yield; etc.
Source: Narayanamurthy (1995).

Actual field impacts of alternative modes of management following state disengagement

This section is based on the work in Sudan by Samad and Dingle (1995) and Samad (1996). It compares the actual performance of the three management modes of operating lift irrigation schemes on the White Nile. Data presented here are based on empirical evidence obtained from a sample of farmers in selected schemes for the wheat season of 1993–94.

Data are used to make an assessment of the impacts of the changes in production management models on tenant incomes.

Cost effectiveness of inputs and services

A key argument in support of transferring management for the schemes from state to non-governmental entities centres on the potential for more cost effective provision of services. This argument is critical to the success of such a transfer in Sudan, given the capital intensity of agricultural production in the irrigation schemes. Consequently, cost effectiveness in the provision of inputs and services is a significant indicator of management performance in this context. However, based on the data from the six schemes under three different management organizations, the total cost of inputs and services in the farmer managed schemes ($83/ha) were not significantly different from the parastatal ($89/ha) and company managed schemes ($89/ha) except for minor differences in the cost of fertilizer and harvesting (Samad, Table 1, 1996).

There are no major changes in wheat production technology in the schemes under parastatal and company management. However, there is a shift in production technology in the farmer managed schemes. For example, a substantial number of farmers did not follow the standard agricultural practices with respect to fertilizer application rates.

Quality of irrigation service and crop yields

The recommended irrigation for wheat is eight irrigations at 14 day intervals. As stated in IFAD (1994) each irrigation is supposed to supply 950 m^3/ha. Results of the sample survey revealed that the weighted average number of irrigations received by farmers were 5.38 in farmer managed schemes, and 6.21 and 6.42 in the parastatal and company managed schemes, respectively. Only a small proportion of the farmers in the parastatal and company managed schemes received eight irrigations. None of the farmers in the farmer managed schemes received the full requirement and more than 50% received five or less irrigations.

Based on field data, Table 4 provides estimates of gross returns per unit of land and irrigation water in the six schemes. Total volume of water pumped in each scheme was estimated on the basis of the recorded number of hours the pump was operated during the growing season (December 1993–March 1994) and measured flow rates. Conveyance loss was set at 10% which is the standard used by the Hydraulic Research Station for the White Nile area.

Assuming the actual irrigation requirements for wheat for the White Nile area to be 7 600 m^3/ha, the relative irrigation supply was estimated on the basis of the weighted average number of irrigations received by farmers. Results are presented in Table 4. Data in the table suggest that in none of the schemes was the water supply sufficient to satisfy crop water requirements.

Partially as a result of the consistent under-irrigation, average wheat yield data in the 1993/1994 season in the transferred schemes and those under parastatal management all indicate less than one ton per ha. Yields in the parastatal schemes (893 kg/ha) were slightly higher than the average yield (476–714 kg/ha) for the White Nile area. Similar yields were realized in the company managed schemes. Wheat yields in the farmer managed schemes (714 kg/ha) were low and the variability in wheat yield from one scheme to another was high.

Profitability of irrigated agriculture

Profitability of irrigated agriculture is measured in terms of net returns per hectare under the three modes of management. To minimize distortion in the value of output due to extreme values, the modal yield per hectare was used instead of the average. Output was valued at the prevailing market prices. Costs of inputs

Table 4 Productivity by management modes for the wheat crop, 1993/1994

Variable	Units	Parastatal managed		Private company		Farmer organization	
		Rawada	Guli	Tawila	Umganeem	Salati[1]	Almagam
Command area	ha	221	524	—	215	218	353
Actual irrigated area	ha	171	505	170	200	76	340
Total yield from scheme	Tons	150	520	149	142	53	306
Total water pumped	000m^3	1256	2973	1797	1237	—	2003
Losses (10%)	000m^3	127	297	178	124	—	200
Water delivered	000m^3	1129	2676	1619	1113	-	1803
Gross product value	LS 10^6	10.7	37.0	10.6	10.0	3.8	21.8
Relative water supply	unitless	0.87	0.69	1.25	0.73	1.9	0.9
Yield	tons/ha	0.9	1.0	0.9	0.7	0.7	0.8
Gross product value/m^3 of water	$/$m^3$	0.020	0.029	0.014	0.019		0.025

[1]Since data on water pumped was unreliable the productivity of water was not estimated.
1 US$ = 452 LS.
Source: Samad (1996).

and services were the actual amounts charged to farmer accounts by management. The cost of hired labour is the amount reported by farmers in the survey. Table 5 details net returns per hectare for wheat under the three types of schemes. The highest net return was realized in the parastatal schemes ($42/ha), followed by farmer managed schemes ($18/ha). Net return in the company managed scheme was $7/ha.

Due to the consistently low yields in all management modes, the net returns per ha are extremely poor. Since these returns do not include the real cost of water, nor all the taxes, it is unlikely that the schemes are financially viable under conditions of private O&M. This issue is explored in the next section.

Financial sustainability

In Sudan, the state has withdrawn from management of agricultural production, but continues to retain ownership of irrigation pumps, and is in charge of their operation and maintenance. However, the Government of Sudan is contemplating the outright transfer of all operation and maintenance costs of the irrigation facilities to farmer organizations and private companies. The critical question that must be answered is, "Do the farmers have the financial capacity to take charge of operation and maintenance of the lift irrigation facilities?"

Prospects for transferring O&M responsibility to farmers must be judged in terms of their ability to pay the fuel and O&M costs for operating the diesel pumps as well as O&M costs relating to irrigation facilities. Table 6 contains the estimated fuel and O&M costs for irrigating a hectare of wheat. Operation and maintenance costs excluding the cost of fuel are about $31/ha. Total O&M costs per hectare range from $48 to $64 for the different fuel cost rates. From this table, compared to the figures in the last row of Table 5, it is evident from the net cash income estimates that farmers would only be able to pay for the fuel costs but would not be able to bear the other O&M costs at their current crop income levels. Even paying only the fuel cost would mean their net income would be zero; leaving farmers with nothing for the support of their family.

Discussion

The present article explores the impacts of the changes in the provision of support services which are necessary to make investments in O&M more cost effective. At present levels of cropping intensity and yields, none of the management models would allow farmers to cover all the fuel and O&M costs of the lift irrigation systems. In this regard, evidence presented in this chapter suggests that in Sudan, irrigation management transfer is premature.

Based on a theoretical model, it would appear that farmers should be able to cover their costs when managing the irrigation system independently. However, not only does this model assume higher levels of cropping intensities and yields, it also assumes that farmers have equal access to credit, labour, agricultural machinery and agricultural inputs. Given

Table 5 Net return per hectare by management modes for wheat crop, 1993–1994

	Units	Parastatal management	Private company	Farmer organization
Yield[1]	kg/ha	893	833	714
Sale price	$/kg	0.165	0.165	0.165
Gross return	$/ha	147	137	118
Production cost	$/ha	95	119	89
Administration charges				
Harvesting fee	$/ha	0	0	1.4
Land and water	$/ha	8.4	8.4	8.4
Management charges	$/ha	1.6	3	2
Total costs	$/ha	105	130	100
Net return	$/ha	42	7	18
Holding net return[2]	$	71	12	31

[1] Modal yields.
[2] Assuming a holding of 5 ha with 1.7 ha in wheat, 0.8 ha in sorghum and 2.5 ha fallow.
Exchange rate: 1 US$ = 425 LS.
Source: Samad (1996).

Table 6 Cost of supplying water and O&M charges — wheat crop

Costs	Fuel cost rates		
	US 0.19 cent (LS 0.8)	US 0.28 cent (LS 1.2)	US 0.36 cent (LS 1.6)
Fuel cost for pumping 8570 m^3/ha of water	US$ 16	US$ 24	US$ 32
O&M charges/ha (excluding fuel cost)	US$ 32	US$ 32	US$ 32
Per ha cost of water supply & O&M	US$ 48	US$ 56	US$ 64
1.7 ha holding cost of water supply & O&M	US$ 82	US$ 95	US$ 109

Exchange rate: 1 US$ = 425 LS.
Source: Narayanamurthy (1995).

the disarray of the country's economy, and the legacy of state control, these assumptions do not obtain. One reason farmer yields are lower in Independent Farmer/ Farmer Group managed systems is that farmers must spend a considerable amount of time in the market trying to obtain the necessary inputs. Farmers are also preoccupied with finding credit to purchase the inputs. The above conditions, in addition to other obstacles, such as lack of spare parts and unavailability of fuel at official prices, practically rule out any chances of success for the privatization of the White Nile pump schemes at the present time.

The economy of the Sudan is in disarray, as characterized by serious problems such as precariously low official reserves, hyperinflation, shortages of production inputs, spare parts and fuel, escalating costs of agricultural inputs and a crumbling infrastructure, all of which directly or indirectly affect the agriculture sector. Production of wheat and cotton continue to be regulated by the state. Under these circumstances it is hardly surprising that, contrary to government's expectations, the private sector has been unenthusiastic about the privatization of the White Nile schemes. Four years after the reforms were initiated, only one company had taken over management of a few schemes, 33 schemes are provisionally managed by farmer organizations and some 90 schemes have been abandoned. As the above analysis shows, farmers growing wheat at present low yields obtain a very low rate of return. Even if wheat yields double, cash surplus will barely suffice to pay for fuel to operate the pumps, much less other operation and management tasks.

The lesson emerging from the recent studies discussed above is that the withdrawal of state management before the necessary support services are in place and available, can be counter-productive. Merely changing the ownership or the mode of management of an irrigation system does not necessarily result in improved performance. Far more important is the economic, political and institutional environment within which the agricultural sector functions. To create a more dynamic irrigated agricultural sector, governments must be committed to comprehensive macro-economic and sectoral policy reforms. These should be aimed at generating the support systems necessary to encourage growth of private sector services, at the creation of viable markets, and at strengthening management capacity among the farmers. All these aspects are necessary to prepare farmers for the competition that will come with privatization. Unless these conditions are satisfied, management reform may cause more harm than good, as has been demonstrated on the White Nile.

References

Alexander Gibb & Partners (1989a) *White Nile Pump Schemes Modernization Study, Volume 3, Final Report.* Sir Alexander Gibb & Partners, London.

Alexander Gibb & Partners (1989b) *White Nile Pump Schemes Modernization Study, Volume 5, Final Report.* Sir Alexander Gibb & Partners, London.

Alexander Gibb & Partners (1989c) *White Nile Pump Schemes Modernization Study, Volume 7, Final Report.* Sir Alexander Gibb & Partners, London.

Deloitte, Haskin and Sells (1990) *Sudan Gezira Rehabilitation Project: Debt, Credit and Marketing Study.* London, U.K.

Halcrow-ULG (1984) *Review of the White Nile Pump Schemes, Final Report.* Halcrow-ULG, London.

Hassan El Tayeb El Hag and Team (1992) *A Study to Draw up Scheme for Operationalizing Privatized Agriculture by Entrepreneur Tenants in Gezira Scheme, Final Report.* Khartoum, Sudan.

International Fund for Agricultural Development (IFAD) (1993) *White Nile Agricultural Services Project. Appraisal Report. Volume 1 — Main Report.* IFAD, Rome.

International Fund for Agricultural Development (IFAD) (1993) *White Nile Agricultural Services Project. Appraisal Report, Volume 2 — Annexes.* IFAD, Rome.

International Irrigation Management Institute (1994) *The Sudan Gezira Rehabilitation Project — Technical Assistance to Sudan Gezira Board, Final Report.* International IIMI, Colombo, Sri Lanka.

Narayanamurthy, S.G. (1995) *Report on Sudan assignment.* International Irrigation Management Institute, Colombo, Sri Lanka.

Samad, M. and Dingle, M.A. (1995) *Privatization and Turnover of Irrigation Schemes in Sudan: A Case of the White Nile Pump Schemes.* International Irrigation Management Institute, Colombo, Sri Lanka.

Samad, M. (1996) *Impact of State Disengagement from the Management of Agricultural Production in White Nile Pump Irrigation Schemes in Sudan: the Privatization and Self-management of Irrigation. Final Report.* International Irrigation Management Institute, Colombo, Sri Lanka.

United Nations (1993) Map of Sudan, Map No. 3707 Rev. 1, United Nations.