PERFORMANCE OF THE TWO MANAGEMENT MODES PRACTICED FOR THE RIVER-LIFT PUMP SCHEMES IN SUDAN

by

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INTRODUCTION

The Government of Sudan is implementing an ambitious program of "*privatization of irrigated schemes*" throughout the country. At this stage, however, the activity is mainly confined to the transfer of some aspects of management, scope depends upon the size of a scheme, from the agricultural corporations to the farmers / tenants or the private companies.

Although the turnover process is being applied to all the irrigated areas, the initial thrust is on the river-lift pump schemes. For many of the small pump schemes along the White Nile, the Government has transferred its management role which was mainly the services rendered through the agricultural corporations. However, the control which is exercised through the Ministry of Irrigation (MOI) for lifting and delivering irrigation water in the area still lies with the Government.

At the next stage, it is an expressed intention of the Government to transfer its remaining responsibilities to the private sector. For the pump-schemes along the White Nile and Main Nile, the pilot testing of a complete transfer is already underway.

In view of the pending donor-assisted pilot testing of the management turnover plan for the irrigation facilities and control of irrigation supply to the farmers, it seems important to quantify its impact and performance of the schemes. For the policy makers, it will be very useful if the research efforts are focussed on providing information about the comparative performance of the river-lift schemes under private and public sector. It is the context in which *"A Framework for Performance Evaluation of River-lift Schemes in Sudan"* was proposed by Shafique (1994a).

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This framework intends to document the efficiencies of the pumping plants for lifting the river water and performance status of the irrigated schemes in the public and private sector. The resulting information is then used to derive indices for comparing the two management modes for the water supply in the area.

METHODOLOGY FOR EVALUATION

I. Diesel Powered Pumping Plant System Efficiency

Shafique (1994a) has developed a relationship to determine system efficiency of diesel powered pumping plants which is given as follows:

$$E_{system} = \frac{0.905 \times Q\,(\frac{m^3}{\sec}) \times H\,(m)}{FCR\,(\frac{l}{h})} \qquad (1)$$

where Q is flow rate in m^3 per second, H is total head in meters and FCR stands for fuel consumption rate in liters per hour. As clear from the above equation, only three types of measurements are required to estimate system efficiencies of the plants.

Over the last two irrigation seasons, 1992-93 and 1993-94, the following data were collected:

(a) flow measurements of selected pumping plants by different techniques according to field conditions;
(b) Total static lifts, and head loss through pipes & fittings (Jane, 1987, and Karassik et al., 1986); and
(c) actual fuel consumption rate in liters per hours.

The testing of pumping plants was not confined only to large pumping plants (27 tests) managed by the Government. This exercise was also extended to small pumps (11 test cases) in the private sector. Such a choice helped to compare efficiencies and performance under the two management modes practiced for lifting and delivering water to the farmers.

II. Indices for Pumping Plant Performance

In order to derive indices for pumping plants, the following data were gathered: (i) optimum efficiencies of large and small pumps, (ii) reported and actual fuel consumptions on hourly basis, (iii) fuel costs per feddan of wheat crop, and (iv) reported and actual daily pump operating hours. These indicators for the performance of pumps are selected as proposed by Shafique (1994b):

1. System Performance of Diesel Powered Pumping Plants

- System Performance of Pumping Plants (P_{system}):

$$P_{system} = \frac{Actual\ System\ Efficiency}{Optimum\ System\ Efficiency} \qquad (2)$$

2. Status Indicator for Fuel Consumption

- Actual fuel Consumption Status (AFCS):

$$AFCS = \frac{Reported\ Fuel\ Consumption\ per\ Hour}{Actual\ Fuel\ Consumption\ per\ Hour} \qquad (3)$$

3. Status Indicator for Cost Recovery

- Actual Cost Recovery and Diesel Cost Status (ACR/DC):

$$ACR/DC = \frac{Cost\ Recovery\ Per\ Unit\ Area\ Per\ Crop}{Fuel\ Cost\ Per\ Unit\ Area\ Per\ Crop} \qquad (4)$$

4. Status Indicator for Pump operating Hours

- Daily Pump Operation Ratio (DPOR):

$$DPOR = \frac{Reported\ Daily\ Pump\ Operating\ Hours}{Actual\ Daily\ Pump\ Operating\ Hours} \qquad (5)$$

III. Indices for the Comparison of Two Management Modes for Lifting and Supplying Irrigation Water

The comparative ratios are based on the indices calculated in the preceding section, yield related data, and seasonal reported hours of pump operation. These parameters are essentially the same as suggested by Shafique (1994b):

(i) Comparative Index for Pumping-plant Performance (CIPP):

$$\frac{[P_{system}]_{private}}{[p_{system}]_{public}} \qquad (6)$$

(ii) Comparative Index for Diesel Consumption (CIDC):

$$\frac{[Diesel\ Consumption\ /\ Cropped\ Area]_{Private}}{[Diesel\ Consumption\ /\ Cropped\ Area]_{Public}} \qquad (7)$$

(iii) Comparative Index for the Pump Volume of Water (CIPV):

$$\frac{[Pumped\ Volume\ /\ Cropped\ Area]_{Private}}{[Pumped\ Volume\ /\ Cropped\ Area]_{Public}} \qquad (8)$$

(iv) Comparative Index for Water Charges (CIWC):

$$\frac{[Water\ Rate\ /\ Feddan\ /\ Crop]_{Private}}{[Water\ Charges\ /\ Feddan\ /\ Crop]_{Public}} \qquad (9)$$

(v) Comparative Index for Crop Yields (CICY):

$$\frac{[Crop\ Yield\ /\ Feddan]_{Private}}{[Crop\ Yield\ /\ Feddan]_{Public}} \qquad (10)$$

(vi) **Comparative Index for Water Use Efficiency (CIWUE):**

$$\frac{[Water\ Use\ Efficiency]_{Private}}{[Water\ Use\ Efficiecy]_{public}} \qquad (11)$$

where water use efficiency is definded as under:

$$WUE = \frac{Crop\ Yield\ (KG)/Unit\ Area}{Volume\ of\ Water\ delivered(m^3)/Unit\ Area} \qquad (12)$$

DATA ANALYSIS & DISCUSSION

I. System Efficiencies of diesel powered Pumping Plants:

During the last two irrigation seasons, 1992-93 and 1993-94, a number of field tests (total 38) were conducted to determine system efficiencies by using Equation 1. Such an evaluation was aimed at public as well as private diesel powered pumping plants. The results of the exercise are given in Tables 1 & 2.

Table 1. System efficiencies of public diesel powered river-lift pumping plants of some selected White Nile schemes

PUMP TEST NO.	DATE	E_S(%)	PUMP TEST NO.	DATE	E_S(%)	PUMP TEST NO.	DAT E	E_S(%)
D3-A	1993	8.73	K2-S	1994	11.30	D1-K	1993	9.32
D3-A	1993	5.10	K2-C	1994	11.32	D1-Y	1993	4.88
D3-A	1994	3.10	D8	1994	8.65	K1-R	1994	11.28
D2	1993	3.35	D8	1994	8.46	K1-R	1994	12.96
K3-A	1993	4.70	D2-B	1994	7.15	K4	1994	9.20
K3-B	1993	6.90	D2-Y	1993	7.41	K4	1994	10.09
K2-L	1993	15.37	D2-B	1993	3.48	K5-S	1994	16.46
K2-L	1994	13.80	D3-Y	1993	6.08	K5-S	1994	15.80
K2-S	1993	13.20	D1-K	1993	10.03	K5-S	1994	13.29

Table 2. System efficiencies of private diesel powered river-lift pumping plants in the White Nile area

PUMP TEST NO.	DATE	E_S(%)	PUMP TEST NO.	DATE	E_S(%)	PUMP TEST NO.	DAT E	E_S(%)
F1	1994	7.43	F5	1994	12.12	F9	1994	6.00
F2	1994	7.24	F6	1994	3.70	F10	1994	8.69
F3	1994	4.46	F7	1994	8.82	F11	1994	9.30
F4	1994	6.61	F8	1994	11.67			

The delivery pipe sizes (cm) of 10 to 12.5, 15 to 22.5, and 25 or more are referred as small, medium and large river-lift systems. According to the criterion opted, all pumping plants in the public sectors are large as compared to small ones in the private sector.

Table 1 provides test results of large public pumping plants. In this sector, the system efficiencies range from 3.10 to 16.46 percent. As expected, these efficiencies are low. However, the results are not very different as found under comparable situations.

For example, in Indonesia these efficiencies for the large river-lift systems are found to be in a range of 5.7 to 16.9 percent (Sam et al. 1992). The average values are 10.3 and 9.31 percent for Indonesia and Sudan respectively. Slightly improved outcome in case of Indonesia may be due to the better availability of spare parts, financial position of the concerned managing agency, morale of the operational staff, etc. However, it is quite surprising to note that Sudan does quite well given much higher level of development in Indonesia.

Table 2 displays results concerning privately owned small diesel powered river-lift pumping plants. The field tests of the sampled pumping systems show an average system efficiency of 7.82 percent. This should be compared with similar mean of 9.31 percent efficiency derived for large river-lift plants.

It is obvious that the mean system efficiency for the small diesel powered plants is slightly less than the one stated for the large systems. In the author's opinion, the difference is not due to the two management modes but the size of the pumps and engines used in the private sector.

As suggested in the GOS report (1955), the pump efficiencies for the small pumps (10 cm diameter of the delivery pipe) are usually 25 percent less than those which can be achieved by the large pumps with delivery pipe size being 50 cm. So, the reduction is not unexpected.

Moreover, the system efficiencies for the public plants been derived using the actual diesel consumption. With the reported fuel consumption, the resulting values would have been significantly less than the private plants.

In contrast to the diesel powered systems, the electrically driven plants are relatively much more efficient. This happens mainly due to higher efficiencies of electric motors (usually around 90 %) whereas the efficiencies of diesel engines are reported to be in a range from 43.9 to 49.5 percent only (Sam et al. 1992).

Akram et al. (1980) evaluated about 106 electrically operated tube-wells in one of the Salinity Control and Reclamation Projects (SCARP) in Pakistan. The authors found an average system efficiency of 48 percent for such plants which is many times more than system efficiency of diesel powered plants. Obviously, the selection of driving source can also help to achieve much higher efficiencies.

II. Indices for Pumping Plant Performance

1. Performance of Pumping (System) Plants:

The performance of the pumping plants is determined by using Equation 2 which is simply a ratio between actual system efficiency to the one which can be attained i.e., optimum system efficiency. Hence, information presented in Tables 1 and 2 can easily be converted into system performance of the diesel powered river-lift plants in the public and private sector respectively.

For both large and small pumping plants, the system performance is obtained based on an average optimum system efficiency of 27.5 percent as proposed by Sam et al. (1992). It is done only for comparison of the two sectors with the same denominator. However, one should recognize that optimum system efficiency for private small plants is going to be significantly less as compared to large systems in the public sector. According to the information provided by the above referred authors and GOS report (1955), mean optimum system efficiency for the small plants comes about 22.5 percent only.

Based on the assumption, maximum index of system performance for the sampled large public plants is 59.9 percent and minimum value of the parameter is 11.3. Mean P_s of all the plants is 33.9 percent. This indicates a three fold potential for improvement.

Similarly, the system performance concerning the sampled private pumping plants is also derived. However, it will also be appropriate to compare the performance indices by using relevant optimum obtainable system efficiencies i.e., 27.5 and 22.5 for the large and small pumping plants as discussed earlier.

As per first assumption, the mean system performance for small tested plant comes 28.5 percent with the maximum and minimum values being 44.1 and 13.5, respectively. Compared to large plants, the performance is reduced by 15.9 percent. However, if the optimum E_s is taken as 22.5 percent, the mean performance for small pumps gets slightly better than the large plants (34.8 percent). In this case also, there is a vast potential for improvement.

2. Status Indicator for Fuel Consumption

In order to discuss fuel consumption, the indicator defined as *the Actual Fuel Consumption Status* (**AFCS**), given by Equation 3, is used. During 1994, thirteen actual diesel consumption tests were conducted in some selected public and private schemes of the Kosti and Dueim regions. Tables 3 & 4 furnish the results of such tests. The values over 1.0 indicate excessive reported fuel consumption and the values less than 1.0 mean actual consumption is higher than reported fuel amounts.

Table 4 **Actual diesel consumption status of private pumping plants**

<u>Plant</u>	Actual diesel (gph)	Reported diesel (gph)	AFCS
F3	0.163	0.167	1.02
F7	0.19	0.167	0.92
F9	0.18	0.167	0.93
F10	0.20	0.167	0.84

Information in Table 3 reports the values of nine actual fuel consumption tests conducted in the public schemes. In the table, the values of AFCS range from 1 to 1.97 and the mean value is of the parameter is found to be 1.29. As the reported rate of fuel used per hour during 1993-94 is almost constant, the speed effect can be ignored. Moreover, the tested plants have been relatively newer (most of them installed around 1992) and hence mechanical condition of the systems is not an important factor either. In addition to a possible human interference, more tests are also recommended for diagnosing other relevant causes.

Table 3 Actual fuel consumption status of public pumping plants

Plant	Actual diesel (gph)	Reported diesel (gph)	AFCS
D8P	6.8	7.0	1.03
K1	3.8	7.5	1.97
K2-1	5.9	8.0	1.36
K2-2	4.0	6.0	1.50
D5	1.5	2.0	1.33
D6	4.5	5.0	1.11
D9	2.0	2.0	1.00
K4-1	4.5	5.5	1.22
K4-2	5.5	6.0	1.09

Table 4 presents data about actual fuel consumption rate in the case of private pumps. It is interesting to note that AFCS values fall in a narrow range of 0.84 to 1.02 with an average for the tests being only 0.93. This indicates that actual consumption is slightly more when compared with the reported rates for fuel consumption. As the private farmers were always eager during the tests to show increased flows by increasing the speed of their pumping plants, the small differences can be attributed to the consumption rate at the higher speed.

3. Status Indicator for Cost Recovery

This parameter is proposed to compare only the cost of the reported diesel consumption per feddan of wheat to the total water charges levied by the Government. The main objective of the suggested indicator is to verify if the following statements are correct: (i) the pumping operations in Sudan are highly subsidized; and (ii) the current cost recovery is less than even the cost of diesel reported and charged for lifting water on unit area basis.

The actual cost recovery and diesel cost status is given by Equation 4. The reported diesel consumption for the six selected river-lift schemes was collected. Based on the diesel price in June 1994 and the declared water charges for wheat, the scheme-wise values of the status indicator are derived as displayed in Table 5.

It is quite important to note that ACR/DC values are extremely low. They range from 0.14 to 0.41 which means that only the diesel cost per feddan of wheat during 1993-94 is 2.5 to 7 times more than the water charges to be recovered. If the reported diesel consumption is the actual amount of diesel consumed, the financial viability of such schemes may have to be questioned.

Table 5. Index for actual cost recovery status per feddan of wheat in 1993-94

Scheme	Diesel consumed (gpf)	Diesel cost (pounds /feddan)	Water charges (pounds /feddan)	ACRS
D4	29.77	10420	1500	0.14
D3	18.80	6580	1500	0.23
D6	11.05	3868	1500	0.39
K4	10.52	3681	1500	0.41
K2	15.21	5322	1500	0.28
K1	19.61	6864	1500	0.22

On the other hand, If reverse is true, then ways and means have to be devised to eliminate these differences.

In order to compare the diesel consumption in the public and private sectors, similar information was collected from six small pumping plants. In the private domain, the diesel cost per feddan of wheat ranges from 2500 to 5600 sudanese pounds. Average diesel costs for the private and public sectors result to be 4050 and 7250 sudanese pounds, respectively.

However, it is important to consider some cost saving measures adopted by the private pump owners. Mostly, it is done by reducing number of irrigations applied to wheat crop. In the sample selected, there was one owner who gave eight irrigations only to reclaim saline patches but others kept the number in the range of four to six.

In the private sector, there is a limited water market. Farmers who do not own pump buy water for an entire irrigation season and pay on the basis of number of irrigations received. The duration of each irrigation is fixed at the start of the season. In one case, a farmer having 4 feddans on lease was paying two thousand sudanese pounds for each irrigation having a duration of 36 hours. His seasonal cost for six irrigations per feddan comes LS. 3000 which appears to be hardly enough to cover the cost of diesel used. This distortion in price was due a two and half times increase in the diesel price during 1993-94 wheat season.

4. Status Indicator for Pump Operating Hours

Actual pump operating hours are difficult to ascertain. However, in an agency operated environment it may help to hold field operators and managers accountable for delivering exactly the amount which is reported in books. A review of records of six selected schemes over the past three years indicates a pattern of an almost "perfect" match between planned and reported hours of pump operation. This may be right but there is no mechanism in place to verify the accuracy of the records.

At present, the only way to document actual hours of pump operation is to monitor engine hour-meters. However, there are very few pumping plants which are equipped with such meters. In the sampled schemes, five relatively new diesel engines were furnished with the meters. One such device was found out of order and remaining four engines with hour-meters were monitored over a period of one to two months during 1993-94. The resulting information is presented in Table 6 & 7.

Table 6. Actual and reported pump operation hours

Site	Reported		Monitored	
	Feb.	Mar.	Feb.	Mar.
K2	124	22	18.5	2.8
K4	354	191	304	171
D6	309		74.8	
D5	395		229	

It is important to note that the reported hours of pump operation are more than actual hour-meter readings. It is possible that all meters were not functioning right. However, this does not seem to be true as the referred plants are relatively new.

In any case, it is clear that the reported and actual hours of operation do not match as desired. At the same time, there exists no mechanism to verify the stated discrepancy either. So, this aspect of the system needs more attention to address the concern.

The daily pump operation ratios (DPORs defined by Equation 5), as presented in Table 7, are more than 1.0 by a small fraction to many folds. Such variation points to a level of over-reporting about hours of pump operation in the selected systems. If this over reporting is not confined only to the selected plants, the results points to a serious problem.

Table 7. Daily pump operation ratios (DPOR)

Site	DPOR	
	Feb.	Mar.
K2	6.7	7.86
K4	1.14	1.12
D6	4.14	-
D5	1.72	

III. Indices for the Comparison of Management Modes

(i) Comparative Index for Pumping-plant Performance (CIPP); This ratio is derived by dividing the average system performance of the private pumps with the average system performance of public pumps monitored during 1992-93 and 1993-94. Using optimum efficiency of 27.5 percent (as reported by Sam et al., 1992), the mean system performance for the private and public pumps results 33.9 and 28.5 percent, respectively. The CIPP ratio (given by Equation 6) based on these averages comes to 0.84. This implies that the system performance of small river-lift plants is 84 percent of the large pumps monitored.

However, the optimum system efficiency or target efficiency for small pumps (becuase of their design) is not equal to large pumps. As discussed earlier in this paper, the optimum efficiency is estimated to be 22.5 percent for small private river-lift systems. With the this target value, the resulting average performance of small pumping plants improves to 34.8 percent. The latter value makes the comparative performance of the private systems slightly (3 %) better than the public systems. This in spite the fact that the reported system efficiencies for the large pumps are based on the actual instead of reported diesel consumed.

Moreover, the selected agency-operated pumps are generally two to three years old whereas the private systems were installed more than 10 years back. This difference in the age of the plants is another variable which makes the comparison even more difficult.

(ii) Comparative Index for Diesel Consumption (CIDC):

This parameter is intended to compare diesel consumption per feddan of wheat for lifting water in the private and public domain. The relevant information collected during the current irrigation season, 1993-94, is presented in Figure 1.

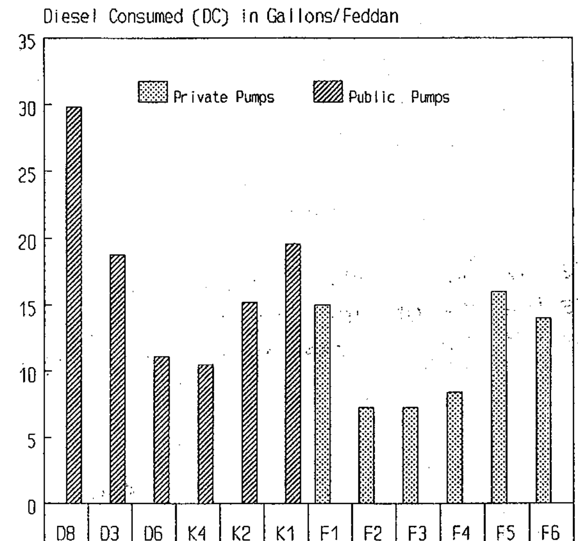
As shown in the referred figure, the diesel consumption for raising one feddan of wheat fluctuates very much. However, such fluctuations are more in case of the agency managed river-lift systems as compared to thse owned by the small farmers.

Based on the information displayed in Figure 1, the average diesel consumption per feddan of wheat in the public and private systems comes to 17.5 and 11.30 gallons, respectively. According to Equation 7, the CIDC ratio results to be 0.65. This low value of the parameter indicates that on an average the fuel consumption in the private domain is 65 percent of the one reported in the public sector.

The above conclusion does not seem to fit in a framework of the economy of scales. It is mainly because the private farmers do try to reduce fuel consumption by reducing the number of irrigations to be applied. Other reason may stem from the fact the fuel consumption for public systems is based on reported amounts which may be grossly exaggerated.

(iii) Comparative Index for the Pumped Volume of Water (CIPV):

This parameter compares volume of water lifted for one feddan of wheat under the two selected management modes. In case of public plants, reported hours of pump operation and measured flow rates are used to calculate total volume of water lifted from December 1993 to March 1994. By dividing the resulting volume with wheat area in feddan, volume of water in m^3/feddan is determined as displayed in Figure 2 for four agency operated systems.



	D8	D3	D6	K4	K2	K1	F1	F2	F3	F4	F5	F6
Private Pumps							15	7.2	7.2	8.4	16	14
Public Pumps	29.8	18.8	11.1	10.5	15.2	19.6						

Pumping Stations in the White Nile Area

Figure 1. Fuel consumption per feddan of wheat in public & private schemes

In case of private pumping plants, the pump running hours are determined on the basis of time required to irrigate one feddan and number of irrigations applied (information collected from private pump owners). Actual flow rates are used to derive total volume lifted for one feddan of wheat. Similar to public pump stations, the volume of water lifted for one feddan of wheat for each of four private pumping plants is also presented in Figure 2.

It can be noted that an average amount of volume pumped per feddan of wheat for four selected public schemes results 7350 m^3 or 14.6 mm/day[2]. The same average volume of lifted water for four private systems is found to be 3800 m^3 or 7.5 mm/day[3]. Hence CIPV ratio becomes 0.52 (as per Equation 8). This means that the private systems consumed almost half of the lifted volume of water as compared to the public schemes.

[2] based on 120 crop-days for wheat

[3] actual irrigation requirements for 1993-94 were 2.2, 5.4, 7.4 and 5.4 mm/day for December, January, February and March, respectively.

It is difficult to say that the actual water consumption per feddan of wheat in the two cases is going to remain same as reported. The author would like to add a note of caution as the reported hours of pump operation may not be very accurate. [This is clear from the overall supply rate of 14.6 mm/day to the actual irrigation requirements (based on 70 % overall irrigation efficiency) given in Footnote 3]. Other factor in this context is the tendency in the private sector to apply minimum possible number of irrigations to reduce the pumping cost whereas no such incentive exists in the public sector.

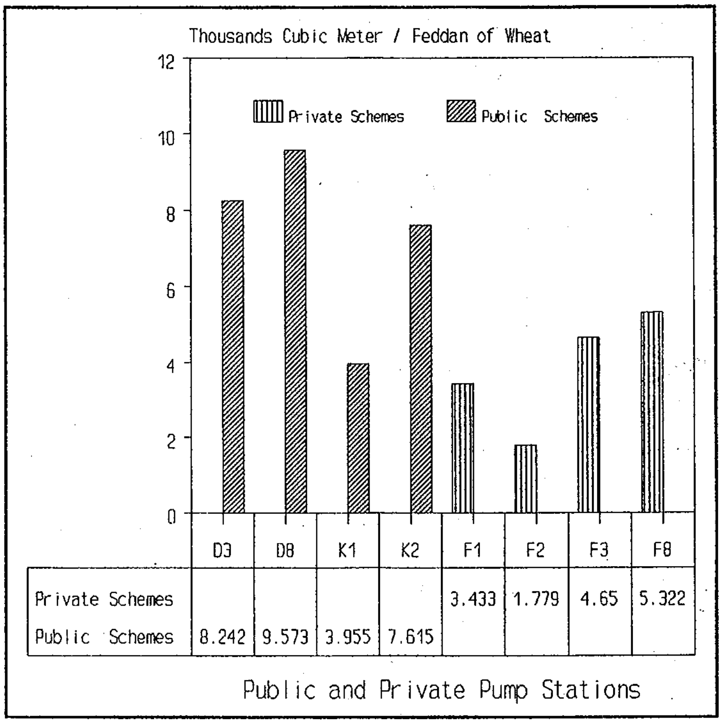


Figure 2. Volume of water pumped for one feddan of wheat

(iv) Comparative index for Water Charges (CIWC): This index is given by Equation 9 to compare price of water paid by the private farmers and water charges assessed for the public schemes. However, it is difficult to give one value of CIWC ratio. This is due the fact that in spite of the fixed water charges in public schemes, price of water for the farmers in the private sector varies depending upon the number of irrigations applied.

On an average, the private farmers tend to apply about 6 irrigations in the range of 4 to 8. There are not very many active water markets to determine an exact price for one irrigation. However, information from the field indicates that in the White Nile area the existing water price is around one thousand sudanese pounds per irrigation for one feddan of wheat.

Based on the above given background information, CIWC ratios are calculated. Depending upon the number of irrigations applied by the private farmers, various CIWC ratios are calculated and presented in Table 8. It is obvious that the private farmers are paying two to five times more for water as compared to their counter-parts in the public domain.

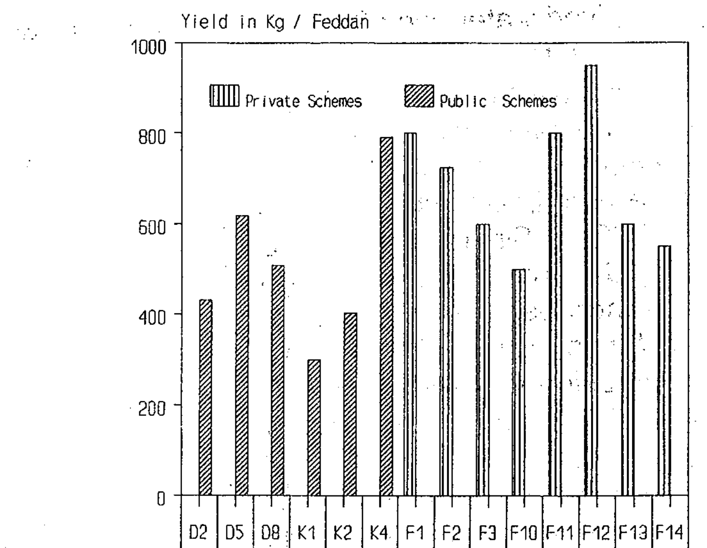
Table 8. Comparative index for water charges

Number of Irrigations	Water Price		CIWC Ratio
	Private	Public	
4	4000	1500	2.67
5	5000	1500	3.33
6	6000	1500	4.00
7	7000	1500	4.67
8	8000	1500	5.33

It is also important to note that in the sampled public schemes, the usual number of irrigations delivered varied from 6 to 9 during 1993-94. However, there is no mechanism to charge water based on number of irrigations which could provide incentive for an efficient water use.

(v) Comparative Index for Crop Yields (CICY): This parameter is derived by averaging yield data of wheat collected from six public schemes and eight small schemes served by private river-lift pumps. In case of agency-operated irrigation supply systems, a total number of randomly selected 162 farmers (about 27 from each scheme) were interviewed.

Based on the information gathered, average yields per feddan are calculated. Similar data concerning eight small private pump scheme were obtained also. Yield data about the wheat crop under two modes of management for water deliveries are displayed in Figure 3 (letter K and D stand for public schemes in Kosti and Dueim and F for farmers' systems).



	D2	D5	D8	K1	K2	K4	F1	F2	F3	F10	F11	F12	F13	F14
Private Schemes							800	725	600	500	800	950	600	550
Public Schemes	430	617	509	301	402	791								

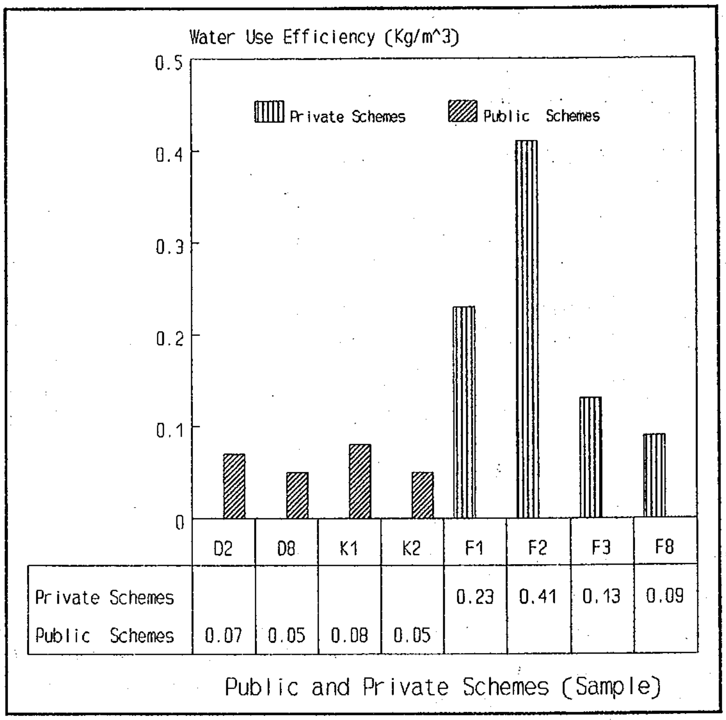
Figure 3. Average wheat yields in public and private pump schemes

As apparent from the sample data presented in the above referred figure, average wheat yields per feddan are relatively higher in case of small private schemes when compared with the large public schemes. Overall average yield per feddan for private and public schemes are 691 and 508 Kg /feddan, respectively. Hence, according to Equation 10, the CICY ratio comes to 1.36. This ratio implies that on an average, the yield in private scheme are 36 percent higher than those in the large agency-operated schemes.

(vi) Comparative Index of Water Use Efficiency (CIWUE): This is a good parameter to compare water use efficiency (WUE as defined by Equation 12) for wheat under the two management modes responsible for the lifting and supplying water to the farmers. From the sampled schemes, four public and four private schemes are selected because of the availability of needed data. The derived water use efficiencies for public as well as private schemes are exhibited in Figure 4.

An average WUE in public domain (based on selected four schemes) is 0.06. Similarly, average WUE for the four private schemes comes 0.22. Hence, CIWUE is derived by using Equation 11 to get 3.67. This implies that water productivity in case of the studied private small schemes is 3.67 folds higher than observed for the four public schemes.

Again, to some extent the drastic difference might have occurred because of "over-reporting" of pumping hours of operation in the public sector and incentive in the private domain to control the number irrigations to be applied.



	D2	D8	K1	K2	F1	F2	F3	F8
Private Schemes					0.23	0.41	0.13	0.09
Public Schemes	0.07	0.05	0.08	0.05				

Figure 4. WUEs for wheat crop in public & private schemes

Haq et al. (1993) have calculated WUE for wheat crop in the Gezira scheme. According to the referred authors, the WUE for wheat has varied from 0.1 to 0.46 with an average being 0.26. Comparing it with the data from the White Nile, the productivity of pumped water is drastically lower. When a recommended value of 1.0 for WUE is considered (Haq et al., 1993), it may be questioned if a sustainable and profitable wheat crop can be managed in Sudan.

CONCLUSIONS

Based on the findings of this study, following tentative conclusions can be drawn:

(1) *When the actual diesel consumption rates are used for deriving the system efficiencies, the results slightly favor the agency-operated instead of farmer-operated pumps. If, on the other hand, the reported diesel consumption rates are considered, the positions are reversed.*

(2) *If targets are adjusted appropriately for attainable system efficiencies regarding the small (private) and large (public) river-lift systems, the system performance becomes slightly better in the private domain.*

(3) *Only the diesel cost per feddan of wheat is many folds higher than the water charges assessed.*

(4) *Diesel consumption per feddan of wheat for the private pumping plants is almost two-third of the public systems (partly due to over-reported fuel consumption).*

(5) *Volume of water lifted per feddan by the farmers' pumps is about half of the amount supplied by the agency-operated large plants (one factor being the inflated hours of pump operation).*

(6) *Farmers in the private domain pay almost 3 to 5 times more for water as against their counter-parts under public management mode.*

(7) *Wheat yields of private farmers are significantly higher than those resulting under the other option.*

(8) *Water use efficiency for wheat is 2 to 3 times higher in case of privately owned river-lift systems as against the ones exist under public water supply domain (one reason being the exaggerated hours of pump operation).*

RECOMMENDATIONS

Based on the data presented in this paper, following are few tentative recommendations for consideration:

(1) *There seems to be a pattern of "over-reporting" about the diesel consumption rates and daily hours of pump operation in the public sector. Such an occurrence is depriving the Government and farmers from the benefits associated with the economy of scale favoring large pumping plants in the public sector. In this context, the following actions are recommended:*

   (a) *It may help the Government to provide only diesel to a group of farmers, say on tenancy level, and they should be charged accordingly. Public fuel storage should be managed in such a way that farmers can keep accounts of the fuel used for each irrigation.*

   (b) *Diesel provided for the public pumping plants should be of different quality / grade as compared with one used in automobiles.*

   (c) *Water charges (excluding the cost of the fuel used) should be based on the number of irrigations provided to farmers.*

(2) *Private management seems to perform better and present less financial liability for the Government. It is, therefore, recommended to plan and provide all the required support services for a successful completion of irrigation management transfer to the farmers.*

(3) *Mismatch between designed and actual use of the pumping plants, along with difficulties associated with repair and maintenance, might have pushed the system efficiency down. It is therefore recommended that in future proper pump selection should be done. Also, if possible, power source should be changed to electricity.*

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