Chapter 2

EVALUATION OF WATER SUPPLY AT THE MAIN IRRIGATION SYSTEM OF THE RAHAD SCHEME

Omer M. A. Elawad[4] and Salih H. Hamid[5]

2.1 INTRODUCTION

Irrigation water for the Rahad Scheme is pumped from the Blue Nile near Meina village east of Singa town and about 75 km. upstream of Sennar Dam. The pump station is equipped with eleven electrically driven units having a total capacity of 8.5 million cubic meters per day (105 m^3/sec.). From the pumping station, irrigation water is carried through a supply canal having a design capacity of 8.5 million cubic meters per day and runs for a distance of 81 km before it joins the Rahad seasonal river. Abu Rakham Barrage on the Rahad River is constructed some 500 m. downstream from the point where the supply canal joins the river. The objective of the barrage is to use part of the river flows to supplement the water pumped from the Blue Nile. From the barrage, the main canal of the scheme emerges to run for a distance of about 150 km in the north-western direction. From the main canal, water is supplied to some 8 major canals. Major canals supply minor canals, which in turn supply the field canals called Abu Ishreen.

At the main irrigation system level, water is scheduled on a demand basis, similar to the one used in the Gezira Scheme (i.e. water is supplied in response to demands of the Agricultural Officer of the Rahad Agricultural Corporation). The Agricultural Officer determines each week which field canals (Abu Ishreens) are to be opened in the coming week and submits his water demand (called ***Indent***) for each of the Minors to the Ministry of Irrigation (MOI) engineer in control of the area. The MOI engineer sums up the indent of all the Minors in the Major to form the indent at the head of the Major. The accumulated indent of all the Majors forms the indent at Abu Rakham barrage. Gates at the barrage and all the off-takes of the Majors and minors are then adjusted by the MOI engineers to pass the indent asked for in each minor.

In recent years, however, and due to various factors, there are claims that the operation method as described above is not strictly followed, in almost all the large scale irrigation schemes in the Sudan. On the part of the MOI, on one hand, there are complaints that supplies do not necessarily match the indent. On the part of the agricultural corporations, on the other hand, there are complaints that indents may not be related to the actual crop demands, but is rather reflection of the previous difficulties experienced with the MOI supplies.

In this paper the quality of irrigation water supply at different levels of the main irrigation system in the Rahad Scheme are examined. Some performance indices are defined and used in evaluating the

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[4]Senior Engineer of the Hydraulic Research Station, Wad Medani.

[5]Resident Engineer, Abu Rakham Barrage in the Rahad Irrigated Scheme.

performance of the system. The performance of the Rahad Irrigation System was also compared with that of the Gezira Scheme.

2.2 PERFORMANCE INDICES

In order to judge the quality of supply of an irrigation system, some indices must be defined and used to quantify the extent to which the supplies satisfy target levels. In this section, the indices employed in the analysis are defined. The first two indices were taken from Francis et.al. (1988) and the second two were adopted from Elawad (1991).

2.2.1 Indent/Crop Demand Ratio

This is a measure of the accuracy by which the agricultural officer estimates the indent. Clearly, the ideal value for this ratio is unity. Values larger than one indicate over indenting and values less than one, on the other hand, means under indenting.

2.2.2 Supplies/Indent Ratio

The MOI engineer may not always be able to respond exactly to the indent of the agricultural officer, or may decide to make some adjustment to that indent before giving authorization. This ratio is a measure of the level by which the engineer was able to satisfy the indent. The target value here is unity. Any value greater than one means over supply while values less than one means under supply.

2.2.3 Adequacy of Water Supply

The water supply is said to be adequate if enough water is being supplied to satisfy the Crop Water demands or Requirements (CWR). The water supply adequacy can be measured by the ratio of the supply to the CWR. Clearly, the target value is one. An adequacy of less than one means at least some areas were under stress for some time. An adequacy value of more than one means the supply is more than the requirement, which means some water is being lost without being effectively used. In fact, the reciprocal of the adequacy value can be taken as a measure of the efficiency by which water was used.

2.2.4 Equity

Equity is referred to as the difference in the quality of services provided by the irrigation system to different parts of the scheme. This difference is best measured by the difference in the adequacy by which water was supplied to different parts of the scheme rather than the difference in depth of water

supplied (Elawad 1991). Christiansen co-efficient (Christiansen 1942) which is the most widely used measure of equity or uniformity of distribution is adopted.

$$Equity = 100 \left[1 - \frac{\sum_{i=1}^{i=N} | a_i - A |}{NA} \right]$$

Where a_i = Adequacy at area i.
A = Average adequacy of all areas.
N = Number of areas.

2.3 ANALYSIS OF THE WATER SUPPLY

The indices described previously were used to evaluate the performance of the Rahad main irrigation system at three levels: (i) at the barrage headwork; (ii) at the major[6] canal level; and (iii) at the minor[7] canal level. Data for indents and water supplies were collected from the MOI records. For estimating CWR, however, data on areas of different crops and their sowing dates was collected from the Rahad Agricultural Corporation records. This data was used with the table of crop water requirements published by the Agricultural Research Corporation for the Gezira Scheme (Farbrother 1977) and the calculations were performed on a monthly basis.

In estimating CWR, the rainfall contribution and the canal open water surface evaporation losses were not taken into consideration. Good estimation of the rainfall contribution to the CWR requires consideration of the timing of the rainfall event with respect to the sowing date as the rain can only be useful if it falls on a cropped area. A consideration of the soil moisture condition is also required at the time of the rainfall event. This has not been done in this analysis because the objective here is to see how a simple approximate analysis, which can be conducted by the irrigation manager himself using the data routinely collected, can be useful.

However, proper evaluation of the effect of rainfall on the irrigation supplies through the use of soil moisture simulation models has been conducted for the Gezira Scheme (Elawad 1991). This analysis shows that on average rainfall contributes 14% of CWR. In the Rahad Scheme, the average rainfall is probably higher than in the Gezira. Moreover, in the Rahad Scheme, almost all the area is cultivated during the rainy season, and as such, has the chance to catch some rain. This is unlike in the Gezira Scheme where large areas are cultivated with wheat which is grown after the rainy season.

For these reasons, a 15-20% rain contribution to the CWR in the Rahad Scheme seems a reasonable estimate. The canal open water surface evaporation is considered the only transmission water loss in the Rahad Scheme which is estimated to be 5% of the supply as compared to 8% in the Gezira Scheme (Elawad 1991).

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[6]sub-main canals are called "Majors" in Sudan.

[7]secondary canals are called "Minors" in Sudan.

2.3.1 Supply at the Barrage Headwork (scheme level)

Abu Rakham Barrage is the point from which water supplies to the whole Rahad Scheme is diverted. Table 2.1 gives a picture of the level of performance at the scheme wide level for 10 seasons from 1981/82 to 1990/91 inclusive.

Table 2.1. Irrigation indents, supplies and requirements (billion m^3) at Abu Rakham (scheme level).

Season	Thousand Million m^3			IND/CWR	SUP/IND	(Adeq.) CWR	(Adeq.) for Gezira
	Indents	Releases	CWRs				
1981-82	1.295	1.305	1.422	0.911	1.008	0.92	1.08
1982-83	0.904	0.907	1	0.904	1.003	0.91	1.24
1983-84	1.415	1.405	1.334	1.061	0.993	0.95	1.16
1984-85	1.242	1.217	1.351	0.919	0.980	0.90	1.00
1985-86	1.322	1.31	1.326	0.989	0.999	0.99	1.15
1986-87	1.215	1.195	1.489	0.816	0.984	0.80	1.03
1987-88	1.236	1.219	1.453	0.851	0.986	0.84	1.39
1988-89	1.116	1.21	1.385	1.084	1.084	0.87	---
1989-90	1.091	1.1	1.4	1.008	1.008	0.79	---
1990-91	1.332	1.345	1.282	1.039	1.010	0.95	---
Average				0.91	0.995	0.89	1.15

As can be seen from Table 2.1, the water supplies are highly adequate and efficient. Assuming a 10-15% net contribution to the CWR from the rain minus canal evaporation, the indents and supplies agree very well with the CWR.

Table 2.1 also shows values of the adequacy of the water supply from Sennar Dam to the whole Gezira Scheme (Elawad 1991) for some of the seasons under consideration. Clearly, the adequacy in the Gezira Scheme is higher than that in the Rahad Scheme which means the water use efficiency in the Rahad is better. Although, the higher rainfall contribution in the Rahad have some effect on this but this result reflects the fact that the MOI is more conservative in supplying the more expensive pumped water in the Rahad than in the Gezira Scheme, which is irrigated by gravity.

2.3.2 Supplies at the Major Canals Level

Three majors were selected for analysis, Major 2 at the head, Major 4 at the middle and Major 7 at the tail of the irrigation system. Data on the total seasonal indent, irrigation supplies and CWR for the 1991/92 season are given in Table 2.2.

The table also shows some performance indices. Clearly, in the three majors, in spite of the over indenting, supplies reasonably match CWR which indicates that the MOI engineers make reasonable adjustments to the indents. It should also be noticed here that there is a clear decrease of adequacy with increasing distance along the main canal with an equity index of 0.94.

Table 2.2. Irrigation indents, supplies and requirements (thousand m^3) during 1991/92 at Major level.

Canal	Indent	Release	CWR	Ind./CWR	Sup/Ind.	Sup/CWR
Major 2	12,720	12,085	11,000	1.16	0.95	1.10
Major 4	4,184	3,077	3,140	1.33	0.74	0.98
Major 7	167,735	136,980	146,000	1.15	0.82	0.94
Average						1.01

2.3.3 Supplies at the Minor Canal Level

Six minors were selected for analysis, three minors from major 2 and three minors from major 4. In each of the two majors, the minors were selected such that, one from the head, one from middle and one from the tail of the major. Table 2.3 shows the data and indices for the selected minors.

Clearly, the level of adequacy at the minor level is much lower than that at the major canals level. It is also interesting to note that, in both majors, the level of adequacy in the minor increases with the distance along the major. This is an unexpected phenomena. Probably, this resulted from the increasing over indenting towards the tail of both majors as can be seen from the table.

Table 2.3. Irrigation indents, supplies and requirements (in thousand m^3) at Minor level.

Major	Minor	Indent	Sup.	CWR	Ind./CWR	Sup./Ind.	Sup./CWR
No. 2	Minor 6	4,890	4,945	5,050	0.97	1.01	0.98
	Minor 36	5,510	5,510	4,850	1.14	1.00	1.14
	Minor 41	10,050	8,900	7,000	1.44	0.89	1.27
No. 4	Minor 55	3,020	1,895	3,020	1.00	0.63	0.63
	Minor 56A	2,820	1,780	2,180	1.29	0.63	0.82
	Minor 56	3,005	2,130	2,320	1.30	0.71	0.92

2.4 CONCLUSIONS

(1) Simple approximate analysis of the data routinely collected in irrigation schemes can provide a powerful tool for the irrigation manager by giving him a good picture of the level of performance of his system and the direction in which he should move for improvement. Such analysis can also be used to compare the performance of two different irrigation systems, or the same system over time.

(2) Although the analysis conducted in this paper is approximate, as the rainfall and water losses are not properly taken care of, yet the results indicate that at the scheme wide level, the Rahad Irrigation System performs at high levels of adequacy and water use efficiency. At lower levels of the system, however, the levels of adequacy and water use efficiency differs widely between majors and between minors.

(3) There are varying levels of over indenting between individual minor and individual major canals. Because the indenting in different minors is conducted by different people, it seems that there is an element of personal judgement in estimating these indents.

(4) Equity between Minors in the Rahad Scheme is more evident than in the Gezira Scheme.

2.5 REFERENCES:

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