PERFORMANCE OF THE GEZIRA CANALS – REPORT BASED ON SECONDARY DATA (IIB)

By
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2. Gamusia Major (Middle Sub-main)

Gamusia Major is located 114 kilometers from Sennar dam (main source for the scheme). As Zanda Major, the head sub-main canal, and the Gezira main canal receive their supplies from a common pool located at Kilo 57, Gamusia Major is the first Major which receives its supplies from the first defined section of the main canal.

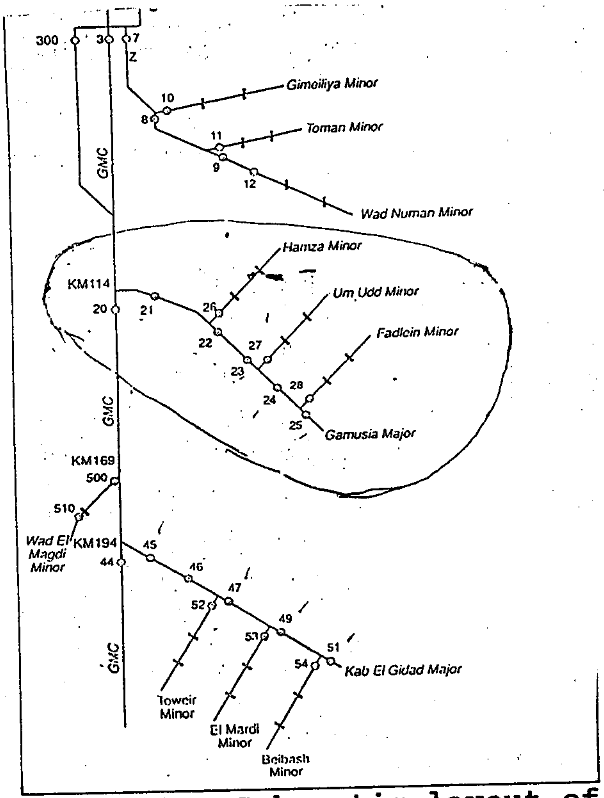

figure 3. Schematic layout of locations monitored along the Gezira main canal

According to the original report (TOR), the schematic layout of the system monitored during 1988-90 is presented in Figure 3. For control point and section-analyses, selected points (CP-21, CP-23 and CP-25) are shown in the schematic layout. This CP-system is similar to the head Major. However, the middle Major has data for almost all control points (21 to 25) which will be used for an analysis based on reaches. Figure 10 is another schematic display which defines all reaches of the Major.

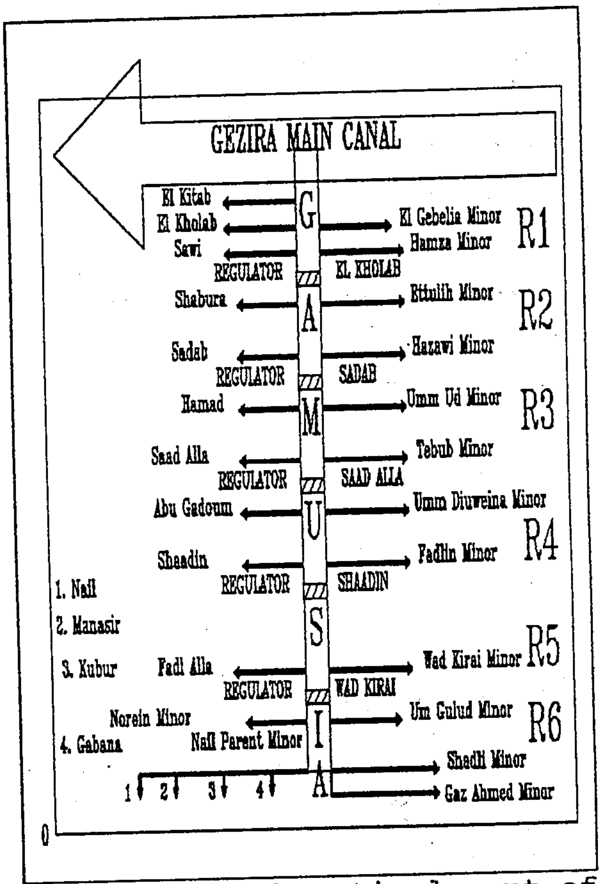

Figure 10. Schematic layout of Gamusia Major

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Adam (1989) has also reported monitoring results of the middle Major. This study was conducted during the irrigation of 1988-87. Although these data are not as comprehensive as those presented in TOR (1990), the information can still provide useful comparison by adding one more season.

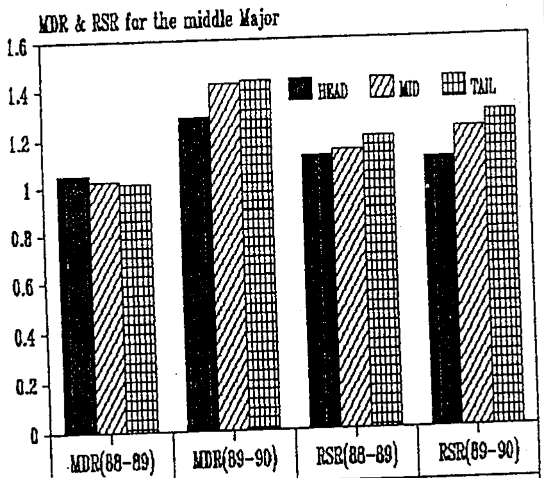
a. **Analysis According to Control Points (CP-analysis) & Discussion**

As stated earlier, the performance indices determined at the head control point represent average conditions for the entire command area (19002 ha or 45242 feddans) of a selected sub-system. However, this assumes that water distribution beyond the first control point will be equitable which may not hold true in most of the cases. This becomes evident when the indices are computed at the middle and tail control points serving their fractional command areas (13728 ha or 32684 feddans and 7301 ha or 17384 feddans respectively). To minimize this discrepancy, the indices for individual points are calculated by equations given in Appendix A and overall or mean values of these indices for a selected system are derived using equations given in Appendix B (information reproduce from Vol. 3).

According to CP-analysis, only MDR (management delivery ratio) and RSR (relative supply ratio) values are determined based on data collected during 1988-90 (two irrigation seasons). The resulting information is presented in Fig. 11.

In terms of MDR, the sub-main canal shows almost an even water distribution during the period. Although MDR numbers are around 1 during the first monitoring season, values for the same index range from 1.29 to 1.43 during the second period. In the first case, the MDR related numbers lie in a narrow band. However, latter data set shows supply being 29 to 43 percent more than required amounts. If +/- 10 percent is accepted to be a yardstick, first year shows good performance; however, same can not be said for the second monitoring period.

It is also interesting to note a significant increase in the value of MDR from 1988-89 to 1989-90. The reported upward jump is a function of two factors: (i) an overall excess supply of 2.5, 12.9 and 13.3 percent, and (ii) drop in water requirements by 4.1, 6.1, and 7.2 percent at head middle and tail points of the Major respectively. If supplies go up when water demand moves down, as is the case reported above, then one may have to rethink about the current practices of decision-making regarding the water distribution in the scheme.



	MDR(88-89)	MDR(89-90)	RSR(88-89)	RSR(89-90)
HEAD	1.05	1.29	1.12	1.1
MID	1.02	1.42	1.14	1.23
TAIL	1.01	1.43	1.2	1.3

Water Distribution along Gamusia Major

Fig. 11. Performance indices at selected control points

The index of RSR is to show relationship between supply at a selected point / section or reach to the one available at the head of the main canal level. Values of RSR higher than 1 indicate relatively excess supply at a picked level and vice versa.

As shown in Fig. 11, the values of RSR are more than 1 during both monitoring seasons. During the first period (1988-89), the excessive supply ranges from 12 to 20 percent; it jumps to 10 to 30 percent in the following period (1989-90).

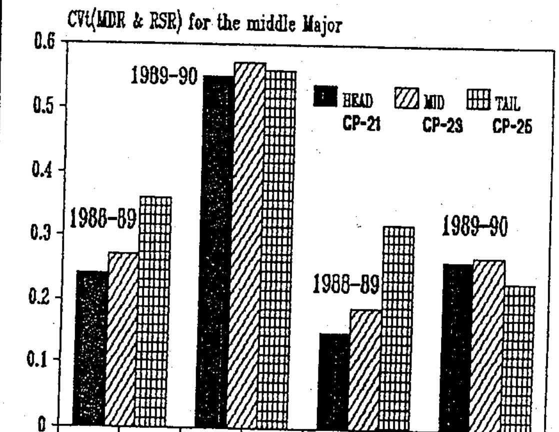
The above stated changes in RSR have been caused due to relative increases or decreases of water supplies at the main and the Major levels. At main system, water supply in the second period increased by an average of 5.2 percent. Whereas, the corresponding increases in water supply at the Major level were to be 2.5, 12.9 and 13.3 percent at head, middle and tail control points respectively. Such differences at these levels explain how an inequity in water distribution develops.

The values of adequacy index, P_A (Appendix A), are 0.93, 0.90, 0.86 for 1988-89 and 0.93, 0.93, 0.96 for 1989-90 at control points located at head, middle and tail of the Major. This shows, as in the case of head Major, a significant jump in the value of MDR from an average value of 1.03 in the first year to 1.38 in the following year brought a small change in the value of P_A from 0.90 to 0.95. It is evident that a striking upward change in MDR in the second period causes jump in the over-supply from 14.6 to 43.5 percent at the Major level (over-supply is calculated by Eq. 7 in Vol. 3 of this newsletter).

In order to evaluate dependability of water supplies at a specific location or a control point, R parameter in Eq. 2 (Appendix A) is taken as 1. For each control point the coefficient of variation, either CV_T(MDR) or CV_T(RSR), is determined.

The resulting values of the coefficient are tested according to a criterion suggested by Molden and Gate (1990) for evaluating the dependability of water distribution at a particular control point.

Figure 12 displays information about index of dependability for head, middle and tail control points over the two irrigation seasons. The figure also provides comparison between CV_T(MDR) and CV_T(RSR) over the monitoring period.



	CVt-MDR(1)	CVt-MDR(2)	CVt-RSR(1)	CVt-RSR(2)
HEAD	0.24	0.55	0.15	0.26
MID	0.27	0.57	0.19	0.27
TAIL	0.36	0.56	0.32	0.23

Water Distribution along Gamusia Major

Fig. 12. Dependability index at selected control points

Comparison of P_Ds (= CV_T(MDR or RSR) for R = 1 in Eq. 2 of Appendix A) shows that almost all values are o.2 or more during the both years of monitoring. The only exception in this case is the CV_T(RSR) at head and middle of the Major being equal to 0.15 and 0.19 respectively during the first monitoring period.

The index of dependability based on MDR got bad to worse as the monitoring progressed from 1988-89 to 1989-90. This implies that efforts related to a reliable water delivery as per crop water requirement are not satisfactory. However, as the values of MDR are mostly more than 1, perhaps the high level of variability may not play havoc in the planning process of crops by the tenants of the scheme (such a planning is done by the SGB / GOS anyway).

The values of the parameter for dependability based on RSR, as exhibited in Fig. 12, are also less than desired. However, these values do not go beyond 0.32 and with little attention the index can be brought in good or fair range. In relative terms also, P_D(RSR) is better than P_D(MDR). This indicates that water supplies are relatively more reliable when distribution is merely based on available water in the system with no adjustments or consideration for crop water requirements.

Comparison of head and middle Majors in terms of dependability of water deliveries is also appropriate to be considered. From Fig. 7 (Vol. 3 of this newsletter) shows that in case of head Major the values P_D(MDR) all fell in an unsatisfactory range. Same is true for middle Major too. However, there middle Major has slightly higher variability. When similar comparison is extended to the derived values of P_D(RSR), the difference is even more vivid. According to the criteria being followed, P_D(RSR) lies in fair range for head Major whereas the same index shows unsatisfactory level for the middle Major.

As discussed in case of head Major, for individual points the parameter of equity, P_E, can not be calculated. However, this parameter will also be determined at a stage of overall evaluation of the middle Major.

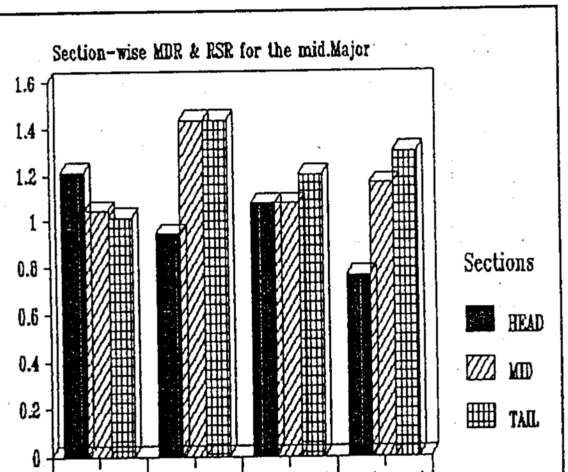
b. **Analysis According to Sections (Section - analysis) & Discussion**

A "reach" in the context of irrigation conveyance system can defined as a stretch between two control structures along a canal. Whereas a section of a canal is a stretch of a canal which may contain one or more than one reaches. After analyzing data according to control points, the performance of middle Major will be evaluated according to its head, middle and tail sections. In case of Gamusia Major, the canal stretch from control point # 21 to Control Point # 23 (Fig. 3) constitutes the head section. The middle section consists of canal span that lies between Control Points # 23 and 25. The remaining length of the Major below Control Point # 25 is the third and tail section of the canal.

The total service area of the Gamusia Major is 19002 ha (45242 feddans). The command area served by the head section is 5274 ha (12557 feddans). The middle section commands 6462 ha (15301 feddans). The remaining area (7301 ha or 17384 feddans) receives its supplies from the tail section.

The performance of the middle Major according to sections is also described by two indices: (1) management delivery ratio or MDR, and (2) relative supply ratio or RSR. Figure 13 displays results for two irrigation seasons monitored during 1988-89 and 1989-90.

The section-analysis shows that in the first monitoring period the values of MDR for head, middle and tail sections are 1.21, 1.04 and 1.01 respectively. For the same period, an average management delivery ratio of 1.05 for the entire Major, MDR ratio at head according to CP-analysis, is shared among the sections as described above. In this case, the head section gets 21 percent more supplies than required



	MDR(88-89)	MDR(89-90)	RSR(88-90)	RSR(89-90)
HEAD	1.21	0.94	1.07	0.76
MID	1.04	1.43	1.07	1.16
TAIL	1.01	1.43	1.2	1.3

Water Distribution along Gamusia Major

Fig. 13. Performance indices for selected sections

whereas the middle and tail sections almost get right amounts of water.

During the second year, 1989-90, the values of MDR are 0.94, 1.43 and 1.43 for the head, middle and tail sections. This distribution is against an average MDR of 1.29 estimated according to CP-analysis for the Major during the second year. It is interesting to note that in the latter case the middle and tail sections received 43 percent more supplies than estimated crop water requirements; whereas the head section got 6 percent less supplies than what was needed.

A careful look indicates a contradictory happening: (1) in the first period the head section gets supplies more than required relative to other two sections, and (2) during the following season the head section receives less than other two section when compared with crop water needs. Although there was an increase in overall supply from 1988-89, the above changes can not entirely be explained by this phenomenon alone. Moreover, the share of middle Major from 5.2 percent increase at the main canal was only 2.5 percent. Main reason for the reported reversal at the head section is that in the second monitoring year the supply to head section got reduced by 26.2 percent and crop water requirements went up by 2.5 percent only. Whereas in the second year, for the middle and tail sections the supplies went up 12.3 and 13.3 percent and requirement went down by 4.8 and 7.2 percent respectively. This also shows that canal operations need more scientific base for making decision regarding water distribution along the Major.

The index of adequacy, P_A, is calculated according to Eqs. 1a, 1b and 1c. During the first monitoring year, the values of the parameter were 0.88, 0.89 and 0.86 for head, middle and tail sections respectively. As per criteria proposed by Molden and gate (1990), the adequacy level falls in a fair category. For the second year these values were 0.80, 0.93 and 0.96 in the order stated above. In this case, the adequacy for middle and tail sections is good. However, this level was marginally fair for the head section for the reasons described earlier.

One important point to observe is that in spite of an overall increase of MDR from 1.09 in 1988-89 to 1.27 in 1989-90 the value of P_A changes only from 0.88 to 0.90. However, the increase mainly appears in over-supply ratio (OSR) which can estimated by the Eq. 7 given in Vol. 4 of this newsletter:

$$OSR = \left[\frac{MDR - P_A}{P_A}\right] \quad ------ \quad (7)$$

According to this relationship, an average OSR was found 24 percent in

1988-89 which increased to 41 percent in 1989-90. Distribution of OSR for each section is also merits reporting. During the first monitoring year, these ratios in percent for head, middle and tail sections were 38, 17 and 17 respectively. In the following period, these ratios in the same order resulted as 18%, 54% and 49 %. Considering the special nature of surface irrigation, some over supply is unavoidable. However, irrigation researchers and managers have to agree to certain levels of over supply acceptable for surface irrigation. For the time being, following yardstick can be used:

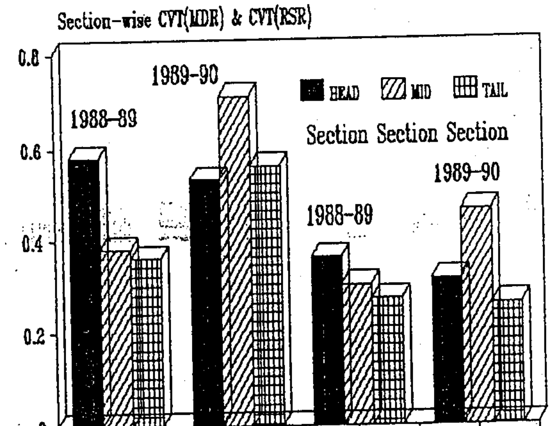
0.0 - 10 %	Good Category
>10 - 20 %	Fair Category
>20 %	Unsatisfactory Category

Based on the criterion suggested, one can easily classify the levels of performance for different section over the two monitoring seasons.

Figure 13 also presents section-wise relative supply ratios (RSR) over the two monitoring seasons. According to the data displayed, Gamusia Major received supplies more than its due share by 7, 7 and 20 percent at the head, middle and tail sections respectively during 1988-89. These numbers were estimated by comparing available supplies at Major level to average supplies monitored at the head of the main Gezira canal. During the second year, the head and middle section again received more than their due share by 16 and 30 percent. However, the head section of the Major during the second period realized supplies 26 percent less than its potential share based on available water at the main Gezira canal as compared to 7 percent more in the preceding year. In 1989-90, this happened due to an increase by 5.2 percent at the main canal and reduction by 26.2 percent for the head section when compared with previous season.

Another parameter of performance, P_D, is defined by Eq. 2 (Appendix A). However, this index of dependability for individual sections is calculated by considering R (region or locality) equal to 1 in the referred equation. So, accordingly Eq. 2 reduces to CV_T(MDR or RSR or any other such ratios). Based on the availability of data, Figure 14 presents the values of CV_T(MDR) and CV_T(RSR) for different sections monitored during 1988-89 and 1989-90. These values are not very promising in terms of dependable supply for each section.

Section-wise CVT(MDR) & CVT(RSR)



	CVT-MDR(1)	CVT-MDR(2)	CVT-RSR(1)	CVT-RSR(2)
HEAD	0.58	0.53	0.36	0.31
MID	0.36	0.71	0.3	0.46
TAIL	0.36	0.56	0.27	0.26

Water Distribution along Gamusia Major

Fig. 14. Dependabilty indices for selected sections

Farmers are always concerned with the existing level of dependability for water supplies while planning their crops. However, in case of regimented agriculture the planning is beyond the control of farmers; it rests with the officials of government / corporations. In this context, there is real possibility that the existing level of dependability for water supply in an irrigation season may not be viewed with the same concern as the tenants or farmers will do. Perhaps officials are going to assume a more dependable water supply at their planning stage. This is evident from the figures of abandoned cropped areas in the middle of irrigation seasons.

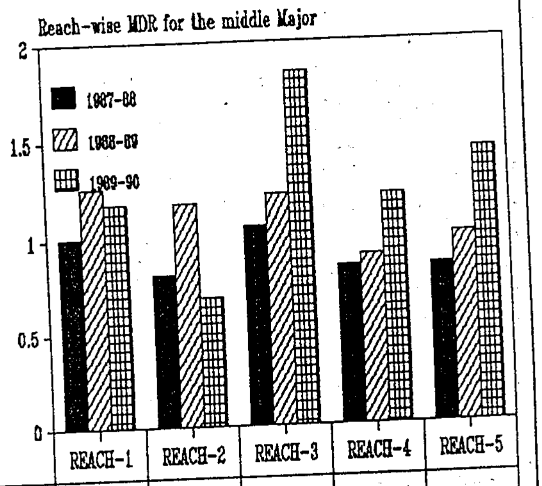
When head, middle and tail locations are considered (R = 3 in Eq. 2), the resulting parameter of dependability, P_D, for the Major based on MDR is 0.44 and 0.60 for 1988-89 and 1989-90 respectively. Using the evaluation standard proposed by Molden and Gate (1990), performance in terms of P_D is not satisfactory. Also the index gets bad to worse as monitoring results of the first year are compared with those of second year. Similarly, the average values of P_D calculated based on RSR are 0.31 and 0.34 in the above stated order. In this case also, the index falls in the unsatisfactory class. However, it is relatively better as compared to the one based on MDR.

c. <u>Analysis According to Canal-reaches (Reach-analysis) & Discussion</u>

A canal-reach is a basic unit for water distribution within a conveyance system. Defined by consecutive control structures, Figure 10 shows six reaches for the Major. The availability of data had made possible to extend the analysis to another level: analysis based on reaches. As flow at the tail control point, Wad Kirai regulator, was not monitored during 1988-90, the last two reaches, R5 & R6, are combined into one. So, the stretch of the middle Major beyond "Wad Kirai" regulator is a section instead of a last reach. However, for convenience and to avoid confusion this stretch is still termed as last reach or Reach-5 (actually same as tail section).

Out of total command area of 19002 ha (45242 feddans), the reach-wise area distribution at middle Major is given as follows:
Reach - 1: 2565 ha (6106 Feddans)
Reach - 2: 2709 ha (6451 Feddans)
Reach - 3: 3475 ha (8274 Feddans)
Reach - 4: 2981 ha (7027 feddans)
Reach - 5: 7301 ha (17384 feddans)
These differential areas will be used later on to calculate adjusted performance parameters by using equations given in Appendix B.

The performance of the middle Major in terms of management delivery ratio (MDR) can also be compared for three years: (i) 1987-88, (ii) 1988-89, and (iii) 1989-90. Data for the last two years is extracted from the original report - TOR (1990) and information for 1987-88 is deduced from Adam (1989). The graphic presentation of the ratios for referred three years is displayed in Fig. 15-A.



	REACH-1	REACH-2	REACH-3	REACH-4	REACH-5
1987-88	1.01	0.81	1.06	0.84	0.84
1988-89	1.26	1.18	1.22	0.9	1.01
1989-90	1.18	0.69	1.84	1.21	1.43

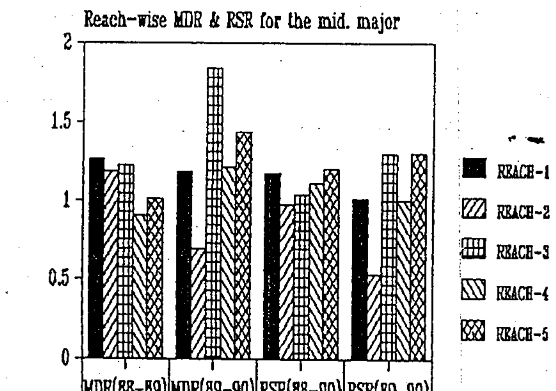
Water Distribution along Gamusia Major

Fig. 15-A. Performance indices for selected reaches

Important point to note is that there is general trend of higher and higher MDR values as the monitoring season progressed. Perhaps the monitoring factor caused the supplies to go up each year at cost of other Majors of the main canal.

As the data reported by Adam (1990) was collected during November and December 1987, it can not be utilized for deriving other indices of performance to compare with the following two years. For proper comparison, therefore, only the data collected on intensive basis during 1988-89 and 1989-90 are used for additional analyses and discussion.

Like the earlier description of performance indicators, the reach-analysis revolves around two indices: (i) MDR, and (ii) RSR. Figure 15-B provides information about these ratios based on data collected during 1988-89 and 1989-90.



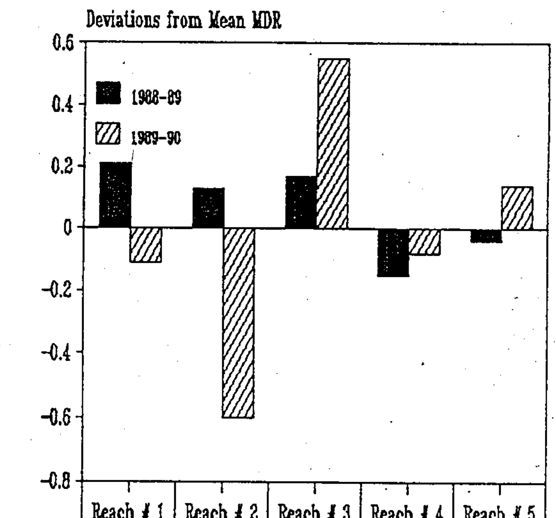
	MDR(88-89)	MDR(89-90)	RSR(88-90)	RSR(89-90)
REACH-1	1.26	1.18	1.17	1.01
REACH-2	1.18	0.69	0.97	0.53
REACH-3	1.22	1.84	1.04	1.29
REACH-4	0.9	1.21	1.11	1
REACH-5	1.01	1.43	1.2	1.3

Water Distribution along Gamusia Major

Fig. 15-B. Performance indices for selected reaches

As displayed above, during 1988-89 the MDR for various reaches ranges from 0.9 to 1.26 compared with the values in following year which vary from 0.69 to 1.84. In the first case, difference between the maximum and minimum seasonal values of MDR is 0.36 as compared to 1.15 in the following year. Such differences are indicators of the status of water distribution at the Major level.

It is interesting to note that by breaking the system into its basic water distribution segments, the MDR-values which appear to be very uniform under CP and section analyses are in real sense far from being so. Referring back to figure 11, average values of MDR for the entire command of the Major during 1988-89 and 1989-90 were 1.05 and 1.29 respectively. In order to show non-uniformity of water distribution at reach-basis, Fig. 16 is presented to show reach-wise deviations from the referred average MDR-values.



	Reach # 1	Reach # 2	Reach # 3	Reach # 4	Reach # 5
1988-89	0.21	0.13	0.17	-0.15	-0.04
1989-90	-0.11	-0.6	0.55	-0.08	0.14

Water Distribution According to Reaches

Figure 16. Non-uniform water distribution on reach-basis

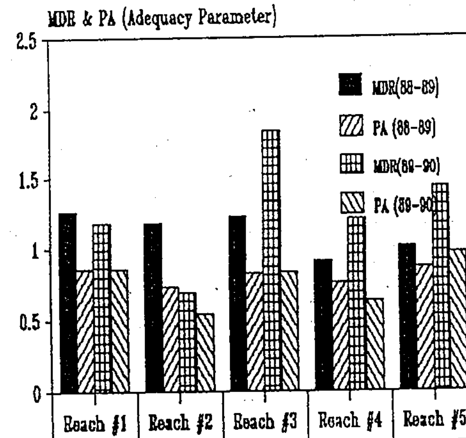
The values of reach-MDR as given in Fig. 15-B when averaged are 1.11 and 1.27 for the first and second monitoring years. However, when respective command areas are used as weights, the resulting numbers are almost same as derived at the head control point.

The reach-wise deviations displayed in Fig. 16 have resulted either of the following reasons: (i) increase / decrease in supplies, (ii) rise / reduction in crop water requirements, (iii) joint impact of items (i) and (ii). For example, in 1989-90 a very low value of MDR for Reach #2 (0.69) is mainly because of 44.5 % reduction in supply over the previous year. Similarly, in the same period Reach #3 received 32.5 % more supplies and reduction in demand by 1.9 % over 1988-89 for positive difference 0.55 (MDR = 1.84).

Obviously, the first two techniques, CP and section analyses, suffer from "lumping-factor". However, such a lumping effect is much more evident in case of CP-analysis as compared to the evaluation based on sections. For determining actual water distribution at any level of conveyance system, it is therefore preferable to use reaches being basic units.

The management delivery ratios are used as intermediate inputs to determine adequacy parameters, P_A. The values of reach-wise adequacy index are derived using Eqs. 1a to 1c and presented in Fig. 17 along with respective MDR for comparative purposes. As clear from the figure, there is very significant difference between the management delivery ratio and adequacy parameter for individual locations. Such a difference is presented in Figure 18 in terms of over supply ratio (OSR) as determined by Eq. 7. As per the information in the latter figure, OSR ranged from 17 to 62 percent and 28 to 101 percent in 1988-89 and 1989-90 respectively.

According to criterion proposed about OSR in this article, there were only two reaches in 1988-89 which fell in fair category; rest of the reaches



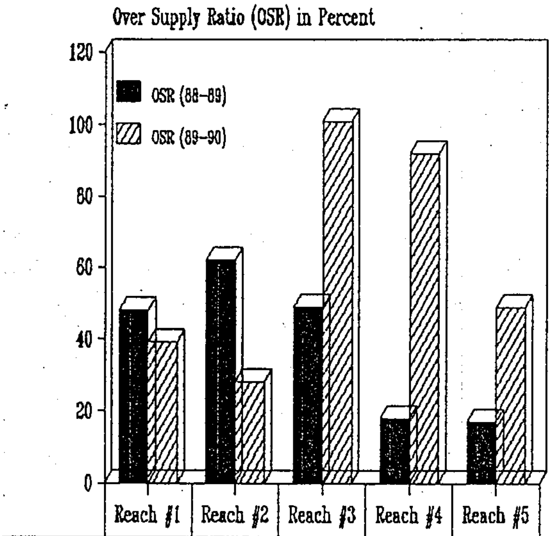
	Reach #1	Reach #2	Reach #3	Reach #4	Reach #5
MDR(88-89)	1.26	1.18	1.22	0.9	1.01
PA (88-89)	0.85	0.73	0.82	0.76	0.86
MDR(89-90)	1.18	0.69	1.84	1.21	1.43
PA (89-90)	0.85	0.54	0.83	0.63	0.96

Reaches of the Middle Major (Gamusia)

Figure 17. Management delivery ratios & adequacy parameters

showed unsatisfactory level in this context. Had the crop water requirements been matched better, difference between MDR and P_A would have been minimized. Management efforts when directed to bridge such gaps, P_A may approach to corresponding values of MDR and with minimized OSR.

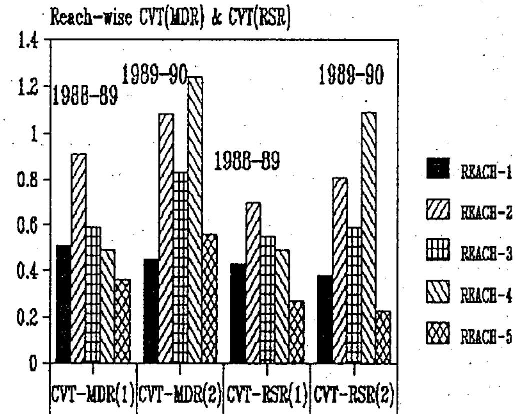
With Reach-analysis, the relative supply ratio (RSR) ranges from 0.97 to 1.20 and 0.53 to 1.3 during 1988-90 and 1989-90 respectively. Simple average values of RSR for the referred period are 1.10 and 1.03; however, weighed mean on command area basis in both cases is 1.12. This implies that the Major on average received 12 percent more supply if due share was determined on command area basis at the head of Gezira main canal. Another important point to consider is that in spite of 12 percent extra supply, Reach #2 received only 53 percent of its due share defined earlier. This seasonal change occurred because in the second monitoring period the supply to Reach



	Reach #1	Reach #2	Reach #3	Reach #4	Reach #5
OSR (88-89)	48	62	49	18	17
OSR (89-90)	39	28	101	92	49

Canal Reaches of Gamusia Major

Figure 18. Reach-wise over supply ratios



	CVT-MDR(1)	CVT-MDR(2)	CVT-RSR(1)	CVT-RSR(2)
REACH-1	0.51	0.45	0.43	0.38
REACH-2	0.91	1.08	0.7	0.81
REACH-3	0.59	0.83	0.55	0.59
REACH-4	0.49	1.24	0.49	1.09
REACH-5	0.36	0.56	0.27	0.23

Water Distribution along Gamusia Major

Fig. 19. Dependabilty index for selected reaches

#2 dropped 44.5 percent and increase in the supply of main canal was 5.2 percent over the previous year. This also shows that the average values may appear very satisfactory but not enough to tell the whole story; they reveal only half truth. To understand water distribution at selected level fully, the values based on units; control points, sections and reaches are essential.

At the next, the performance of the Major is discussed in terms of dependability index, P_D. This parameter id defined by Eq. 2 as reproduced in Appendix A. However, the parameter for a particular locale is a temporal coefficient of variation, standard deviation divided by mean (CV_T(MDR or RSR, etc). With reference to Eq. 2, for a locality under consideration region R is taken equal to one. For the selected reaches of the Major, Fig. 19 displays CV_T(MDR) and CV_T(RSR) for the two monitoring irrigation seasons of 1988-89 and 1989-90.

Lower values of the parameter are important for effective planning of area under crops. It is even more crucial to know about the dependability of water supplies when areas to be planted are planned and enforced by a centeral authority / parastatal agency. It is not difficult to comprehend the extent to which things could go wrong with high level of unreliability of irrigation supplies.

In terms of MDR, the temporal coefficient of variation ranges from o.36 to 0.91 in the first season and 0.45 to 1.24 in the second season. Referring again to the standard proposed by Molden and Gate (1990), the resulting values of the index being more than 0.20 indicates an unsatisfactory level of dependable supplies.

Similarly, CVT(RSR) varies from 0.27 to 0.70 in 1988-89 and 0.23 to 1.09 in 1989-90. Using the adopted yardstick of performance, all values of CV_T(RSR) fall in the unsatisfactory class. The Fig. 19 also shows that the trend established by other CP and Section analyses still holds i.e., the resulting numbers show that reliability of irrigation supplies gets worse in the second monitoring season.

d. <u>Comparative Analysis for Overall Performance</u>

Methods used for data analysis are as follows: (i) Cp-analysis, (ii) Section-analysis, and (iii) Reach-analysis. Description about each type of analysis has already been provided in the preceding sections. At this stage, weighted seasonal averages in terms of MDR and RSR will be calculated and compared with each other. Moreover, coefficients of variation under each category will also be averaged on similar lines for comparison purposes. This exercise is also intended to show that there is lot more to be added beyond the stage at which the authors of TOR(1990) finalized their findings.

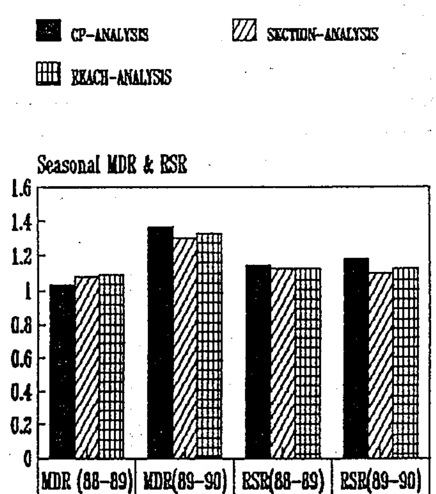
Seasonal weighed averages of MDR, RSR, CV_T(MDR) and CV_T(RSR) are calculated using following relationship:

$$\overline{PRAM} = \frac{\sum_{i=1}^{i=n} PRAM_i \times A_i}{\sum_{i=1}^{i=n} A_i} \quad ---- (8)$$

where
"PRAM" stands for any above stated parameter, A_i is the command area below an ith control point or command area served by a ith section or reach as the case may be. Also, PRAM with bar is used for an average seasonal parameter.

The above relationship is used to derive seasonal values for MDR, RSR and CV_T(MDR or RSR). The resulting information is then presented in Figs. 20 and 21.

For the three methods of data analysis, Fig. 20 displays seasonal averages of MDR and RSR over the monitoring period of two irrigation seasons. It is interesting to see that the resulting averages under each method are not too different. Standard deviations range from 0.01 and 0.04. This should prompt to question the logic to extend analysis to sections and reaches whereas CP-analysis, as used in the original source report, gives almost the same results. In this particular context, answer is that there was no need to apply other two techniques. However, in this article the indices like MDR, RSR, SIR, etc., serve only as intermediate inputs for determining parameters for adequacy, dependability and equity. As it will become clearer in the following sections, the additional techniques do have their utility.



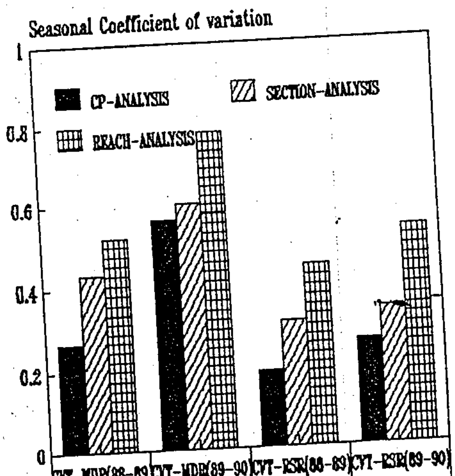
	MDR (88-89)	MDR(89-90)	RSR(88-89)	RSR(89-90)
CP-ANALYSIS	1.03	1.36	1.14	1.18
SECTION-ANALYSIS	1.08	1.3	1.12	1.1
REACH-ANALYSIS	1.09	1.33	1.12	1.12

Average Indices at Gamusia Major

Fig. 20. Comparison of 3 methods adopted for data analysis

Figure 21 illustrates average

seasonal coefficients of variation based on intermediate inputs such as MDR and RSR over the two years. As clear from the display, each technique provides noticeable differences in the resulting values for the same coefficient. The Cp-analysis gives lowest values and reach-analysis provides maximum variations. The Section-analysis falls in between the ones estimated with other two techniques. It seems logical as the CP-analysis is influenced by lumping factor. Similarly, the Section-analysis which is based on more than one reach can have relatively smoothing effect. However, this effect will be of lesser degree as compared to CP-analysis. Among the three methods, Reach-analysis is preferable for pinpointing those reaches having serious water distribution problems. For example, Reach #2, stretch lying between El Khilab and Sadab regulators (Fig. 10).



	CVT-MDR(88-89	CVT-MDR(89-90	CVT-RSR(88-89	CVT-RSR(89-90)
CP-ANALYSIS	0.27	0.56	0.19	0.26
SECTION-ANALYSIS	0.43	0.6	0.31	0.34
REACH-ANALYSIS	0.52	0.78	0.44	0.53

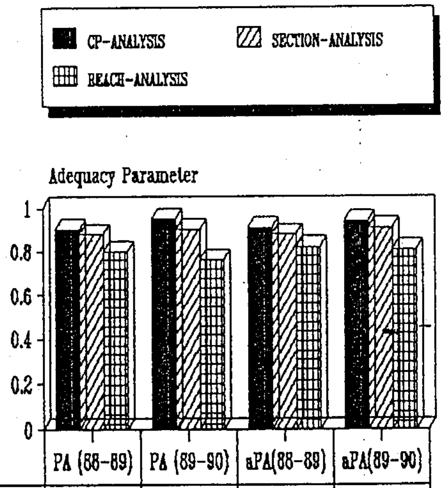
Average Indices at Gamusia Major
Fog. 21. Comparison of 3 methods adopted for data analysis

As evident from the information provided in the above figure, there is 40 to 100 percent differences for the same coefficient derived using different methods. The temporal coefficient when averaged over region becomes P_D as given by Eq. 2 or 5 in Appendices A & B. Such a temporal variation also suggest that spatial coefficient of variation averaged over time, P_E, may also vary with these three techniques applied for data analysis. Also, such marked differences suggest that the parameter for adequacy, P_A, as defined by Eq. 1 or 4 may follow the same trend to some extent (it is evident from Figs. 17 & 18 also).

As hinted above, the overall performance in terms of adequacy, dependability and equity is compared and evaluated under the three alternatives applied in this paper. The parameters of adequacy and dependability have also been adjusted by using Eqs. 4 & 5 as given in Appendix B. However, after finding no significant change in the adjusted and unadjusted values of P_A and P_D, no effort was made to apply EQ. 5 for P_E.

Following Fig. 22 presents adequacy parameter for the Major over the monitoring period. Application of the yardstick proposed by Molden and Gate (1990), the adequacy lies in good range if CP-analysis is considered. Under the section-analysis, the adequacy parameter lies at the boundary of the suggested ranges for good and fair levels. The third option used for data analysis, Reach-analysis, puts the adequacy status of Major in between the unsatisfactory and fair ranges. Canal reaches being the basic units for water distribution, the last evaluation will be assumed relatively more realistic.

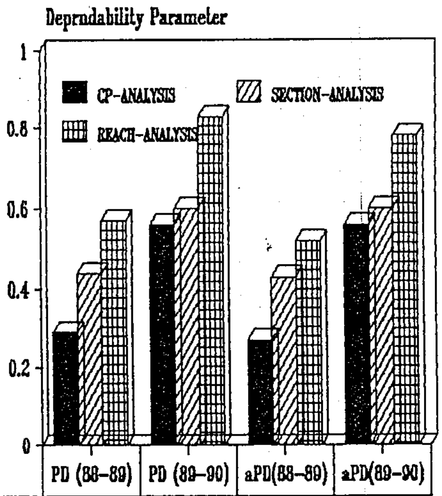
Figure 23 presents parameter of dependability for the referred duration. As evident from the referred illustration, the parameter



	PA (88-89)	PA (89-90)	aPA(88-89)	aPA(89-90)
CP-ANALYSIS	0.9	0.95	0.91	0.94
SECTION-ANALYSIS	0.88	0.9	0.88	0.91
REACH-ANALYSIS	0.8	0.76	0.82	0.81

Adequacy Status at Gamusia Major

Fog. 22. Comparison of 3 methods adopted for data analysis



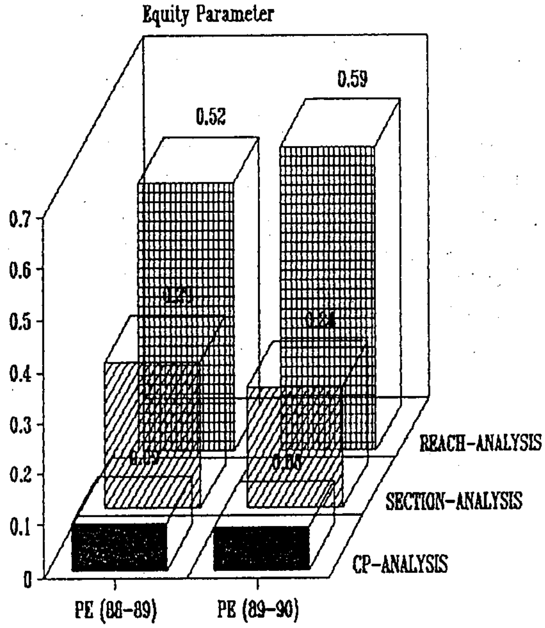
	PD (88-89)	PD (89-90)	aPD(88-89)	aPD(89-90)
CP-ANALYSIS	0.29	0.56	0.27	0.56
SECTION-ANALYSIS	0.44	0.6	0.43	0.6
REACH-ANALYSIS	0.57	0.83	0.52	0.78

Dependability Status at Gamusia Major

Fog. 23. Comparison of 3 methods adopted for data analysis

of dependability, P_D, ranges from 0.27 to 0.83. According to the evaluation standard, the performance of the Major is not satisfactory. As discussed earlier, lowest values of the parameter are derived by CP-analysis and maximum with Reach-analysis; the numbers estimated by Section-analysis lie in between. So, irrigation supplies at the Major are classified as undependable.

Next, the parameter for equitable water distribution is discussed. Figure 24 displays the information about the resulting values of the P_E over 1988-90.



Equity Status at Gamusia Major

Fog. 24. Comparison of 3 methods adopted for data analysis

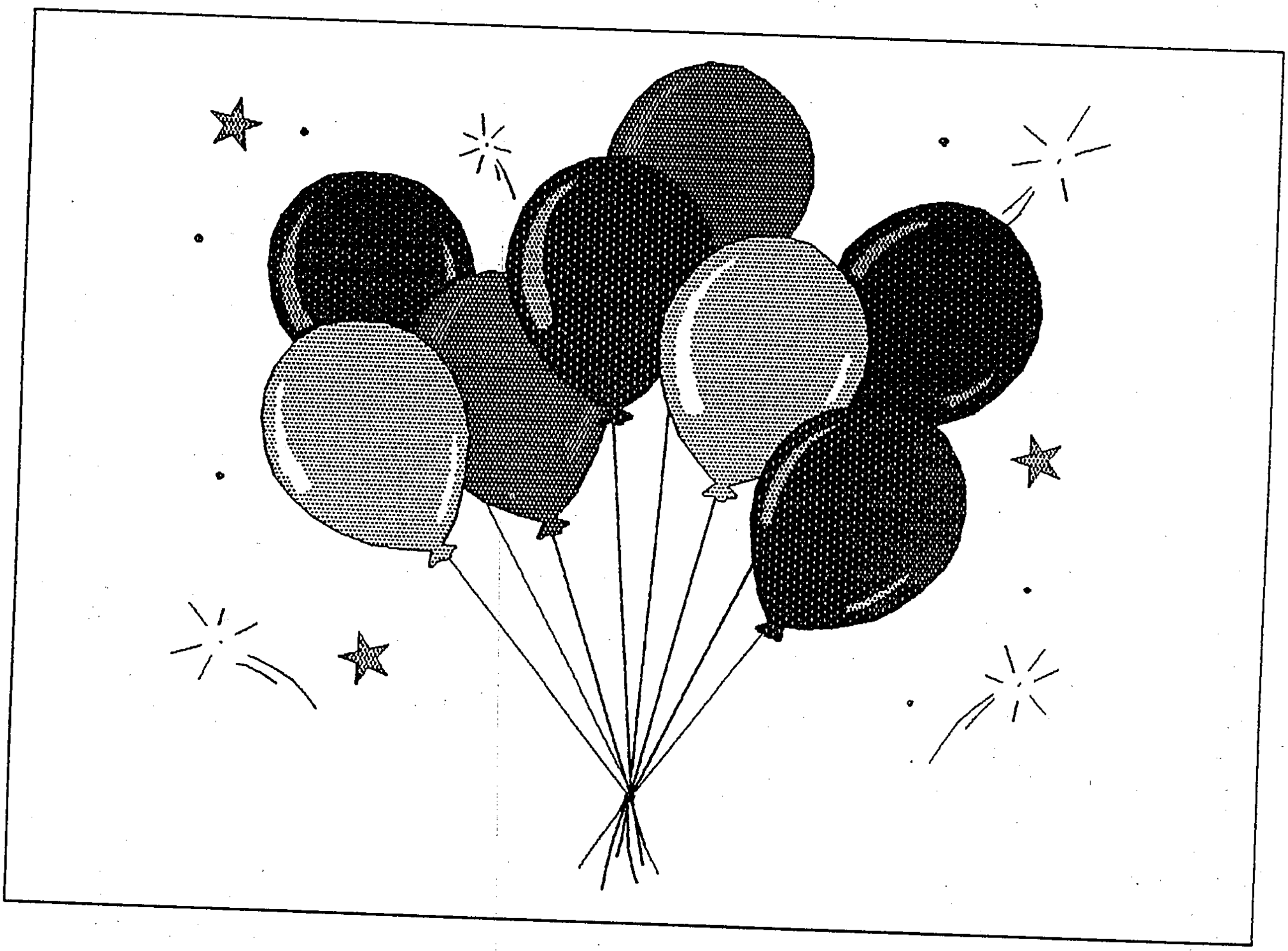
It is interesting to note the difference among the values of P_E determined by the three techniques. The CP-analysis suggests the water distribution being equitable as P_E is less than 0.1. However, other two methods suggest unsatisfactory level and the parameter in each case is more than 0.20. Again considering Reach-analysis free from lumping effect and more realistic, the performance in terms of equity is also unsatisfactory.

Additional Reference

Adam, Ahmed Mohamed. 1988. A Study of Water Equity In the Gamusia Major System. Report No. IIRC 10. Hydraulic Research Station, Wad Medani.

To be continue

Note: All views expressed in this news letter are personal and IIMI does not take any responsibility whatsoever.



AFTER EID CELEBRATIONS

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FROM
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APPENDIX A

Performance Indices

Adequacy: A fundamental objective of irrigation systems in Sudan is to deliver the amount of water required to crops. To quantify the adequacy achieved, the authors have defined P_A as

$$P_A = \frac{1}{T}\sum_T (1/R\sum_R P_a) \text{ ---(1a)}$$

$$P_a = \frac{Q_d}{Q_r} \quad If \;\; Q_d \leq Q_r \text{------(1B)}$$

and

$$P_a = 1 \quad otherwise \text{--------(1c)}$$

Where $P_a = Q_d/Q_r$ is the ratio of water delivered over water required. In the context of Sudan, the water demand can be either crop water requirements or indents placed. The Equation 1 implies that Q_d and Q_r are defined for discrete locations where water is conveyed in a region R at finite time intervals within a period T.

Molden and Gates (1990) also proposed that P_a value more than 0.9 is assumed to be good, between 0.8 to 0.9 fair, and below 0.8 poor (unsatisfactory as used in this paper).

Dependability: The performance measure indicates the uniformity of Q_d/Q_r over time. system which achieves almost steady state is considered to be dependable. The dependability parameter is defined as follows:

$$P_D = \frac{1}{R}\sum_R CV_T \left(\frac{Q_d}{Q_r}\right) \text{-----(2)}$$

In this case CV_T (Q_d/Q_r) is the temporal coefficient (standard deviation / mean) of variation of the ratio Q_d/Q_r over discrete locations in a region R, in a time span T.

Molden and Gate (1990) presented performance standard for P_D as given below:

P_D 0.0 to o.1 -- good,
P_D 0.11 to 0.2 -- fair, and
P_D over o.2 -- unsatisfactory.

(The authors have used term "poor" instead of unsatisfactory).

Equity: As defined by Mohamed (1987), it indicates the ability of a system to uniformly deliver water. Molden and gate (1990), Kuper and Kijne (1992) have suggested the following performance indicator for equity:

$$P_E = \frac{1}{T}\sum_T CV_R\left(\frac{Q_d}{Q_r}\right) \text{----(3)}$$

where $CV_R(Q_d/Q_r)$ is the spatial coefficient (standard deviation / mean) of variation of the ratio of delivered water to the required amount (Q_d/Q_r). This coefficient of variation is defined for a specific time over a region R.

In this case also Molden and gate (1990) have proposed that the performance should be taken good if the equity parameter is between 0.0 to 0.1, fair if it falls between 0.1 and 0.2 (and unsatisfactory if it exceeds 0.2).

APPENDIX B

Adjusted indices of Performance

In view of design objectives of the Gezira canals, following performance parameters are selected: (1) adequacy, (2) dependability, and (3) equity. These parameters are defined by Eqs. 1 to 3 given in Appendix A. However, it is proposed that for an overall performance values the referred equations have to modified. As the resulting parameters for different control points and sections will contribute toward an overall value differently, use of some kind of weighting factors seems appropriate. One such weighting factor could be an areas (A_is) served by a reach, section or canal command below a control point. If the suggested weighting factor is used, the Eqs. 1 to 3 of Appendix A can be rewritten as follows:

$$P_A = \frac{1}{T}\sum_T \left[\frac{\sum_R (P_a)_i \times A_i}{\sum_R A_i}\right] \quad ----(4)$$

However, Eqs. 1b and 1c will define $(P_a)_i$ as before.

The performance parameter for dependability (P_D) can be redefined as

$$P_D = \frac{\sum_R [CV_T(\frac{Q_d}{Q_r})]_i \times A_i}{\sum_R A_i} \quad -----(5)$$

In this case also, A_i are areas of ith reach, section or canal command below a control point. Rest of the variables are already defined.

While deriving the equity parameter, P_E), Eq. 3 will be used as it is. However, only one slight change is proposed to calculate mean value (Q_d/Q_r) over entire region R at time period T by the following relationship:

$$Mean(\frac{Q_d}{Q_r}) = \frac{\sum_R [(\frac{Q_d}{Q_r})_{itimes} A_i]}{\sum_R A_i} \quad -(6)$$

Rest of the procedure to calculate CV_R will not change.