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performance indicators
Sudan
Gezira

PERFORMANCE OF THE GEZIRA CANALS - REPORT BASED ON SECONDARY DATA (IIC)

By
M. S. Shafique[1]

3. Kab El Gidad Major (Tail Sub-main)

Keb El Gidad (KEG) Major is located 194 kilometers south of Sennar dam which is the main supply-source for the Gezira scheme. Zananda Major (head sub-main canal) and the Gezira main canal get their supplies from a common pool located at a point 57 kilometers downstream of the dam (locally referred as Kilo 57). Gamusia Major (middle sub-main canal) is the first Major which receives its supplies from the first defined section, canal stretch from kilo 57 to Kilo 114, of the main canal. Whereas the selected tail Major, KEG, takes off from the middle-section of the main canal which spans from Kilo 114 to Kilo 194. The main canal below Kilo 194 is considered as the third and tail section. It is important to note that no Major was monitored from the last section of the Gezira canal.

According to the original report (TOR, 1991), the schematic layout of the system monitored during 1988-90 is presented in Fig. 25. For control point (CP) and section-analyses, selected points (CP-45, CP-47 and CP-49) are shown in the schematic layout. This CP-system is similar to the ones chosen for the head and middle Majors.

a. <u>Analysis According to Control Points (CP-analysis) & Discussion</u>

As discussed earlier (Shafique, 1993), the performance indices determined at the head control point will represent average conditions for the entire command area (5817 ha or 13850 feddans) of the KEG system. Such a statement assumes that water distribution beyond the head control point will be equitable. However, this did not hold true in case of head and middle major canals as reported earlier (shafique, 1993). In this paper, similar trend is established for the KEG system by computing indices at the middle and tail control points which serve their relevant downstream command areas as 3771 ha or 8979 feddans and 1639 ha or 3902 feddans respectively. To minimize this discrepancy, the indices for individual points are calculated by the equations given in Appendix A (plus other indices defined in Volume 2 of the news-letter) and overall or mean values pertaining to some of these indices for a selected system are derived using equations given in Appendix B (Volme 4).

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[1]Head, Sudan Field Operations, IIMI

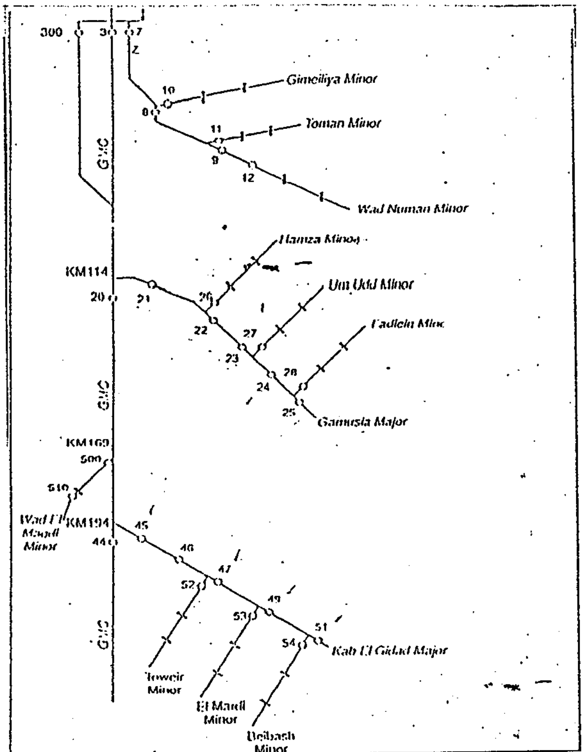


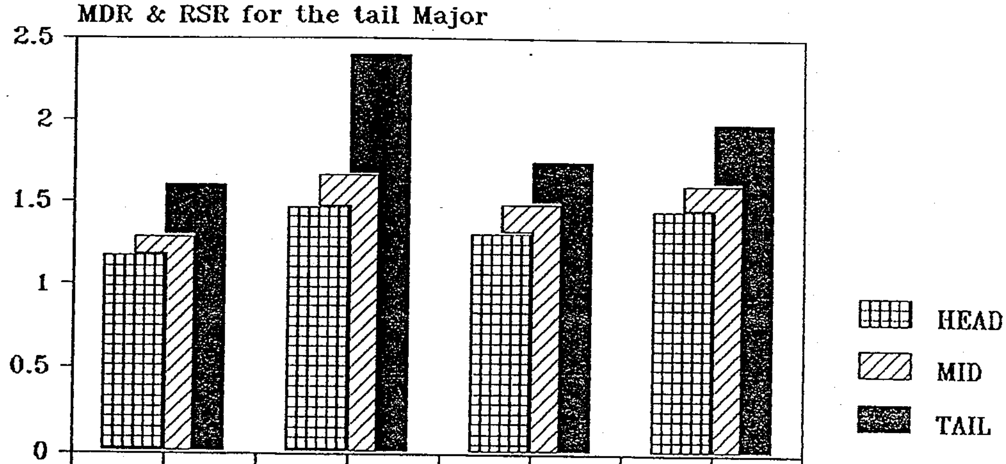
Figure 25. Schematic layout of locations monitored along the Gezira main canal

According to CP-analysis, MDR, management delivery ratio; RSR, relative supply ratio; IRR, indent-requirement ratio; SIR, supply indent ratio; and SAR, supply-authorized supply ratio are calculated based on data collected during two irrigation seasons: 188-89, and 1989-90. The resulting information is presented in Figs. 26 and 27.

In terms of MDR, the tail-end of the sub-main canal (KEG) presents a rare example of an over-supply phenomenon at the Major. A seasonal average of MDR is found to be 1.36 in the first monitoring year which further rises to 1.85 in the following year. Actually this index ranges from 1.17 to 1.61 and 1.47 to 2.4 (Fig. 26a) during the first and second season respectively. An interesting observation is that the trend established based on the derived ratios for the both irrigation seasons shows a significant increase in the values of MDR from head to tail - contrary to a general belief held in this context.

An average seasonal supply in excess of crop-water requirements, 36 and 85 percent in the order of first and second season, and the above reported trend tempts to speculate following: (i) as if the tail were also being used to drain off excess water, (ii) a deliberate effort to show that the available supplies at the tail being more than required, (iii) it is partly due the side benefits of the monitoring study, and (iv) a management style which is based on the practice for the main canal and upstream Majors to receive as much as they can handle or use and "left-over" excess amounts are diverted to the tail system. However, the reality may comprise of one or more elements of all such factors.

As stated before, there is a significant increase in the values of MDR from 1988-89 to 1989-90. This upward shift during the second season has also occurred due to an additional factor: an overall excess supply of 17 percent was a response to a corresponding 5.2 percent increase at the main canal level. Similarly, relevant average increase in indent placing was about 13 percent more whereas the demand decreased by 5.26 percent over the first season. There was an upsurge of 56 percent for the authorized supplies in the second year. The above stated situation points to two probable explanations: (1) demand and supply are not



	MDR(88-89)	MDR(89-90)	RSR(88-89)	RSR(89-90)
HEAD	1.17	1.47	1.31	1.45
MID	1.29	1.67	1.49	1.61
TAIL	1.61	2.4	1.75	1.99

Water Distribution along KEG Major

Figure 26a. Performance Indices at selected control points

very well matched and / or (2) the on-going monitoring exercise made some officials to go overboard. Whatever the case may be, the fact remains that the process of decision making regarding water distribution needs a real careful review as soon as possible.

The index RSR, the relative supply ratio, shows relationship between the irrigation supplies delivered per unit command area at selected points / sections or reaches of a subsystem to the corresponding unit supplies available at the head of the main canal level. If only the available supply at the main canal level has to be distributed equitably, the RSR should be kept around one. Obviously, the RSR higher than 1 indicates relatively excess supply at a picked level and vice versa. It is hypothesized that if RSRs rather than MDRs are found relatively close to one, then the water distribution is more on supply basis as compared to demand basis. Such a distinction seems quite appropriate as the system is designed to meet crop-water requirements as against equitable "rationing" of water deliveries.

As shown in Fig. 26a, all the values of RSR are more than 1 during both monitoring seasons. During the first period (1988-89), the excess supply ranges from 31 to 75 percent; it jumps to 45 to 90 percent in the following period (1989-90). The seasonal RSR averages, as determined at the head control point, are found to be 1.52 and 1.68 as compared to MDRs being 1.36 and 1.85 for the first and second year respectively. Both types of ratios indicate a case of over-supply at the Major but do not establish any clear trend to accept or reject the hypothesis as stated above. Perhaps more data are required to establish any particular trend in this context.

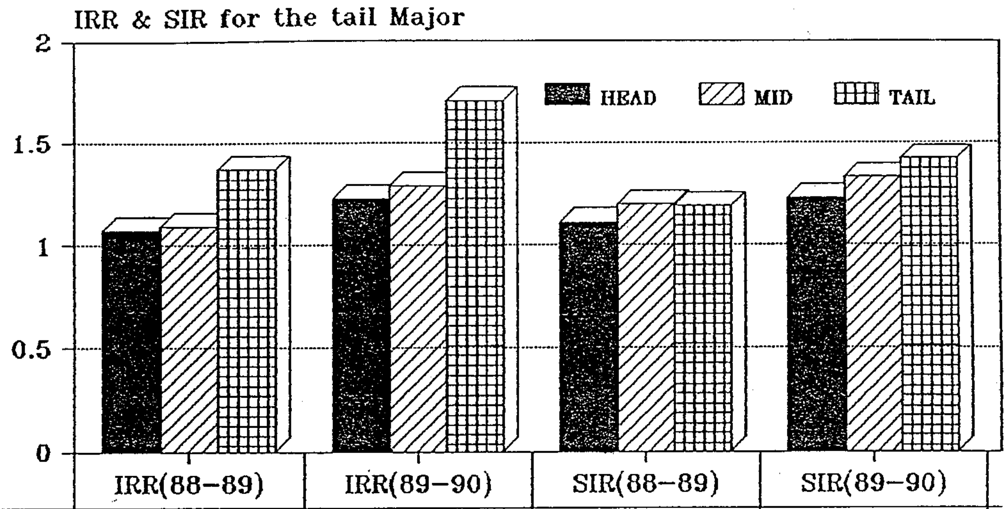
The above stated more upward changes during the second season in RSR have mainly occurred due to relative increases in water supplies at the main canal and the Major levels. At the main canal level, water supply in the second period increased by an average of 5.2 percent; whereas the corresponding increases in water supply at the Major level were 17, 15 and 23 percent at head, middle and tail control points respectively. Such differences at these levels explain how an inequity, even on pure available supply basis, in water distribution has developed.

The values of adequacy index for individual points, P_A (Appendix A in Volume 4), are 0.98, 0.98, 1.00 for 1988-89 and 1.00, 1.00, 1.00 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 MDRs from an average value of 1.36 in the first year to 1.85 in the following year caused a very small change in the value of P_A i.e. 0.99 to 1.00. It is evident that a striking upward change in MDR in the second period causes only the over-supply to jump up from 37 to 85 percent level (over-supply is calculated by Eq. 7 given in Vol. 4 of this newsletter).

Other two related indices are IRR and SIR. The second parameter shows relationship between supplies and indents whereas the first parameter links indents with irrigation requirements. Product of the both ratios ties the supplies with irrigation requirements given by MDR in our case.

The selection of the indices helps to understand the irrigation management practices very closely. On one hand, SIR indicates to what extent the available supplies are more or less than the indents placed, and on the other hand, IRR qualifies the level to which the indents are more or less than irrigation requirements. The product of the two parameters, MDR, suggests the degree to which supplies are more or less when compared with irrigation requirements. In each case, however, surpluses and shortages will be determined by the magnitude of these ratios being more or less than one.

Figure 26b. presents the resulting values of IRR and SIR for the two seasons monitored during 1988-90. As can be noted, the indents are 10 to 70 percent higher than irrigation requirements whereas supplies are found to be 10 to 40 percent more than indents . Due to such existing phenomenon at the Major, supplies are detected to be as 20 to 140 percent more than irrigation requirement (Fig. 26a.).



	IRR(88-89)	IRR(89-90)	SIR(88-89)	SIR(89-90)
HEAD	1.07	1.23	1.11	1.23
MID	1.09	1.29	1.2	1.33
TAIL	1.37	1.71	1.19	1.42

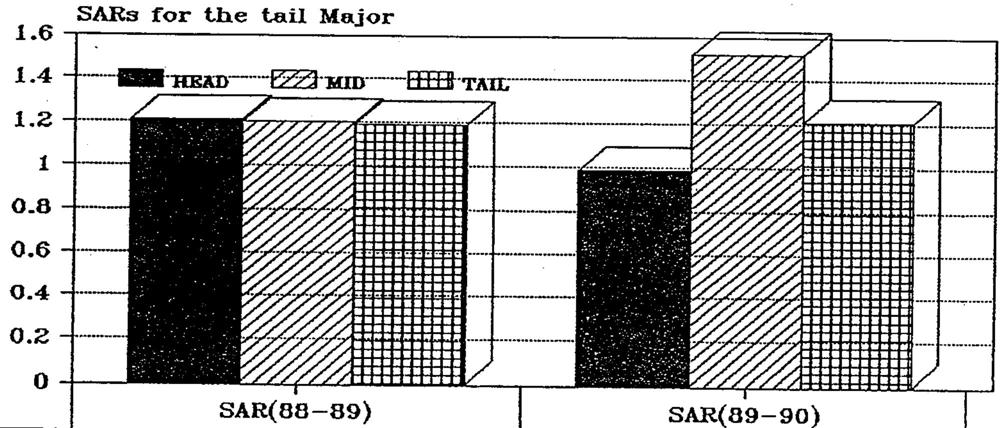
Water Distribution along KEG Major

Figure 26b. Performance indices at selected control points

In Sudan, it is usual practice that concerned irrigation officials after receiving indents from the agricultural staff of a scheme decide authorized releases for a canal system. Such canal operation related decisions are made by considering mainly indents placed, condition of different canals and availability of water supply. As a result the concerned irrigation officials are suppose to match actual supplies with authorized releases. The degree to which they succeed is determined by actual supply and authorized-release ratio or SAR.

As shown in Fig. 26c., SARs vary from 0 to 52 % depending upon measurements made at control points. During the first season, supplies are consistently about 20 % more as compared to authorized releases at the head, middle and tail control points. However, in the second season the difference goes up to more than 50 %. This indicates that such fluctuations will further magnify when the analysis is made on sections or reach basis. Even if an accepted *level of variation being 10 % is opted, the ratios suggest clear room for improvements.*

In order to evaluate the dependability of water supplies at a specific location or a control point, R parameter in Eq. 2 (Appendix A in Volume 4) is taken as 1. For each control point the coefficient of variation, CV_T(index), is determined. The resulting values of the coefficient are tested according to a criterion suggested by Molden and Gates (1990) for evaluating the dependability of water distribution at particular control points.



	SAR(88-89)	SAR(89-90)
HEAD	1.21	0.99
MID	1.2	1.52
TAIL	1.19	1.21

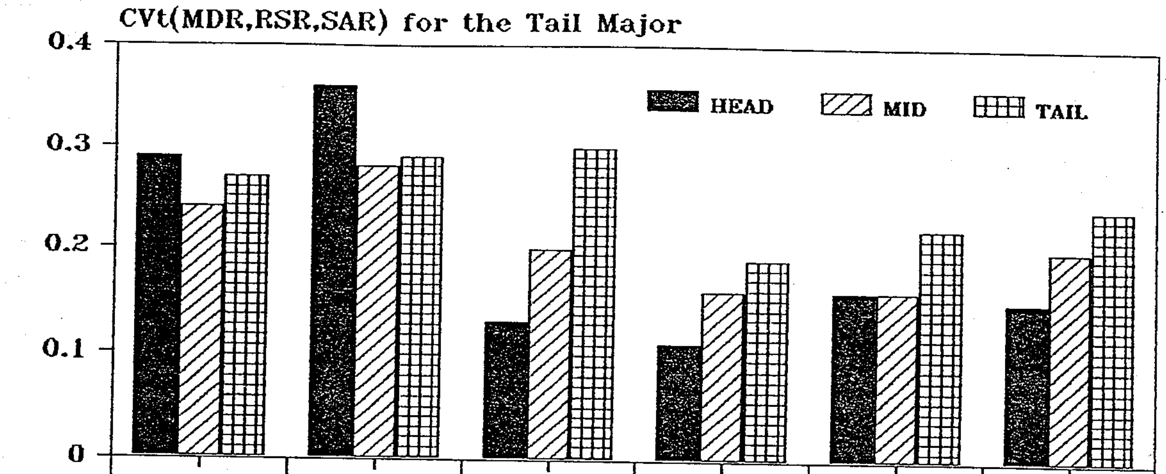
Water Distribution along KEG Major

Figure 26c. Performance indices at selected control points

Figure 26d 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), CV_T(SAR) and CV_T(RSR) over the monitoring period.
As shown, the coefficients of variation based on RSR and SAR at individual CPs are either in a fair range or with little effort they can be brought in the range. However, the same is not true when CV_T(MDR) is considered. At every control point, the coefficient lies in the unsatisfactory category. In case of CV_T(IRR), during first season it falls in the fair range (0.12-0.13) but in following period is rises to 0.25 (0.24 - 0.27) which is not considered good. When the same coefficient is viewed for SIR, the values are 0.22 (0.17 - 0.30) and 0.20 (0.16 - 0.23) for the period defined by 1988-89 and 1989-90 respectively. Overall trend for the second season suggests the temporal variations go up.

The index of dependability based on MDR indicates unsatisfactory levels at all control points for both irrigation seasons. This implies that overall efforts related to provide a reliable water supplies as per crop water requirements are not very satisfactory. However, as the values of MDR are more than 1 in case of each control point, perhaps the high level of temporal variability may not play havoc in the crop planning process 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. 26d, are also less than desired. However, these



	CVt–MDR(1)	CVt–MDR(2)	CVt–SAR(1)	CVt–SAR(2)	CVt–RSR(1)	CVt–RSR(2)
HEAD	0.29	0.36	0.13	0.11	0.16	0.15
MID	0.24	0.28	0.2	0.16	0.16	0.2
TAIL	0.27	0.29	0.3	0.19	0.22	0.24

Water Distribution along KEG Major

Figure 26d. Performance indices at selected control points

values range between 0.15 to 0.27 and hence with little more attention the index can be brought in a 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 the water distribution is based on the rationing of available water in the system with no adjustments or consideration for the crop water requirements.

Comparison of head, middle and tail Majors in terms of dependability of water deliveries is also appropriate to be considered. From Fig. 7 (Vol. 3 of this newsletter) it is shown that in case of head Major all values of P_D(MDR) fell in an unsatisfactory range. Same is true for the middle Major (Fig. 12 of Vol. 4) too. A similar trend is detected even in case of the tail Major, but the resulting values are relatively on lower side. When similar comparison is extended to the derived values of P_D(RSR), the difference is even more vivid for the head and middle Majors but the tail Major falls in between. 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. In case of Tail Major, the head CP-analysis indicates a fair level of the temporal coefficient but rest of the points lie in the unsatisfactory category.

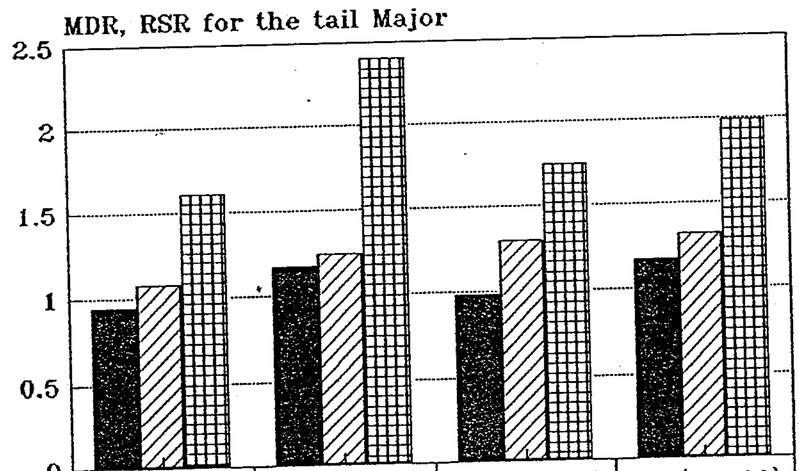
As discussed in case of the head and middle Majors, for individual points the parameter of equity, P_E, can not be calculated. However, this index will also be determined at a stage of overall evaluation of the tail Major.

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 two or more than two reaches. After analyzing the data according to control points, the performance of the tail Major will be evaluated according to its head, middle and tail sections. In case of KEG Major, the canal stretches from control point # 45 to Control Point # 47 (Fig. 25) constitutes the head section. The middle section consists of canal span that lies between Control Points # 47 and 49. The remaining length of the Major beyond Control Point # 49 is the third and tail section of the canal.

The total service area of the KEG Major is 5817 ha (13850 feddans). The command area served by the head section is 2046 ha (4871 feddans). The middle section commands 2132 ha (5077 feddans). The remaining area, 1293 ha(3902 feddans), receives its supplies from the tail section.

The performance of the tail Major according to sections is also first described by two indices: (i) management delivery ratio or MDR, and (ii) relative supply ratio or RSR. Figure 27a. displays results as per section-analysis for the two irrigation seasons.



	MDR(88-89)	MDR(89-90)	RSR(89-90)	RSR(89-90)
HEAD SECTION	0.94	1.16	0.98	1.16
MID. SECTION	1.07	1.24	1.29	1.32
TAIL SECTION	1.61	2.4	1.75	1.99

Water Distribution along KEG Major

Figure 27a. Performance indices for selected sections

The section-analysis shows that in the first monitoring period the values of MDR for head, middle and tail sections are 0.94, 1.07 and 1.61 respectively. For the same period, an average management delivery ratio of 1.21 (head CP MDR being 1.17) for the entire Major. In this case, the head section on average gets 6 percent less seasonal supplies than required. But, the middle and tail sections get 7 and 61 percent excess seasonal amounts of water respectively. The first two sections do not appear to be doing too bad when compared with the values of MDR at the head and middle control points. This is mainly because the CP-values at the head and middle points are influenced by an excess supply diverted to or ended up at the tail.

During the second monitoring year, 1989-90, the values of MDR are 1.16, 1.24 and 2.40 for the head, middle and tail sections. Mean MDR is found to be 1.60. This value can be compared with the MDR of 1.47 measured at the head-CP representing the entire command of the system. If weighted averages, based on respective areas, of sections are utilized, the differences are expected to contract. It is important to note that in the latter case (data based on sections) the head, middle and tail sections received 16, 24 and 140 percent more supplies than estimated crop water requirements.

A cursory look at the results of section based analysis indicates an abnormal trend which is quite contrary to the head-tail syndrome. During the two seasons monitored, the tail Major was found delivering excess supplies to its tail as compared to head and middle sections. However, it does not mean that the first two sections received short supplies rather difference lies in the degree of excess irrigation provided. Although there was an increase in overall supply from 1988-89 to 1989-90 in the main canal (5.2 % to be precise), the above changes can not entirely be explained by this phenomenon alone.

One factor could be that the share of tail Major due to a 5.2 percent increase at the main canal shot up by 17 percent even though there was a corresponding drop of 5.3 percent in the crop water requirements. In the context of section based analysis, the crop water requirement went up only by 1 percent for an increase of 22 percent of water supply for the first section. But for the remaining middle and tail sections, the irrigation requirement went down by 5 and 15 percent against excess water supplies of 7 and 23 percent respectively. Other factor appears to be perhaps an on-going practice to use the tail-end canals for draining off excess supplies too. These factors may explain the resulting higher values of MDR at the Major. Anyway, the phenomenon also shows that the canal operations need more scientific base for making decision regarding canal operations of the Major.

The index of adequacy, P_A, for individual sections is calculated according to Eqs. 1a, 1b and 1c (by taking R = 1) given in Appendix A. During the first monitoring year, the values of the parameter were 0.86, 0.93 and 1.0 for head, middle and tail sections respectively. As per criteria proposed by Molden and gates (1990), the adequacy level falls in a fair for the head section and good category for the remaining two sections. For the second year these values were 0.89, 0.95 and 1.0 in the order stated above. In this case, the adequacy for the middle and tail sections is again good; however, it improves slightly to highly fair level for the head section.

One important observation is that in spite of an overall increase of MDR from 1.21 in 1988-89 to 1.60 in 1989-90 the value of P_A changes only from 0.93 to 0.95. However, the increase mainly appears in over-supply ratio (OSR) which can estimated by the Eq. 7 given in Vol. 4 of this newsletter:

$$OSR = [\frac{MDR - P_A}{P_A}]$$

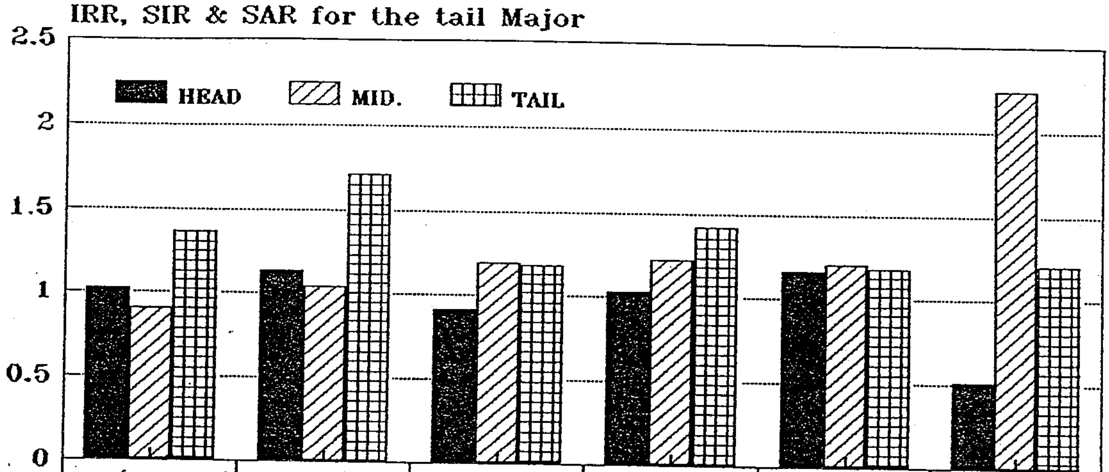
According to this relationship, an average oversupply was found 30 percent in 1988-89 which increased to 68 percent in 1989-90. Distribution of the oversupply for each section also merits reporting. During the first monitoring year, such excess supplies in percent for the head, middle and tail sections were 9, 15 and 61 percent respectively. In the following period, these quantities in the same order went up by 30%, 31% and 140 %. Considering the special nature of the surface irrigation, some oversupply is unavoidable. However, irrigation researchers and managers have to agree to certain levels of oversupply acceptable for the 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 sections over the two monitoring seasons. In most of the cases, the performance based on OSR falls in the unsatisfactory category.

Figure 27a also presents section-wise relative supply ratios (RSR as defined earlier) over the two monitoring seasons. According to the data displayed, KEG Major in most cases received irrigation supplies more than its due share when compared with the main canal by -2, 29, and 122 percent more at the head, middle and tail sections respectively during 1988-89. These numbers were estimated by comparing available average per unit area supplies for different sections served by the Major and the main Gezira canal. During the second year, the head, middle and tail sections received even more than their due share by 16, 32 and 152 percent. When compared with the previous year, the reported increases in 1989-90 happened due to the following main reasons: (i) an increase by 5.2 percent at the main canal, and (ii) corresponding increase of 17 percent at KEG Major. This is on the top of the fact that RSR values were quite high during the first irrigation season too.

Next three more indices: IRR, SIR and SAR are considered to evaluate the water distribution from a different angle. Figure 27b. presents these resulting parameters according to sections of



	IRR(88–89)	IRR(89–90)	SIR(88–89)	SIR(89–90)	SAR(88–89)	SAR(89–90)
HEAD	1.02	1.14	0.91	1.03	1.17	0.51
MID.	0.9	1.04	1.2	1.23	1.21	2.24
TAIL	1.37	1.71	1.19	1.42	1.19	1.21

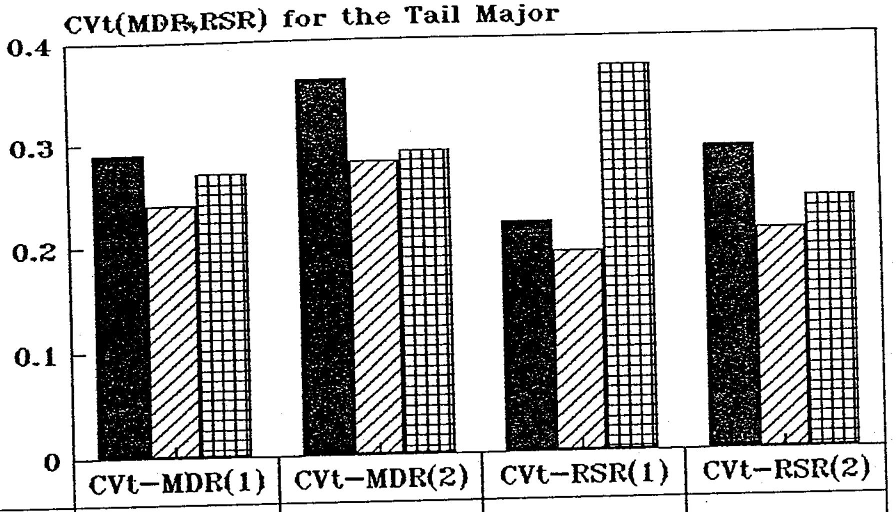
Water Distribution along KEG Major

Figure 27b. Performance indices for selected sections

the Major. Discussion about the indices is very similar to the one given under the first section based on CP-analysis. However, the figure is provided to contrast the results (Figs. 26b, c and 27a.) achieved under to methods of data analysis. It is interesting to note that the data sorting and use according to CPs and sections can change outcome quite significantly. It usually happens due to a degree of averaging or lumping effect when the system is divided from higher level to individual components. For example, SARs were found to be 0.99 to 1.52 under CP-analysis whereas they result in the range of 0.51 to 2.24 when data are treated as per sections. Had the data were analyzed according to canal reaches, such fluctuation may further magnified.

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 27c presents the values of CV_T(MDR) and CV_T(RSR) for different sections monitored during 1988–89 and 1989–90. Except in one case which is marginally fair, all other values are not satisfactory in terms of delivering dependable supplies for each section.

It is true that 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



	CVt−MDR(1)	CVt−MDR(2)	CVt−RSR(1)	CVt−RSR(2)
HEAD SECTION	0.29	0.36	0.22	0.29
MID SECTION	0.24	0.28	0.19	0.21
TAIL SECTION	0.27	0.29	0.37	0.24

Water Distribution along KEG Canal

Figure 27c. Dependability index for selected sections

government / corporations. In this context, there is real possibility that the existing level of dependability for excess water supply in an irrigation season may not be viewed with great concern. On the other hand, it does affect in a certain ways. For example, when the concerned officials plan by assuming dependable supplies at all locations and it does not hold true which is evident from the fact that thousands of cropped areas are abandoned right 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 0.27 and 0.31 for 1988-89 and 1989-90 respectively. These indices are better than other two Major but still the performance lies in a category termed as unsatisfactory. Similarly, the average values of P_D calculated based on RSR are 0.26 and 0.25 in the order stated above. 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>Comparative Analysis for Overall Performance</u>

As described in the preceding text, methods for the data analysis include: (i) Cp-analysis, and (ii) Section-analysis. Reach based analysis is not considered for the tail Major because of unavailability of data. At first, weighted seasonal averages in terms of MDR, RSR, IRR and SIR will be calculated and compared with the results achieved by other averaging options. Then on the second stage, average / overall parameters for water distribution in terms of adequacy, dependability and equity derived by the two data analysis techniques will be compared with each other.

I. Results & averaging options

Three averaging options have been considered: (i) values of parameters derived at the head control point, (ii) simple arithmetic means, and (iii) weighted averages. Seasonal weighted averages of MDR, RSR, IRR, SIR and parameter of adequacy, P_A are calculated using following relationship:

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

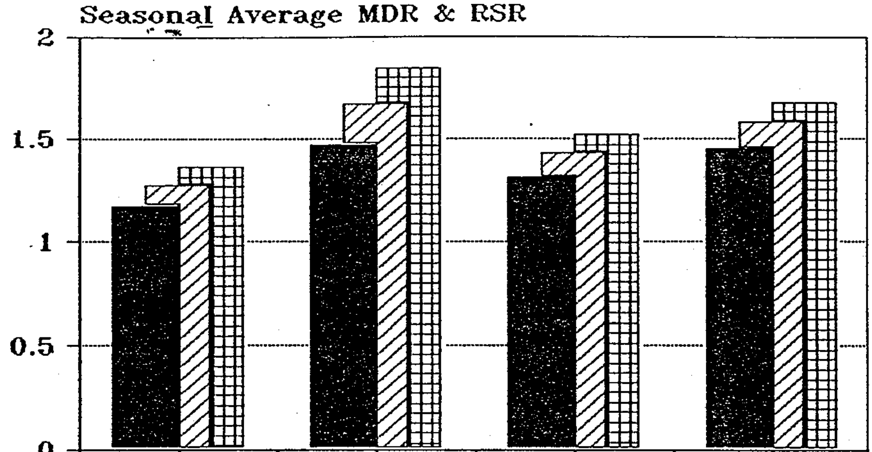
where
"PRAM" stands for any above stated parameter, A_i is the command area below an ith control point or command area served by a ith section or reach as the case may be. As differences in the weighted and simple averages are small, parameters of dependability and parameter of equity, P_D and P_E, are averaged without giving any weight for the command areas of selected canal segments.

(i) **Data analysis according to control points:** The above three averaging options are used to derive seasonal values for MDR, RSR, and SIR. The resulting information is then presented in Figs. 28a and 28b. The reason for taking the derived parameters at a head control point as average values is that the point serves the entire command area of its selected system or sub-system.

The results given in Figs. 28a and 28b are based on control point analysis. It is important to note that the parameters in both figures provide a trend: averages based on CP-head represent the lower end and the simple arithmetic means specify the upper end of the spectrum. In all cases, the weighted averages fall in between the two extremes. This may be mainly due to the selected ratios magnify toward the tail of the Major.

The ranges for the seasonal parameters are based on the method used for averaging the indices determined at different control points along a canal. As discussed above, CP-head and simple means define such ranges.

Looking at the seasonal values of MDR, depending upon the method of averaging, it can be said that supplies were 17 to 36 percent and 47 to 85 percent more than the irrigation requirements during 1988-89 and 1989-90 respectively. At the same time the same supplies were 11 to 17 percent and 23 to 33 percent more than the indents placed during the referred two years. It is clear case of surplus water made available at the lower end of the Gezira system.



	MDR(88–89)	MDR(89–90)	RSR(89–90)	RSR(89–90)
CP – HEAD	1.17	1.47	1.31	1.45
CP – WEIGHTED	1.27	1.67	1.43	1.58
CP – SIMPLE	1.36	1.85	1.52	1.68

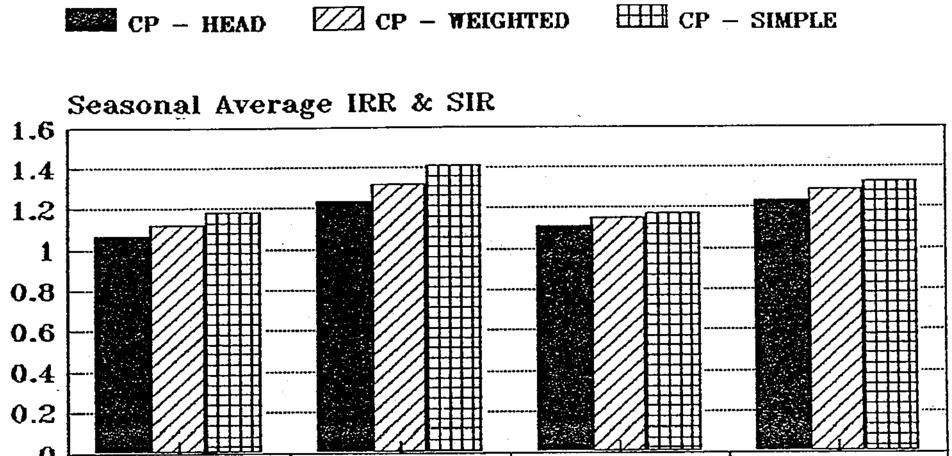
Water Distribution along KEG Major

Figure 28a. Seasonal performance indices according to control points

There has been debate going on about the actual irrigation requirements and the indents placed. The parameter IRR is selected to quantify the relationship between the indents and the irrigation requirements. As presented in Fig. 28b, the indents are found 7 to 18 percent more in the first season. In view of the nature of surface irrigation, the outcome seems a good match between the indents and water needed based on crop water requirements. In the following season, however, the indents are 23 to 41 percent more the required amounts. However, if the seasonal MDR at the head control points are considered as appropriate overall / average values (as the indents are accumulated the head points for releasing supplies), then the difference between the two may not look very bad.

The fourth index used is relative supply ratio or RSR. As displayed in Fig. 28a, the seasonal ratio indicates supplies at the Major being 31 to 52 and 45 to 68 percent more than the supplies per unit command area available at the head of the main Gezira canal. The higher percentage of the supplies at Major may have resulted mainly due to two factors: (i) relatively more share drawn at tail Major, and (ii) an overall increased supply monitored at the main canal level during 1989-90.

The discrepancy which results due to three averaging techniques lies in the nature of control point data analysis. In this case, the downstream segments of a selected system influence results in more than one way. The indices derived at the head



	IRR(88-89)	IRR(89-90)	SIR(89-90)	SIR(89-90)
CP - HEAD	1.07	1.23	1.11	1.23
CP - WEIGHTED	1.12	1.32	1.15	1.29
CP - SIMPLE	1.18	1.41	1.17	1.33

Water Distribution along KEG Major

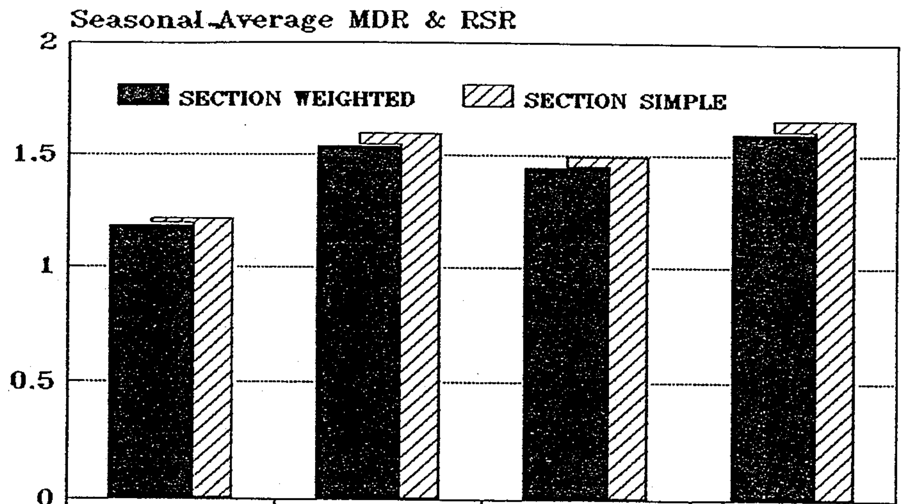
Figure 28b. Seasonal performance indices according to control points

control point represent the entire command area of the system whereas the parameters calculated at the middle control point again depict results for part of the command area that lies below such point. Moreover, the bias due the area below the tail control point is repeated again in this process. Such factors support the argument that one should be careful in using head, middle and control points for determining status of water distribution at a selected irrigation system.

(ii) **Data analysis according to sections:** To avoid the above stated concerns, the data analysis based on sections of a system may be preferable. In this case, indices derived do not represent areas of other sections of a canal. Hence, weighted or arithmetic averaging becomes a simple matter. If the command areas of selected sections do not differ too much, then weighted and arithmetic means will tend to converge to similar values.

When the seasonal averages are calculated after rearranging and analyzing data according to canal-sections, the variations due to averaging techniques in quantifying the indices also shrink. Figures 29a and 29b provide seasonal averages for MDR, RSR, IRR and SIR. As can be noticed, the differences between the weighted and simple arithmetic means are minimized. Also, these results are very similar to the ones obtained at the head control point; close but slightly on higher side.

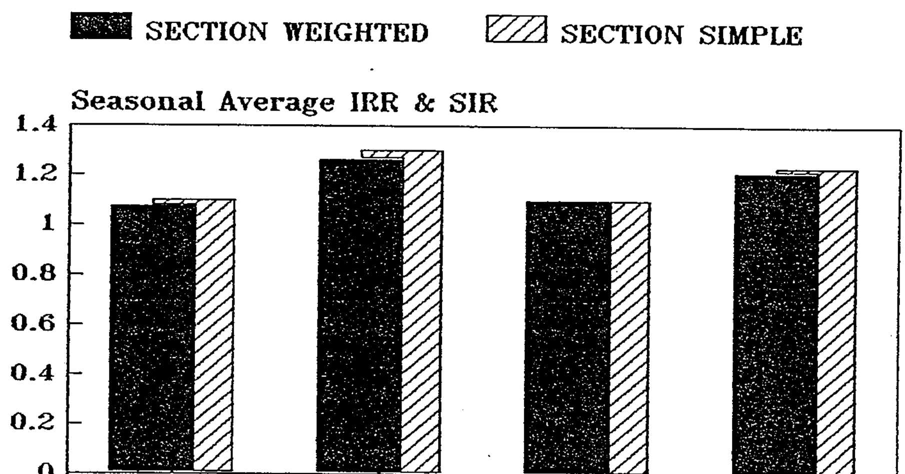
As per data displayed in the above referred figures, the seasonal MDRs suggest that supplies during the two monitoring



	MDR(88–89)	MDR(89–90)	RSR(89–90)	RSR(89–90)
SECTION WEIGHTED	1.18	1.54	1.44	1.6
SECTION SIMPLE	1.21	1.6	1.49	1.66

Water Distribution along KEG Major

Figure 29a. Seasonal performance indices according to sections



	IRR(88–89)	IRR(89–90)	SIR(88–89)	SIR(89–90)
SECTION WEIGHTED	1.07	1.26	1.1	1.21
SECTION SIMPLE	1.1	1.3	1.1	1.23

Water Distribution along KEG Major

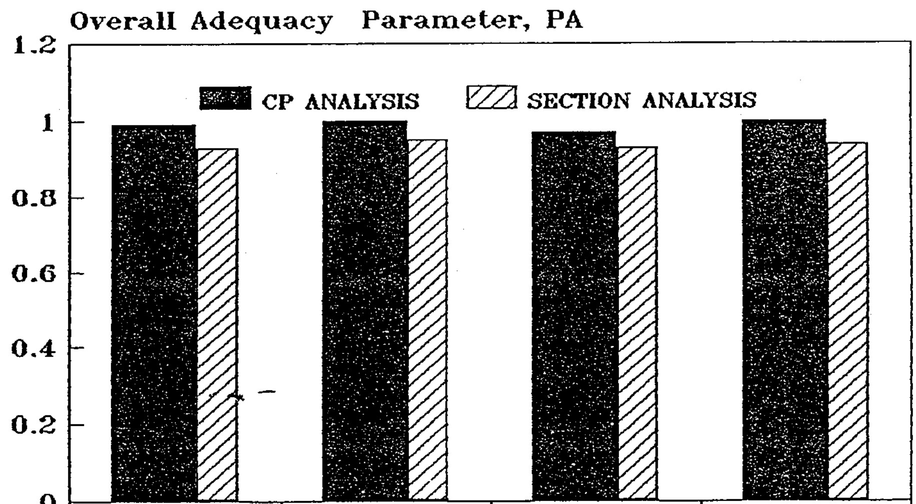
Fig. . Seasonal Performance Indices of KEG Major

Figure 29b. Seasonal performance indices according to sections

periods were 20 to 60 percent more than required amounts. Also these supplies were 10 to 20 percent more than the indents placed during the same period (based on seasonal SIRs). This should be coupled with seasonal IRRs which indicate that the indents were 10 to 30 percent more than required amounts of irrigation water in the period. This appears to happen because the relative supplies (based on RSRs) were 50 to 70 percent more than available at the main canal. It is a clear case of an excess supply situation at the Major. It might have happen because of a defacto management style whereas other main factors have already been discussed in this paper.

II. Comparison of results based on CP and section analyses

The comparison of the two options for data analysis is presented by describing three parameter for water distribution: (i) adequacy, (ii) dependability, and (iii) equity. The preceding discussion based on MDR, RSR, SIR and IRR also provides information about possible difference which occurs due to opted schemes for



	PA (88-89)	PA (89-90)	aPA(88-89)	aPA(89-90)
CP ANALYSIS	0.99	1	0.97	1
SECTION ANALYSIS	0.93	0.95	0.93	0.94

Water Distribution Status at KEG Major

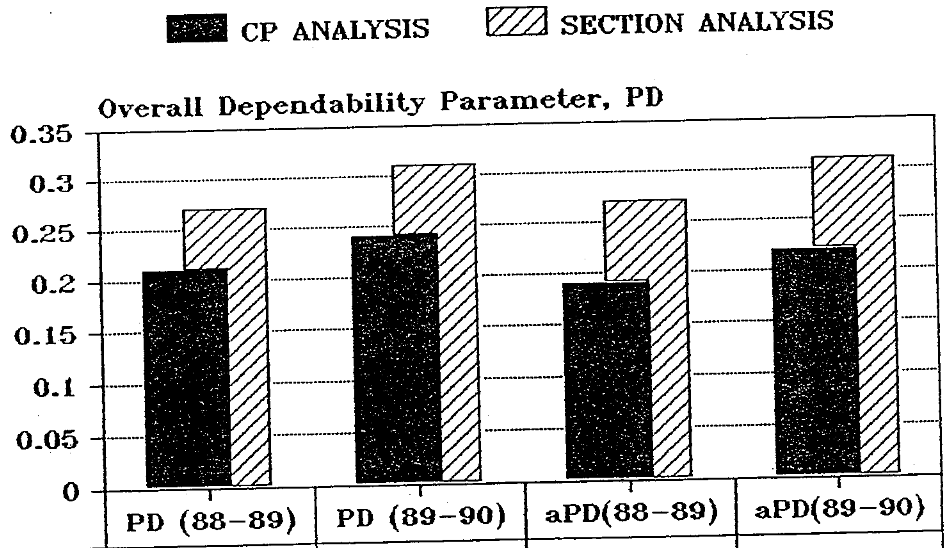
Figure 30. Comparison of seasonal performance indices

data analysis. Following section substantiates the same discussion by considering three additional performance indices in this context.

For discussing the adequacy levels of water distribution, Fig. 30 is exhibited. As illustrated, adequacy lies in good range as suggested by Molden and Gates (1990). However, the comparison of the parameter derived based on CP and section analyses suggests that CP-based values are on the higher side. In a case where water is available in more quantity than required, the finding is not surprising.

The seasonal dependability parameter, P_D, is derived again by two ways: (i) data analyzed according to control points, and (ii) data treated as per canal sections. The results are given in Fig. 31.

The seasonal values of the dependability parameter show that all except one fell in a category termed as unsatisfactory. However, CP-results show less variability as compared to the ones derived with sections based analysis. Again, the CP-analysis follows the pattern as discussed under adequacy of water supplies i.e. indices showing less problem with water distribution.



	PD (88-89)	PD (89-90)	aPD(88-89)	aPD(89-90)
CP ANALYSIS	0.21	0.24	0.19	0.22
SECTION ANALYSIS	0.27	0.31	0.27	0.31

Water Distribution Status at KEG Major

Figure 31. Comparison of seasonal performance indices

The parameter of equity of water distribution, P_E, is also determined by the CP and section based analyses. The resulting parameters for the two monitoring season are presented in Fig. 32.

As proposed by Kupper and Kijne (1993), the P_Es show unsatisfactory water distribution when the results of section based analysis are considered. However, CP-based values suggest an improvement i.e. the parameter characterizes the distribution as marginally fair. Again, the CP-based analysis depict slightly better water distribution as compared to the one shown by section based results.

However, looking at Figs. 30, 31 and 32 it helps to establish a pattern which implies that when the water distribution is studied

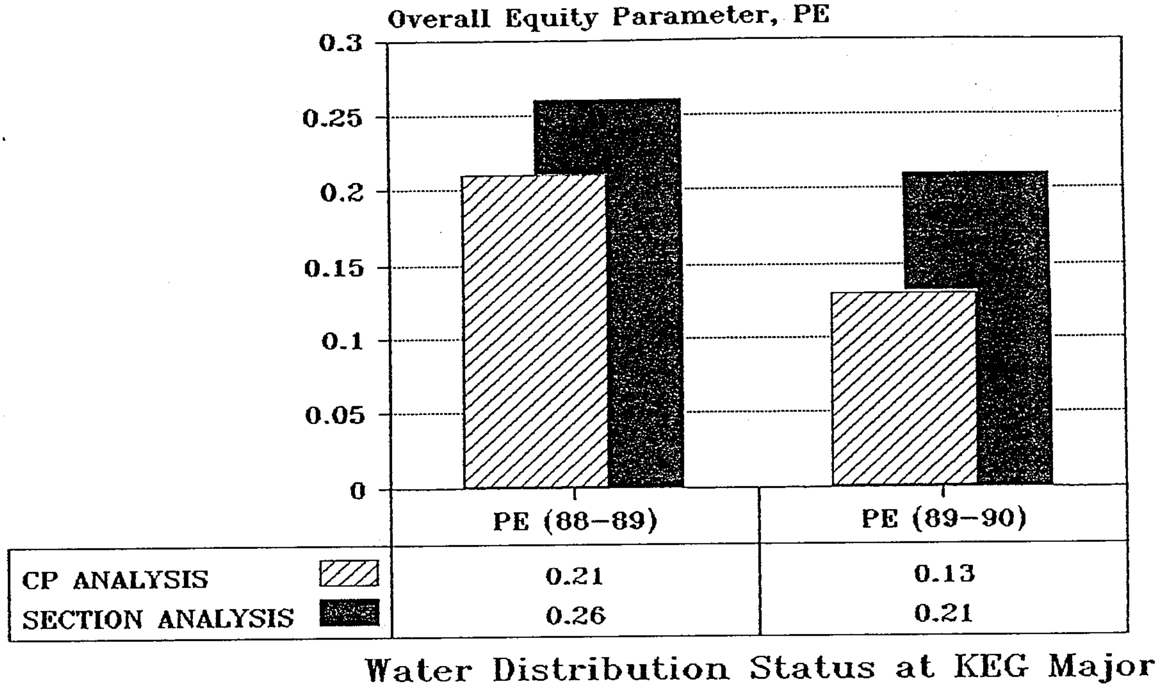


Figure 32. Comparison of seasonal performance indices

by breaking a selected system into segments, the distribution deteriorates. If these results are compared with the report about the middle Major by Shafique(1993), it supports the hypothesis that water distribution further goes down as system is studied according to basic units such as reaches. In the opinion of the author, levels of water distribution based on the natural units may give relatively more accurate assessment of the water distribution performance.

CONCLUSIONS

Based on the discussion about the tail major (KEG) in this paper, following important conclusions are drawn:

1. For estimating average relationships among different determinants of irrigation performance such as actual supply, authorized supply, indents and irrigation requirements, the simple and quick way is to considered the results based on the head control point. However, one must understand that such results are slightly on the "optimistic" side.

2. For documenting the water distribution status at a selected system, canal reaches are recommended as basic units for the data analysis. Next to this option is the distribution evaluated on the basis of canal sections.

3. The results associated with the tail Major point to a defacto management style:*A system is usually operated as per its full carrying capacity, on the way the water is withdrawn as per demand, and remaining supplies end up in the tail-end channels of the system.* However, there are so many other factors, as described in this paper, which may also contribute to the referred state of affairs.

Additional Reference

Shafiue, M. S. 1993. Performance of Gezira Canals. Paper presented at IIMI's Internal Program Review Meeting held in December 1993. IIMI, Colombo, Sri Lanka