EQUITY IN WATER DISTRIBUTION

In the following, equity in irrigation water distribution is deemed to be achieved when water is distributed in proportion to the areas served by a conveyance system. If a branch canal commands an area of 2000 ha through 10 distributaries each having a command area of 200 ha and each distributary receives the same amount of water which is equal to 10 percent of the volume of water withdrawn at the heads of all the distributaries, the distribution is then considered equitable. That means, each distributary gets equal treatment and gets its due share of water. The same operational concept of equity in the sense of equality will apply at other levels of the conveyance systems - main canal, water course etc. Obviously, the operational concept is based on many assumptions regarding crops, soils, topography, lengths of channels and losses, and contributions from drainage of the upper reaches of the command area to the lower reaches. If these conditions of the phvsical system are more or less the same on an average, equality in distribution of water approximates to equity. There also be socio-economic values governing equity: for example, small holdings might get a higher weightage in distributing water than large holdings especially when water is scarce, or farmers having access to additional sources of water (conjunctive use opportunities) might get lower priority in allocation of scarce supplies. In such cases, equitable distribution has to be defined carefully and will be different from equality. It may also be possible in many cases to reduce the problem such that equality implies equity. For example, if there are two turnouts (or outlets) T1 and T? and they are serving ha each similar in all respects except that T1 area is ail paddy and T2 area is all non-paddy with its irrigation water requirements roughly equivalent to half of the paddy water requirements, then the equivalent paddy area of is 20 ha. If T2 receives half of what T1 receives the water distribution can be considered fair and equitable each having received its due share of water. Conceptually, it should be possible to make similar modifications to take care of other variations that equal treatment implies equity.

HEAD, MIDDLE AND TAIL

Inequity in water distribution exists in many systems where the offtakes in the head-reaches draw more than their shares of water depriving those at the tail. It is possible that there are some offtakes in the middle where the withdrawals approximate to their due shares and the water distribution is nearly equitable. In many canal systems without adequate structures (cross regulators, duckbill weirs etc) for regulation and control of water levels apd discharges, the head-reaches have a locational advantage and can draw more than their entitlement. But, if there are regulating structures in the'canals, it is not always the case that only the head-reaches get more water. It is possible that those located at the tail end get more than their due share of water while those in the middle get less than their due share. Therefore, we need a concept other than the head, middle and tail associated with location along the length of a conveyance channel For the purpose of this paper the following definitions are used:

Head: All the offtakes in the conveyance and distribution system which are supplied with volumes of irrigation water more than their due shares that are proportional to their cultivable command areas. These areas are 'oversupplied'.

Middle: All the offtakes which receive their due shares which are proportional to their cultivable command areas. They get neither more nor less than their entitlement; neither 'oversupplied' nor 'undersupplied'.

Tail: All the offtakes which receive less than their due shares of water. They are 'undersupplied'.

Head, middle and tail thus correspond to offtakes which are oversupplied, just adequately supplied and undersupplied and do not have any reference to the actual location of the offtakes. in due course, we have to find better terminology to avoid the confusion between the locational concept of head, middle and tail and the oversupplied, just adequate and undersupplied concept of head, middle tail indicated here.

METHOD OF DETERMING HEAD, MIDDLE AND TAIL

The head, middle and tail can be determined using the form of Lorenz curve where the percentages of the command areas served by each offtake unit (turnout, distributary etc) are arranged in the rank order from the most undersupplied to the most oversupplied in terms of water received. The cumulative percentage distribution of the unit command areas is represented on the horizontal axis and the cumulative percentages of volumes of water received by the unit command areas are represented on the vertical axis (Fig. 1). The middle is defined by that part of the curve where the tangent is parallel to the diagonal and has a slope of 450. In this segment, the command areas receive their due share of water. The middle separates the head on the right which is oversupplied and the tail on the left which is undersupplied.

RELATIVE EQUITY RATIO

It is possible to compute the extent of oversupply to the head and the extent of undersupply to the tail. Referring to Fig. 1 for illustration:

. At the head, 44.6 percent of the total area receives 60 percent of the total volume of water. This area then receives 60/44.6 = 1.35 times its share of irrigation water.

At the tail, 44 percent of the total area receives 78.6 percent of the total volume of the water. (ie) 28.6/44 = 0.65 times its share of water.

In the middle, 11.4 percent of the area receives exactly 11.4 percent of the volume of water which is its due share.

The extent of inequity between the head and the rail can be indicated by a parameter, Relative Equity Ratio (R.E.R.) which is defined as the ratio of the supply to the head and the supply to the tail both expressed as percentage of total volume of water divided percentage of the total area at the head and tail respectively.

In the illustration of Fig. 1.

Relative Equity Ratio (RER) = Supply at the head / Supply at the tail

$$= \frac{\frac{\text{Percentage of total volume of water}}{\text{Percentage of total area}} \text{ at the head}}{\frac{\text{Percentage of total volume of water}}{\text{Percentage of total area}} \text{ at the tail}}$$

$$\frac{(60/44.6)}{(28.6/44)} \quad \frac{1.35}{0.65} = 2.08$$

The RER shows that the head is two times more privileged than the tail. The method of computation shows that the head which constitutes 44 percent of the area receives 35 percent more than its due share and the tail which constitutes 44 percent of the area receives 35 percent less than its due share.

The ideal of equity between head and tail is reached when RER is equal to 1. It could be argued that it is perhaps more appropriate to call it Relative Ratio as higher values of the ratio indicate greater inequity between head and tail. The term RER is chosen to emphasize more the objective of equity though it indicates the extent of inequity when it is different from unit?

ANALYTICAL PROCEDURE OF COMPUTING RER

It might be considered a very stringent requirement in the definition of the 'middle' that the area represented by that segment should receive its exact share of the water. In practice, an area might be considered well served if it receives its share of water within a margin of 10 or 15 percent. Such a provision can be built into an analytical procedure to define head, middle and tail and then compute RER. This is best illustrated by an example which is taken from Abernethy (1986). Abernethy used the example to illustrate the various inequity parameters including the Inter-quartile ratio (IQR:I_1) and the modified IQR (I_2) which he developed. The same example is used here to compute RER in order to compare with Abernethy's I_1 and which have contributed considerably to advance the thinking on equity and the quantification of inequity in a meaningful way. Besides, one more example of distribution of water from a branch canal to various distributaries in the Kalankuttiya system of Sri Lanka is also used to illustrate the concept of RER.

EXAMPLES

Water distribution at tubeuell 81-R, Mona, Pakistan

This example deals with water distribution on a tubewell watercourse in Mona, Pakistan presented by Trout and others (1977), and is adapted in Table 1 in Abernethy (1986). It refers tcr area of 148 ha, a single watercourse in a typical Punjabi Warabandi (time-sharing) system. There were 20 holdings of different. sizes. Each farmer is entitieo, once a week, to exclusive use of the flow in the watercourse for a fraction of a week is equal to his fraction of the land served. The researchers measured the flows actually delivered to each of the holdings for one week. The purpose was to demonstrate that the system, though apparent!> equitable in terms of the proportional equality implied the time sharing of the

Warabandi svstem, becomes significantly inequitable in actual practice. In old and ill-maintained channels, the seepage losses along the watercourse reduce the amount of water actually received by the users at the tail-end.

The data in Table 1 is taken from Abernethy (1986). The holdings are ranked in order of the water received from lowest to the highest; holding 1 received the minimum 7.3 mm and holding 20 received the maximum 29.2 mm. Table 2 shows the computations needed for drawing the curve shown in Figure 1 and defining head, middle and tail areas which are oversupplied, just adequately supplied and undersupplied respectively. It also provides the information required for the analvtical procedure for computing the RER. Column 5 indicates the area of each holding as a percentage of the total area served the watercourse, column 6 gives the cumulative area of the holdings as a percentage of the total area, column 7 similarly shows the volume of water received bv each holding as a percentage of the total volume of water received by all the holdings, and column 8 the cumulative volume as a percentage of the total volume.

The data in columns 6 and 8 of Table 2 are plotted in Figure 7 to obtain a curve in a form similar to a Lorenz curve. This curve ha5 been used earlier to illustrate the concept of head, middle and tail and also to compute the RER using the data from the curve after drawing a tangent to the curve parallel to the diagonal. Table 3 summarizes the data used in computing RER.

The analytical procedure for computing RER uses the data in columns 5, 7 and 9 of Table 2. Column 9 gives the ratio (Z) of the volume of water received a holding as a percentage of total volume of water (V/TV) and the area of the holding as a percentage of the total area of all holdings (A/TA) (ie) the ratio of the figures in columns 7 and 5 for each of the holdings. If Z is equal to unity for a holding, it implies that the holding received its exact share of water. If Z is more than unity, the holding received more water than its due share and if Z is less than unity, less than the due share. For example, holding no. 20 received 158 percent of its share whereas holding no. 1 received 40 percent of its share. examining the values of Z in the last column, it is possihle to know what fraction of its share is received by each holding.

If it is accepted that a holding is deemed to have received its due share of water within a 15 percent margin, it implies that 2 is equal to or greater than 0.85 or equal to and less than 1.15 (ie) 0.85 Z 1.15. Examining column 9, it will he seen that holdings 1 to 9 have Z values less than C.85 and constitute the tail; hoidings 16 to 20 with 2 values greater than 1.15 constitute the head; and holdings 10 to 15 have got their due share as defined within a margin of error cf 15 percent. The areas corresponding to these holdings and the respective volumes of water received are used to compute RER as shown in Table 4 (a). The same procedure is used for computing RER with a margin of 10 percent instead of 15 percent in the value of 2 and the r-esults are shown in Table 4 (b).

From Tables 3, 4 (a) and 4 (b), the middle which received its due share of water varies from 11.4 to 30.3 percent of the total area, depending on the margin of error accepted in the definition of the due share; the tail varies from 45.3 to 36.8 percent; and the head from 44.6 to 32.8 percent. There is not much variation in the proportions of water received by the heads and the tails and the RER varies from 2.08 to 2.36.

Abernethy (1986) computed for this case the Inter-quartile ratio, I_1, of 1.79 and the modified inter-quartile ratio, I_2, of 2.81. Unlike and I_2 which make use of the data pertaining to only the upper and lower quartiles of the cumulative distribution, RER makes use of all the data in delineating the head, middle and tail. Not only does RER indicate the inequity between the head and tail but its computation also indicates the extent of oversupply to the head and the extent of undersupply to the tail. The value of Z, of course, indicates for each unit of analysis, in this case a holding, the extent of oversupply or undersupply.

Kalankuttiya canal of Mahaweli System H in Sri Lanka

The halankuttiya Block is located within System H of the Mahaweli development in the North-Central Province of Sri Lanka. The Kalankuttiya tank with a capacity of 1.86 x m^3 supplies the Kalankuttiya branch canal and commands an irrigable area of 2040 ha. The tanks own catchment area is only 26 km^2 but its water resources are supplemented, since 1977, by Mahaweli water diverted to the larger Ealawewa reservoir. The branch canal is 11.5 km long and has a maximum design capacity of 5.66 m^3/s (200 cusecs) at the head of the canal. 20 distributary canals take off the branch canal and in turn feed a network of field canals. Nine duck-bill weirs constructed along the branch canal help maintain hydraulic head 'at distributary canal offtakes irrespective of fluctuations of discharge in the branch canal. Control of discharges into a majority of distributary canals is thereby enhanced. Figures 2 and 3 show the Kalankuttiya branch canal and the distributaries. There are five blocks numbered 305 to 309 and a distributary is described by the block number followed by its number. Thus 306 D_2 refers to distributary D_2 in block 306. The soils in the command area vary from the more pervious Redish Brown Earths (RBE) in the upper reaches to the relatively impervious Lor; Humic Glavs (LHG) nearer the valleys with intermediate range of soils in between. Paddy is usually grown over the whole area in the Maha (wet) season. Paddv and a mix of Other Food Crops (OFCs) are grown in the Yala (dry) season; the extent of area under each of the crops varies with the expected availability of irrigation water supply.

Research is being conducted by **IIMI** since 1985 under the theme of crop diversification and there has been a comprehensive, multidisciplinary data collection program. The flow data used here is taken from the research project data.

Table 5 provides the data of the areas served each of the distributaries and the volumes of water received at the heads of the distributaries for the entire Maha (wet) season of 1986/87. The computations in Table are similar to those in Tabie 2. Fipure 4 describes the curve and the delineation of head, middle and tail and the RER is computed for this case (ie) Z = 1 and shown in Table 6(a). Table 6(b) and 6(c) show the results of analytical procedure for computing RER from Z values of Table 5 for the two cases respectively of 15 and 10 percent margin of error in The RER varies from 1.57 to 2.05. The IQR, I_1, and the modified IQR, I_2 computed as per Abernethy's procedure are shown in Figure 5 for comparison with RER. I_1 is equal to 1.29 and is 2.29.

In Yala season of 1986, paddy and OFCs were grown in the command areas of all the distributaries as shown in Table 7. It is therefore necessary to convert the area cropped with OFCs into an equivalent paddy area. This is achieved by multiplying the OFC area by a conversion factor of 0.6. It assumes that 1 ha of OFC and 0.6 ha of paddy have the same water requirements at the head of the distributary. Column 4 of Table 7 gives the sum of the area cropped to paddy and the equivalent paddy area of the OFC. This is the area to be used in the RER computations.

Figure 6 and Tables (b) and (c) show the RER computations for the Yala season of 1986 and Figure 7 provides the basis for I_1 and values of Abernethy's method. The RER values varp from 1.62 to 2.03 for different values of Z. I_1 and I? are 1.44 and 2.03 respectively.

It will be seen from Tables 5 and T and Figures 8 and 9 that the extent of inequity between head and the tail is about the same in the Maha and Yala seasons. The undersupplied 'tail' channels seen from Tables 5 and 7 are not really at the tail end locationally but in the middle in blocks 308 and 309 and the oversupplied 'head' channels are not all at the head-end. 307 D2, for example, which received an oversupply in both the seasons is located at the tail-end of the branch canal. 309 D1 was undersupplied in the Maha season but was oversupplied in the Yala season. In the IIMI research, five distributaries were chosen for detailed study. They were 305 D2, 305 D3, 305 D4, 306 D4 and 307 D2 which are dispersed locationally at head, middle and tail of the branch canal. As will be seen from Tables 5 and 7, these channels have all received reasonably fair shares of water giving the impression that head-tail inequities did not exist. It was thought that the control of water levels bv the duckbill weirs was perhaps responsible for that. Whereas it is true that the water level control with the help of duckbill weirs enables even tail-end distributaries to draw their due shares, it does not follow that the problems of inequity are necessarily solved by them.

CONCLUSION

The concept and method of computation of RER enable precise demarcation of the head (oversupplied), middle (fairly supplied) and tail (undersupplird) units of a conveyance and distribution system, and also assess the extents of oversupplies and under supplies. Their utility has to be tested in practice. RER has, of course, the same limitations as the other inequity parameters suggested the iiterature on the subject.

REFERENCE

Abernethy, Charles L. (1986) " Performance Measurement in Canal Water Management: A discussion ", ODI- IIMI Management Network 86/2d, August 1986.

CREDITS

The flow data on Kalankuttiya Branch canal and distributaries was collected by H.M. Hemakumara. Computations were done by A.P. Keerthipala and S. B. Tennakoon.

Table 1 Water distribution at tubewell 81-R, Mona, **Pakistan**

Holding number		Water received h (mm)
1	4.29	7.3
2	4.33	7.3
3	4.33	7.3
4	2.67	8.6
5	18.67	11.6
6	5.39	12.9
7	7.49	13.3
8	1.46	15.0
9	5.87	15.0
	4.07	16.1
11	8.46	16.3
12	17.25	18.9
13	6.24	19.3
14	6.24	19.3
15	2.59	21.1
16	5.43	21.9
17	10.33	21.9
18	8.30	27.5
19	7.81	29.2
20	16.76	29.2

Total area = 148.0 ha

Weighted mean water supply received = 18.44 mm

Data adapted from T Trout, S A Bowers, Mohsin Wahha, Hayat Ullah Khan Mohamed Yasin and M Iqbal: Operational conveyance losses on tubewell 81-R watercourse. Mona Reclamation Experimental Station, publication no. 76, July 1977.

(Source: Charles L Abernethy, 1986)

Table 2 Cumulative irrigated area as percentage of total area(X) and cumulative volume of irrigation water supply as percentage of total volume of supply(Y)

Holding No.	Area (A) ha	Water received (h) mm	Vol of water received (V) ha mm	TA %	Cumu. area TA	TV %	Cumu. vol TV	
1	4.29	7.3	31.32	2.90	2.90	1.15	1.15	0.40
2	4.33	7.3	31.61	2.93	5.83	1.16	2.31	0.40
3	4.33	7.3	31.61	2.93	8.75	1.16	3.46	0.40
4	2.67	8.6	22.96	1.80	10.56	0.84	4.31	0.47
5	18.67	11.6	216.57	12.62	23.17	7.94	12.24	0.63
6	5.39	12.9	69.53	3.64	26.81	2.55	14.79	0.70
	7.49	13.3	99.62	5.06	31.88	3.65	18.44	0.72
8	1.46	15.0	21.90	0.99	32.86	0.80	19.24	0.81
9	5.87	15.0	88.05	3.97	36.83	3.23	22.47	0.81
10	4.07	16.1	65.53	2.75	39.58	2.40	24.87	0.87
11	8.46	16.3	137.90	5.72	45.30	5.05	29.92	0.88
12	17.25	18.9	326.03	11.66	56.95	11.95	41.87	1.02
13	6.24	19.3	120.43	4.22	61.17	4.41	46.28	1.05
14	6.24	19.3	120.43	4.22	65.39	4.41	50.70	1.05
15	2.59	21.1	54.65	1.75	67.14	2.00	52.70	1.14
16	5.43	21.9	118.92	3.67	70.81	4.36	57.06	1.19
17	10.33	21.9	226.23	6.98	77.79	8.29	65.35	1.19
18	8.30	27.5	228.25	5.61	83.40	8.36	73.71	1.49
19	7.81	29.2	228.05	5.28	88.67	8.36	82.07	1.58
20	16.76	29.2	489.39	11.33	100.00	17.93	100.00	1.58
Total	147.98		2728.97	100.00		100.00		

Total area (TA) = 148.0 ha

Total volume (TV) 2729 ha mm

Weighted mean water supply received = 18.44 mm

Table 3 Definition of Relative Equity Ratio

$$\text{Relative Equity Ratio (R.E.R)} \quad \frac{1.35}{0.65} = 2.08$$

From figure 1

Table 4(a) Computation of RER with 0.85 Z 1.15

	Head	Middle	Tail
Area	32.86	30.31	36.83
Volume %	47.30	30.23	22.47
Volume/Area	1.44	1.00	0.61

Relative Equity Ratio (R.E.R) $= \frac{1.44}{0.61} = 2.36$

Table 4(b) Computation of RER with $0.90 \leqslant Z \leqslant 1.10$

	Head	Middle	Tail
Area %	34.61	20.09	45.30
Volume %	49.30	20.78	29.92
Volume/Area	1.47	1.00	0.66

Relative Equity Ratio (R.E.R) $= \frac{1.47}{0.66} = 2.23$

Table 5 Cumulative irrigated area as percentage of total area(X) and cumulative volume of irrigation water supply as percentage of total volume of supply(Y) during Maha (wet) season 1986/87 in Kalankuttiya Branch Canal of Mahaweli H, Sri Lanka

D-Channel No.	Area ha	Water received (h) mm	Vol of water received (V) ha mm	A/TA %	Cumu. area / TA (X)	V/TV %	Cumu. vol / TV (Y)	(A/TA) (Z)
309-02	76.9	366	28135	3.83	3.83	1.18	1.18	0.31
309-D1	59.7	548	32685	2.97	6.80	1.37	2.55	0.46
309-03	102.2	795	81174	5.09	11.89	3.41	5.96	0.67
308-D2	69.8	852	59474	3.48	15.36	2.50	8.46	0.72
308-03	107.8	981	105742	5.37	20.73	4.44	12.91	0.83
305-D4	70.8	1019	72181	3.53	24.26	3.03	15.94	0.86
305-D3	101.7	1045	106320	5.07	29.32	4.47	20.40	
309-D4	96.2	1062	102107	4.79	34.11	4.29	24.69	0.90
306-02	109.1	1129	123188	5.43	39.54	5.17	29.87	0.95
306-03	35.4	1135	40184	1.76	41.31	1.69	31.56	0.96
306-D5	178.1	1226	218350	8.87	50.17	9.17	40.73	1.04
309-05	84.0	1281	107644	4.18	54.36	4.52	45.25	1.08
307-03	218.3	1285	280464	10.87	65.22	11.78	57.03	1.08
306-01	82.5	1305	107608	4.11	69.33	4.52	61.55	1.10
305-02	76.9	1308	100594	3.83	73.16	4.23	65.78	1.10
305-D1	294.3	1371	403635	14.66	87.82	16.96	82.73	1.16
307-Dl	55.0	1467	80656	2.74	90.56	3.39	86.12	1.24
306-04	49.6	1496	74150	2.47	93.02	3.11	89.24	1.26
307-02	68.3	1640	111996	3.40	96.42	4.70	93.94	1.38
308-01	71.8	2008	144241	3.58	100.00	6.06	100.00	1.69
Total	2008.5		2380526	100.00		100.00		

Total area (TA) = 2008.5 ha

Total volume (TV) = 2380526 ha mm

Weighted mean water supply received = 1186

K nkuttiya Br ich Canal, Maha season 1986/87

Table 6(a) Computation of RER with Z = 1.0 (Data from figure 4)

	Head	Middle	Tail
Area (%)	50.0	11.4	38.6
Volume (%)	59.3	11.4	29.3
Volume/Area	1.19	1.00	0.76

Relative Equity Ratio (R.E.R) = $\frac{1.19}{0.76}$ 1.57

Table 6(b) Computation of RER with 0.85 Z 1.15

	Head	Middle	Tail
Area (%)	26.84	52.43	20.73
Volume (%)	34.22	52.87	12.91
Volume/Area	1.27	1.01	0.62

Relative Equity Ratio (R.E.R) = $\frac{1.27}{0.62}$ = 2.05

Table Computation of RER with 0.90 Z 1.10

	Head	Middle	Tail
Area (%)	26.84	43.84	29.32
Volume (%)	34.32	45.37	20.43
Volume/Area	1.27	1.03	0.70

Relative Equity Ratio (R.E.R) = $\frac{1.27}{0.70}$ = 1.81

Table 7 Cumulative irrigated area as percentage of total area(X) and cumulative volume of irrigation water supply as percentage of total volume of supply(Y) during Yala (dry) season 1986 in Kalankuttiya Branch Canal of Mahaweli H, Sri Lanka

D-Channel No.	Paddy area ha	OFC area ha	Total area (A) ha	Water received (h) mm	Vol of water received (V) ha mm	TA %	Cumu. area TA	TV	vol TV (Y)	(A/TA)*
309-D2	58.1	16.5	68.0	613	41654	4.25	4.25		1.48	0.35
308-D2	53.7	16.1	63.4	1245	78918	3.96	8.21	2.79	4.27	0.71
306-D2	60.9	47.7	89.5	1250	111958	5.60	13.81	3.97	8.24	0.71
308-D3	60.1	45.2	87.2	1309	114198	5.45	19.26	4.04	12.28	0.74
305-D4	39.2	31.2	57.9	1378	79700	3.62	22.88	2.82	15.10	0.78
309-D3	60.9	43.3	86.9	1429	124158	5.43	28.31	4.40	19.50	0.81
305-D3	30.2	68.6	71.3	1601	114138	4.46	32.76	4.04	23.54	0.91
309-D4	43.5	52.7	75.1	1715	128689	4.69	37.46	4.56	28.10	[illegible]
306-D5	87.2	89.9	141.1	1725	243332	8.82	46.27	8.62	38.72	
305-02	36.7	41.2	61.4	1838	112892	3.84	50.11	4.00	40.72	1.04
307-DI	32.5	30.2	50.7	1842	93328	3.17	53.28	3.31	44.02	1.04
306-01	42.6	43.1	68.4	1859	127167	4.28	57.56	4.50	48.52	1.05
309-05	46.6	37.4	69.1	1948	134543	4.32	61.87	4.76	53.29	1.10
306-04	18.0	28.5	35.1	2006	70397	2.19	64.07	2.29	55.78	1.14
305-DI	104.0	202.7	225.6	2022	456189	14.10	78.17	16.16	71.94	1.15
307-03	70.1	150.0	160.1	2028	324641	10.01	88.18	11.50	83.44	1.15
	28.2	31.0	46.8	2310	108036	2.92	91.10	3.38	87.26	1.31
308-01	61.3	10.5	67.6	2441	165052	4.23	95.33	5.85	93.11	1.38
307-02	20.5	47.0	48.7	2475	120509	3.04	98.37	4.27	97.38	1.40
306-D3	14.0	20.1	26.1	2843	74110	1.63	100.00	2.62	100.00	1.61
Total	968.3	1052.9	1600.0		2823611	100.00		100.00		

Paddy area = 968.3 ha

Other food crops (OFC) area = 1052.9 ha

Conversion Factor (CF) = 0.6

Total area (TA) [Paddy area area;! = 1600.0 paddy area equivalent hi!

Total volume = 2823611 ha mm

Weighted mean water supply received = 1765 mm

Kalankuttiya Branch Canal, Yala season 1986

Table 8(a) Computation of RER with $Z = 1.0$ (Data from figure 6)

	Head	Middle	Tail
Area (%)	48.9	14.2	36.9
Volume (%)	58.6	14.2	27.2
Volume/Area	1.20	1.00	0.74

$$\text{Relative Equity Ratio (R.E.R)} = \frac{1.20}{0.74} = 1.62$$

Table 8(b) Computation of RER with $Z \leq 1.15$

	Head	Middle	Tail
Area (%)	11.82	59.87	28.30
Volume (%)	16.56	63.94	19.50
Volume/Area	1.40	1.07	0.69

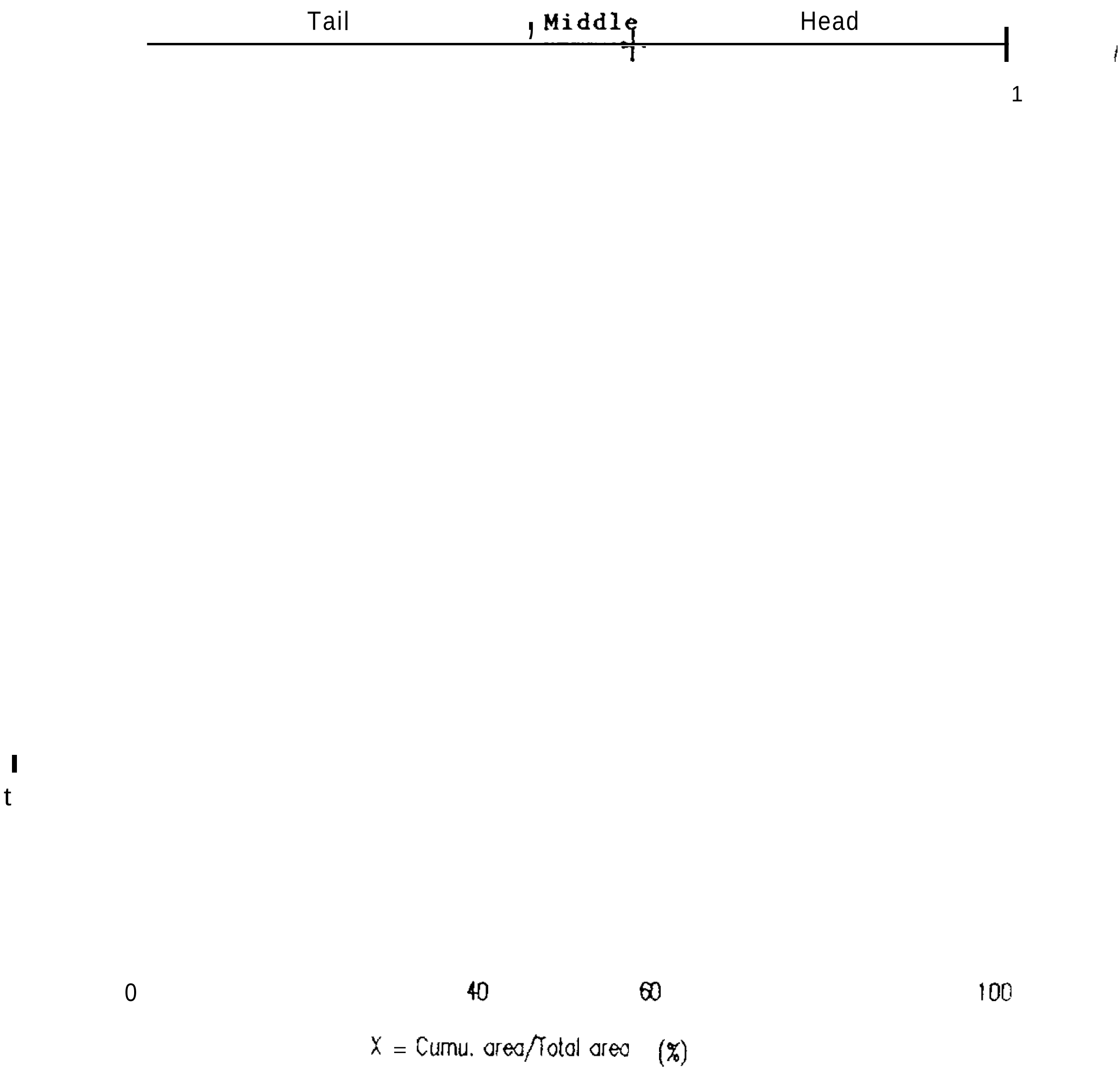
$$\text{Relative Equity Ratio (R.E.R)} = \frac{1.40}{0.69} = 2.03$$

Table 8(c) Computation of RER with 0.90 Z 1.10

	Head	Middle	Tail
Area (%)	38.13	33.57	28.30
Volume (%)	46.71	33.79	19.50
Volume/Area	1.23	1.01	0.69

$$\text{Relative Equity Ratio (R.E.R)} = \frac{1.23}{0.69} = 1.78$$

Figure 1 Definition of head, middle and tail



F gure 2 Kɜ ɷnkuttiyɜ B ock of M hɜωeli system H

Figure 3 Issue tree diagram – Kalankuttiya (2023 ha)

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Figure 4 Definition of head, middle and tail
Kalankuttiya Branch Canal, **Maha** season **1986/87**

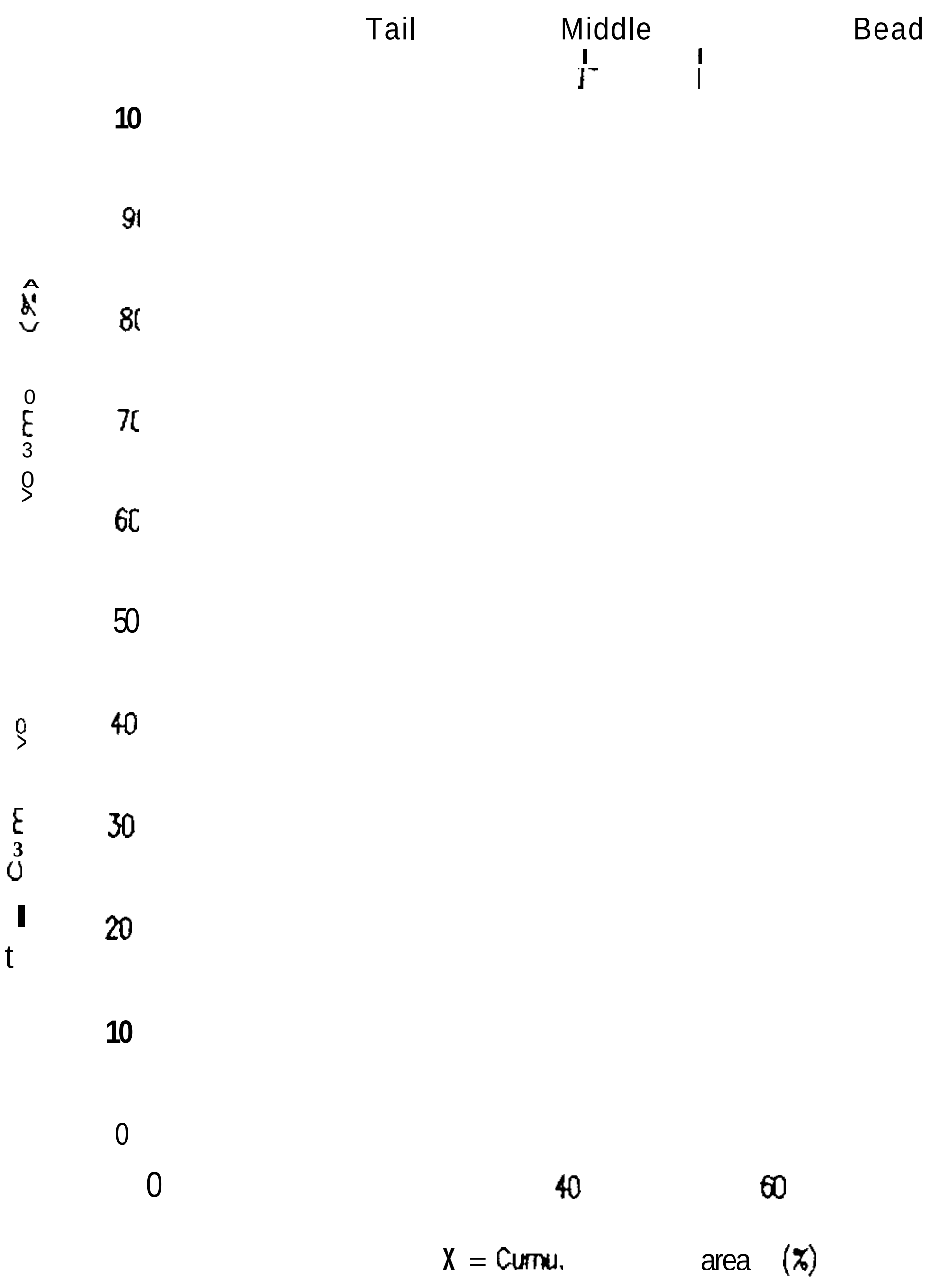

Figure 5 Definition of Inter - quartile ratio
Kalankuttiya Branch Canal, Maha season 1986/87

0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2
(Thousands)
h, Depth of water delivered (mm)

Figure 6 Definition of head, middle and tail
Kalankuttiya Branch Canal, Yala season 1986

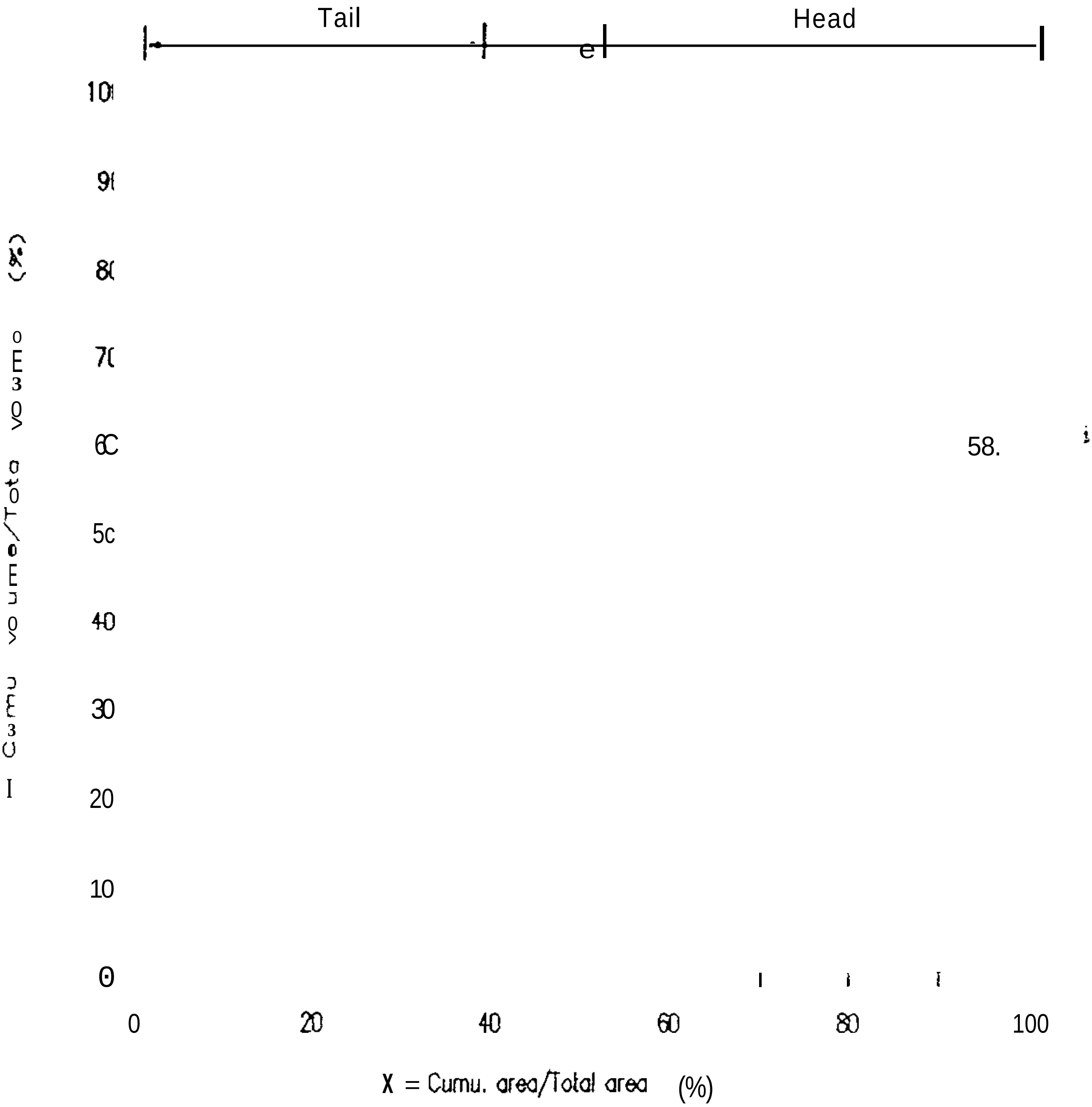

Figure 7 Definition of Inter - quartile ratio
Halankuttiya Branch Canal, Yala season 1986

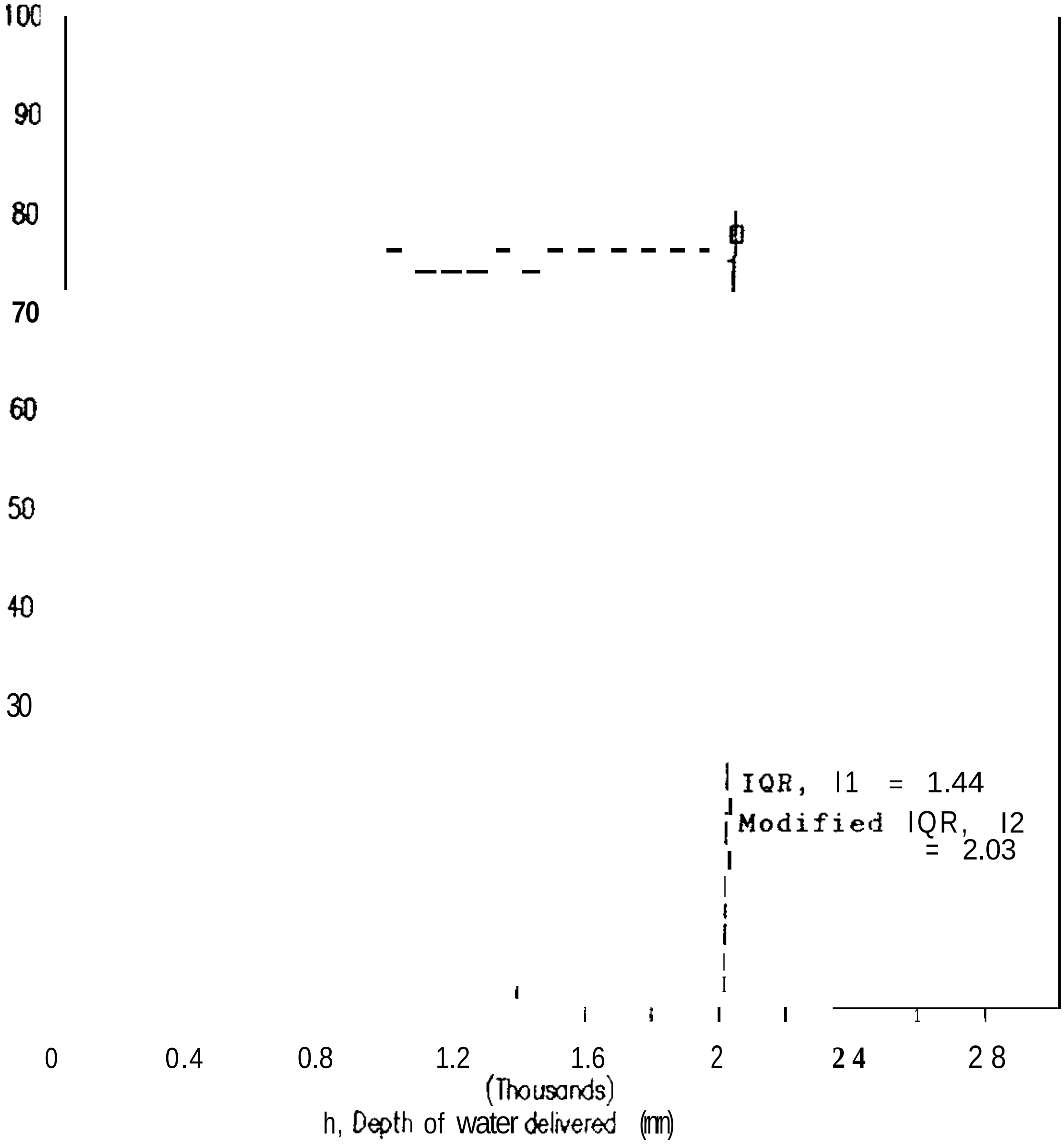

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Figure 9 Z values for each distributary, 1986 Yala