Water Distribution Equity In Sindh Province, Pakistan

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1. Concepts of Equity and Equality in Water Distribution

a) The Concept of Fairness

The concept of equity of water distribution is widely used in assessment of irrigation water management performance but in reality there is considerable confusion between the concepts of equity and equality. In understanding what options are open to both groupings of water users and national or provincial irrigation agencies it is useful to distinguish carefully between different strategies for water allocation and distribution.

Equality divides up a common resource in a set of equal shares that can be related to a directly measurable parameter. The most common form of division in irrigation systems is by area, whereby each unit area of land receives the same water allocation. In some systems, frequently smaller systems managed entirely by the local community, a water share may be assigned to each person irrespective of the area of land they own or cultivate, and can include landless members of the community.

At a more complicated level equality of water distribution may be based on assessment of the potential productivity of land resources, giving more water to more productive land, or to assessment of soil type so that soils with high water holding capacities receive less water than those with lower water holding capacity.

Equity is based on a principle of fairness that is accepted by all members of the community involved in sharing a common resource. The fairness involved reflects the values of the society and does not have to be based on any sense of an equal share. Some people may get a larger share of water than others either due to prior rights, in compensation for more inputs into system construction or maintenance. It is much more difficult to define entitlement to water based on value systems than entitlement based on a principle of equal sharing.

In practice large-scale irrigation systems are almost always based on a water entitlement based on equality rather than equity because of the difficulty of accurately determining what a society considers fair. Further, many larger irrigation systems are constructed in areas previously unirrigated, cover several different communities which may have different views of fairness, and where there is weak communication between system designers and future water users.

The result is that it has been much easier for irrigation system designers to design systems based on an assumed concept of equality which later is translated to also be assumed to be equitable. As irrigation communities grow and mature and their experience of what may or may not be considered fair becomes clearer, a second phase of reassessing water entitlements may emerge at local level that may require adjustments in the way in which systems are operated by national or provincial agencies.

Moves towards transferring management responsibilities from government agencies to water users may re-ignite the debate over what is considered fair. The process of transferring responsibility of operation and maintenance inevitably carries with it the right of water users to reassess how they decide to allocate water among themselves. The simple principles of equality inherited from government agencies is not automatically viewed as the most appropriate or desirable allocation principle for local communities, but government agencies who retain some form of oversight for the newly established communities may still desire to keep the old allocation principles active.

This is the situation facing both the newly established Farmer Organizations (FOs) in Sindh and the newly created Sindh Irrigation and Drainage Authority (SIDA). As FOs begin to take full responsibility for operation and maintenance they may wish to change the allocation rules to reflect other principles they see as important.

b) Water Allocation and Distribution Policies in Pakistan

The standard allocation practice in Pakistan has been to allocate water on the basis of an equal share of water per unit area of land. Although there are variations in the water allocations between different canal commands, the result of changing national policies or assessment of overall water availability at the time of construction, within a canal command the share is normally more or less equal.[1]

As a result of this allocation principle it is normally possible to define a canal command water allowance in a simple term. Traditionally this is expressed in cusecs/1000 acres.[2] Typical water allocations are between 2.5 – 3.5 cusecs/1000 acres, or something in the order of 2 mm/day.

As it is impossible to cultivate all of the irrigable area of a canal command with a low water allowance of this kind, a planning goal was derived to accompany the water allowance. The planning goal indicated the expected cropping intensity for each of the two main seasons (rabi or winter season and kharif or summer season). Typical cropping intensity targets expect twice as much cultivation in the winter when crop water requirements are lower than in the hotter, more water-demanding summer months. A typical annual target is a 50% cropping intensity (33% in rabi and 17% in kharif).

In the areas covered in the pilot area for this project the water allowance is approximately 3.8 cusecs/1000 acres, or 2.28 mm/day, with an annual cropping intensity target of 81%. This means that in the rabi (winter) season 54% of land should be irrigated, while in the kharif (summer) only 27% would be irrigated. If these cropping intensity targets were met, then the functional water allowance would be about 4.2 mm/day in rabi and 8.4 mm/day in kharif.

c) Design and Operational Strategies to achieve Water Allocation Policies

The water allowance policy is perhaps the classic case of a supply-based system where there is no intention of delivering sufficient water for all cultivators to enable them to irrigate all of their land. Water, by design, is always scarce.

At the same time, the principle of equity of water allocation among cultivators was seen as essential to the effective use of irrigation facilities. The expectation was that all cultivators should always receive their equal share of water irrespective of location within the system. This contrasts strongly with experiences in other countries where only a set portion of the irrigation system is irrigated whenever water is insufficient to meet all of the potential demand.[3]

To accomplish this very demanding policy, two overriding principles were adopted within the majority of systems in British colonial India: proportional division of water in the water delivery system at secondary level, and a rigid turn system between water users at the tertiary level. Under abnormal conditions a third strategy, that of rotation between secondary canals, is also adopted.

Proportional division of water at secondary level is normally accomplished by using a submerged fixed orifice at the head of every tertiary canal. The size and elevation of the orifice is calculated to allow a set and proportional discharge to enter the tertiary canal as long as operational water levels are at or close to design levels. As long as the orifice dimensions are not be altered and as long as channels do not accumulate sediment or suffering scouring, it is possible to achieve quite accurate control over water levels along a secondary canal without using any cross-regulation structures of control gates, and as long as water levels are at design level then flow through the orifice will be close to the design. To ensure integrity of the system water users were not allowed by law to try to modify

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[1] In some canal commands villages that had an existing irrigation system or had some other prior right may have a higher water allocation than the rest of the system

[2] 1 cusec/1000 acres is 28.3 l/sec for 405 ha, approximately 0.07 l/s/ha or 0.6 mm/day

[3] Different countries have different policies to share scarce water. In Indonesia there is typically a priority for different parts of a system that has a three-year cycle (golongan system), so that over the full cycle each farmer has one year of high priority and two years of lower priority. In Sri Lanka traditional bethma systems allow tail end farmers to cultivate land in the head end of the system when water is in scarce supply, with head end farmers giving up a portion of their land for that season only.

the dimensions of the outlet structure, while the Irrigation Department had to closely monitor water levels at head and tail of each secondary canal.

Turn Systems, or warabandi, were the necessary and logical complement to proportional water deliveries at the head of each tertiary canal. A standardized formula was developed over several years that determined the exact number of minutes that each water user should receive each week in order to share water equally. The formula allows for the precise area owned by each water user and also includes allowances for filling or draining of sections of the watercourses as the turn passes from one farmer to another.

Rotation between secondary canals is required if there is insufficient water to keep all secondary canals within 30% of design discharge. If the water level drops too low in a canal then the hydraulic principles used in determining outlet dimensions and elevation no longer can guarantee accurate or equal water distribution. Under such conditions certain secondary canals will be closed completely so that the remaining canals flow at design discharge. Normally closure is for a 7 or 8 day period, after which the priorities change and dry canals get full supply discharge. In this way water shortages at system level are shared equally among all water users.

d) Constraints to Achieving Water Distribution Equity

In reality it is not always easy to achieve water distribution equality as called for in the operation principles. Typical causes of deviation from design are included in Table 1.1, from which it can be seen that the location of the causes may be far removed from the place where unequal access to water is being felt.

Table 1.1 Causes of Unequal water distribution in typical Pakistan irrigation systems

Factor causing unequal distribution of water	Location in canal system	Responsibility
Incorrect canal discharge	Main canal headgate	Executive Engineer
Fluctuating discharge	Main canal headgate	Executive Engineer
Incorrect canal discharge	Secondary canal headgate	Assistant Engineer
Fluctuating discharge	Secondary canal headgate	Assistant Engineer
Improper rotation	Secondary canal headgate	Assistant Engineer
Sedimentation	Secondary canal	Assistant Engineer
Scouring	Secondary canal	Assistant Engineer
Outlet tampering	Tertiary outlet	Water users
Poor maintenance	Watercourse	Water users
Improper turn system	Watercourse	Water users

It is also clear from Table 1.1 that the nature of the cause of inequality of water distribution can either be operational, either at the main or secondary canal headgate of along a watercourse, or it can be related to ineffective maintenance at secondary or watercourse level.[4]

The net conclusion from this discussion is that the real causes of inequality of water distribution in a typical Pakistan canal system are not easily identifiable. While the effects will always be seen at watercourse level, it is not immediately obvious where the inequality started and who was responsible. This makes it difficult to determine effective remedial action, and makes it easy to assign blame to the incorrect authority. To overcome this problem, IWMI has undertaken three sets of studies in the three districts included in the Left Bank Outfall Drain (LBOD) that were aimed at measuring water, assessing the effectiveness of water distribution practices, and attempting to identify at which locations in the system inequality was introduced. These studies are described in the next section.

[4] Ineffective maintenance at main canal level has fewer negative effects because discharges can be regulated at secondary canal cross regulators. This option is not available below secondary canal headgates because there are few, if any, cross-regulators along secondary canals.

Table 2.3 Distributaries Included in Farmer Managed Irrigated Agriculture Project–Phase II

Secondary Canal	Main Canal	Area (ha)	Design discharge (m3/sec)	Number of Watercourses
Rawtiani Minor	Dim Branch	3658	0.83	19
Mohammed Ali Minor	Dim Branch	337	0.31	10
Tail Minor	Shahu Branch	3355	0.63	14
Mirpurkhas Distributary	Jamrao Main	6566	2.75	59
Sanharo Distributary	Jamrao Main	6222	1.52	30
Belharo distributary	Jamrao West	6914	1.66	34
Digri Distributary	Jamrao West	12394	2.69	70
Potho Minor	Jamrao West	3264	0.82	19
Khatian Minor	Jamrao West	3996	0.78	21
Bagi Minor	Jamrao West	3630	1.16	15

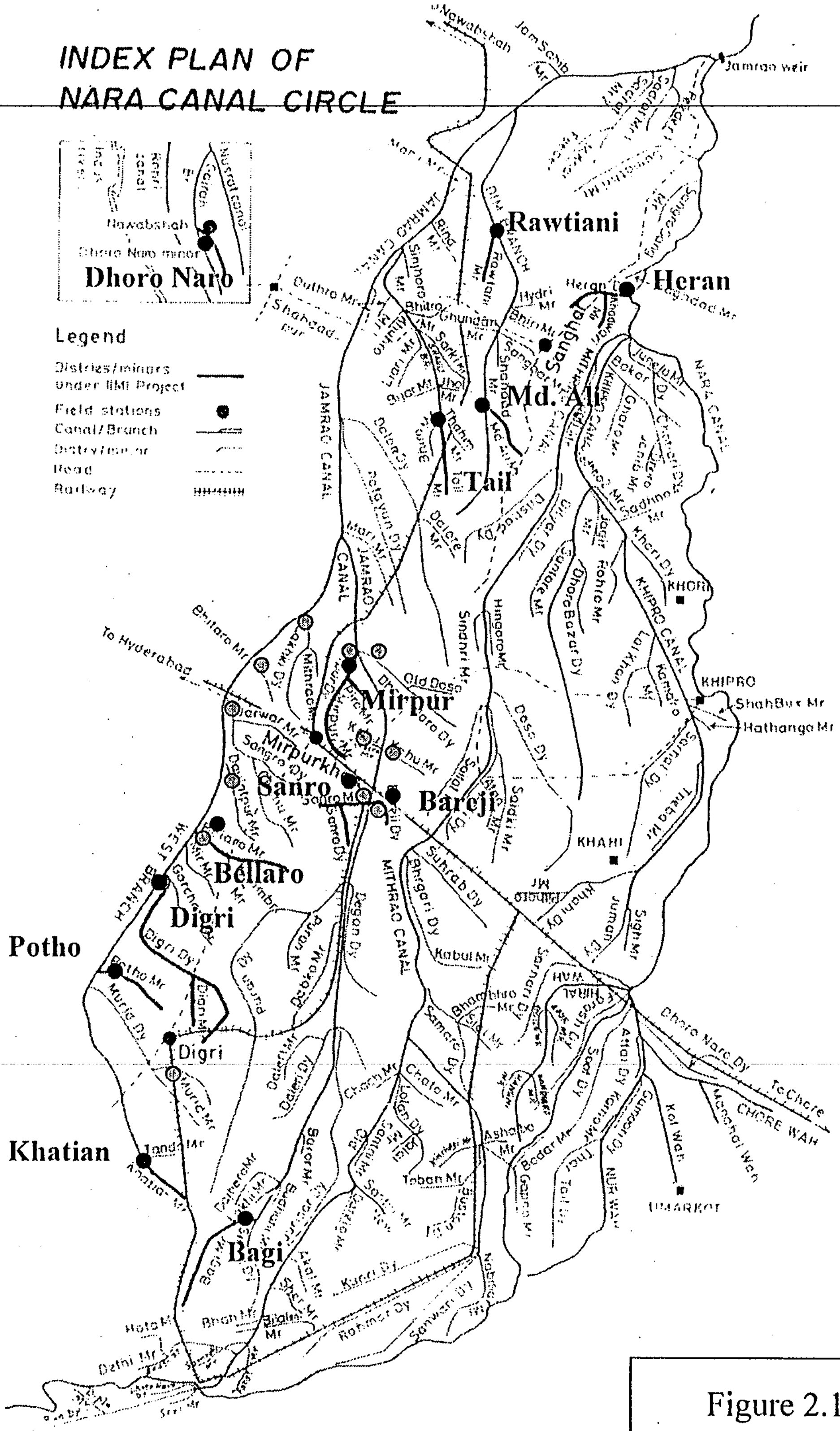
iv) Overall data availability

From these three data collection programs a total of 20 canals had measurements taken during the period November 1996 to May 2000. There are a total of 281 canal-months of data falling into six seasons: Rabi 1996/97, Kharif 1997, Rabi 1997/98, Kharif 1999, Rabi 1999/2000, and part of Kharif 2000.

During both the DSS study and the FMIA-Phase II study daily data were collected at canal heads so the data sets are complete (except for Sundays and public holidays). These data allow a full analysis to be undertaken because days when water was not flowing in canals was recorded.

In the FMIA-Phase I study, however, data were only collected twice a week and only when canals were flowing. This data set, covering three canals and involving a total of 22 canal-months of data, do not provide information on canal closures and so it is not possible to determine the frequency of closed days or undertake an analysis of rotational closures.

The location and periods of measurement are provided in Table 2.4. It is clear that there is good coverage in four of the six seasons of study, limited data for Kharif 1999, and incomplete data for Kharif 2000. However, the data collection program will continue until September 2000 which will enable a complete analysis of the Kharif 2000 data to be made at a later stage. Data for every January has been ignored because canals are normally closed for most of the month and the remaining data are too few to be subject to any serious analysis.



◎ DSS Canals

● FMIA-II Canals

Figure 2.1

Location of IWMI Sample Secondary Canals in Sindh

Table 2.4

Data Availability for analysis of Water Distribution Equity

Command	Kotri	Nara	Jamrao																	
Main Canal	Gajrah	Nara	Dim		Shahu	Jamrao						West Branch								
Secondary	Dhoro N	Heran	Rawtiani	Md.Ali	Tail	Mirpur	Doso	Visro	Kahu	Bareji	Sanro	Lakhi	Bhitaro	Sangro	Daulat	Bellaro	Digri	Potho	Khatian	Bagi
Nov-96						x	x	x	x	x	x			x	x	x				
Dec-96						x	x	x	x	x	x	x	x	x	x	x				
Jan-97																				
Feb-97						x	x	x	x	x	x	x	x	x	x	x				
Mar-97						x	x	x	x	x	x	x	x	x	x	x				
Apr-97	o	o				x	x	x	x	x	x	x	x	x	x	x				
May-97	o	o				x	x	x	x	x	x	x	x	x	x	x				
Jun-97	o	o				x	x	x	x	x	x	x	x	x	x	x				
Jul-97	o	o				x	x	x	x	x	x	x	x	x	x	x				
Aug-97	o	o				x	x	x	x	x	x	x	x	x	x	x				
Sep-97	o	o				x	x	x	x	x	x	x	x	x	x	x				
Oct-97	o	o				x	x	x	x	x	x	x	x	x	x	x				
Nov-97	o	o				x	x	x	x	x	x	x	x	x	x	x				
Dec-97	o	o				x	x	x	x	x	x	x	x	x	x	x				
Jan-98																				
Feb-98	o	o				x	x	x	x	x	x	x	x	x	x	x				
Mar-98	o	o				x	x	x	x	x	x	x	x	x	x	x				
Apr-98						x	x	x	x	x	x	x	x	x	x	x				
May-99	x	x																		
Jun-99	x	x								x										
Jul-99	x	x								x										
Aug-99	x	x								x										
Sep-99	x	x								x										
Oct-99	x	x								x										
Nov-99	x	x	x		x	x				x	x					x				
Dec-99	x	x	x		x	x				x	x					x	x	x	x	x
Jan-00																				
Feb-00	x	x	x		x	x				x	x					x	x	x	x	x
Mar-00	x	x	x	x	x	x					x					x	x	x	x	x
Apr-00	x	x	x	x	x	x					x					x	x	x	x	x
May-00	x	x	x	x	x	x					x					x	x	x	x	x

x Complete daily dats set available
o Sample daily data set available

b) Data Collection Program and Performance Assessment Criteria

The main strategy of the measurement program to better understand water distribution is to determine the values for a set of performance indicators that describe how well the designed objectives of the system are being met. The designed objectives discussed in Section 1.c above indicate the following conditions should be met:

- as long as there is adequate water available at the head of the main canal,
- to distribute this water equitably among secondary canals,
- to maintain secondary canals so that correct discharges pass into each reach of the secondary canal, and
- to maintain secondary canals so that correct discharges pass into watercourse every day, and
- ensure that discharges are within an acceptable tolerance, but
- in the case of shortages of water at the head of the main canal,
- to implement a fair and equal rotation among secondary canals,
- ensure discharges in operating canals do not fall below 70% of design discharge, and
- ensure that discharges are within an acceptable tolerance.

The designed objectives of the system and the appropriate performance indicators are summarized in Table 2.5

Based on this analysis of objectives and performance indicators, it is a simple task to develop the monitoring program needed to meet the evaluation objectives. IWMI therefore developed a monitoring and evaluation package that included the following elements.

i) Discharge

Secondary Canal Heads: discharges were measured at the head of each secondary canal on a daily basis in each of the three measurement programs.

At each secondary head in the FMIA projects a staff gauge was installed, and readings of water levels taken each day (except for one day a week and on public holidays). Each staff gauge was calibrated using a current meter and a rating curve developed. If changes in canal cross-sections occurred, staff gauges were recalibrated.

In the DSS project discharges were calculated by calibrating the headgates in the main canals cross-regulators and in secondary canal offtake structures. The calibration was based on gate openings and dimensions, and upstream and downstream water levels, with rating curves developed by current metering the canal downstream of the headgate. This was done using a boat in main canals and large secondaries.

Table 2.5 Designed objectives, performance indicators and data requirements

Objective	Performance Indicator	Data Requirement
a) Normal Conditions		
Equity of water distribution at secondary canal level	Delivery Performance Ratio at head of secondary canals	Design discharge and actual discharge at secondary canal head
Equity of water distribution along secondary canals	Delivery Performance Ratio of head, middle, and tail reaches of secondary canals	Design discharge and actual discharge at head of each canal reach

To make the evaluation easier, there is one tolerance standard defined by the Irrigation Department. If the actual discharge drops below 70% of design discharge then rotation should be implied, so the minimum acceptable DPR is 0.7. There is no comparable upper limit but it seems realistic to have a similar upper limit, so anything above 1.3 would be considered poor performance.

A more rigorous performance criteria is used at watercourse level where discharges are supposed to be within ±10% of design. We therefore adopt the following performance assessment criteria:

Good performance:	DPR between 0.9 and 1.1
Fair performance:	CV between 0.7 and 0.9 or between 1.1 and 1.3
Poor Performance:	CV less than 0.7 or more than 1.3

Wherever possible, IWMI has converted actual discharge data into DPR values because this is a standardized ratio that permits simple comparison of performance in canals with different design discharges. This comparison can be made using daily data for a single day for several canals, or be calculated for a single location over a set time period (typically a week or a month) so that a time series of DPR values can be developed.

A second way of using DPR values is merely to add up the number of occurrences when DPR falls outside the acceptable limit. The percentage of sub-standard days should be equal over space if all areas are to be treated equally.

iii) Variability of Discharges

The second performance parameter used by IWMI is aimed at assessing the variability in canals over a specified time period because there is evidence that if canal supplies are unreliable, water users risk fewer inputs and yields drop.

While an average figure for discharge or DPR over a period of time may fall within the tolerance limits defined above, the variability may not. The easiest standardized measure of variability that can be compared to DPR is the Coefficient of Variation (CV), which is independent of the actual average:

$$\text{Coefficient of Variation (CV)} = \frac{\text{Standard Deviation of Discharge}}{\text{Average Discharge}}$$

CV values can also be used on both a spatial manner, where CVs for the same time period in different locations are compared, and in a temporal dimension to see how variability changes over time at a single location.

The tolerance for CV is more difficult to define because there are no specified targets in the operational rules of the Irrigation Department. Two approaches can be adopted, one based on general guidelines developed by Molden and Gates (1990), or more site-specific tolerances based on operational rules of the Irrigation Department.

Molden and Gates propose that the temporal measure of variability, which they term reliability, should have three categories: if CV_t is <0.10 variability is good, if CV_t is between 0.10-0.20 it is fair, and if CV_t is more than 0.20 it is considered poor. The spatial measure (CV_s) is slightly less stringent: good is still less than 0.10, fair is when CV_s is between 0.10-0.25, while poor is when CV_s is greater than 0.25.

However, these limits do not fit comfortably with those inherent in the Irrigation Department rules. It would be acceptable under current Department rules to deliver water on alternate days into a secondary canal with a DPR of 0.7 and a DPR of 1.3. This would translate over a month into a CV of 0.305. A rather more stringent rule is applied at watercourse level where discharges are not supposed to vary by more than ±10%, so that the maximum acceptable CV is 0.101. Combining these two criteria is impossible, and so a three-fold assessment of CV is used here:

Good performance:	CV <0.10
Fair performance:	CV <0.30
Poor Performance:	CV >0.30

No distinction is made between spatial and temporal CV because the rules of the Irrigation Department do not distinguish between tolerances for spatial and temporal variation: all canals should be treated equally at all times.

One methodological problem that arises is that there are sometimes days when no water is delivered to the head of a secondary canal but rotational irrigation is not being practised. Typical causes for such interruptions in supply include upstream or downstream breaches that require canals to be closed so that repairs can be made, or closure of canals due to rainfall that means crops do not require water. Most data sets do not indicate whether water users knew of such disruptions in advance or, more likely, they did not. The CV values can be calculated to include or exclude occasional closures depending on whether we assume there is good communication or not.

We therefore calculate the data in two ways. We use all data, including days when there was no discharge recorded, to represent the situation where communications are extremely poor and water users do not know when water supplies will stop, and we use a data set with all zero discharge days removed to represent the situation where water users are assumed to have advance warning of all closures and disruptions to supply. In reality, some intermediate situation is probably close to what water users actually experience.

iv) Rotation

The final performance evaluation relates to the implementation of rotations. Normally most water users know when they are in a period of rotation, and will therefore expect some periods when canals are closed. However, the precision of implementation of rotational irrigation is not always guaranteed. Performance assessment therefore looks at two different elements of the implementation of rotational irrigation: equality of dry days between canals, and the attainment of minimum discharge targets during periods when water is flowing.

A well-implemented rotation period would ensure that all canals get an equal number of days of closure, but when water is delivered it is with a DPR of 0.7 to 1.3 to maintain hydraulic integrity along the secondary canal. It is inevitable that there will be higher variability of discharges in periods of rotation because of the frequent draining and filling of canals but the differences in CV between different canals should be more or less the same if the implementation is done with care.

3. Analysis of Water Distribution Equity in Sindh Province

This section describes the results of the analysis of the data set descıibed in Section 2. It is based on monthly data only. While it would be possible to undertake a more detailed daily or weekly analysis this has not been included in this report.

Monthly analyses tend to be more indicative of overall conditions because they even out short-term deviations and fluctuations. It therefore includes any managerial adjustments that were made for unexpected changes in water availability at the head of the system.

To put the monthly data into perspective it is useful to calculate the average DPR for all canals included in each season of study. These data are summarized in Table 3.1.

Table 3.1 Seasonal Delivery Performance Ratios (DPR) and Coefficients of Variation (CV)

Season	Rabi 96/97	Kharif 97	Rabi 97/98	Kharif 99	Rabi 99/00	Kharif 00
Number of Canals	13	13	13	3	13	13
DPR						
All data	1.18	1.23	1.25	1.31	1.12	0.83
Excluding closed days	1.22	1.43	1.26	1.61	1.28	1.18
CV	0.21	0.40	0.17	0.47	0.38	0.68
All data	0.14	0.12	0.11	0.11	0.12	0.11
Excluding closed days						

From a seasonal perspective the overall performance is generally only satisfactory. Looking at the DPR values using the entire data set five of the six seasons show DPR values within the 0.7-1.3 range, and the exception is Kharif 1999 where the data set is too small to be significant. Rabi 1999/2000 shows the best performance, but this was a winter season when water availability was lower than normal due to restricted releases from Tarbela and Mangla reservoirs.

The restrictions on water in Rabi 1999/2000 are evident from the overall seasonal CV, which is much higher than a normal Rabi season, and reflect the need to impose rotations in January-March 2000. The effect of rotations is seen in every Kharif season where CV values are always above 0.4, a value that is classified as poor performance.

By excluding zeros the effects of rotations can be better understood. By only considering days when water was issued to canals we observe two main trends:

- Variability of discharges drops dramatically so that in every season the average CV is in the range of 0.11-0.14, which is satisfactory for all seasons, and
- DPR values all rise, showing that when canals are operated, discharges are actually much higher than design and performance is poor in two seasons and only satisfactory in the remaining four seasons.

This seasonal analysis puts into context all of the remaining analysis described in this section.

a) Equity of Water Distribution Between Secondary Canals

This sub-section looks at the monthly equity of water distribution at the head of all of the secondary canals in each season of the study.

i) Monthly Delivery Performance Ratios

The full set of results for the entire period of observation is shown in Appendix 1, Tables A.1 (all data) and Table A.2 (excluding days when water was not issued to that canal).

It is clear that there is a very wide range of DPR values in Table A.1. To easily understand the equity the best indicator is the Interquartile ratio (IQR) that compares the ratio of the highest 25% of values to the lowest 25% of values. In a situation of true equity, the value of this ratio will be 1.0 and will increase with greater inequity. The results of this analysis are shown in Table 3.2.

Table 3.2 Interquartile Ratios for Delivery Performance Ratios for Secondary Canal Heads

Season	Rabi 96/97	Kharif 97	Rabi 97/98	Kharif 99	Rabi 99/00	Kharif 00
Number of Canals	13	13	13	3	13	13
All data						
Ave. DPR, high 25%	1.49	1.64	1.52	1.84	1.53	1.20
Ave. DPR, low 25%	0.88	0.89	1.00	0.80	0.72	0.60
Interquartile Ratio	**1.69**	**1.84**	**1.52**	**2.03**	**2.13**	**2.00**
Excluding zeros						
Ave. DPR, high 25%	1.52	1.90	1.59	1.98	1.86	1.51
Ave. DPR, low 25%	0.95	1.03	1.02	0.95	0.84	0.82
Interquartile Ratio	**1.60**	**1.84**	**1.56**	**2.08**	**2.21**	**1.84**

This table shows that even under the most charitable interpretation, there is very large inequity between secondary canals in the sample area.

When all data, including zero discharge days, are analyzed, the canals with the highest water deliveries have DPR values 1.20 to 1.84 and average 1.50 (150% of design discharge). The canals with the lowest DPR values range from 0.60 to 1.0 and average only 0.81 (or 81% of design discharge).

As a result interquartile ratios are extremely high, ranging from 1.52 to over 2.0, meaning that the most favored canals get 50 to 100% more water than the least favored canals. There is no clear seasonal trend.

When zero days are excluded then the situation hardly changes, except that the DPR values naturally all increase. When water is flowing, the most favored canals get between 151% and 198% of design discharge, while the least favored canals get only 82% to 103% of design discharge. Interquartile Range figures are almost exactly the same.

A second way of assessing the inequity of water distribution is to look at the distribution of months in the three performance categories of good, satisfactory and poor. These data are summarized in Table 3.3.

Table 3.3 Delivery Performance Ratios for Secondary Canal Heads

Season	Rabi 96/97	Kharif 97	Rabi 97/98	Kharif 99	Rabi 99/00	Kharif 00
Number of Canals	13	13	13	3	13	13
Seasonal DPR	1.18	1.23	1.25	1.31	1.12	0.83
DPR > 1.3	13 (31%)	25 (37%)	22 (40%)	7 (50%)	9 (19%)	1 (4%)
1.1 < DPR <1.1	12 (28%)	18 (27%)	20 (36%)	2 (14%)	15 (31%)	4 (17%)
0.9 < DPR <1.1	11 (26%)	11 (17%)	7 (13%)	2 (14%)	13 (28%)	3 (13%)
0.7 < DPR <0.9	2 (5%)	7 (11%)	6 (11%)	1 (8%)	5 (11%)	5 (21%)
DPR < 0.7	4 (10%)	5 (8%)	0 (0%)	2 (14%)	5 (11%)	11 (45%)
Good	11 (26%)	11 (17%)	7 (13%)	2 (14%)	13 (28%)	
Satisfactory	14 (33%)	25 (38%)	26(47%)	3 (22%)	20 (42%)	3 (13%)
Poor	17 (41%)	30 (45%)	22 (40%)	9 (64%)	14 (30%)	9 (38%)
						16 (49%)

Table 3.12 Effect of water shortage at secondary head on tail end water conditions, *Dhoro Naro Minor*

	Kharif 1997	Rabi 1997/98	Kharif 1999
DPR at Canal Head	**1.08**	**1.29**	**0.95**
Average number of head watercourses without water	0.6	0.0	0.2
Average number of tail watercourses without water	5.4	2.2	11.8
Interquartile Ratio	**9**	**--**	**59**

4. Management Implications

Two broad conclusions arise from analysis of the data collected by IWMI over the past four years which have considerable implications for the work of both the Area Water Boards established under SIDA, and of Farmer Organizations currently being established in the Province.

Firstly, water distribution equity is unsatisfactory at main, secondary and tertiary level. There are few instances where performance is within the criteria established for many years by the Sindh Irrigation and Public Health Department. Insofar as the IWMI data collection program was undertaken before any transfer of management responsibility to farmer organizations, much of the responsibility for sub-standard performance rests with the Irrigation Department.

Secondly, water distribution in the type of canal system used in Pakistan is a continuum from barrage, through main and branch canals to secondary headgates, along secondary canals and into watercourses. The lack of much control infrastructure means this is an unforgiving type of design: the effects of changes in upstream discharge and variable upstream discharges will automatically be transmitted downstream, and there is little or nothing that downstream users can do to mitigate these negative effects.

a) Management Implications for Area Water Boards

Under the current structure of the Sindh Irrigation and Drainage authority, the Canal Area Water Boards (AWB) are responsible for operation and maintenance of main and branch canals, and for the operation of secondary headgates. The only responsibility they lose from the perspective of operation and maintenance is their obligation to maintain secondary canals and operate the very few cross-regulators that exist along secondary canals.

In all other respects the AWB obligations remain the same: they must deliver discharge into the head of each secondary canal, at which point responsibility for operation passes to a Farmer Organization (FO), and do to this they must operate and maintain all main and branch canals.

A major difference, however, is that FOs will have greater legal entitlements to demand a clear water management contract that specifies the water delivery conditions at the point of transfer of responsibilities. Not only will AWBs have to agree to deliver a specified discharge, they will have to meet their commitment to share any excess water equally among all FOs. This has several implications for AWB management.

i) Discharge measurement

In order to meet both the contractual commitment to individual FOs and also share any surplus water equally between different FOs, AWB must have a capacity to measure discharges. In all of the IWMI studies the canals monitored had no head gauge or other device to measure discharges into secondary canals. While the reasons for this sorry state of affairs are not discussed in this paper, it is clear that at present AWBs will not be able to meet their legal commitments to FOs until such time as they establish a measurement capacity.

At present AWB staff deliver water to secondary canals on the basis of whether the water level looks about right: this is hardly professional, and certainly insufficient to meet legal challenges from FOs who claim they are getting less water than that to which they are entitled. There needs to be a complete overhaul of the procedures involved in collecting, storing and disseminating information on discharges before FOs have a realistic chance of receiving what they are entitled to, and to protect AWBs from actions taken by FOs.

As a corollary to discharge measurement, AWBs must continue to maintain those canals for which they retain responsibility. Maintenance is not an end in itself, but is the process required to ensure that conveyance of water can be properly accomplished so that target discharges at each location in the system can be properly met.

ii) Water Distribution between FOs

A second major change that will be required from AWBs is the capacity to deal simultaneously with different FO groups. The present system, which relies heavily on paternalism, has never had to face a situation where several secondary canal groups will be in legitimate communication concerning their water deliveries and other related matters. The opportunity to play one canal group off against another will diminish as FOs develop better communication among themselves, and begin to demand more openness about discharges being issued to canals other than their own.

Whereas in the past the discharge data was not released to outside parties, the situation will change because FOs can, and will, measure their discharges alongside AWB staff, and will communicate to others their information. As a result the AWBs will face an unprecedented situation where their capacity to deliver water simultaneously to several different FOs along the same main or branch canal will become a mater of public rather than private debate.

At present there is no evidence that AWBs have this capacity, either technically in terms of data collection, storage and dissemination, or managerially in terms of negotiation and compromise.

It is also unclear how well rotations are actually managed at present when water is in short supply. While the Kharif 2000 rotation seems to be run fairly well, the exact days of cut-off and restoration of supplies are not always known or adhered to, so that a water user may lose two warabandi turns instead of one through no fault of his own. Failure to communicate such deviations make water deliveries increasingly unreliable and lead to greater conflict among water users within FO groups.

iii) Monitoring Water Distribution Performance by FOs

The third challenge for AWBs is more complex and probably the one that will lead to the most intense disputes between AWBs and FOs.

In the past Irrigation Department staff had the right to check dimensions of outlets, monitor discharges in watercourses, and rectify dimensions of structures to ensure that as far as possible equity was maintained between watercourses along a secondary canal.

With the establishment of FOs and transfer of operation and maintenance responsibility, it is no longer clear that AWB staff have this responsibility. Many AWB staff would like to see the FOs obliged to monitor watercourse discharges, check outlet dimensions and keep everything the same as it is supposed to be. There are two aspects of this situation that merit more discussion.

Firstly, AWB staff themselves have clearly failed in their responsibility of ensuring equitable water distribution along secondary canals and it is therefore unrealistic to expect FOs to be able to readily accomplish something the AWB has been unable to do. If AWBs handed over secondary canals that were perfect, then they might have higher moral ground to stand on.

Secondly, transfer of management responsibility means just that. It does not mean that the work is transferred but the rules must be unchanged. If FOs wish to reallocate water among their members, they can and should do so, with the single proviso that they still have to pay the same amount of money to the government as a service fee for water delivered to the head of the secondary canal.

The implication of this last statement is critical. If AWBs feel that they will take over a policing role to ensure that old and largely unworkable water distribution rules at secondary canal levels, and blame FOs if they fail to accomplish the dream of perfect water distribution, then there will be long and bitten conflict between AWB and FO members.

AWBs must, therefore focus their operation and maintenance activities at main and branch canal level, ensure as equal and fair water delivery into secondary canals, do this in an open and transparent manner, and provide advice and assistance to FOs rather than try to police them.

b) Management Implications for Farmer Organizations

The newly established FOs are at the start of a long and probably very difficult period. They have had to endure an inordinately long delay in the passing of the necessary legislation by the government of Sindh, they have been ready for months and, in three cases, years to take over legal responsibility for infrastructure as well as operation and maintenance tasks, they have been trained in water measurement, management, accounting, budgeting and planning.

Despite these delays it is clear that the initial enthusiasm is still there, and that they clearly understand they have two distinct and different roles to play in accomplishing their objectives.

i) Ensuring Fair Access to Water

Perhaps the more important, and certainly the most innovative, aspect of FO obligations is to ensure that they draw up a water contract with the AWB and can monitor their water deliveries into their secondary canal.

That by itself would be a major change but what perhaps is even more intriguing is that FOs recognize the need to work in a concerted manner to ensure that they are all treated fairly and as equally as possible. FO leaders meeting together recognize that unless they work together they run the risk of being picked apart by AWB staff in much the same manner as they were by Irrigation Department staff, and that as a divided group they have little prospect of getting a more equitable water allocation and distribution policy.

To say this is a challenge for FOs is a gross understatement: it will be difficult to get agreement and consensus among all of the different FOs represented on a newly established Farmer Organization council so that they can make a united and strong case when their two representatives attend meetings of the Area Water Board. But it is essential.

The current inequity at secondary canal level is quite unacceptable on both professional and political levels. To fail to meet a set of simple discharge targets at secondary head gates is a sad reflection on the technical and managerial capacity of a government agency, and fails to meet the basic political rights and policies espoused a national and provincial level.

By acting as a strong pressure group on the AWB the FOs can both individually and jointly obtain more reliable and predictable water supplies at the heads of their canals and, as has been demonstrated earlier, this will automatically result in improved performance at secondary and tertiary level.

Fair and reliable water deliveries at the head of secondary canals are a necessary condition for secondary and tertiary level improvements in performance. It is technically impossible to overcome inequity and unreliability imposed on a secondary canal by poor management upstream.

Therefore it is clear that the first and overriding task of FOs is to be concerned about how much water they receive, when they receive and how reliable the timing and discharges actually are. Only then do they need to turn their attention to internal management issues.

ii) Internal Management by FOs to Achieve Water Distribution Equity

Issues of internal water allocation and distribution along secondary canals appear to have received undue attention compared to the upstream issues of main and branch canal operation and the management of secondary head gates. The data presented in Section 3 indicate that at least as much, if not more, inequity is introduced in the main and branch systems and operation of secondary headgates than along secondary canals, and that a significant percentage of problems between watercourses can be attributed to improper water delivery conditions at the secondary canal head.

This is not to say that there is not conflict over water distribution among water users within a secondary canal command: there is, and in many cases it results in a significant magnification of the problem.

But the solution does not start at the watercourse head. FOs claim that if they get proper water delivery to the head of their secondary canal, they can solve their internal problems. Time will tell if this is correct or not, but they must be given a fair chance. They certainly have undertaken maintenance tasks at secondary level with enthusiasm and as a result have reduced previous inequities in water distribution.

Further, and alluded to in Section 4.a.iii above, there is no reason why farmers in an FO cannot choose to reallocate water among themselves if they believe it is fair and equitable. In some watercourses there is land that is no longer cultivable due to waterlogging and salinity and so do not require water. Some farmers prefer not to take their full share of water in some seasons due to high water tables.

The original determination of watercourse discharges dates back 70 years and it is completely unrealistic to assume that the areas used in those calculations are the same as those currently farmed. Why not let FOs determine new and acceptable water allocation policies and practices? They are, after all, legal entities, they have a democratically elected leadership structure, and all water users can become equal members of good standing. This is what management transfer is all about.

5. Conclusions

The current pattern of water distribution in Sindh is unfair and inequitable. From the head of the system at each level of operation, increasing unreliability in terms of volume and timing of deliveries is experienced. While the effects are always felt by water users, the causes may be well above their level of responsibility, even with the establishment of Farmer Organizations who will take over full control of operation and maintenance at secondary canal level.

To accomplish the restoration of effective and fair water distribution within the Sindh irrigation systems several enabling conditions are required. However, four seem to be particularly important and are likely to underlie the success or failure of current activities.

c) Water Rights and Due Share

The development of agreed contracts between FOs and AWBs must include specific reference to the discharge and timing of water deliveries. This is a de facto water right, if not a de jure one, because it obligates the AWB to either deliver the correct amount of water or to explain why they are unable to do so.

To date the AWBs have agreed to issue design discharge and then share excess water equally among all FOs. The first part is comparatively easy because, except under unusual conditions such as those being experienced in 2000, discharges in almost all canals are already above official design capacity.

The second part is much more complex because it involves knowing the degree of excess water available at the head of a canal command, already a challenge for most AWBs, and then operating the system to give a proportional share of the excess to all FOs. With typically over 100 FOs per AWB, this is no trivial task and yet no plans exist to make this agreement a reality. FOs need to ensure this promise becomes a reality and does not remain merely lip service on the part of AWB staff.

d) Measurement Capacity

The above conditions cannot be accomplished without measurement capacity being re-established. At present all secondary canal level measurement capacity has been lost, and it appears to be largely true at branch and main canal level as well.

AWBs run a real risk of being embarrassed professionally and legally if they cannot measure water in support either of a contract with an individual FO or to meet the more complicated commitment to share excess water equally.

e) Transparency

Attitudes to information must change from the current arcane process to a more transparent and open situation. With FOs legally entitled to know their water delivery, and independently check secondary canal discharges, the old situation where only engineers knew (or professed to know) discharges will have disappeared.

The development of a more transparent attitude means not only that the AWBs lose their monopoly over data, but also can be help more accountable than they have been in the past. It would be surprising if they welcomed this situation, but that is the way things have developed, like it or not. But the obligation is also imposed on FOs. Those FOs who currently receive excess water must, in the interest of fairness and equity, accept they must give their surplus to those canal commands that are less well served. For all involved, transparency is a two-edged sword that can cut both ways.

f) Communication

Finally, the improvement of water distribution to obtain a more equal share for everyone means that there must be improved communication.

This is not restricted to access to data about discharges, but must include improved communication concerning shortfalls in water availability, disruptions in supply due to breaches, clear and properly implemented rotational irrigation plans, and any other pertinent information that will help reduce uncertainty over the timing and volume of water deliveries.

Table A.1

Monthly Delivery Performance Ratio of Secondary Canals, including rotations and other closures

	Kotri	Nara									Jamrao										
	Gajrah	Nara	Dim	Dim	Shahu			Jamrao								West Branch					
	Dhoro	Heran	Rawtiai	Md.Ali	Tail	Mirpur	Doso	Visro	Kahu	Bareji	Sanro	Lakhi	Bhitt	Sangro	Daulat	Bellaro	Digri	Potho	Khatiar	Bagi	Ave.
Nov-96						1.19	1.02	1.68	1.89	1.57	0.97			1.46	0.98	1.20					1.33
Dec-96						1.16	1.17	1.42	1.66	1.60	1.02	1.30	1.60	1.56	1.03	1.20					1.34
Jan-97																					
Feb-97						0.73	0.93	1.21	1.16	1.33	0.55	1.09	1.45	1.15	0.54	0.93					1.01
Mar-97						1.11	0.51	1.33	1.24	1.37	1.07	0.64	1.44	1.02	0.82	1.07					1.06
Apr-97						1.00	1.17	1.37	1.73	1.60	1.08	0.74	1.51	1.26	0.55	1.13					1.20
May-97						1.30	1.18	1.82	2.39	1.52	1.03	1.16	1.59	1.25	0.91	0.85					1.36
Jun-97						1.11	1.25	1.59	2.24	1.69	0.86	1.07	1.46	1.41	0.64	1.13					1.31
Jul-97						0.92	1.43	1.18	1.75	1.46	0.81	0.65	1.06	1.03	0.76	0.54					1.05
Aug-97						0.85	1.31	1.54	1.60	1.45	1.18	1.14	1.46	1.08	0.74	0.95					1.21
Sep-97						1.13	1.39	1.93	1.28	1.36	1.06	1.25	1.25	1.32	0.63	1.20					1.25
Oct-97						1.20	1.51	1.77	1.22	1.58	1.13	1.25	1.64	1.23	0.73	1.13					1.31
Nov-97						1.17	1.32	1.57	1.10	1.40	1.17	1.23	1.66	1.35	0.76	1.02					1.25
Dec-97						1.11	1.27	1.60	1.08	1.49	1.08	1.32	1.62	1.36	0.81	1.17					1.26
Jan-98																					
Feb-98						1.11	1.18	1.75	1.27	0.96	0.70	1.14	1.18	1.31	0.81	1.09					1.14
Mar-98						1.35	1.32	1.44	1.11	1.63	1.52	1.17	1.53	1.18	0.81	1.09					1.29
Apr-98						1.25	1.26	1.60	1.38	1.67	1.17	1.33	1.60	1.25	0.89	1.09					1.32
May-99	0.58	1.70																			1.14
Jun-99	0.69	2.14								1.39											1.41
Jul-99	0.72	1.75								1.14											1.21
Aug-99	1.02	1.82								1.30											1.38
Sep-99	0.97	1.78								1.41											1.38
Oct-99	0.91	1.16								1.85											1.30
Nov-99	1.10	1.47	1.72		1.50	0.96				1.73	1.11					1.07					1.33
Dec-99	1.13	1.30	1.69		1.27	0.96				2.08	1.27					1.00	1.06	0.72	1.18	0.48	1.18
Jan-00																					
Feb-00	1.06	1.23	1.68		1.35	1.11				1.24	0.79					1.02	1.09	0.57	1.09	0.40	1.05
Mar-00	0.64	1.22	1.24	1.23	0.95	0.95					1.14					0.77	0.84	0.68	1.14	0.71	0.96
Apr-00	0.75	1.29	0.86	1.13	0.65	0.68					1.01					0.55	0.77	0.66	0.68	0.45	0.79
May-00	0.46	1.14	1.24	1.56	0.81	0.69					0.76					0.91	0.56	0.68	0.94	0.63	0.86
Jun-00																					
Ave	0.835	1.501	1.404	1.305	1.087	1.047	1.2	1.549	1.506	1.493	1.022	1.099	1.47	1.2636	0.775	1.005	0.863	0.661	1.004	0.534	1.13

Table A.5

Number of days when water was not delivered

	Kotri	Nara	Jamrao																		
	Gajrah	Nara	Dim	Dim	Shahu	Jamrao						West Branch									
	Dhoro	Heran	Rawtia	Md.Ali	Tail	Mirpur	Doso	Visro	Kahu	Bareji	Sanro	Lakhi	Bhitt	Sangrd	Daulat	Bellaro	Digri	Potho	Khatian	Bagi	Ave.
Nov-96						0	1	0	0	0	0			0	0	0					0.1
Dec-96						0	0	0	0	0	0	0	0	0	0	0					0.0
Jan-97																					
Feb-97						6	0	0	0	0	0	0	0	0	8	4					1.6
Mar-97						0	13	4	4	4	4	0	0	4	0	0					3.0
Apr-97						3	4	5	7	0	0	10	0	0	8	0					3.4
May-97						1	3	0	0	3	0	2	0	0	0	6					1.4
Jun-97						5	5	5	4	0	3	5	2	0	6	1					3.3
Jul-97						7	3	9	8	6	8	17	9	6	6	18					8.8
Aug-97						11	6	6	0	5	0	8	2	8	5	8					5.4
Sep-97						4	3	0	4	6	0	2	6	2	9	0					3.3
Oct-97						0	0	0	0	0	5	0	0	3	5	0					1.2
Nov-97						0	0	2	0	0	0	0	0	0	0	0					0.2
Dec-97						0	0	0	0	0	0	0	0	0	0	0					0.0
Jan-98																					
Feb-98						1	0	0	0	10	10	0	6	0	4	0					2.8
Mar-98						0	0	0	0	0	0	0	0	0	0	0					0.0
Apr-98						0	0	0	0	0	0	0	0	0	0	0					0.0
May-99	7	0																			3.5
Jun-99	7	0								7											4.7
Jul-99	6	6								12											8.0
Aug-99	0	3								11											4.7
Sep-99	0	1								9											3.3
Oct-99	4	4								5											4.3
Nov-99	0	0	0		7	7				3	7					0					3.0
Dec-99	1	0	0		3	8				0	7					4	3	9	3	3	3.4
Jan-00																					
Feb-00	0	2	0		0	3				12	14					4	0	6	5	6	4.3
Mar-00	15	7	5	10	7	0					5					9	6	1	2	6	6.1
Apr-00	8	0	12	12	8	8					8					14	7	6	13	12	9.0
May-00	13	6	6	6	12	8					14					7	16	7	9	3	8.9
Jun-00																					
Sum	61	29	23	28	37	72	38	31	27	93	85	44	25	23	51	75	32	29	32	30	

Table A.6

Number of days when delivered discharge was less than 70% of design

	Kotri Gajrah Dhoro	Nara Nara Heran	Dim Rawtia	Dim Md.Ali	Shahu Tail	Mirpur	Jamrao Doso	Jamrao Visro	Jamrao Kahu	Bareji	Sanro	Jamrao Lakhi	Jamrao Bhitt	Jamrao Sangro	West Branch Daulat	West Branch Bellaro	Digri	Potho	Khatiar	Bagi	Ave.
Nov-96						0	2	0	0	0	0	0	0	0	0	0					0.2
Dec-96						0	0	0	0	0	0	0	0	0	0	0					0.0
Jan-97						0	1	0	3	0	0	0	0	0	0	0					
Feb-97						6	3	0	0	1	11	4	0	0	11	4					3.6
Mar-97						4	17	4	4	4	4	22	0	4	5	0					6.2
Apr-97						3	4	5	7	0	0	11	0	0	19	0					4.5
May-97						1	4	0	0	3	0	3	0	3	0	6					1.8
Jun-97						5	5	5	4	0	4	6	2	0	10	1					3.8
Jul-97						8	3	12	8	6	8	17	9	7	6	18					9.3
Aug-97						11	6	6	0	5	0	8	2	8	5	8					5.4
Sep-97						4	3	0	4	6	0	2	6	2	9	0					3.3
Oct-97						0	0	0	0	0	5	0	0	3	7	0					1.4
Nov-97						0	0	2	0	0	0	0	0	0	7	1					0.9
Dec-97						0	0	0	0	0	0	0	0	0	4	0					0.4
Jan-98						0	0	1	1	0	1	1	0	0	0	0					
Feb-98						1	1	0	0	10	10	0	6	0	4	1					3.0
Mar-98						0	0	0	0	0	0	3	0	1	1	0					0.5
Apr-98						0	0	0	0	0	0	0	0	0	0	0					0.0
May-99	0	0																			0.0
Jun-99	0	0								0											0.0
Jul-99	0	0								0											0.0
Aug-99	0	0								0											0.0
Sep-99	0	0								0											0.0
Oct-99	0	0								0											0.0
Nov-99	0	0	0		0	0				0	0					0					0.0
Dec-99	0	0	0		0	0				0	0					0	0	0	0	3	0.3
Jan-00																					
Feb-00	0	0	0		0	0				0	0					0	0	0	0	0	0.0
Mar-00	0	0	0	0	0	0					0					0	0	0	0	0	0.0
Apr-00	0	0	0	0	0	0					0					0	0	0	0	0	0.0
May-00	0	0	0	0	0	0					0					0	0	0	0	0	0.0
Jun-00																					
Sum	0	0	0	0	0	43	49	35	31	35	43	77	25	28	88	39	0	0	0	3	