REPORT NO. R-27

FLUCTUATIONS IN CANAL WATER SUPPLIES

(A CASE STUDY)

SHAHID SARWAR
H.M. NAFEES
M.S. SHAFIQUE

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PAKISTAN NATIONAL PROGRAM
INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE
LAHORE

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PREFACE

Irrigated agriculture is the backbone of economy in our country which rely on the timely availability of water at the farm gate. The productivity of this scarce natural resource is linked with its uniform and well managed supply through the existing canal system. We have presented here an analysis *of* the different aspects of canal irrigation system in our study area. For the interest of reader and to avoid the complexity of computer models, we have followed a simple approach while summarizing this work.

We are highly grateful to the Hasilpur Field Staff for their continuous and hard data collection job to complete this report. We would also like to thank Professor Gaylord V. Skogerboe for his encouragement to work on this issue and also, for his comments on the manuscript.

Authors

I. INTRODUCTION

1.1. POINT OF CONCERN

The occurrence of fluctuations in canal water supplies at the secondary canal level and their effect on the tertiary outlets performance is a focal point of this study. The phenomenon of water fluctuations, which is in the control of the Irrigation Department, is completely a black-box for the farmers and have a negative impact on the decision making process to manage their irrigated agriculture. In addition, the problem creates questions for the system's design objectives of equity and reliability.

Plusquellec (1988) stated that a system providing a dependable flow to tertiary units will provide the foundation for an equitable distribution of water to farmers and promote their participation in operating and maintaining the tertiary system. Provision of a reliable water supply to the tertiary units should be a primary operational objective of a project. This objective was sometimes neglected in the past when emphasis was placed on farmer participation and on-farm water management, without considering possible mismanagement upstream in the system.

Nonuniform flows that vary in an unpredictable manner greatly complicate the performance and evaluation of farm irrigations: farm irrigators cannot know whether on-farm or off-farm factors are responsible for an application system's performance. As sources of flow variation are further identified, structural and operational measures can be developed to reduce or eliminate them. The result will be more positive control of canal systems and delivery of known, uniform flows of water to the farm (Palmer et al., 1989).

1.2. PURPOSE OF THE STUDY

In 1990, IIMI started its research work in Fordwah/Eastern Sadiqia Canal Commands under the Waterlogging and Salinity Research Project sponsored by the Dutch Government to identify the problems of irrigated agriculture in this area. With an integrated research approach from the main canal level to the farming system, different studies have been completed and published until now. The present work is mainly focused to summarize the canal water supplies over long and short time intervals in Fordwah Distributary and its impact on the water availability at tertiary subsystems of the distributary. As an introduction and elaboration of the system, the designed allocations of water in Chishtian Sub-division and its actual distribution during a comprehensive calibration exercise (Tareen et al 1996) is also further analyzed here.

1.3. STRUCTURE OF REPORT

The following steps were taken to compile this report;

1. Chapter **2** deals with the presentation of designed allocations of water in Chishtian Canal Subdivision in comparison with the actual water distribution for some particular days.

2. Analysis of canal water supplies in Fordwah Distributary and its distribution to the tail end during the past five-year period is summarized in Chapter 3.

3. Results of an hourly monitoring exercise for a week period along Fordwah Distributary and its four sample watercourse command areas are given in Chapter **4.**

4. Finally, the discussion on conclusions and recommendations is given in Chapter *5.*

1.4. BASIS FOR ANALYSIS

In canal water allocation, design duty is normally fixed in the units of 1000 acres of cultivated command area (CCA). Therefore, design discharges of distributaries and outlets differ normally in proportion to their CCA. For easy understanding of graphical presentations and also to identify the differences in the designed water allocations, all of the discharge data in this report is normalized back to the base of 1000 acres of CCA. Therefore, whether it is mentioned or not, the discharges (designed & actual) are compared on the basis of per 1000 acre CCA throughout the whole report. Only the farm gate discharges given in Chapter **4** have the exception which are just the observed inflows at the farm in relation to the outlet discharge.

II. CANAL WATER ALLOCATION IN CHISHTIAN SUBDIVISION

2.1. GENERAL INFORMATION

There are 14 distributaries in Chishtian Canal Subdivision. The layout and design data of these distributaries is given in Annex 2.1 and 2.2, respectively. Figure 2.1 shows the design discharge at their heads by grouping them as perennial and non-perennial because the design duties are different for the groups. These discharges per 1000 acres of CCA are based on the distributaries design discharges and their CCA taken from the Irrigation Department (ID) records. Iqbal (1996) has presented the hydraulic characteristics of all these channels explaining the reasons for their perennial and non-perennial status.

Seepage losses are normally accounted for in designing the head discharges of distributaries. Even then, the wide variations in the designed head discharges/1000 acres CCA is not clear because the smaller distributaries (Phogan. Mohar and Soda) with lesser losses are having higher discharges than the larger distributaries (Daulat, Shar Farid) in the non-perennial group. Same is the case with the perennial group in which the largest distributary (Fordwah) is having the same head discharge per thousand acres of CCA as others, while Jagir is having an excess of almost 1 cusec per 1000 acre.

Without studying the actual water requirements along different distributaries, it is difficult to conclude whether this inequity in the designed allocations is productive or not. However, Abernethy (1986) stated that inequity has a direct influence upon productivity because, whereas the parts of a system that receive less than their agronomic requirement of water will produce less than their potential, the areas which receive more water than they need do not show improvement in yield; the excess water is not serving a productive purpose.

2.2. COMPARING THE WATER ALLOCATION AND DISTRIBUTION

The above mentioned designed water allocations are compared with the actual water distribution during the inflow-oufflow tests for estimation of seepage losses in Chishtian Subdivision (Tareen et al 1996). Figures 2.2 to 2.15 present this comparison individually for all of the distributaries. These figures show the following four discharge terms normalized to the same base of 1000 acres of the respective CCA:

- design discharge at distributary head;

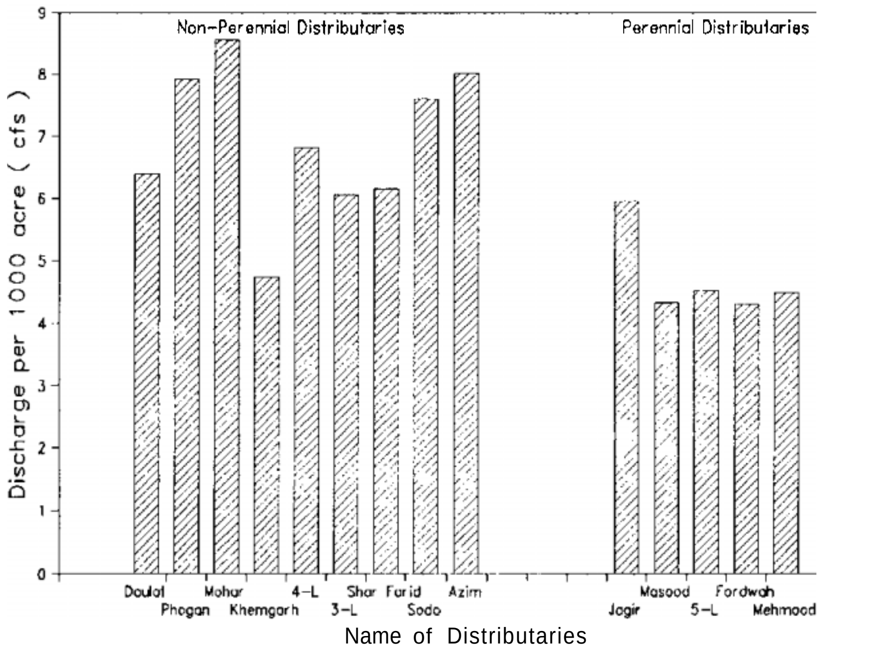

Figure 2.1. Design discharge at the head of distributaries in Chishtian Sub-division.

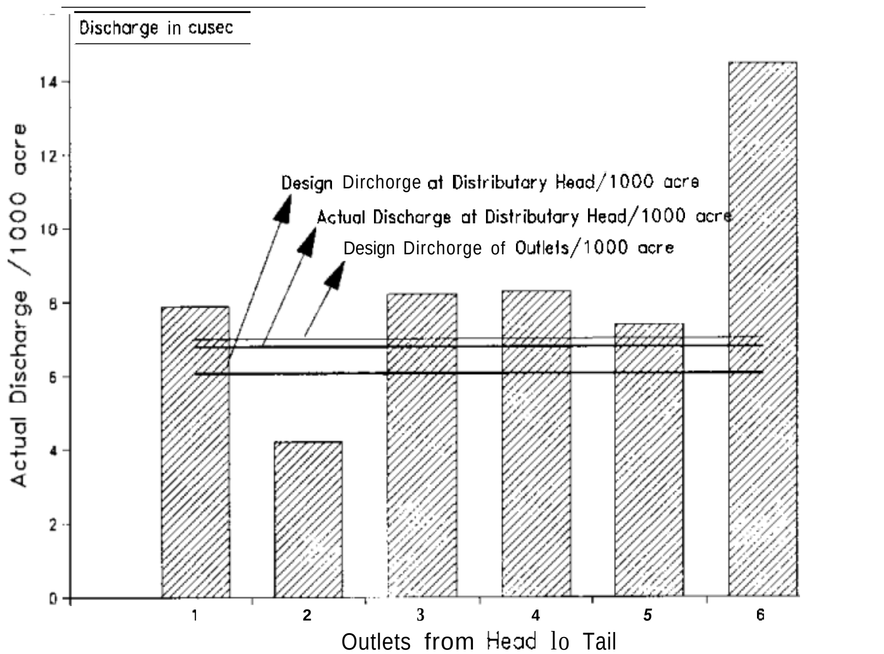

Figure 2.2. Normalised discharges of Fordwah 3-L Distributary and outlets.

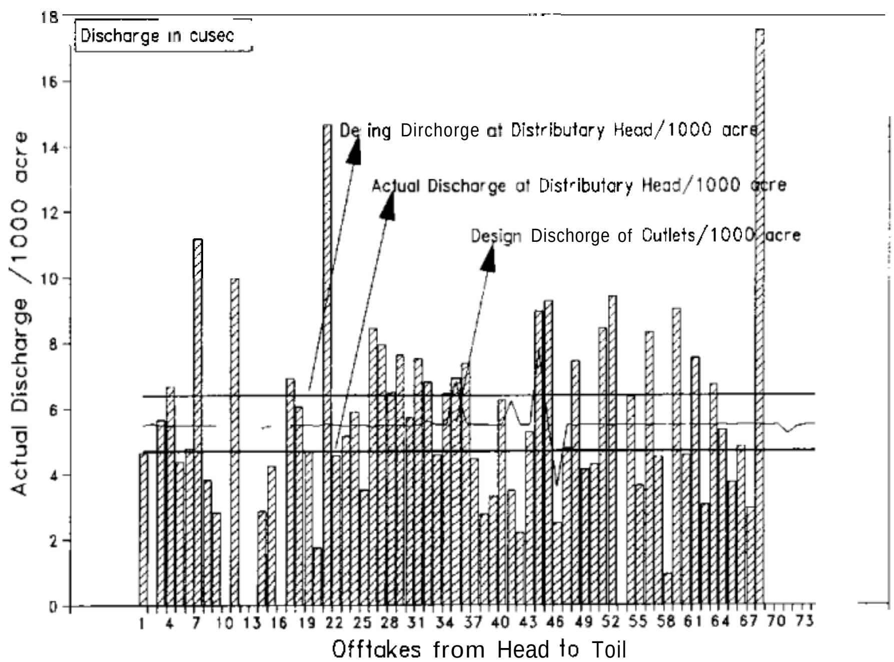

Figure 2.3. Normalised discharges of Daulat Distributary and outlets.

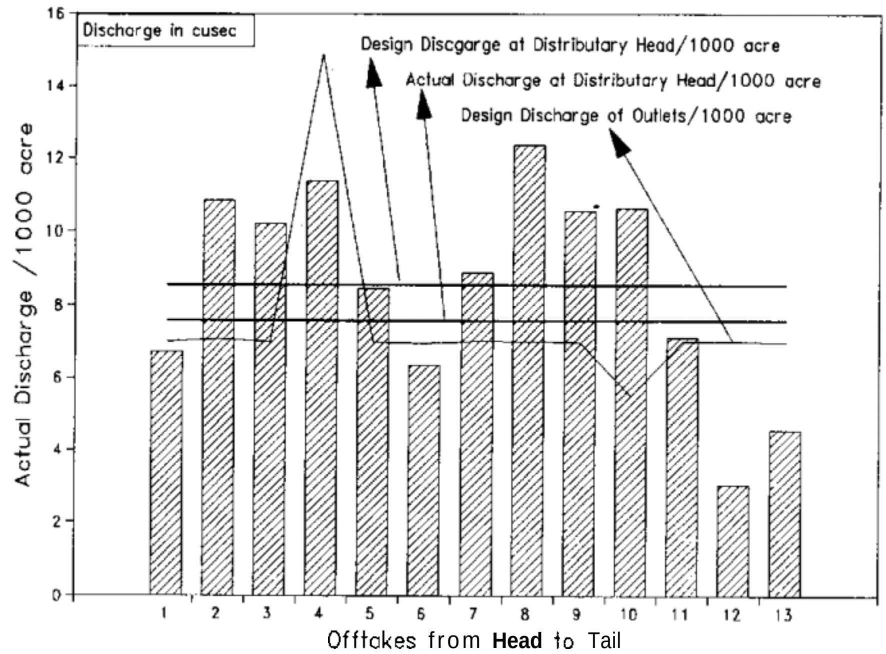

Figure 2.4. Norrnalised discharges of Mohar Distributary and outlets.

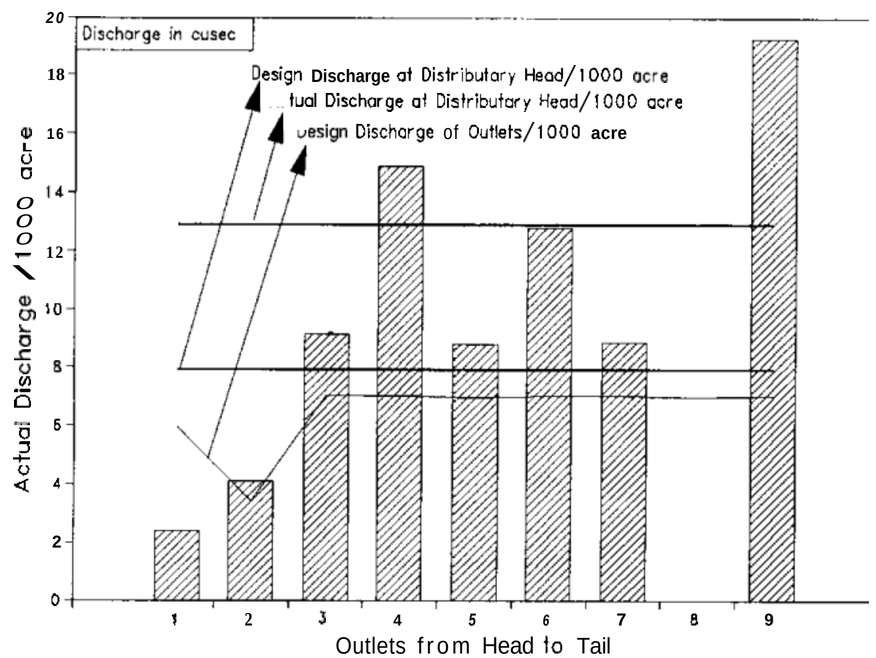

Figure 2.5. Norrnalised discharges of Phogan Distributary and outlets.

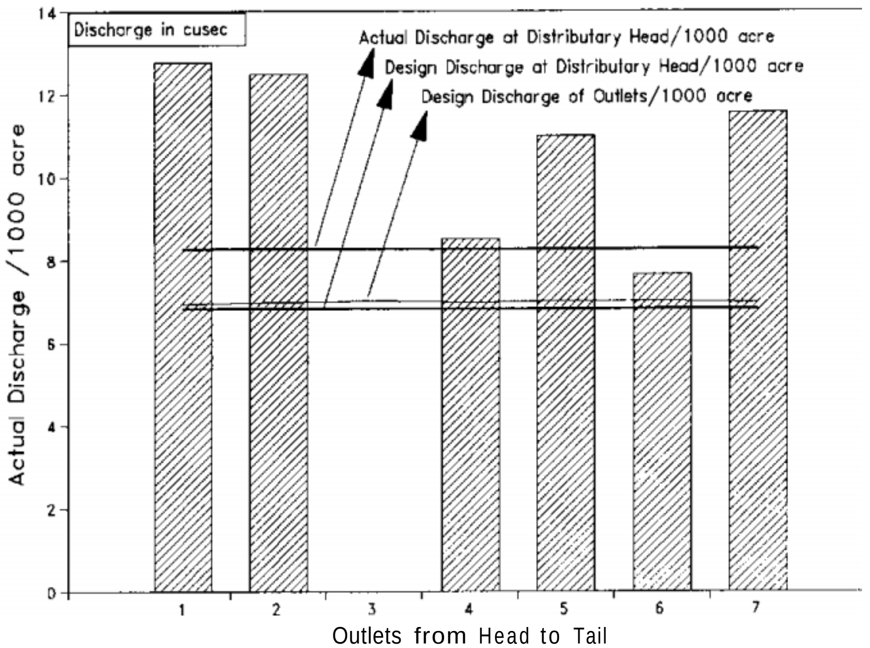

Figure 2.6. Normalised discharges of Fordwah 4-L Distributary and outlets.

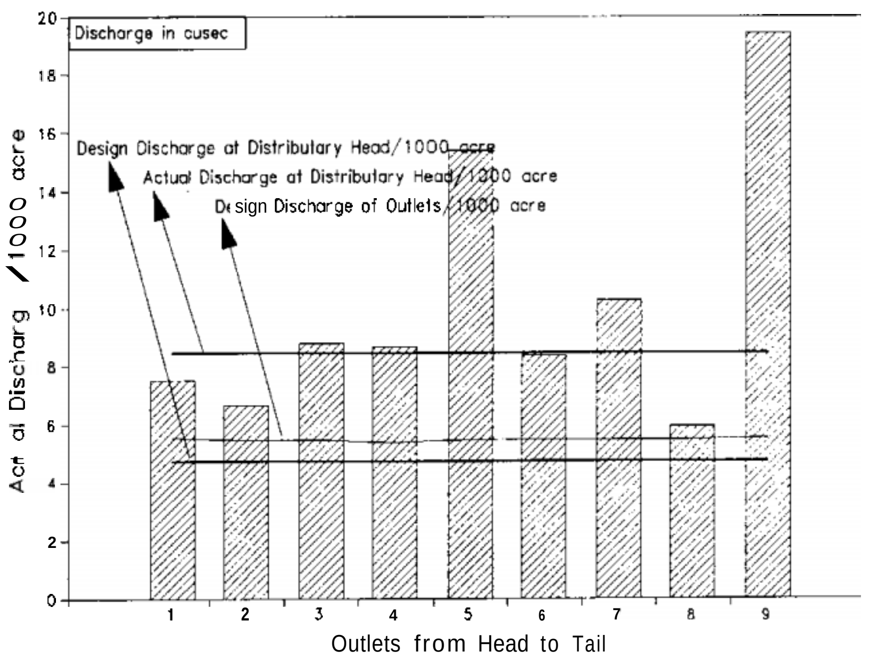

Figure 2.7. Normalised discharges of Khemgarh Distributary and outlets.

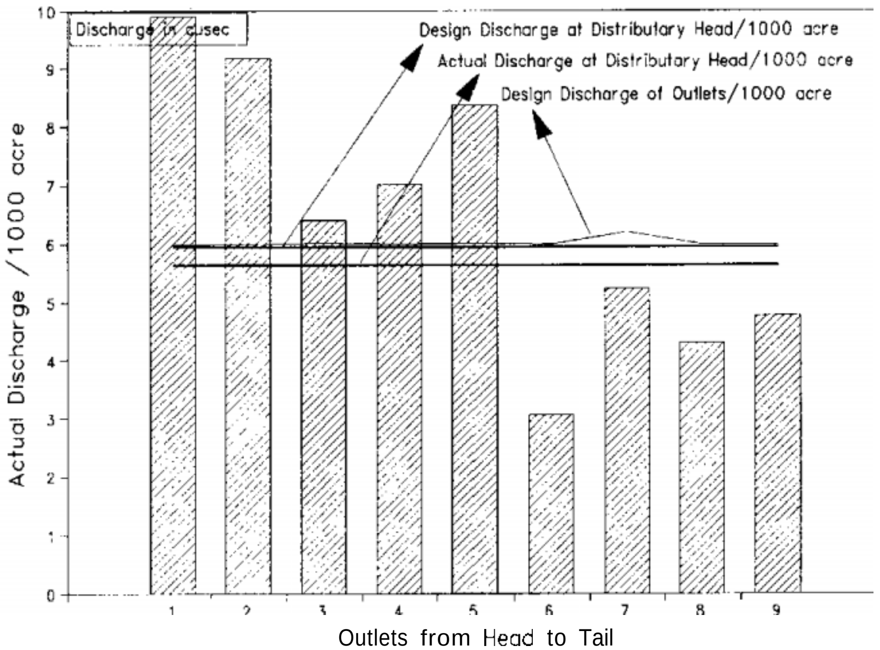

Figure 2.8. Normalised discharges of Jagir Distributary and outlets.

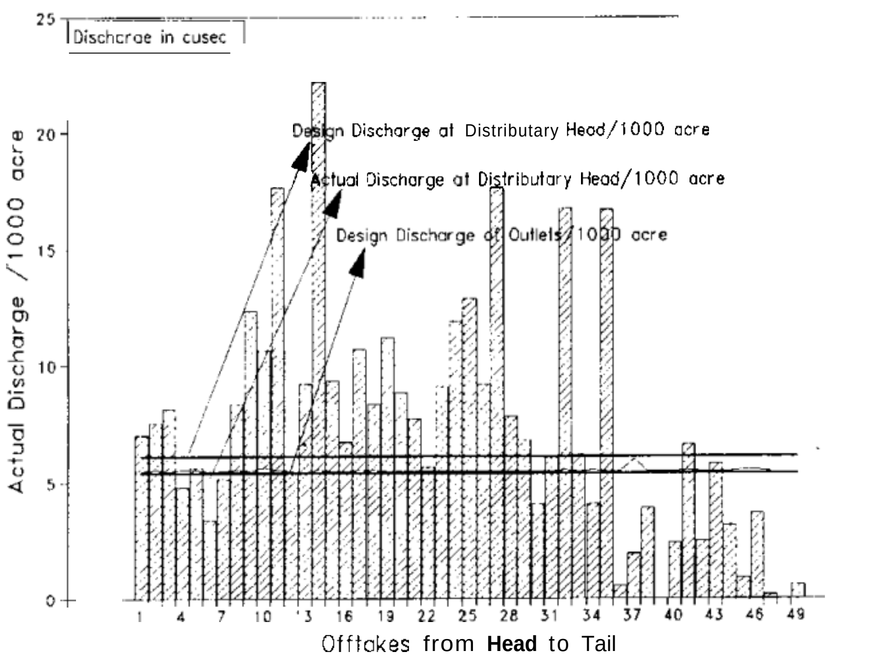

Figure 2.9. Norrnalised discharges of Shahar Farid Distributary and outlets.

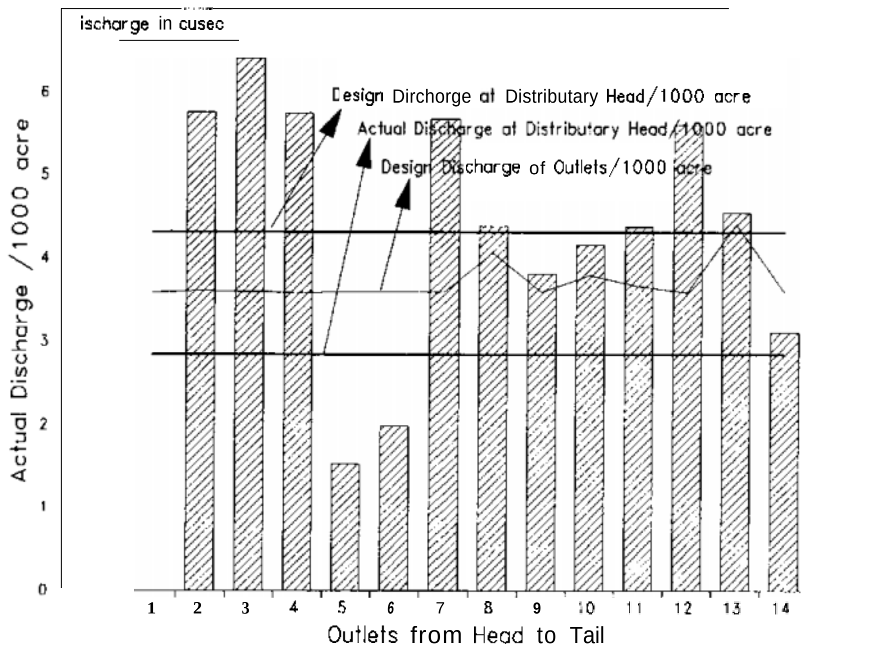

Figure 2.10. Normalised discharges of Masood Distributary and outlets.

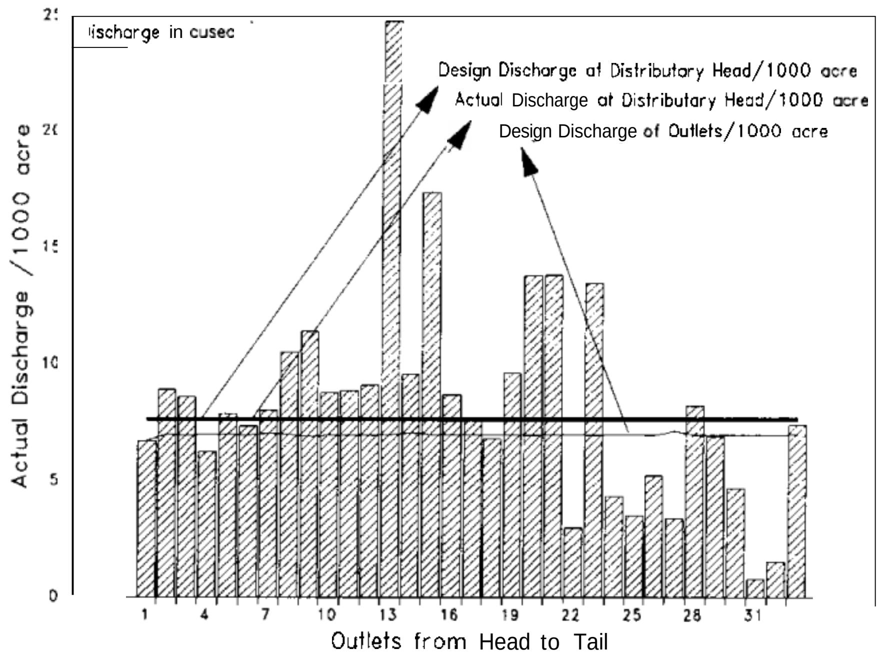

Figure 2.11. Normalised discharges of Soda Distributary and outlets.

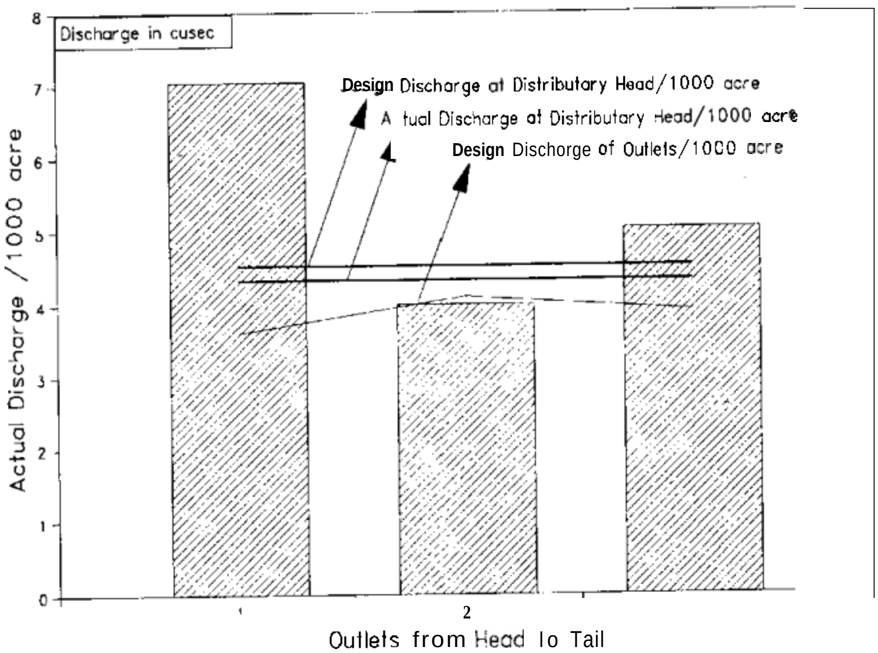

Figure 2.12. Normalised discharges of Fordwah 5-L Distributary and outlets.

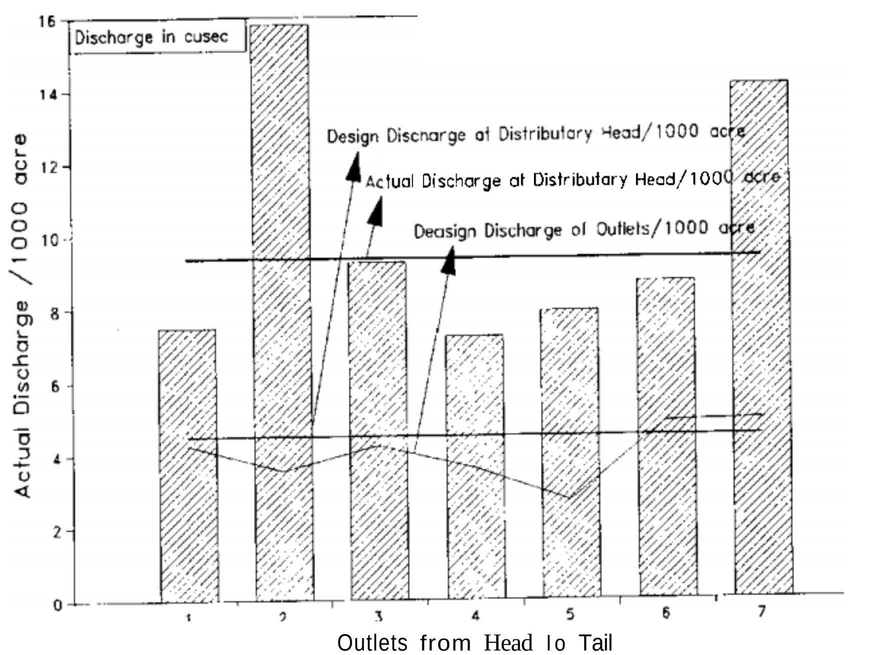

Figure 2.13. Normalised discharges of Mehmood Distributary and outlets.

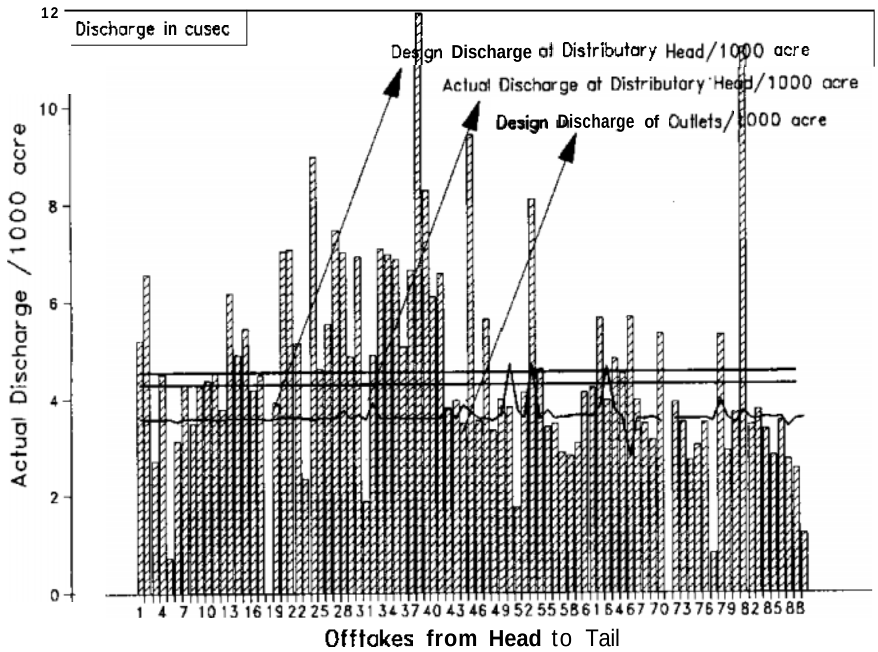

Figure 2.14. Normalised discharges of Fordwah Distributary and outlets.

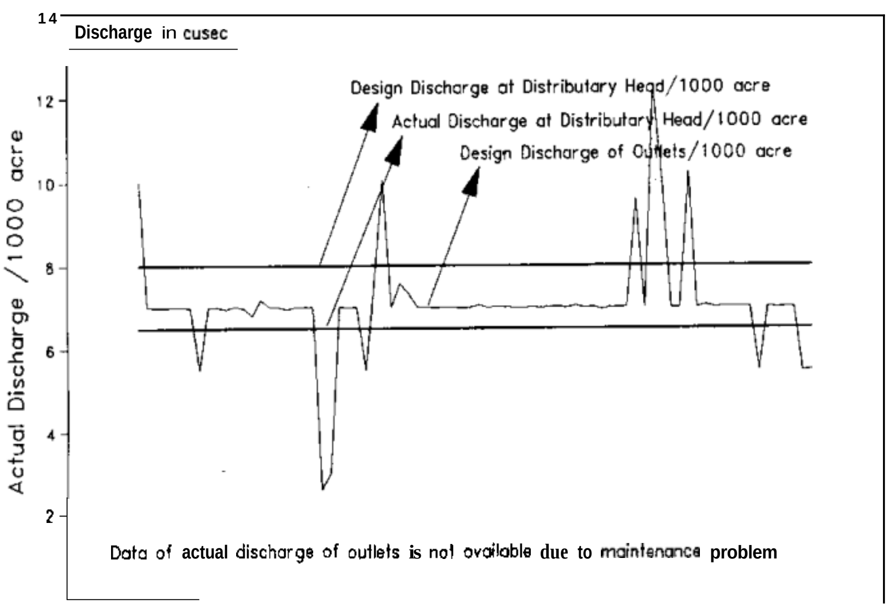

Figure 2.15. Normalised discharges of Azim Distributary and outlets.

Distributary	Qh vs Qo	Equality of design at head & outlet (YES/NO)	Provision for losses in design (cusec/1000 ac)
3-L (Fig 2.2)	Qh < Qo	**NO**	0.00
Daulat (2.3)	Qh > Qo	YES	0.89
Mohar (2.4)	Qh > Qo	YES	1.06
Phogan (2.5)	Qh > Qo	YES	1.43
4-L (2.6)	Qh < Qo	**NO**	0.00
K.Garh (2.7)	Qh < Qo	**NO**	0.00
Jagir (2.8)	Qh = Qo	YES	0.00
S.Farid (2.9)	Qh > Qo	YES	0.64
Masood (2.10)	Qh > Qo	YES	0.62
Soda (2.11)	Qh > Qo	YES	0.61
5-L (2.12)	Qh > Qo	YES	0.65
Mehmood (2.13)	Qh > Qo	YES	0.47
Fordwah (2.14)	Qh > Qo	YES	0.66
Azim (2.15)	Qh > Qo	YES	0.94

Further indications from these figures are:

- the design discharge/1000 acres of CCA for the outlets is not uniform in certain cases (Figures 2.3, 2.4, 2.5, 2.10, 2.12. 2.13, 2.14 and 2.15);

- outlets draw non-uniform shares of water/1000 acres CCA along all the distributaries due to different problems which are reported in Tareen et al (1996); and

- water distribution to outlets on those distributaries having higher allowance for losses are not effected by the lower head discharges to some extent (Figures 2.4 and 2.10).

All of the above mentioned aspects require some considerations as to reviewing the water allocations and planning in terms of the sustainability issue. In this context, the perennial and non-perennial status of different distributaries, which is continuing from the system initiation, may require the first consideration. Several IIMI studies in the area have reported the buildup of salinity/sodicity problems because of continuous use of tubewell water in the non-perennial distributary command areas. Moreover, severe maintenance problems on the non-perennial distributaries have arisen due to an absence of water for a long time in these channels. For example, Tareen et al (1996) have reported very high seepage losses along Shahr Farid Distributary (non-perennial) as compared to Fordwah (perennial). Similarly, Azim Distributary (non-perennial) is having weak banks with most of the structures and outlets damaged.

Therefore, an yearly rotation among the perennial and non-perennial distributaries can improve the present situation. The accumulated salts in the root zone resulting from frequent use of tubewell water within non-perennial commands can possibly be leached using canal water. Further, the alternate presence of water in different distributaries can motivate the farmers and the department to carry on the required rehabilitation work on all of the distributaries. In addition, the inequity in the old design allocations necessitate a review and the priorities for such differences require justification in the light of existing problems.

This review of designed allocations in comparison with an actual example of water distribution has shown a picture of the different aspects of the canal system status in Chishtian Subdivision. However, as the discharge at the head of all the distributaries was kept constant to fulfil the requirement of an inflow-outflow test, it is not possible to discuss the proportionality of water distribution in relation to the discharge fluctuations on different distributaries heads. It is also difficult to finalize conclusions on the overall system performance with the example case discussed here which is based on a short duration database on water distribution at the secondary level.

III. CANAL WATER SUPPLIES IN FORDWAH DISTRIBUTARY

3.1. SAMPLE SECONDARY CHANNEL

The Fordwah Distributary (Figure 3) offtaking at the tail of Fordwah Branch Canal is the sample for analysis on water supply patterns over a long time period and its fluctuations during short intervals. It has a total length of 42.60 km and the designed discharge at the head is 4.46 m^3/s (158 cusecs). The average slope of the bed is 21 cm/km and there are three drop structures in the whole reach of the channel. The distributary is perennial with 88 outlets of different size and their command area varies from 43 ha to 496 ha. At RD-65, a minor distributary takes off from the right bank which is called Jiwan Minor. The cross structures in Fordwah Distributary are all broad-crested weirs. In the initial design, there were four cross regulating structures (RD 15, 33.3, 42.8 and 65) but the one at RD 42.8 is not functional now after a redesign of the distributary in the past. Originally designed to operate under free flow conditions, only the weir, at RD 15 is working in this condition and the other two at RD 33.3 & 65 are submerged (Hart 1996).

3.2. SAMPLE TERTIARY UNITS

Four outlets along the distributary were the sample points (Figure 3) for data collection to study the water availability at the tertiary level and its relationships with water supply and fluctuations at the head. The basic information about these outlets is provided in Table 3.1.

3.3. CANAL WATER SUPPLIES AT HEAD OF DISTRIBUTARY

There are two aspects of water delivery performance: (1) degree or amount and type of flexibility allowed by the system and (2) how well the system can deliver the water desired or ordered in terms of both volume and flow rate (Clemmens and Dedrick, 1984). They have further stated that the type and amount of flexibility desirable is a complex problem both technologically and politically. Any such analysis must come from knowledge of irrigation and farm management practices as related to soil conditions, field and farm sizes, irrigation scheduling practices and the level of technology and labor available. The second aspect of performance is directly measurable from the rate and duration of the delivery, computing the volume delivered and comparing this with the requirements.

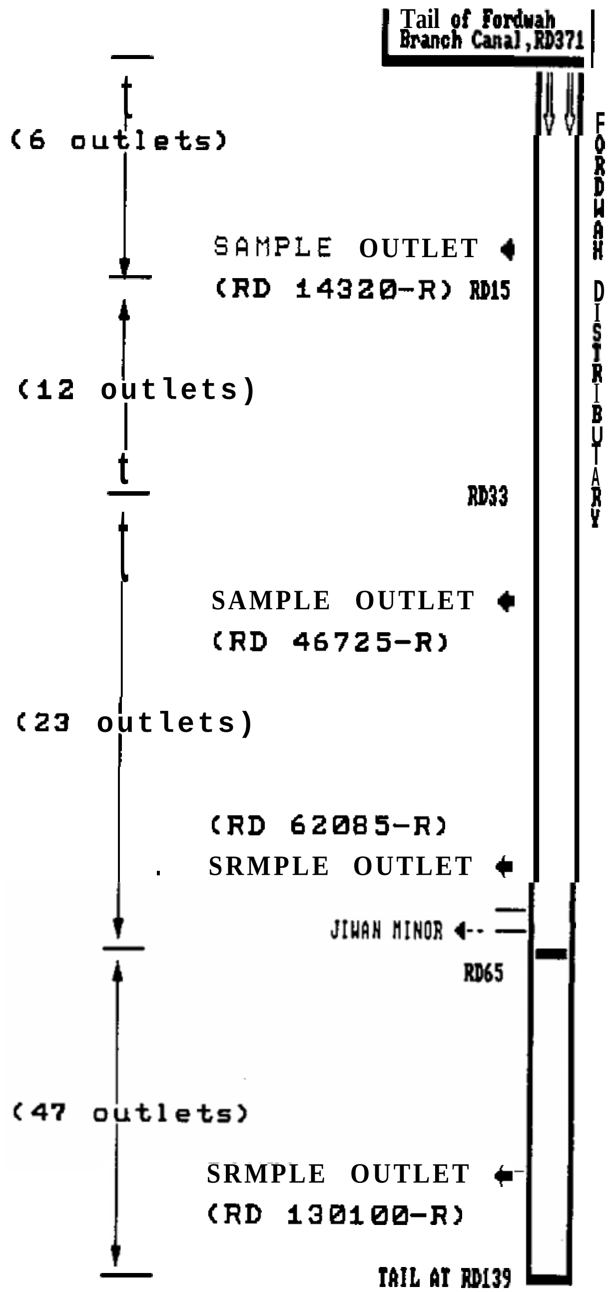

Figure 3. Schematic of Fordwah Distributary and Sample Tertiary Subsystems.

OUTLET	TYPE	DESIGN Q (cfs)	GCA acre	CCA acre	NO OF TURNS	TIME/ ACRE (min)	FARM SIZE RANGE (acres)
14320R	OCOFRB	1.76	490	490	104	20	1 - 1 3
46725R	OFRB	1.68	445	445	67	22	2 - 15
62085R	OCOFRB	1.18	342	328	63	30	1 - 14
130100R	APM	2.40	675	663	80	22	2 - 15

APM : adjustable proportional module

The objective of this study is only to discuss the delivery fluctuations in respect to the design and its relation with different problems of the system. The present analysis is based on one discharge observation in a day. Figures 3.1 to 3.4 show the monthly coefficient of variation (CV) of the deliveries in different years and this data is given in Annex 3.1. Without specifying a reference CV for good performance, the graphs indicate wide variations in the deliveries for different months within and over the years. Kuper and Strosser (1992) have reported some reasons for these fluctuations as the overall shortage of water in the system, along with changing water requirements, with the added disadvantage for Chishtian Subdivision to be at the end of the system. Only when the water requirements upstream in the system have been satisfied is water conveyed downstream to the Chishtian Subdivision. This means that the problems of supplies and fluctuations for Fordwah Distributary is further amplified while being located at the tail end of Chishtian Subdivision.

The figures clearly show that during a slack period in the month of May due to wheat harvesting, less discharge fluctuations occur, indicating less interference in the upstream channel. In this way, it seems to be mainly an operational problem and can be rectified to some extent with effective control over the system. Figure 3.5 presents the seasonal coefficient of variation for the deliveries at the distributary head. There is no particular trend of CV variation for the rabi and kharif seasons over this period of analysis. However, the overall CV is significantly high which is not good for a canal water distribution system and farm irrigation management.

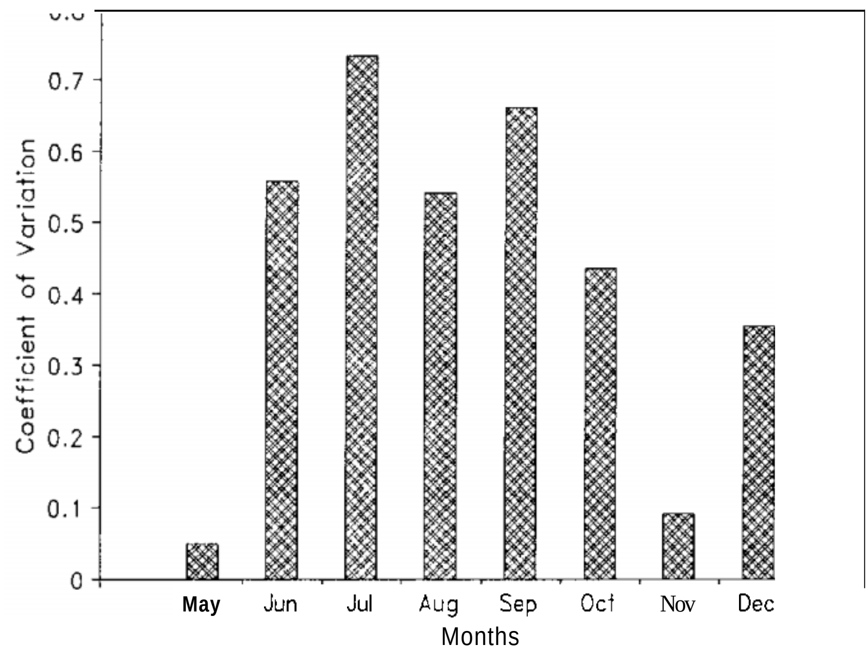

Figure 3.1. Temporal coefficient of variation at Fordwah Distributary head, 1992.

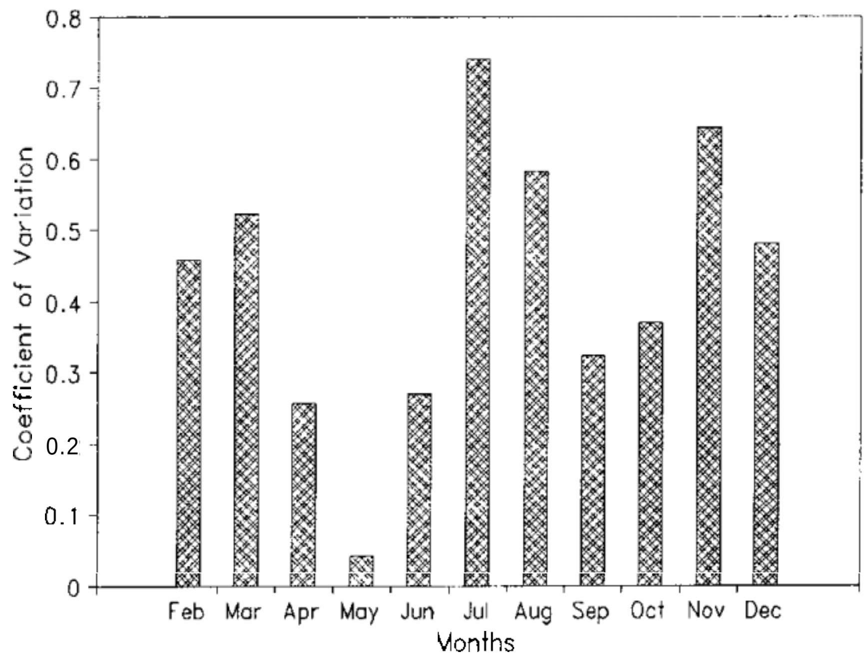

Figure 3.2. Temporal coefficient of variation at 'Fordwah Distributary head, 1993.

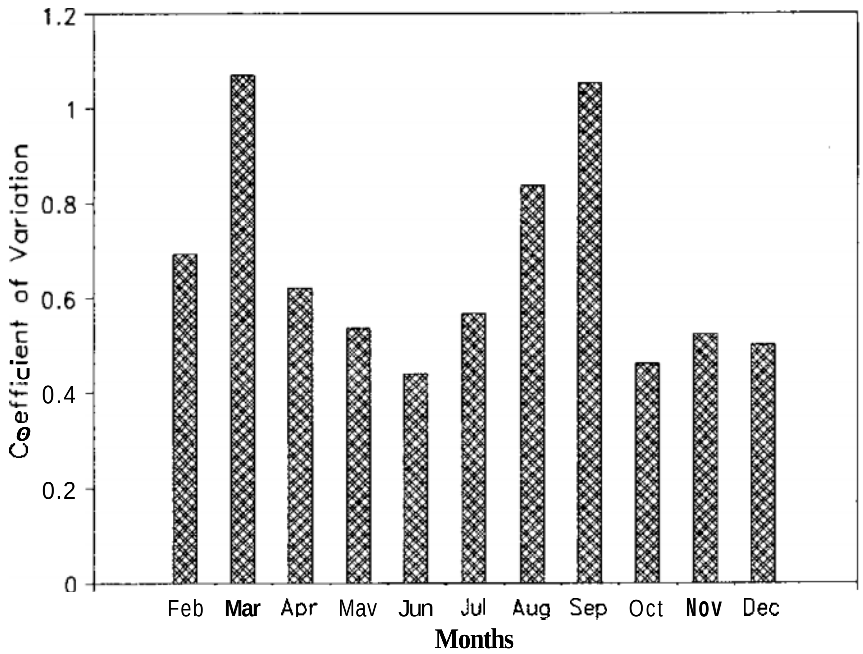

Figure 3.3. Temporal coefficient of variation at Fordwah Distributary head, 1994.

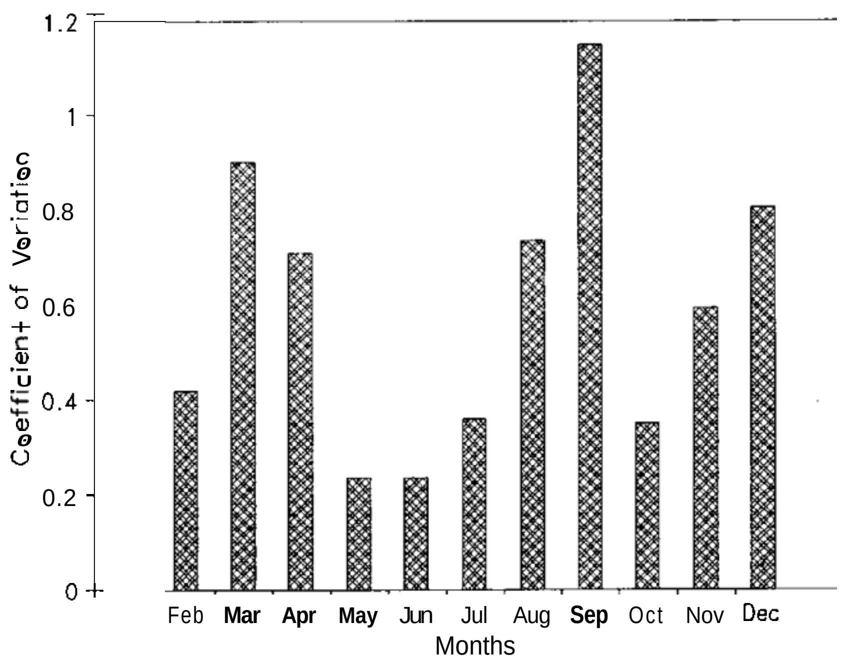

Figure 3.4. Temporal coefficient **of** variation at Fordwah Distributary head, 1995.

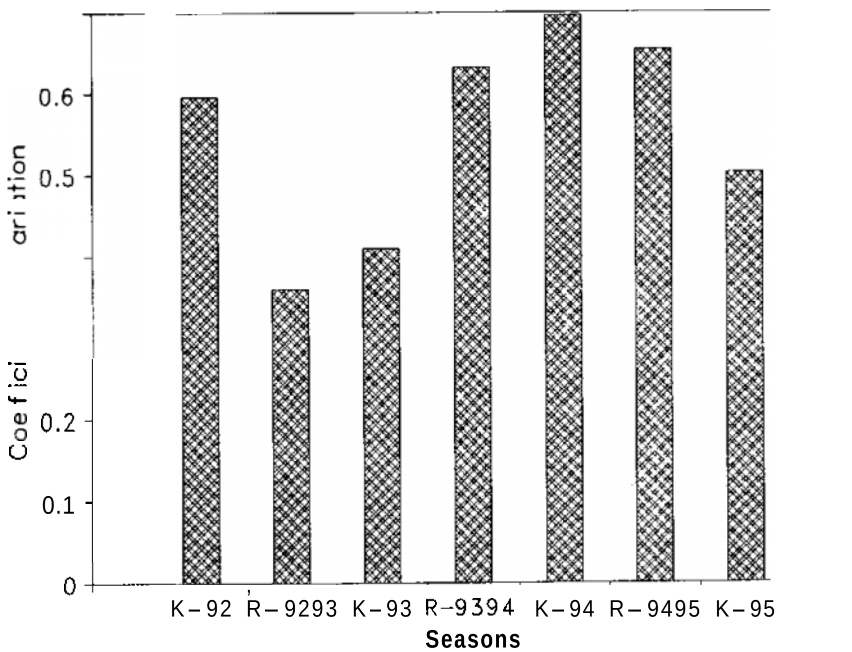

Figure 3.5. Temporal coefficient of variation at Fordwah Distributary head, 1992-1995