Future Reservoirs & Irrigation Schemes
Some important considerations

by

The Reformers
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The Reformers

1. Introduction

1.1. Pakistan depends almost entirely on the water of Indus System for its requirements of irrigated agriculture. Under the Indus Water Treaty, 1960, three eastern rivers were allocated to India for their exclusive use and the western rivers, Indus, Jhelum and Chenab were assigned to Pakistan. However India has been allowed to irrigate over 1.3 million acres of land from the western rivers under the Treaty.

1.2. The flow pattern of our rivers is highly erratic. The highest annual flow in the recorded history was 186.79 MAF in the year 1959-60 as against the minimum of 97.74 MAF in the year 1974-75. During Kharif season the maximum flow of 154.74 MAF was recorded in the year 1959-60 as against minimum of 79.47 MAF in the year 1974-75. Out of the total annual flows, about 84% are in Kharif and 16% in Rabi. For storage of surplus floodwater of Kharif, when available, to be used in shortage periods, the following storages have been constructed: -

(i) Mangla (live capacity 5.8 MAF) on river Jhelum.

(ii) Tarbela (live capacity 9.3 MAF) on river Indus.

(iii) Chashma (live capacity 0.5 MAF) on river Indus.

1.3. Two Link Canals i.e. Chashma Jhelum Link and Taunsa Panjnand Link have also been constructed to divert the surplus flow when available in the river Indus, over and above the requirements of the canals settled on that system, and when there is shortage in the tributary rivers at that time.

2. Future Reservoirs in Pakistan

2.1. The need for constructing more storages is being stressed time and again by WAPDA, it is necessary to study and consider the following aspects in this respect: -

(i) Operation and management of the present reservoirs and Indus Link Canals.

(ii) The surplus water availability in the rivers after meeting the present commitments.

3. Operation and Management of the present reservoirs and Indus Link Canals.

3.1. Before launching of any new reservoir project it is important to review the working, management and operations of the present reservoirs and Link Canals. In this context, it is important that the following basic criteria/thumb rules for operation of reservoirs are properly and faithfully observed.

(i) The reservoirs are water banks, where water is stored in Kharif season only when it is surplus to the requirements/allocations of the present Canal Systems, for subsequent use during shortage periods particularly the following Rabi season.

(ii) During Kharif season itself the reservoirs are to be used for balancing so that the fluctuations in the river flows are absorbed and steady flow maintained in the river downstream even during shortage period.

(iii) The Indus Link Canals are to be operated only when the water in Indus is in excess of the allocations/ requirements of the canals settled on that system and there is shortage in the tributary rivers.

3.2. The experience of the past has however shown that these basic criteria are not being observed. A study, carried out by the Water Management and Distribution Committee of The Reformers, regarding the operation of reservoirs and Link Canals for the season Kharif 2000 reveals the following facts: -

(a) Water was stored in the reservoirs specially in Mangla even during the periods when there was extreme shortage of water in the lower riparian provinces of Sindh and Balochistan.

(b) Heavy fluctuations were passed downstream Chashma and Taunsa Barrages, which caused further difficulties for the regulation and distribution of water in Sindh and Balochistan. The fluctuations could have been avoided if the reservoirs were managed, regulated and operated properly.

(c) The Indus Link Canals were opened when there was acute shortage of water in Sindh and Balochistan, though at the same time water was being stored in Mangla reservoir, which proves that there was no shortage in tributary system to justify the transfer of water from Indus. The link canals continued to operate almost throughout the season inspite of severe shortage of water in the lower provinces.

3.3. Before even thinking of a new reservoir, it is very necessary that the operation and management of present reservoirs and link canals is stream lined so that the legitimate interest of the lower riparian provinces is safeguarded. Unless this is done and satisfactory foolproof arrangements are made by Federal Government for the operation and management of the present reservoirs and link canals to the satisfaction of the lower riparian provinces, no new reservoir project can even be considered.

4. Surplus water availability

4.1. As stated above the need for constructing more reservoirs is being stressed to meet the water shortage in the country. It is being argued that Turkey has 44 dams and therefore we should have similar number of dams. However the construction of dams depends upon the quantity of surplus water available, as we can not afford to construct dams at huge cost which remain high and dry.

5. Water availability computations by WAPDA

5.1. Notwithstanding the fact that the water of Indus system has been utilized/committed to a very great extent, no regular systematic periodical studies for water availability and utilization were ever carried out in the past nor any such studies are being carried out /updated at present. However, WAPDA has made the water availability computations on two occasions as under: -

(i) Water availability computations made for the Water Resources Committee of National Commission for Agriculture (1987).

(ii) Water availability computations by WAPDA (1994).

Both these computations were made much after the construction of Mangla and Tarbela reservoirs. Some water availability computations were also presented by WAPDA representative in Seminars.

5.2. These WAPDA computations have been challenged because of inconsistencies and inaccuracies. Moreover they are not complete and comprehensive, because some important aspects of water availability have not been focused upon. In this paper, it is proposed to highlight these important aspects, on the basis of analysis of the basic data contained in the WAPDA's latest document of water availability of December 1994.

6. Annual and Kharif inflows of western rivers

6.1. The record of river flows is available from 1922-23. A statement showing the annual and Kharif inflows of western rivers from the years 1922-23 to the year 1993-94 is attached as Annexure I. A statement showing the same information arranged in descending order is attached as Annexure II. A bar chart showing the annual river flows for the same period is attached as Annexure III. A bar chart showing the Kharif inflows of the western rivers for the same period is attached as Annexure IV. The figures given in Annexure I and II indicate that the total annual river flows during the 72 year period were 9987.56 MAF whereas the total Kharif flows were 8344.14 MAF.

7. Annual water availability on year to year basis

7.1. It is necessary to compute the annual surplus water availability on year to year basis, after accounting for the present water requirements / commitments of the existing Canal Systems. The existing requirements / commitments are as under: -

(i)	Water Accord allocations below rim stations	114.4 MAF
(ii)	Average system losses (Post Tarbela 1977-94)	14.7 MAF
(iii)	India's authorized uses on western rivers(unutilized portion)	4.8 MAF
(iv)	Outflows to sea (Water Accord figure)	10.0 MAF
	TOTAL	143.9 MAF

7.2. In the above table the figures for (i) are in accordance with the Water Accord 1991. However some small percentage of the allocations have not yet been fully utilized particularly in the recently completed and ongoing projects. But this unutilized part of allocation can not be considered as surplus.

The figure of 14.7 MAF for annual system losses shown under (ii) above is the average for the Post Tarbela period 1977 to 94 as indicated in WAPDA document of December 1994. However the maximum system losses during Post Tarbela period as recorded in WAPDA document occurred in 1990-91 were 24.5 MAF. There are also a few more years during this period when the losses were in excess of 20 MAF. The extent of system losses has been varying from year to year. No attempt has however been made by WAPDA to study the causes for the variations and to co-relate them to the different variables in the river regime. In the absence of any such study and co-relation, it would have been proper to adopt the maximum figure of the system losses, because it is always better to err on the safe side while planning huge projects like storage dams. However in this paper the WAPDA average figure of 14.7 MAF has been adopted.

7.3. As regards the figure of 4.8 MAF shown under (iii) above, it represents the unutilized portion of India's authorized uses on western rivers. Under the Indus Water Treaty, India is entitled to develop 1,343,477 acres of cropped area on western rivers. There is no restriction on the quantity of water, which they can utilize, nor there is any time period prescribed for developing the area. Out of the above area, India has developed 785799 acres and utilized 6.75 MAF of water. Therefore for developing the remaining area of 557,678 acres, India will require additional 4.8 MAF on pro-rata basis. Though there is no restriction on India about the quantum of water, the figure of 4.8 MAF calculated on pro-rata basis has been adopted in this report.

7.4. The figure of 10 MAF for outflow to sea is in accordance with the Water Accord. According to the Accord, further studies were required to be carried out to determine if this quantity is adequate or not but these studies have not even

been started. However independent international agencies like IUCN have estimated the requirements for outflow to sea to be 27 MAF.

7.5. According to the river flow records (Annexure I and II) the quantity of 143.9 MAF of water to meet the commitments of existing canals and outflows to sea as per Accord is available for 26 out of 72 years. The percentage probability is only 36%.

8. Pattern of annual surplus water availability

8.1. Statement showing the annual surplus water availability in western rivers during the 26 years out of a total of 72 years (1922-23 to 1993-94) is enclosed as Annexure V. These details arranged in descending order are given in Annexure VI.

8.2. A study of the analysis in Annexure V and VI reveals that during the 26 years period after meeting the annual requirements of 143.9 MAF, the total quantity of surplus water available in the rivers was 330.16 MAF. This quantity of surplus water available in only 3.3% of the total inflow of western rivers during 72 years (1922-23 to 1993-94) which was 9987.56 MAF. Thus the concept that huge quantity of surplus water is available in our rivers is totally incorrect.

A further study of the analysis given in Annexure V and VI shows that:

(i) Over 50% of the surplus water has been available in 6 years of very high floods.

(ii) A dam of 6.0 MAF capacity requires a surplus availability of 10.0 MAF (6.0 MAF for storage + 4.0 MAF for additional system losses). The quantity over and above 10.0 MAF is available for a period of 14 years out of 72 years i.e. only 19.4% of the time.

(iii) During the very high flood years, the annual surplus water availability is much in excess of the capacity of storage dam of usual size (which is about 6.0 MAF.)

(iv) The highest surplus availability was 42.89 MAF during the year 1959-60. The surplus flow of over 20.0 MAF was available for 7 years. These high flows can only be stored in a carry-over dam of a large capacity.

9. Kharif water availability

9.1. The analysis made in the foregoing paragraphs is based on the total annual inflows of the western rivers. However it is more important to analyze the availability of water in Kharif season, because floods occur in this season and

surplus water can be available only in this season. Let us first see the existing water requirements/commitments during Kharif season.

(i)	Water Accord Kharif allocations (below rim stations)	77.3 MAF
(ii)	System losses average Post Tarbela (WAPDA figures)	15.5 MAF
(iii)	India's authorized used on western rivers (75% of annual 4.8 MAF)	3.6 MAF
(iv)	Outflow to sea (Accord figure)	10.0 MAF
(v)	Total without present storages	106.4 MAF
(vi)	Requirement of present storages	15.0 MAF
	Total with existing storages	121.4 MAF

9.2 The figures in Annexure I and II indicate that this quantity of 121.4 MAF required to meet the allocation of the existing canals, requirement of existing storages and outflow to sea as per Accord was available for a period of 24 years out of 72 years (1922-23 to 1993-94). This gives a percent probability of 33%.

10. Pattern of surplus Kharif water availability

10.1 Analysis of the pattern of surplus Kharif water availability in western rivers during 24 years is reflected in Annexure VII. The same analysis in descending order is given in Annexure VIII.

10.2 An examination of the analysis indicates that during the 72 year period (1922-23 to 1993-94), the total surplus quantity was 277.32 MAF as against the total annual inflow in Western Rivers of 9987.56 MAF and total Kharif inflows of 8344.14 MAF in the same period. Thus the surplus Kharif availability works out to 2.77% of total annual inflows and 3.32% of total Kharif inflows. This clearly shows that it is not correct that huge quantity of surplus water is available for storage.

10.3 Further study of the analysis of Annexure VII and VIII reveals that: -

(i) Over 50% of surplus Kharif water has been available in 6 years of very high floods out of 72 years.

(ii) A dam of 6.0 MAF capacity requires a surplus availability of 10.0 MAF (6.0 MAF for storage plus 4.0 MAF for additional system losses). The quantity of over and above 10.0 MAF is available for a period of 12 years out of 72 years i.e. only 16.66% of the time.

(iii) During the very high flood years the annual surplus water availability is much in excess of the capacity of storage dam of usual size, which is about 6.0 MAF.

(iv) The highest Kharif surplus availability was 33.30 MAF in 1959-60. The surplus flow of over 15.00 MAF and above was available during the period of 8 years, which could only be stored in a carry over dam of large capacity.

11. Some other aspects of water availability

11.1. A further study of the periodical frequency of the surplus water availability is given in Annexure IX and X. A study of this analysis reveals the following:-

(i) The numbers of years of annual surplus water availability in each decade varies between 2 and 5. However the maximum surplus water availability of 105.99 MAF was in the decade 1951-60 and minimum of 4.1 MAF only during the decade 1961-70.

(ii) The number of years of Kharif surplus water availability in decade varies between 1 and 5. However the maximum Kharif surplus availability was 78.41 MAF during the decade 1951-60 as against minimum of 3.57 MAF during the decade 1961-1970.

(iii) The continuous period of low flow years with no-surplus annual water availability has been 9 years from 1924-25 to 1932-34. The continuous low flow period of Kharif was from 1961-62 to 1972-73 i.e. 12 years. The total extent of low flow periods of four years and more during 72 years period (1922-23 to 1993-94) has been 37 years on annual basis and 38 years during Kharif season. This reveals that over 50% of the time, there have occurred continuous low flow cycles of 4 years and more.

In planning any future reservoirs, these facts about the vagaries of the rivers have to kept in view.

12. A glaring example of poor planning

12.1 Hub Dam was built by WAPDA for providing water supply for irrigation to areas in Balochistan and drinking water to city of Karachi. The dam is completely dry since over three years. It is because the planners did not consider and examine the water availability scenario in the right perspective. Surely, the engineers and their consultants will not blame themselves and have the moral courage to accept the responsibility. Instead, they will blame nature for what has happened.

12.2 Similar situation, or even much worse, will surely occur if we build more reservoirs on Indus system without regards to the realities.

13. Future Irrigation Schemes

13.1 Since the past few years there has been a drive to launch programs for construction of reservoirs and new irrigation projects to utilize surplus water. Initially the "Integrated Valley Development Program" with huge estimated cost of Rs. 250 billion was prepared by Mr. Farooq Ahmed Laghari when he was Federal Minister for Water and Power. Subsequently, a program titled "National Water Resources Development Program" with fabulous investment of Rs. 562 billion was prepared by the former Mian Nawaz Sharif Government, which had more or less similar contents. The present government also seems to be inclined to launch this programme.

13.2 The prospects for future reservoirs have been examined in the foregoing paragraphs. Now let us examine the case for new irrigation projects, but before doing so we must consider the position of the present irrigation projects in operation.

13.3 The list of irrigation projects in operation is given in WAPDA's publications titled "Indus Basin Irrigation System - Abstract of Operational Data". A copy of this list is enclosed as Annexure XI. This list also indicates the water allowance of each project according to the original sanctioned design. Though there are some mistakes in the figures given by WAPDA in this list, still it is fairly indicative about the general picture of water allowance of each project. Most of the present projects date back to the nineteenth or early part of twentieth century. These projects have very low water allowance, presumably because there was no pressure on land at the time when these projects were constructed. In practice, these projects have been drawing more water than their design, over the past many years.

14. Water Accord Allocations

14.1 Under the Water Accord, 1991, the allocations of water have been made as under: -

(i) A quantity of 114.35 MAF has been allocated to the provinces under para 2 of the Accord.

(ii) The Ratio for sharing balance river supplies (including future shortages) amongst provinces has been fixed under para 4 of the Accord.

14.2 For the utilization of this quantity of water (114.35 MAF) allocated to the provinces under para 2 of the Accord, ten daily statements were prepared under para 14 (a) (b) of the accord on the guideline of average system uses for the period 1977-82 adjusted pro-rata to correspond to the seasonal allocations of the Canal Systems. These 10-daily statements have since been approved for existing Canal System by Council of Common Interests (CCI) and been made a

part and parcel of the Accord. Thus the quantity of 114.35 allocated under para 2 of the Accord already stands allocated and distributed amongst the existing canals according to 10-daily statements approved by CCI. An extract of relevant paras of Water Accord is enclosed as Annexure XII.

15. Water availability for existing canals

15.1 As explained in the foregoing paras, the analysis of the water flow data for 72 years indicates that the water in the rivers is available for meeting the existing allocations/commitments for only 24 years i.e. 33% of the time. This clearly indicates that we have already far exceeded the limits of water availability and therefore we have to often resort to sharing of shortages under paras 14 (a) (b) of the Water Accord.

15.2 As such, there is no scope for any new projects to be undertaken from the allocations under para 2 of the Accord. Inspite of this, a few new projects have been sanctioned which is clear violation of the Accord. In view of very dismal position of water availability, it will be disasterous if any more new projects are undertaken at this stage because every such project will mean damaging the established agriculture on existing projects by further reducing their supplies even below the present level. Moreover every new project means huge capital expenditure not only on the construction of the projects but also for colonisation, developing the lands, building towns and infrastructure like roads, electricity lines, hospitals, school etc.

15.3. Under the circumstances, the correct option is to undertake rehabilitation and improvement of existing Canal Systems, particularly older ones, which have very low and unrealistic water allowances. However the remodelling plan has to be accommodated within the Water Accord allocation of each province.

16. Balance river supplies

16.1. Para 4 of the Water Accord determines the provincial shares in the balance river supplies (including future storages). The availability of surplus water has been analyzed in Annexures V and VI and discussed in foregoing paragraphs. The total surplus availability is only about 300 MAF over a period of 72 years, out of total inflow of about 10000 MAF during the period, i.e. only 3% of the total inflow. This availability is limited to a few years of very high floods. No new irrigation project can be conceived under such a poor water availability scenario. This surplus water can be utilized only in a carry over storage dam, which will have to be designed in consideration of the factual position.

17. Conclusion and recommendations

1. Before any project for new storages is considered, the management, regulation and operation of the existing reservoirs and Indus Link Canals should be thoroughly reviewed, to the satisfaction of lower riparian provinces. The Federal Government should ensure that no water is stored in reservoirs during shortage periods in the rivers and that Indus Link Canals are not operated during shortage periods in Indus.

2. It is an illusion that there is lot of surplus water in the rivers available for storage. Actually there is no enough water available for 48 years out of 72 years recorded history, even for present commitments of Canal System and existing storages. Moreover there have been continuous low flow periods as long as 12 years duration. Also there have been several cycles of low flow years of 4 years and more, which have occurred over a period of 38 years i.e. more than 50% of the time.

3. The quantity of 10 MAF tentatively allocated under the Water Accord for outflow to sea is available only for 24 years out of 72 years i.e. 33% of the time. It seems highly improbable that any additional quantity can become available for the purpose. It is therefore important to ensure that at least the present position is maintained, so that the already precarious environmental situation does not deteriorate further.

4. The only way to somehow show surplus water availability for future storage and irrigation schemes is to assume that the water allocated to existing projects is also available for future storages and irrigation schemes. But you cannot eat the cake and have it too. If another reservoir, other than a carry over dam is built under these circumstances, then it will be argued that since the reservoir has been constructed, it has to be filled even if no surplus water is available. This will mean disaster for established agriculture on existing Canal Systems.

5. The total quantity of surplus water after meeting present commitments over a period of 72 years is only about 300 MAF out of total river inflows of about 10000 MAF, or just 3% of the total flows, such a high percentage of water commitment, leaving a balance of only 3%, is most unrealistic on a river system having highly variable flows. Most of this small surplus quantity is available in a few very high flood years. These facts will have to be considered while planning any new reservoirs. The only possibility is a carry over dam, which can hold enough water, which is available in very high flood years, to be used in subsequent drought years.

6. If all the available surplus water of 72 years were to be stored in a big carry over dam, an average of about 4 MAF of water per year would become available (assuming no losses). However there are bound to be evaporation and absorption losses due to long period of storage, as well

as additional system losses in conveyance, which will reduce the annual average availability to 2.5 to 3 MAF.

7. The total available surplus flow of about 300 MAF over a period of 72 years is all that can be available in the kitty. We may store it in reservoirs, use it for new irrigation schemes, or let it flow into the sea to meet the environmental needs. However, this very small quantity of available surplus water cannot be thinly spread, as it will cause difficulties of management and operation.

8. The quantity of 114.35 MAF allocated under para 2 of Water Accord is meant for existing irrigation schemes and stands distributed to each Canal System according to the 10 daily statements approved by the Council of Common Interests, which have also been made a part and parcel of the Accord. Also there is no possibility of any new irrigation scheme out of the surplus balance flow available because its quantity is very small and probability/frequency very unreliable. Any new scheme undertaken hereafter will therefore be highly detrimental to the established agriculture on existing schemes. Moreover the new schemes will require huge expenditure on infrastructure development in addition to their capital cost.

9. It is necessary to review the water allowances of the existing Canal Systems and to undertake a remodelling programme within the limits of seasonal provincial Accord allocations. The water allocated under the Accord can best be utilized within the existing Canal System, especially those whose present water allowance is very low.

10. The programs for water conservation, economic water use, improved agricultural practices, water saving devices and water course lining particularly in saline ground water areas need to be accelerated.

ANNEXURE I - ANNUAL AND KHARIF INFLOWS OF WESTERN RIVERS

(FIGURES IN MAF)

Year	Annual Flow	Year	Kharif Flow

1	1899	147.44	**1**	1899	121.48
2	1899	154.01	**2**	1899	130.46
3	1899	129.69	**3**	1899	109.56
4	1899	118.73	**4**	1899	100.51
5	1899	117.31	**5**	1899	99.16
6	1899	110.83	**6**	1899	90.42
7	1899	130.31	**7**	1899	108.22
8	1899	124.14	**8**	1899	97.20
9	1899	136.86	**9**	1899	117.13
10	1899	123.40	**10**	1899	101.10
11	1899	125.26	**11**	1899	107.62
12	1899	144.45	**12**	1899	125.66
13	1899	126.86	**13**	1899	108.19
14	1899	139.09	**14**	1899	116.81
15	1899	145.82	**15**	1899	124.91
16	1899	131.44	**16**	1899	110.10
17	1899	147.95	**17**	1899	125.36
18	1899	144.78	**18**	1899	127.24
19	1899	120.10	**19**	1899	104.52
20	1899	133.67	**20**	1899	107.75
21	1899	167.08	**21**	1899	143.57
22	1899	147.00	**22**	1899	127.39
23	1899	136.16	**23**	1899	116.06
24	1899	150.50	**24**	1899	131.64
25	1899	128.88	**25**	1899	110.44
26	1899	124.67	**26**	1899	101.36
27	1899	155.72	**27**	1899	132.15
28	1899	156.00	**28**	1899	132.29
29	1899	171.66	**29**	1899	151.28
30	1899	113.81	**30**	1899	93.60
31	1899	130.30	**31**	1899	112.33
32	1899	143.08	**32**	1899	116.31
33	1899	140.25	**33**	1899	119.98
34	1899	132.53	**34**	1899	107.51
35	1899	157.38	**35**	1899	131.92
36	1899	151.10	**36**	1899	123.00
37	1899	158.56	**37**	1899	124.47
38	1899	186.79	**38**	1899	154.74
39	1899	145.71	**39**	1899	124.97
40	1899	140.51	**40**	1899	119.58

41	1899	109.81	**41**	1899	89.96
42	1899	135.06	**42**	1899	113.40
43	1899	138.43	**43**	1899	116.11
44	1899	138.98	**44**	1899	117.89
45	1899	140.47	**45**	1899	116.64
46	1899	146.19	**46**	1899	120.43
47	1899	138.84	**47**	1899	115.63
48	1899	134.26	**48**	1899	114.49
49	1899	106.17	**49**	1899	90.27
50	1899	104.14	**50**	1899	88.40
51	1899	128.07	**51**	1899	101.62
52	1899	164.09	**52**	1899	144.97
53	1899	97.74	**53**	1899	79.47
54	1899	139.52	**54**	1899	116.30
55	1899	135.28	**55**	1899	116.85
56	1899	127.46	**56**	1899	104.36
57	1899	163.48	**57**	1899	137.45
58	1899	131.98	**58**	1899	108.84
59	1899	136.39	**59**	1899	109.81
60	1899	140.62	**60**	1899	117.69
61	1899	122.37	**61**	1899	97.10
62	1899	149.95	**62**	1899	128.28
63	1899	134.92	**63**	1899	115.99
64	1899	117.70	**64**	1899	91.66
65	1899	146.65	**65**	1899	116.38
66	1899	141.07	**66**	1899	111.79
67	1899	161.40	**67**	1899	136.56
68	1899	131.32	**68**	1899	102.01
69	1899	166.12	**69**	1899	130.98
70	1899	172.10	**70**	1899	141.53
71	1899	169.68	**71**	1899	138.62
72	1899	127.47	**72**	1899	104.67
	TOTAL	**9987.56**		**TOTAL**	**8344.14**

ANNEXURE II - ANNUAL AND KHARIF INFLOWS OF WESTERN RIVERS

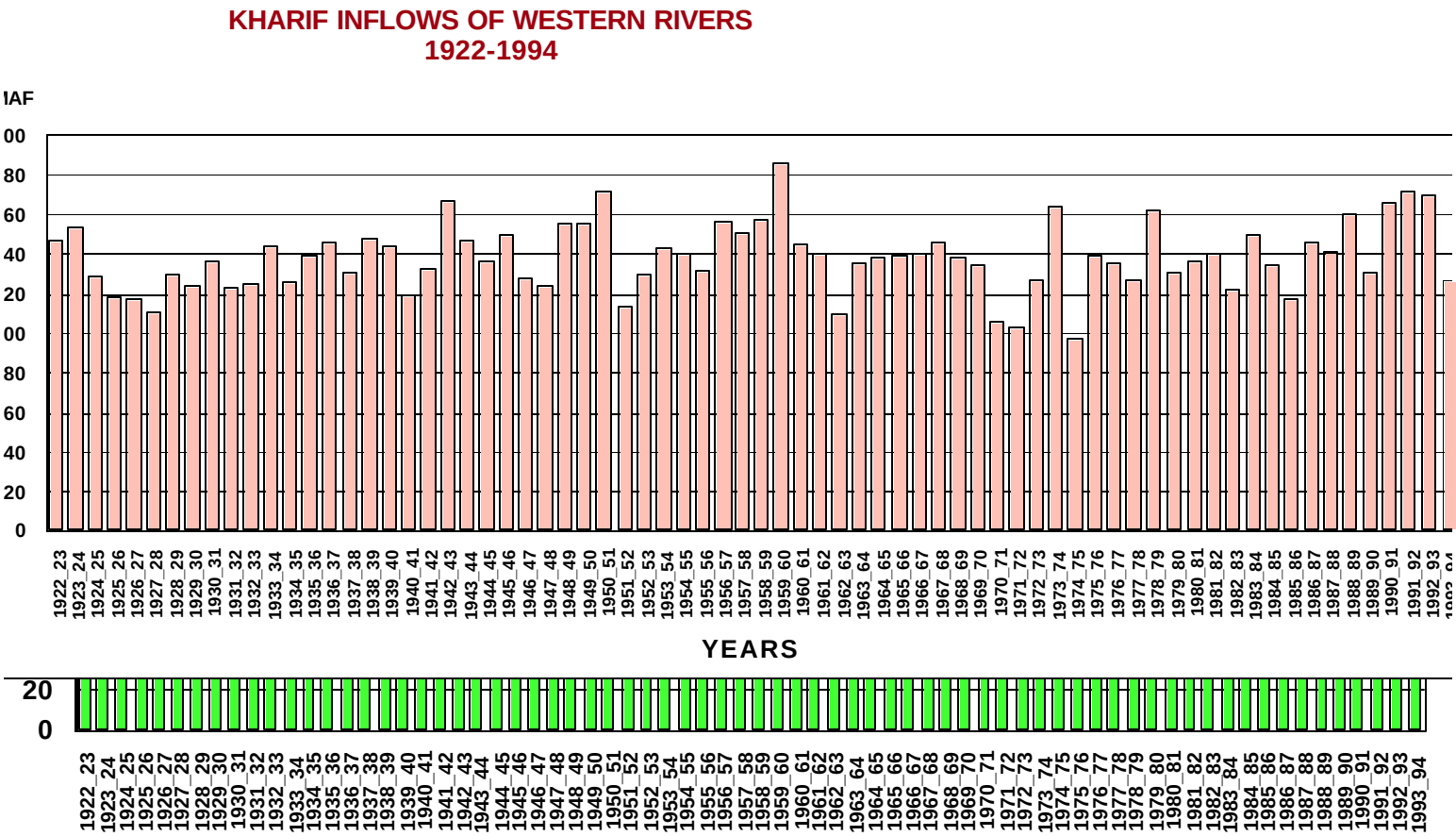
(FIGURES IN MAF) **(IN DESCENDING ORDER)**

Year	**Annual Flow**	**Year**	**Kharif Flow**

1	1899	186.79	**1**	1899	154.74
2	1899	172.1	**2**	1899	151.28
3	1899	171.66	**3**	1899	144.97
4	1899	169.68	**4**	1899	143.57
5	1899	167.08	**5**	1899	141.53
6	1899	166.12	**6**	1899	138.62
7	1899	164.09	**7**	1899	137.45
8	1899	163.48	**8**	1899	136.56
9	1899	161.4	**9**	1899	132.29
10	1899	158.56	**10**	1899	132.15
11	1899	157.38	**11**	1899	131.92
12	1899	156	**12**	1899	131.64
13	1899	155.72	**13**	1899	130.98
14	1899	154.01	**14**	1899	130.46
15	1899	151.1	**15**	1899	128.28
16	1899	150.5	**16**	1899	127.39
17	1899	149.95	**17**	1899	127.24
18	1899	147.95	**18**	1899	125.66
19	1899	147.44	**19**	1899	125.36
20	1899	147	**20**	1899	124.97
21	1899	146.65	**21**	1899	124.91
22	1899	146.19	**22**	1899	124.47
23	1899	145.82	**23**	1899	123
24	1899	145.71	**24**	1899	121.48
25	1899	144.78	**25**	1899	120.43
26	1899	144.45	**26**	1899	119.98
27	1899	143.08	**27**	1899	119.58
28	1899	141.07	**28**	1899	117.89
29	1899	140.62	**29**	1899	117.69
30	1899	140.51	**30**	1899	117.13
31	1899	140.47	**31**	1899	116.85
32	1899	140.25	**32**	1899	116.81
33	1899	139.52	**33**	1899	116.64
34	1899	139.09	**34**	1899	116.38
35	1899	138.98	**35**	1899	116.31
36	1899	138.84	**36**	1899	116.3
37	1899	138.43	**37**	1899	116.11
38	1899	136.86	**38**	1899	116.06
39	1899	136.39	**39**	1899	115.99
40	1899	136.16	**40**	1899	115.63

41	1899	135.28	**41**	1899	114.49
42	1899	135.06	**42**	1899	113.4
43	1899	134.92	**43**	1899	112.33
44	1899	134.26	**44**	1899	111.79
45	1899	133.67	**45**	1899	110.44
46	1899	132.53	**46**	1899	110.1
47	1899	131.98	**47**	1899	109.81
48	1899	131.44	**48**	1899	109.56
49	1899	131.32	**49**	1899	108.84
50	1899	130.31	**50**	1899	108.22
51	1899	130.3	**51**	1899	108.19
52	1899	129.69	**52**	1899	107.75
53	1899	128.88	**53**	1899	107.62
54	1899	128.07	**54**	1899	107.51
55	1899	127.47	**55**	1899	104.67
56	1899	127.46	**56**	1899	104.52
57	1899	126.86	**57**	1899	104.36
58	1899	125.26	**58**	1899	102.01
59	1899	124.67	**59**	1899	101.62
60	1899	124.14	**60**	1899	101.36
61	1899	123.4	**61**	1899	101.1
62	1899	122.37	**62**	1899	100.51
63	1899	120.1	**63**	1899	99.16
64	1899	118.73	**64**	1899	97.2
65	1899	117.7	**65**	1899	97.1
66	1899	117.31	**66**	1899	93.6
67	1899	113.81	**67**	1899	91.66
68	1899	110.83	**68**	1899	90.42
69	1899	109.81	**69**	1899	90.27
70	1899	106.17	**70**	1899	89.96
71	1899	104.14	**71**	1899	88.4
72	1899	97.74	**72**	1899	79.47
	Total	**9987.56**			**8344.14**

ANNEXURE III



X-Axis

ANNEXURE IV

ANNEXURE V - ANNUAL SURPLUS AVAILABILITY OF WATER IN WESTERN RIVERS

	Year	Annual Flow (MAF)	Surplus over commitment (MAF) (INCLUDING PRESENT STORAGE) **-143.90**	Cumulative Surplus (MAF)	% of Total Surplus
1	1899	147.44	3.54	3.54	1.07
2	1899	154.01	10.11	13.65	4.13
3	1899	144.45	0.55	14.20	4.30
4	1899	145.82	1.92	16.12	4.88
5	1899	147.95	4.05	20.17	6.11
6	1899	144.78	0.88	21.05	6.38
7	1899	167.08	23.18	44.23	13.40
8	1899	147.00	3.10	47.33	14.34
9	1899	150.50	6.60	53.93	16.33
10	1899	155.72	11.82	65.75	19.91
11	1899	156.00	12.10	77.85	23.58
12	1899	171.66	27.76	105.61	31.99
13	1899	157.38	13.48	119.09	36.07
14	1899	151.10	7.20	126.29	38.25
15	1899	158.56	14.66	140.95	42.69
16	1899	186.79	42.89	183.84	55.68
17	1899	145.71	1.81	185.65	56.23
18	1899	146.19	2.29	187.94	56.92
19	1899	164.09	20.14	208.08	63.02
20	1899	163.48	19.58	227.66	68.95
21	1899	149.95	6.05	233.71	70.79
22	1899	146.65	2.75	236.46	71.62
23	1899	161.40	17.50	253.96	76.92
24	1899	166.12	22.22	276.18	83.65

25	1899	172.10	28.20	304.38	92.19
26	1899	169.68	25.78	330.16	100.00
			330.16		

ANNEXURE VI - ANNUAL SURPLUS AVAILABILITY OF WATER IN WESTERN RIVERS

IN DESCENDING ORDER

	Year	Annual Flow (MAF)	Surplus over commitment (MAF)	Cumulative Surplus (MAF)	% of Total Surplus
			-143.90		
1	1899	186.79	42.89	42.89	12.99
2	1899	172.10	28.20	71.09	21.53
3	1899	171.66	27.76	98.85	29.94
4	1899	169.68	25.78	124.63	37.74
5	1899	167.08	23.18	147.81	44.77
6	1899	166.12	22.22	170.03	51.50
7	1899	164.09	20.14	190.17	57.60
8	1899	163.48	19.58	209.75	63.53
9	1899	161.40	17.50	227.25	68.83
10	1899	158.56	14.66	241.91	73.27
11	1899	157.38	13.48	255.39	77.35
12	1899	156.00	12.10	267.49	81.02
13	1899	155.72	11.82	279.31	84.60
14	1899	154.01	10.11	289.42	87.66
15	1899	151.10	7.20	296.62	89.84
16	1899	150.50	6.60	303.22	91.84
17	1899	149.95	6.05	309.27	93.67
18	1899	147.95	4.05	313.32	94.90
19	1899	147.44	3.54	316.86	95.97
20	1899	147.00	3.10	319.96	96.91

21	1899	146.65	2.75	322.71	97.74
22	1899	146.19	2.29	325.00	98.44
23	1899	145.82	1.92	326.92	99.02
24	1899	145.71	1.81	328.73	99.57
25	1899	144.78	0.88	329.61	99.83
26	1899	144.45	0.55	330.16	100.00
		Total	**330.16**		

ANNEXURE VII - KHARIF SURPLUS AVAILABILITY OF WATER IN WESTERN RIVERS

	Year	Kharif Flow (MAF)	Surplus over commitment (MAF) (INCLUDING PRESENT STORAGE) -121.4	Cumulative Surplus(MAF)	% of Total Surplus
1	1899	121.48	0.08	0.08	0.03
2	1899	130.46	9.06	9.14	3.30
3	1899	125.66	4.26	13.40	4.83
4	1899	124.91	3.51	16.91	6.10
5	1899	125.36	3.96	20.87	7.53
6	1899	127.24	5.84	26.71	9.63
7	1899	143.57	22.17	48.88	17.63
8	1899	127.39	5.99	54.87	19.79
9	1899	131.64	10.24	65.11	23.48
10	1899	132.15	10.75	75.86	27.35
11	1899	132.29	10.89	86.75	31.28
12	1899	151.28	29.88	116.63	42.06
13	1899	131.92	10.52	127.15	45.85
14	1899	123.00	1.60	128.75	46.43
15	1899	124.47	3.07	131.82	47.53
16	1899	154.74	33.34	165.16	59.56
17	1899	124.97	3.57	168.73	60.84
18	1899	144.97	23.57	192.30	69.34
19	1899	137.45	16.05	208.35	75.13
20	1899	128.28	6.88	215.23	77.61
21	1899	136.56	15.16	230.39	83.08
22	1899	130.98	9.58	239.97	86.53
23	1899	141.53	20.13	260.10	93.79

24	1899	138.62	17.22	277.32	100.00
		Total	**277.32**		

ANNEXURE VIII - KHARIF SURPLUS AVAILABILITY OF WATER IN WESTERN RIVERS

IN DESCENDING ORDER

	Year	Kharif Flow (MAF)	Surplus over commitment (MAF)	Cumulative Surplus(MAF)	% of Total Surplus
			-121.40		
1	1899	154.74	33.34	33.34	12.02
2	1899	151.28	29.88	63.22	22.80
3	1899	144.97	23.57	86.79	31.30
4	1899	143.57	22.17	108.96	39.29
5	1899	141.53	20.13	129.09	46.55
6	1899	138.62	17.22	146.31	52.76
7	1899	137.45	16.05	162.36	58.55
8	1899	136.56	15.16	177.52	64.01
9	1899	132.29	10.89	188.41	67.94
10	1899	132.15	10.75	199.16	71.82
11	1899	131.92	10.52	209.68	75.61
12	1899	131.64	10.24	219.92	79.30
13	1899	130.98	9.58	229.50	82.76
14	1899	130.46	9.06	238.56	86.02
15	1899	128.28	6.88	245.44	88.50
16	1899	127.39	5.99	251.43	90.66
17	1899	127.24	5.84	257.27	92.77
18	1899	125.66	4.26	261.53	94.31
19	1899	125.36	3.96	265.49	95.73
20	1899	124.97	3.57	269.06	97.02
21	1899	124.91	3.51	272.57	98.29
22	1899	124.47	3.07	275.64	99.39
23	1899	123.00	1.60	277.24	99.97

24	1899	121.48	0.08	277.32	100.00
		Total	**277.32**		

ANNEXURE IX - SURPLUS ANNUAL WATER AVAILABILITY DURING VARIOUS DECADES 1922-94

	Decade		No. of years of Surplus availability	Total Suplus Availability MAF
1	1892	(9 Years)	2	13.65
2	1891		4	7.40
3	1891		5	56.80
4	1891		5	105.99
5	1891		2	4.10
6	1891		2	39.72
7	1891		3	26.30
8	1897	(4 Years)	3	76.20
		Total	**26**	**330.16**

SURPLUS KHARIF WATER AVAILABILITY DURING VARIOUS DECADES 1922-94

	Decade		No. of years of Surplus availability	Total Suplus Availability MAF
1	1892	(9 Years)	2	9.14
2	1891		4	17.57
3	1891		5	60.04
4	1891		5	78.41
5	1891		1	3.57

6	1891		2	39.62
7	1891		2	22.04
8	1897	(4 Years)	3	46.93
		Total	**24**	**277.32**

ANNEXURE X - I. CONTINUOUS LOW FLOW YEARS (4 YEARS AND MORE)

WITH NO ANNUAL SURPLUS AVAILABILITY (143.9 MAF)

DURING THE 72 YEARS PERIOD (1922-23 TO 1993-94)

1	1924-25 to	1899	9 Years
2	1951-52 to	1899	5 Years
3	1961-62 to	1899	6 Years
4	1968-69 to	1899	5 Years
5	1974-75 to	1899	4 Years
6	1979-80 to	1899	4 Years
7	1984-85 to	1899	4 Years
		Total	**37 Years**

II. CONTINUOUS LOW FLOW YEARS (4 YEARS AND MORE)

WITH NO KHARIF SURPLUS AVAILABILITY (121.4 MAF)

DURING THE 72 YEARS PERIOD (1922-23 TO 1993-94)

1	1924-25 to	1899	9 Years
2	1951-52 to	1899	5 Years
3	1961-62 to	1899	12 Years
4	1974-75 to	1899	4 Years
5	1979-80 to	1899	4 Years
6	1984-85 to	1899	4 Years
		Total	**38 Years**

ANNEXURE XI - CANAL CAPACITIES AND COMMAND AREAS

Cannals	Year Starting Operation	Source of Supply	Rivers	Capacity (CS)	GCA (million acres)	CCA (million acres)			Water Allowance CUSECS/1000 acres	
						PRNL	Non-PRNL	Total	PRNL	Non-PRNL
PESHAWAR VALE										
Lower Swat	1890	Munda	Swat	800	0.196	0.182	-	0.182	6.15	0.0
Kabul River	1890	Below Warasak	Kabul	450	0.055	0.048	-	0.048	9.85	0.0
Left Bank	1962	Warasak	Swat	45						
Right Bank	1962	Warasak	Swat	455	0.140	0.119	-	0.119	2.55	0.0
Upper Swat	1915	Amandra	Swat	1800	0.344	0.279	-	0.279	5.06	0.0
Paharpur	1909	Chashma	Indus	500	0.106	0.104	-	0.104	4.62	0.0
Total Peshawar Vale				4050	0.841	0.732	-	0.732	28.23	0.0
UPPER INDUS PLAINS										
Central Bari Doab	1859	UCC/BRBD	Chenab	2600	0.709	0.649	-	0.649	3.22	-
Sidhnai	1887	Sidhnai	Ravi	4500	0.965	0.869	0.253	0.869	3.00	4.8
Lower Chenab	1892	Khanki	Chenab	11500	3.698	2.886	0.148	3.034	3.17	4.3
Lower Jhelum	1901	Rasul	Jhelum	5300	1.616	1.285	0.215	1.500	2.84	4.3
Upper Chenab	1912	Marala/UCC	Chenab	4100	1.079	0.611	0.406	1.017	2.73	2.9
Raya	1912	UCC/BRBD	Chenab	1725	0.484	-	0.424	0.424	-	2.9
Lower Bari Doab	1913	Balloki	Ravi	7000	1.789	1.626	0.044	1.670	3.00	3.3
Upper Jhelum	1915	Mangla	Jhelum	1900	0.613	0.377	0.167	0.544	3.03	3.3
Eastern Sadiqia	1926	Suleimanki	Sutlej	4900	1.172	0.945	0.024	0.969	3.6/405	-
Pak Pattan	1927	Suleimanki/ Islam	Sutlej	6600	1.320	0.601	0.405	1.006	3.60	5.5
Fordwah	1927	Suleimanki	Sutlej	3400	0.581	0.062	0.364	0.426	3.60	5.5
Qaimpur	1927	Islam	Ravi - Chenab	600	0.045	-	-0.043	0.043	-	5.5/11
Bahawal	1927	M.B Link	Ravi - Chenab	5400	0.733	0.283	0.322	0.605	2.5/4.0	5.5
Upper Dipalpur	1928	UCC/BRBD	Chenab	2283	0.386	-	0.360	0.360	-	5.5
Lower Dipalpur	1928	B.S.I	Ravi	3972	0.656	-	0.615	0.615	-	5.5
Mailsi	1928	S.M. Link	Chenab/	4900	1.098	0.320	0.676	0.996	-	5.5

			Ravi							
Panjnad	1929	Panjnad	Sutlej	9000	1.532	0.445	0.903	1.348	4.20	5.5
Abbasia	1929	Panjnad	Sutlej	1100	0.174	0.074	0.080	0.154		
Rangpur	1939	Trimmu	Chenab	2700	0.358	-	0.344	0.344	-	4.8
Haveli	1939	Trimmu	Chenab	5200	0.201	0.064	0.115	0.179	3.00	4.8
Thal	1947	Kalabagh	Indus	10000	2.219	1.641	-	1.641	3.18	-
M.R. Link (Int.)	1956	Marala	Chenab	2000	0.175	-	0.158	0.158	-	4.8
D.G. Khan	1958	Taunsa	Indus	8800	0.957	-	0.909	0.909	-	6.4
Muzaffargarh	1958	Taunsa	Indus	7300	0.928	-	0.809	0.809	-	6.4
Total Upper Indus Plains				118.546	23.300	12.485	7.784	20.269		
LOWER INDUS PLAINS										
Nortwest	1932	Sukkur	Indus	5100	1.263	1.013	0.202	1.215	3.93	12.0
Rice	1932	Sukkur	Indus	10200	0.543	-	0.519	0.519	0.00	19.1
Daddu	1932	Sukkur	Indus	3200	0.631	0.519	0.065	0.584	4.42	5.2
Khairpur West	1932	Sukkur	Indus	1900	0.424	0.417	-	0.417	3.97	0.0
Rohri	1932	Sukkur	Indus	11200	2.664	2.561	-	2.561	2.84	0.0
Khairpur East	1932	Sukkur	Indus	2700	0.572	0.373	-	0.373	4.98	0.0
Eastern Nara	1932	Sukkur	Indus	13400	2.502	1.875	0.301	2.176	2.90	8.3
Pinyari	1955	Kotri	Indus	14400	0.804	-	0.758	0.758	0.00	13.1
Fuleli	1955	Kotri	Indus	13800	1.005	-	0.923	0.923	0.00	11.4
Lined Channel	1955	Kotri	Indus	4100	0.518	0.502	-	0.502	5.04	0.0
Kalri Baghar	1955	Kotri	Indus	9000	0.694	0.366	0.226	0.592	4.33	11.2
Pat	1962	Guddu	Indus	8300]	1.170	-	0.747	0.747]	0.00	9.8
Desert	1962	Guddu	Indus	12900]		-	0.328	0.328		
Begari	1962	Guddu	Indus	15500	1.082	-	1.002	1.002	0.00	13.5
Ghotki	1962	Guddu	Indus	8500	1.017	-	0.858	0.858	0.00	12.5
Total Lower Indus Plains				134200	14.889	7.626	5.929	13.555		
Grand Total				256796	39.03	20.843	13.713	34.556	(By excluding C.C.A of Qaimpur canal)	

Source: Revised Action Programme for Irrigated Agriculture

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Annexure XII

Extract from Water Accord, 1991

2. In the light of the accepted water distributional principles the following apportionment was agreed to:

PROVINCE	KHARIF	RABI	TOTAL
PUNJAB	37.07	18.87	55.94
SINDH	33.94	14.82	48.76
N.W.F.P. (a)	3.48	2.30	5.78
** (b) CIVIL CANALS:	1.80	1.20	3.00
BALOCHISTAN	2.85	1.02	3.87
	77.34	37.01	114.35
	+	+	+
	1.80	1.20	3.00

Including already sanctioned Urban and Industrial uses for Metropolitan Karachi.

* * Ungauged Civil Canals above the Rim Stations.

3. N.W.F.P./Balochistan projects which are under execution have been provided their authirised quota at water as existing uses.

4. Balance river supplies (including flood supplies and future storages) shall be distributed as below:

Punjab	Sindh	Baloch:	NWFP	Total

37	37	12	14	100%

14 (a) The system-wise allocation will be worked out separately, on ten daily basis and will be attached with this agreement as part and parcel of it.

14 (b) The record of actual average system uses for the period 1977-82, would form the **GUIDE LINE for developing a future regulation pattern. These ten daily uses would be adjusted pro-rata to correspond to the indicated seasonal allocations of the different canal systems and would form the BASIS for sharing shortages and surpluses on all Pakistan basis.**