LONG AND MEDIUM RANGE TARBELA INFLOW FORECAST METHODOLOGY

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Abstract:

The Indus has been truly called a life line of Pakistan. It is the river through which most of the water flows down to the plain of Punjab and Sindh. Most of the flows north of Tarbela are caused by the snowmelt over the elevated catchments of the northern areas. Further more melt water yield of upper Indus basin indicates large scale variation. For example the range of variation of the discharge at Bisham Qila for the month of June during the period 1965-1988 range from 1310 cusecs to about 12800 cusecs.The above two facts alone necessitate a system to predict the variability of flows of such a large extent. A methodology through which the seasonal and the monthly inflows at Tarbela could be forecast, shall constitute an important technical development since the judicial use of the available water for power and irrigation largely depend upon the advance knowledge of the incoming inflows.

WAPDA attempted to tackle the problem through the technical assistance from Canada as a cooperative research program with "Wilfred Laurier University (WLU)" Waterlov and International Development research centre (IDRC). A project called Snow and Ice hydrography project came into existence for this proposal. The project is in existence since early eighties. The approach adopted in computing the seasonal and ten daily inflow is essentially based upon the use of a snow melt model called the university of British Columbia (UBS) model. A number of snow pillows for the measurement of the snow has been established in the upper reaches of the catchment at tremendous cost. Data from these snow pillows constitutes the major input in the UBC model. Maintanance of these snow pillows at such high elevation involves formidable cost.

Indus has large and elevated catchment spread over an area of 180,000 sqr miles. It's river length above Tarbela is about 925 miles and there are five right bank and three left bank tributaries named Singhi river, Shyok river, Shiger River, Gilgit river, Astore river, and Tansher river, Dras river and Siran river respectively. Most of the catchment above Tarbela is mountainous having some of the highest peaks next to the Everest. Most of the snow melt contribution comes from the elevation range between 2500and 5500m and about 80 to 90% of the upper Indus catchment gets covered with snow every year during winter.

The contribution from the Glaciers to the annual inflow volumes volume is included in melt water yield due to the snow and melt able ice. Large number of Glaciers exists within the catchment of which 35 are the larger ones. Some are extremely big like Siachene and Biafo. Glaciers originate in the high snow fall area where there is considerable relief above 4800m ASL. Most of the melt water yield comes from the ice that has flowed to lower altitudes mainly in the range between 3-5000m. The method

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used herein does not involve the study of Glaciers or the consideration of the Glacier melt yield. It takes for granted that the total snow melt shall be an aggregate of the yield due to snow and Glacier melt yields. Thus the melt water yield from snow and the melt able Ice is assumed to generate the runoff component due to melt water yield.

Superimposed upon this is the component of runoff due to the rainfall during the Kharif season. The total inflow shall be an aggregate of the two runoff components. The prediction of the temperature and Kharif period ranfall about six months in advance is presently not possible. Thus the Kharif season forecast methodology shall be based upon the assumption of normal rainfall and temperature conditions. Provision exists in the method to cater for variation from normal conditions in case this could be predicted with reasonable reliability.

The method provides an alternate approach eliminating the need for the direct snow measurements. The method is both cost free as well as convenient involving the use of such data as shall be routinely available immediately at the end of winter season.

Model Concept:

The study is based upon the unique and non-conventional approach as explained below.

Most important element of the approach is the estimation of the catchments snow pack on the basis of the meteorological parameters only, without resorting to the direct snow measurements. Conventionally the snow melt

Run-off is estimated by first estimating the available snow pack of the basin using such conventional means as the establishment of net-work of the snow measuring instruments (snow pillows etc) and then supplementing these Measurements with the satellite based snow pack observations to estimate the extent of the snow covered area. Estimation of the snow-pack through these means is first step in the process after which the water equivalent of the pack is estimated. This is fallowed by the estimation of the melt water yield utilizing the parameters relating to the thermal conditions of the basin as called for by the snowmelt model. As against this the methodology adopted herein is based upon the indirect Assessments of the basin snow pack using the parameters relating to the weather systems which cause the deposition of the snow over the catchment. The initial snow condition is also taken care of through the flow conditions prevailing at the beginning of the Khareef season. Winter time Precipitation is caused by the weather systems called the westerly waves. The westerly waves move from west to east along the Polar front and their origin could be traced back to Mediterranean and at times as west as Atlantic. The waves approach Pakistan along Iran/Afghanistan during winter along the axis which undergoes North-South fluctuations. At times these westerlies are associated with the clear cut frontal System, but more often the frontal system gets diffused on account of the Physical barrier offered by the mountainous terrain to the west and north of the Pakistan. Number and intensity of these westerly systems shall be directly related to the catchment snow fall and in tern to the Kharif season snow melt volume. This is because most of the precipitation that occurs during winter (measured as rain after melting the snow) remains deposited as layer of snow. The subsequent snowfall event causes another deposition making the previous layer thicker and wider. The process continues throughout the winter as long as the temperature remains below freezing point. The total precipitation of the winter season thus provides a fairly close estimate of the total water equivalent available in the catchment. The losses in the form of evaporation etc. shall be quit negligible in the first place and secondly shall be relatively uniform and thus shall be eliminated in the statistical process.

The precipitation data of the Northern area meteorological stations shall be used as independent variables in the process. The frequency and intensity of the westerly wave system during the winter months shall also be used for the runoff estimation. The method does not necessitate exact (actual) determination of the accumulated snow since the statistical relationship derived through the multiple regression process directly yields runoff as output using such meteorlogical variables as are related to winter snow fall.

Bifurcation of the Rain Component from the Snow Melt Component:

Each year's inflow hydrograph was examined to find out the rain component. Sharp rise and fall of the hydrograph provided the initial clue to the rainfall contributing period. This was then confirmed from the rainfall data of the stations lying within summer rain contributing region of the catchment above Tarbela. The rain stations considered for this purpose were Oghi, Phulra, Balakot, Saidusharif, Daggar and Kakul. A total of 22 Hydrographs from 1981 to 2002 were examined for this purpose.

A set of four hydrographs for the four consecutive years was plotted together for each month. As example fig. A gives the hydrographs for the year 1980-03 for the month of June to compare the rain contributing volume for a month for each year. Some of the yearly hydrographs depict sharp changes in the hydrograph normally on account of the heavy rainfall spells. Some such cases are shown in the FIG C. On the other hand the absence of summer monsoon rainfall is indicated by the absence of any sharp changes in the hydrographs. Some of such cases are shown in the fig D.

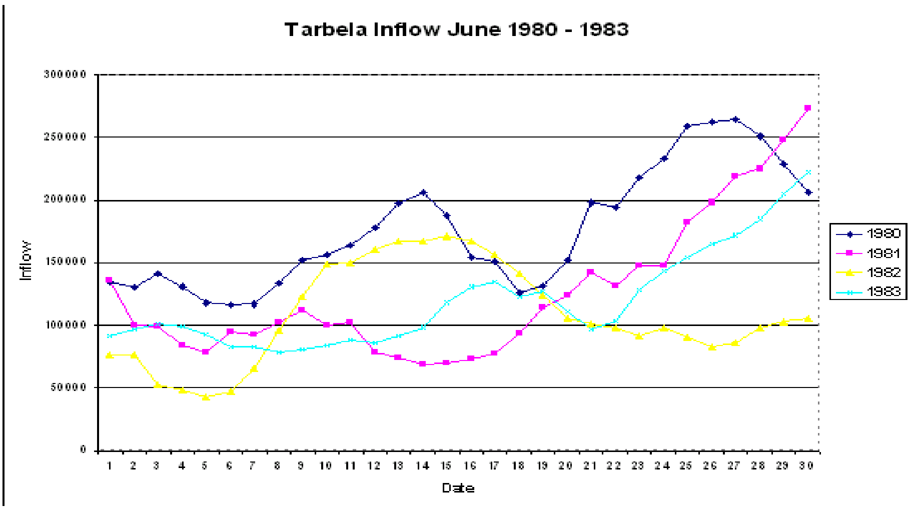

Fig A: Tarbela Inflow June 1980 - 1983

Normal Rainfall Contribution:

In order to compute the volume due to the rainfall of each rain spell the volume of the peak was worked out. As illustrated in the Fig B. The mean of the values at A and B was multiplied by the duration of the base (from A to B) to obtain the volume of the base flow which was then deducted from the total peak volume obtained by adding the actual data of the peak from point A to B.

This way the volume of water contributed by all the monthly rain spells is added together to obtain the total monthly rain contributed volume. Total rain contributed volume for each year was thus worked out by adding the monthly rain contribution volumes of all six months. Then the total monthly rain over the catchment above Tarbela was obtained by taking the mean of the six stations monthly rainfall. This way for each year the rain contributed volume and the amount of rain which caused this volume was obtained. The average rain contributed volume for all the years comes to about 2.6 MAF while the average rainfall comes to 28.61''.

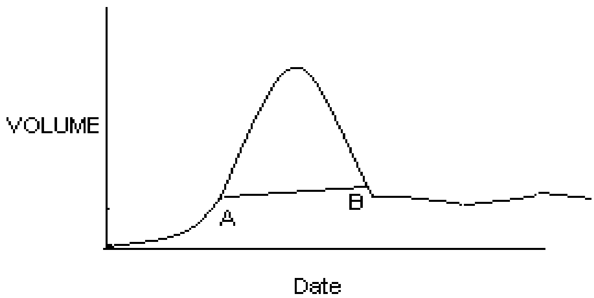

Fig B

This gives a rainfall to volume conversion factor of 0.091 MAF/inch. Consequently the volumes contributed by rainfall is obtained by using the rainfall data of the six stations of the rain contributing catchment above Tarbela for each year, which is multiplied by factor 0.091 to obtain the rain contributed volume for each year. Snow melt volume is then obtained by subtracting the rain contributed volume from the total actual inflow volume of each year. The process yields two data series. One for the snow melt volumes and the second for the rainfall volumes. The two data series along with the forecast snow melt volume and the forecast total inflow volumes for all the years from 1981 to 2002 is given at Table A.

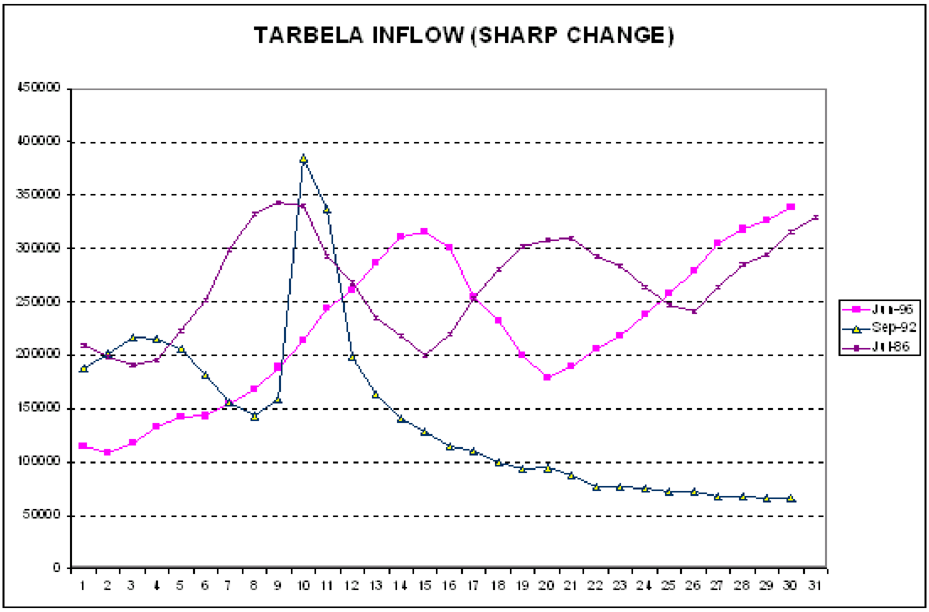

Fig C: Tarbela Inflow (Sharp Change)

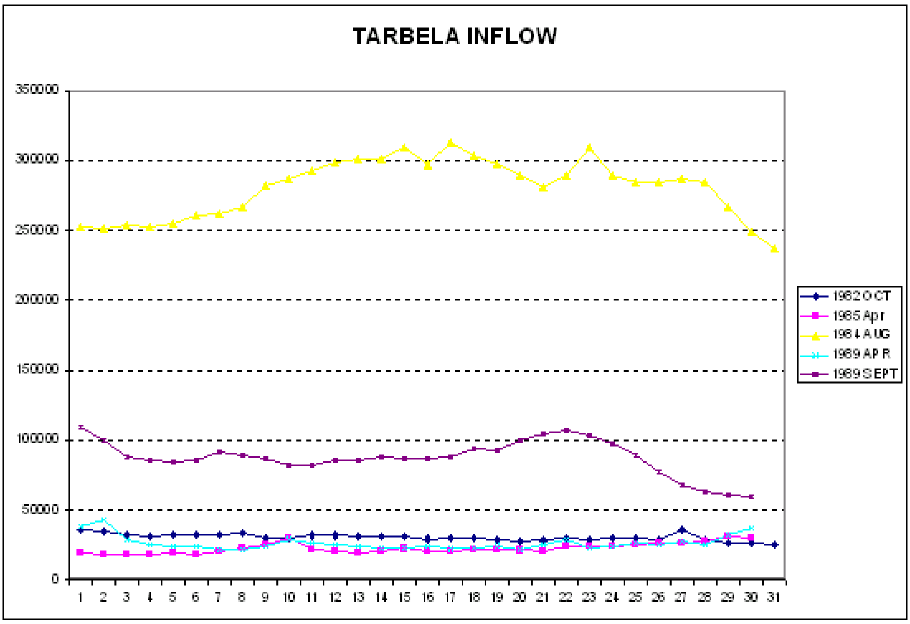

Fig D: Tarbela Inflow

Selection of the predictors:

This was the major task in the entire process. In line with the concept of the study those predictors were selected which shall be positively related to the winter time precipitation and thus shall provide an indirect assessment of the meltable snow pack. Number of the westerly waves if any affecting the preceding (winter) season was an obvious choice for this purpose. Consequently the count of the winter time weather systems above a certain intensity (assessed in terms of the cloud cover) was worked out by counting the cloudy spells. It was assumed that a break in the precipitation/cloudiness indicated the end of the westerly low pressure system. This way number of westerly waves was worked out. Later studies indicated that rather then counting the number of westerly waves, the number of cloudy days provided an equally affective predictor. Since counting of the cloudy days (above four octas) was a lot easier. This was thus adopted (instead of westerly count) as one of the predictors. In order to include some element relating to the intensity of the westerly waves, actual precipitation of the meteorological stations situated along the westerly track was considered. Met. stations like Gilgit, Skardu, Astore, Bunji and Chilas were considered for this purpose. Every time a predictor was selected and its data series worked out. The regression process executed and the results examined. After each run a new predictor was introduced and results examined. In case there was no improvement the new predictor was dropped and the next predictor introduced.

The number and sequence of the predictors used included the following.

1. Total inflow volume for the month of march
2. Total winter rainfall of ASTOR (Variable Name AST)
3. Total winter rainfall of GUPIS (Variable Name GUP)
4. Total winter rainfall of Skardu (variable name SKD)
5. Total winter rainfall of Chilas (variable name CHL)
6. Total winter rainfall of Gilgit (variable name GIL)
7. Sum of the winter rain of Astore, Gupis, Skardu, Chilas and Gilgit (variable RA)
8. Number of cloudy days during winter (variable WW)
9. Drosh Rain(variable DROSH)
10. Total Dir winter rainfall(variable DIR)

The SPSS software picked up the under mentioned three variables as the one's fulfilling the laid down selection criteria.

1. RA i.e., (Sum of Astore, Gupis, Skardu, Chilas and Gilgit rain).
2. DIR (winter rainfall/10)
3. Cloudy days (WW)

Relationship for the Prediction of Snow Melt Inflow Volume:

Final relationship developed to find out the snow melt volume was

Tarbela inflow Snow melt volume

$$= (RA*0.02444 + DIR/10*-0.013 + WW* 0.16724 + 17.30042)$$

Using this equation snow melt volume for all the years from 1981 to 2005 was computed. The calculated values of the variables RA, WW and DIR for all the years are given in TABLE B.

Next step was to include the effect of summer precipitation into the process.

Evaluation of the rain component

Summer (monsoon) rainfall contribution already worked out as per the procedure given at Para 4 was used to find out

a) Maximum rainfall contribution
b) Minimum rainfall contribution
c) Average rainfall component

Values of (a), (b) and (c) came out to be 20 %, 1 % and 5 % of the total inflow volume respectively.

As already mentioned in Para 4 the average rain contributed volume comes to 2.6 maf , while the average rainfall comes to 28.61” . This gives a rainfall to run off conversion factor of 0.91 (rainfall in mm while the volume is in maf).

Since the actual rain forecast for the monsoon rainfall for the monsoon fed Tarbela catchment is not possible six months in advance. So the method perforce assumes the average rainfall conditions of the summer monsoon period. Consequently the average rainfall contributed volume of 2.6maf is added into the snow melt computed volume using the relationship given above.

The total Tarbela inflow forecast volume= Snow melt inflow volume + 2.6

Evaluation of the Results of the Study and Discussion of the Error Sources:

The results of the study are as given at exhibit A, wherein the actual and computed Tarbela inflow volumes are placed together for comparison. As indicated in the exhibit the maximum error of 26% occurs in case of the year 1984 followed by those for the years 2004 and 1990m, which rained at 21% and 13% respectively. Apart from these three cases all other cases are within 5% of the actual. Thus the overall accuracy is very good. The three error cases were critical examined.

The 1984 case is the one in which the abnormally high rainfall occurred during monsoon period causing abnormally higher rainfall component.

Similar was the situation in the year 1990. In case of the year 2004 however the reverse happened and the actual rainfall remained much below normal.

In view of the above it follows that the method yields quite acceptable results which are expected to be well within 10% of actual. Only in case of large scale variation of rainfall fro0m normal the error may reach 20% or may even exceed a little.

Provision for the Abnormal Summer Rainfall:

Obviously the long range prediction of abnormal rain temp is not possible at the moment.

In case it becomes possible to forecast the summer monsoon rainfall of the lower Tarbela catchment with reasonable reliability. Then the normal rainfall contributed volume shall be change by the percentage of the change from the normal in accordance with the forecast.

Medium Range Forecast Methodology:

Monthly forecast are considered as the medium range forecast. Given below is the brief description of the month wise forecast relationships for computing the total Tarbela inflow volume for each month of kharif season.

APRIL

Snow Melt Volume:

The relationship for computing the snowmelt component of the inflow volume is as given below.

April Snowmelt volume = MARV*(0.92567) + 0.56923

Using this equation snow melt volume for all the years from 1981 to 2005 was computed. The calculated values of the variable MARV for all the years are given in TABLE B.

Where MARV stands for the inflow volume for the month of March which shall be available by the end of March.

Rain Contributed Volume

Normal rain component of April i.e 0.3 MAF shall be considered in case a variation from normal is predicted then volume shall be changed accordingly.

Total April Forecast volume = April snowmelt volume + Rain Contributed Volume

MAY

Snow Melt Volume

The relationship for computing the snowmelt component of the inflow volume is as given below.

MAY Snowmelt volume = APRT*(0.29056) - 5.82381

Using this equation snow melt volume for all the years from 1981 to 2005 was computed. The calculated values of the variable APRT for all the years are given in TABLE B.

Where APRT is the mean maximum temperature for the month of April.

Rain Contributed Volume

Normal rain component of April i.e 0.20 MAF shall be considered. In case a variable prediction of % variation from normal is predicted. The volume of the normal shall be changed accordingly to obtain rain-contributed volume.

Total MAY Forecast volume = MAY snowmelt volume + Rain contributed Volume

JUNE

Snow Melt Volume

The relationship for computing the snowmelt component of the inflow volume is as given below.

JUNE Snowmelt volume = RA*(5.0559-3) – Dir/10*(5.21019-3)+ 6.92

Using this equation snow melt volume for all the years from 1981 to 2005 was computed. The calculated values of the variables RA and DIR for all the years are given in TABLE B.

Where RA is the mean winter rainfall for the stations GILGIT, SKARDU, ASTORE, CHILAS and GUPIS, while DIR stands for the winter rainfall of DIR.

Rain Contributed Volume

Normal rain component for JUNE i.e 0.39 MAF shall be considered. In case a variable prediction of % variation from normal is predicted. The volume of the normal shall be changed accordingly to obtain rain-contributed volume.

Total JUNE Forecast volume = JUNE snowmelt volume + Rain contributed Volume

JULY

Snow Melt Volume

The relationship for computing the snowmelt component of the inflow volume is as given below.

JULY Snowmelt volume = SNMS*(0.37607) + 1.67469

Using this equation snow melt volume for all the years from 1981 to 2005 was computed. The calculated values of the variable SNMS for all the years are given in TABLE B.

Where SNMS is the snowmelt volume of the (preceding) winter season minus the sum of the computed inflow volumes of April, May and June.

SNMS = SN – (April + May + June)

Rain Contributed Volume

Normal rain component for July i.e. 0.77 MAF shall be considered. In case a variable prediction of % variation from normal is predicted. The volume of the normal shall be changed accordingly to obtain rain-contributed volume.

Total JULY Forecast volume = JULY snowmelt volume + Rain contributed Volume

AUGUST

Snow Melt Volume

The relationship for computing the snowmelt component of the inflow volume is as given below.

AUGUST Snowmelt volume = RA*(9.965-3) + 10.70432

Using this equation snow melt volume for all the years from 1981 to 2005 was computed. The calculated values of the variable RA for all the years are given in TABLE B.

Where RA stands for the winter rainfall for the GILGIT, SKARDU, ASTORE, CHILAS and GUPIS.

Rain Contributed Volume

Normal rain component for AUGUST i.e 0.80 MAF shall be considered. In case a variable prediction of % variation from normal is predicted. The volume of the normal shall be changed accordingly to obtain rain-contributed volume.

Total AUGUST Forecast volume = AUGUST snowmelt volume + Rain contributed Volume

SEPTEMBER

Snow Melt Volume

The relationship for computing the snowmelt component of the inflow volume is as given below.

SEPTEMBER Snowmelt volume = RA*(2.893240-3) + 4.68064

Using this equation snow melt volume for all the years from 1981 to 2005 was computed. The calculated values of the variable RA for all the years are given in TABLE B.

Where RA stands for the winter rainfall for the GILGIT, SKARDU, ASTORE, CHILAS and GUPIS.

Rain Contributed Volume

Normal rain component for SEPTEMBER i.e 0.25 MAF shall be considered. In case a variable prediction of % variation from normal is predicted. The volume of the normal shall be changed accordingly to obtain rain-contributed volume.

Total SEPTEMBER Forecast volume = SEPTEMBER snowmelt volume + Rain contributed Volume

Second (normal ratio) Method:

An attempt was made to estimate the monthly inflow volumes in relation to the total inflow volume of the Kharif season and percentage ratios of each month's volume to the total Kharif season volume was found out.the monthly percentage ratios are as given below

April	4%
May	9.2%
June	18.1%
July	28.6%
August	27.5%
September	12.5%

The total inflow volume as computed in accordance with the procedure given earlier was distributed into each moth in accordance with the ratios mentioned above.

This method provides a rough monthly distribution based essentially upon the normal summer (monsoon) conditions and thus provides a fairly good counter check the values computed by using Method I. One advantage of the normal ratio method is that it does not call for the data of March inflow volumes or that of April temperature and thus enables the estimation of the monthly inflow volumes of all months immediately at the beginning of the Kharif season.

Evaluation of the Results of the Monthly Volume Forecast:

Generally speaking the monthly forecast is not as good as the seasonal forecast. This is because the rainfall and temperature variation is much more during a monthly period as compared to the seasonal. Temperature and rainfall variations tend to balance out when the extended period of six months is considered. As an example if the snow melt becomes greater during the early monsoon period it shall tend to slow down towards the end period and vice versa.

The seasonal relationships for June, August and September was relatively easier to drive. While in case of April, May and July was faced considerable problem.

Relationship for May was the most difficult one and came out to be the only relationship for which the use of temperature became necessary. No other variable could fit into the equation. Despite the best possible efforts the May forecast for all the years (fig M2) indicates three cases of large anomaly. There are the years 1981, 1990 and 1999. Out of these the forecast error for the year 1990 is much too large being about 50%. Apart from the few such cases the result is mostly well within acceptable limit. April is much better and except for the year 1981 all the other years are within the acceptable limits of accuracy.

Forecast for the month of June (M3) indicates only two cases of bit greater anomaly. This is not bad since most of the cases lie within 10% accuracy limit. July is much better since in this case all errors remained below 20%, while in most cases error was limited to within 5-10% range. August and September monthly forecast was exceptionally good since the error remained below 10% for all the cases.

Concluding Remarks:

Seasonal and monthly forecast computed on the basis of the seven regression equation (one for the seasonal forecast and six for the monthly forecast from April to September) fulfill the criterion of the limits of acceptable accuracy. The only exception is the month of May in which few cases of unacceptably large errors have been encountered. Thus generally speaking the methodology developed through the study project provides set of easily usable equations based upon the readily available meteorological data to yield the seasonal and monthly forecast. The method when used along with the similar method developed for Mangla shall provide an advanced knowledge of the total inflow volume expected into the country's two major reservoirs of Mangla and Tarbela. The information shall provide sound scientific base for the planning of irrigation and power operations.

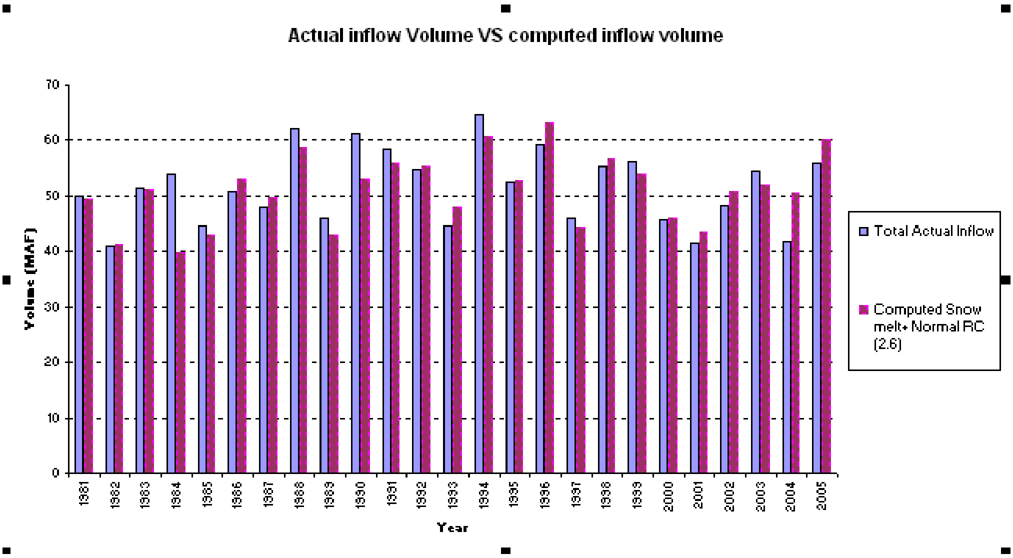

Fig 1: Seasonal Forecast

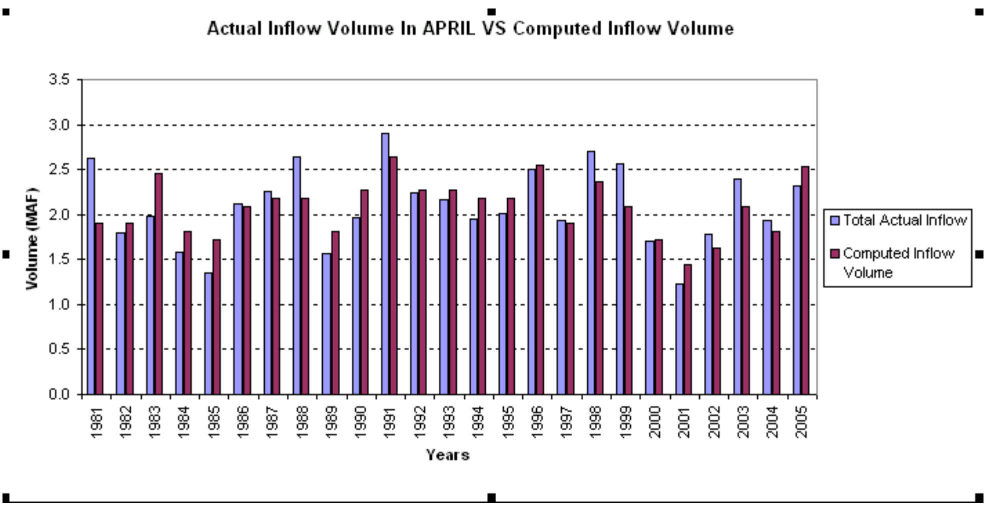

Fig M1

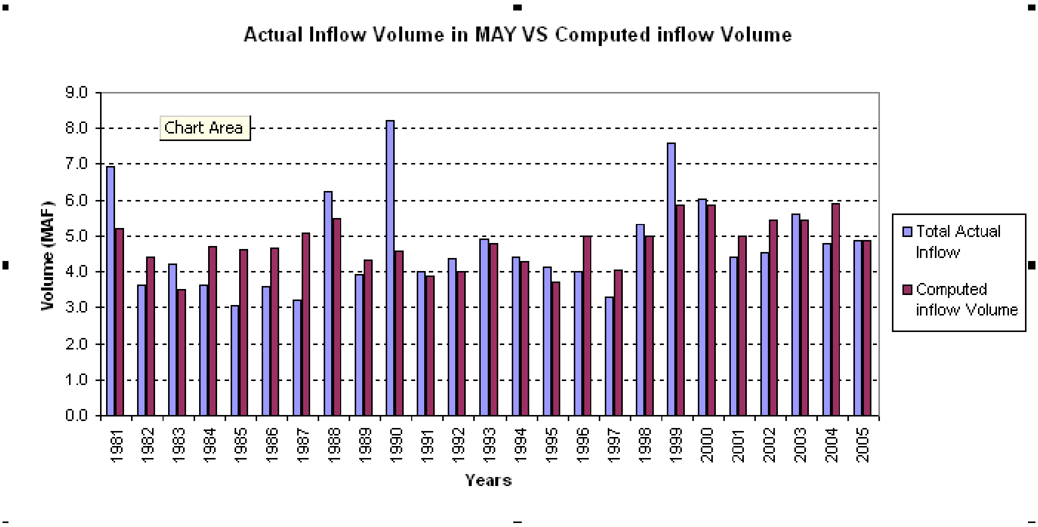
Actual Inflow Volume in MAY VS Computed inflow Volume
Chart Area
Volume (MAF)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Years
Total Actual Inflow
Computed inflow Volume

Fig M2

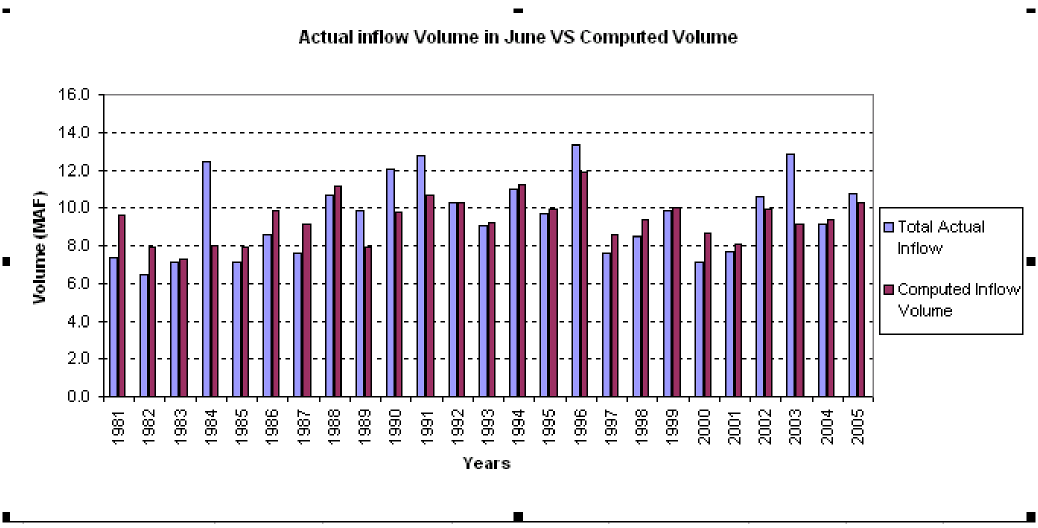
Actual inflow Volume in June VS Computed Volume
Volume (MAF)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Years
Total Actual Inflow
Computed Inflow Volume

Fig M3

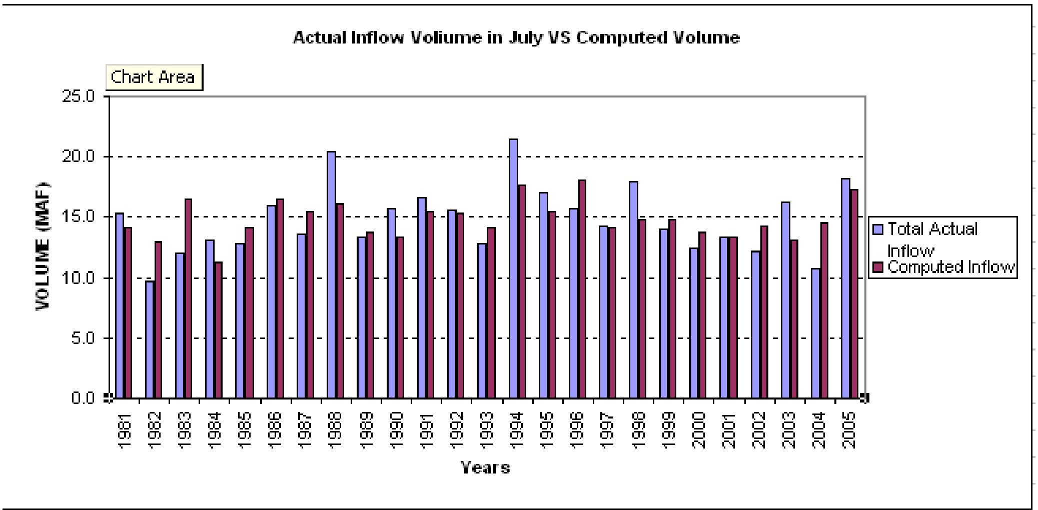
Actual Inflow Voliume in July VS Computed Volume
Chart Area
VOLUME (MAF)
25.0
20.0
15.0
10.0
5.0
0.0
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
Years
Total Actual Inflow
Computed Inflow

Fig M4

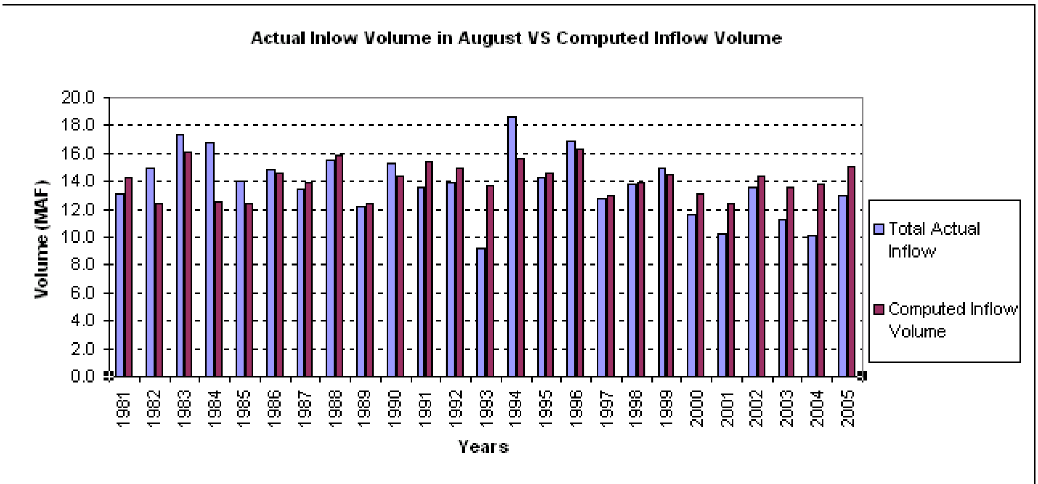
Actual Inlow Volume in August VS Computed Inflow Volume
Volume (MAF)
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
Years
Total Actual Inflow
Computed Inflow Volume

Fig M5

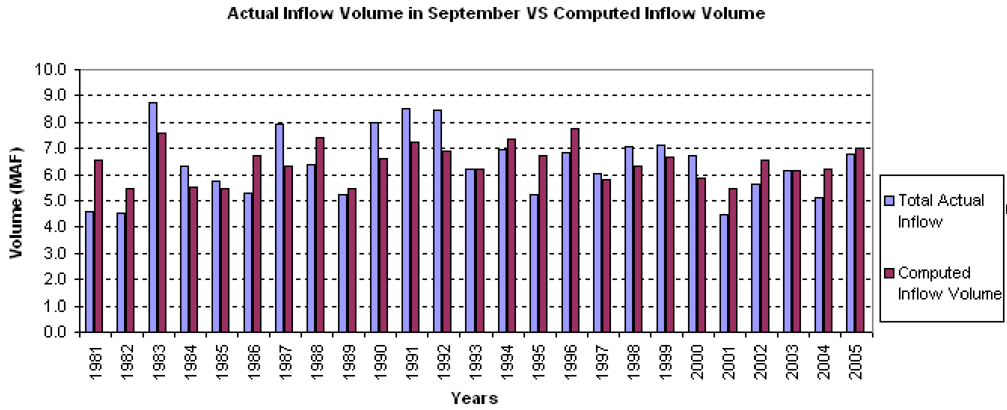
Actual Inflow Volume in September VS Computed Inflow Volume
Volume (MAF)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Years
Total Actual Inflow
Computed Inflow Volume

Fig M6

Table A: Components of the Forecast Inflow Volume

1	2	3	4	5	6	7	8	9	11
	Total Actual Inflow	**Snow Melt Component Actual**	**Snow Melt Computed**	**Rain Computed**	**4+5**	**Difference of 2-7**	**"3-5"**	**Snow melt+ Normal RC (2-6)**	**%age Diff of 2 and 10**
1981	50.1	47.6	**46.9**	2.5	49.4	0.7	0.7	49.5	1.2
1982	41	38.4	**38.7**	2.6	41.3	-0.3	-0.3	41.3	0.7
1983	51.5	48.6	**48.6**	2.9	51.5	0.0	0.0	51.2	0.6
1984	53.8	51.5	**37.3**	2.3	39.6	14.2	14.2	39.9	25.9
1985	44.6	42.3	**40.3**	2.3	42.6	2.0	2.0	42.9	3.8
1986	50.8	48.4	**50.5**	2.4	52.9	-2.1	-2.1	53.1	4.5
1987	48	45.9	**47.2**	2.1	49.3	-1.3	-1.3	49.8	3.8
1988	62	58.8	**56.1**	3.2	59.3	2.7	2.7	58.7	5.3
1989	46.1	43.6	**40.4**	2.5	42.9	3.2	3.2	43.0	6.7
1990	61.3	58.4	**50.5**	2.9	53.4	7.9	7.9	53.1	13.4
1991	58.3	55.1	**53.4**	3.2	56.6	1.7	1.7	56.0	3.9
1992	54.8	51.8	**52.6**	3.0	55.6	-0.8	-0.8	55.2	0.7
1993	44.5	42.3	**45.3**	2.2	47.5	-3.0	-3.0	47.9	7.6
1994	64.7	61.6	**58.1**	3.1	61.2	3.5	3.5	60.7	6.2
1995	52.4	49.7	**50.3**	2.7	53.0	-0.6	-0.6	52.9	1.0
1996	59.2	57.1	**60.5**	2.1	62.6	-3.4	-3.4	63.1	6.6
1997	45.9	42.5	**41.8**	3.4	45.2	0.7	0.7	44.4	3.3
1998	55.3	53.1	**54.1**	2.2	56.3	-1.0	-1.0	56.7	2.5
1999	56.1	53.8	**51.2**	2.3	53.5	2.6	2.6	53.8	4.1
2000	45.6	43.2	**43.5**	2.4	45.9	-0.3	-0.3	46.1	1.1
2001	41.5	38.7	**41.0**	2.8	43.8	-2.3	-2.3	43.6	5.1
2002	48.3	46.1	**48.1**	2.2	50.3	-2.0	-2.0	50.7	5.0
2003	54.5		**49.2**					51.8	4.9
2004	41.8		**48.0**					50.6	21.1

Table B

			Variables			
Year	MARV	APRT i.e.((BPUR+ MULTAN+ BNAGAR)/3)	Dir/10	RA	WW	Sn - (Apr + May + June)
1981	1.3	37.2	105.8	563.1	103	30.0
1982	1.2	34.5	63.1	248.5	106	26.9
1983	1.5	31.4	911	924.3	123	35.3
1984	1.2	35.5	67.5	199.6	95	19.7
1985	1.1	35.3	59.6	184.9	115	28.8
1986	1.5	35.4	116.4	626.1	116	36.2
1987	1.6	36.9	118.5	495.4	118	34.1
1988	1.6	38.2	111.2	1118.1	114	36.5
1989	1.2	34.3	57.9	329.1	117	25.1
1990	1.7	35.1	82	579.6	120	28.2
1991	2.1	32.7	124.1	790.3	110	33.7
1992	1.7	33.2	93.3	686.8	118	35.7
1993	1.6	35.8	74	521.4	108	29.1
1994	1.6	34.2	55.3	835.5	126	40.7
1995	1.6	32.2	92	676.1	114	34.5
1996	2.0	36.5	68.8	975.1	121	40.6
1997	1.3	33.3	59.4	346.6	106	28.9
1998	1.8	36.6	66.4	480.9	155	37.6
1999	1.5	39.5	67.9	609.5	119	31.1
2000	1.1	39.6	70	329.9	114	28.6
2001	0.8	36.5	38.1	190.8	117	27.7
2002	1.0	38.8	53	569.4	105	31.2
2003	1.5	38.1	63.2	421.9	134	28.4
2004	1.2	39.7	39.5	450.9	126	32.2
2005	2.0	36.1	129.1	711.3	147	39.6

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