SINDH SUMMER (JUNE-SEPTEMBER) MONSOON RAINFALL PREDICTION

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Abstract:

In this study effort has been made to examine the relationship of Sindh monsoon rainfall with some of very important global & regional parameters. The Sindh Monsoon rainfall indices (SMRI) were examine with the monthly mean values of SST(SEA Surface Temperature), IHP (Indian Ocean High Pressure), SOI (Southern Oscillation Index), NHT (Northern Hemisphere Temperature), Pakistan's provincials & coastal data. It has been found that the SMRI is significantly correlated with SOI, IHP, Mean pressure & temperature of Balochistan, Mean temperature of Punjab, Mean Monthly Maximum Temperature of Pasni & Jawani. Multiple regression equations have been developed using these predicators for thirty years (1961 to 1990) of monthly mean values. These equations then applied on the eight later years i.e. 1991 to 1998 and gave significant results.

Introduction:

Pakistan is situated in Southwest Asia. Its north and northwest covered with high-rise mountains. The whole of the country lies approximately between 23.5 °N to 37 °N and 61 °E to 77°E. Pakistan is divided into four provinces namely Punjab, NWFP, Balochistan and Sindh.

River Indus and its tributaries are the main rivers. These rivers flow from the north to south towards Arabian Sea. Plain in the south is the Sindh plain. The Sindh plain comprises mainly the province of Sindh.

During the summer monsoon period (July to September) easterly systems/depressions form in the Arabian Sea and the Bay of Bengal, that produces rainfall over Pakistan. The rain bearing system coming from the Bay of Bengal and the depression that locally forms near the coastal region of Sindh province are mainly responsible for the rainfall over this area.

The monsoon precipitation plays a very important role in the social and economic development of Pakistan. Nearly 60% of annual rainfall over most parts of Pakistan is received during summer (June to September). Rainfall occurs primarily due to differential heating of the land and sea.

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Differential heating of the land and ocean creates pressure gradient that drives the winds from high pressure to low pressure. Air circulation will start if one region is heated or cooled more than some other region. Joshi et al. (1988) noted the differential heating of the continents and the adjoining ocean to be the primary cause of the summer monsoon circulation over South Asia.

The distribution of mean annual rainfall over the country indicates that the northern parts of Pakistan receive heavy rainfall of over 700 mm while the southern parts of Balochistan and Sindh receive rainfall less than 200 mm (Table-1). The normal isohyetal map is shown in Figure-1

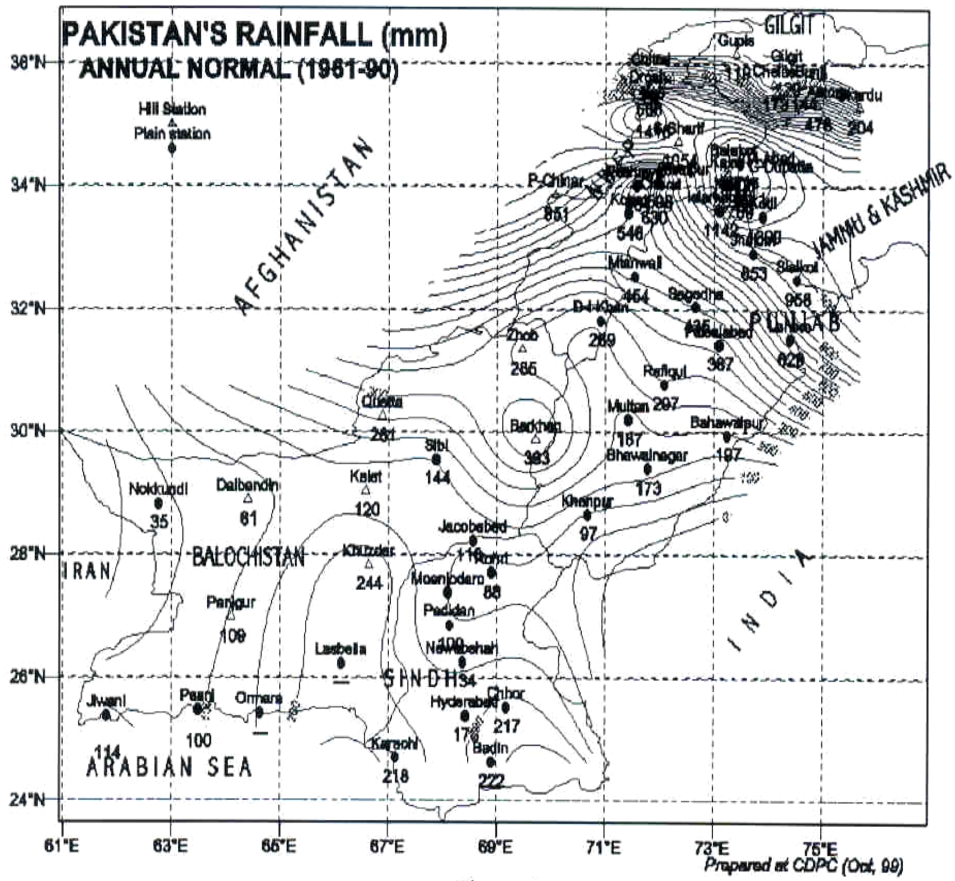

Figure-1

The intra – seasonal variability rainfall is high over Balochistan and Sindh. This intra- seasonal variability is due to snow cover hills, soil moisture and varying sea-surface temperature. (Shukla, 1987). The intra - seasonal variability in summer rainfall (JJAS) sometimes leads to droughts and floods over different parts of Pakistan. The result is reduced agricultural production affecting the national and regional economy.

In view of the agricultural out put and industrial production both being affected by the intra-seasonal variability of the summer (JJAS) monsoon rainfall. Hence prediction of the summer monsoon rainfall is very essential for planning and policy making.

In the present study an attempt has been made to develop a prediction model of summer monsoon rainfall over the Sindh province of Pakistan. In this context the interaction of ocean-atmosphere coupled phenomena like:

- Sea Surface Temperature (SST),Nino 1+2
- Sea Surface Temperature (SST),Nino 4
- Southern Oscillation Index (SOI)
- Indian Ocean High Pressure (IHP)
- Northern Hemisphere Temperature(NHT)
- As well as number of local meteorological parameters have also been considered.

Gilbert Walker (1910, 1923) developed an objective procedure for long-range forecast of monsoon precipitation over India. He (1924) also attempted long range forecast for sub regions of India (pre independence) by dividing the country into three regions: peninsula, north-east India and North-west India. Regression formulae were developed separately for these three regions.

The regression equation for North West developed by Walker was modified by Pakistan Meteorological Department during 1948-1951 for the whole of Pakistan. The new regression equation was developed for predicting summer rainfall (JJAS) for Pakistan and this method has been in operational use since then. So far the prediction results of this model have been satisfactory under normal prevailing conditions. However some time the result has been poor due to abnormal weather conditions (local & topographic effects), Zeya & Khan (1991)

No serious attempts however appeared to be made to modify the operational prediction formula for summer rainfall for quite a long time. Chaudhary (1992) developed a regression formula using six predictors for summer monsoon rainfall over Pakistan as well as for the following two provinces of Pakistan.

I. North West Frontier province summer monsoon rainfall.
II. Punjab-summer monsoon rainfall.

For the other two provinces he has identified the following potential predictors:

- Temperature for number of cities in Pakistan as well as North hemisphere & El-nino.
- Surface level pressure field over Pakistan & Southern Oscillation Index.
- 500 hpa ridge position at 75 degree east in April, 10 hpa zonal pattern in January, Eurasian snow cover of December.

Further development for Sindh summer monsoon rainfall has been under taken in this paper. Gradually prediction equation for other provinces will be developed.

Data:

The SST data consist of monthly mean temperature value for grid points in each 5 degree longitude area with large regions Nino 1+2 (0-10S) (90W-80W)& Nino 4 (5N-5S)(160E-150W)for the period 1960 to 1988. The data sources are NCEP and NOAA.

The SOI is the monthly value (anomaly) of the difference in mean sea level pressure (MSL) between Tahiti (18°S, 15°W) and Darwin (12°S, 131°E) This index was recommended for the inter annual climate variability by chen (1982). The period of the data used is 1960 to 1988 and sources are NCEP and NOAA.

Mean Monthly values of Indian Ocean High Pressure, in hPa for the period of 1960 to 1990 were used.

The monthly mean temperature values (in degree C) of Northern Hemisphere have been taken for the period 1960 to 1988 from CD/AC and ESD.

The rainfall data used in this study consist of monthly total rainfall values (in mm) for eight station of Sindh for the year 1961 to 1988. The data for first 30 years were used to develop regression equation and later eight years data were used to verify the equation. The data were obtained from a Computerized Data Processing Centre (CDPC), Pakistan Meteorological Department. Selected station and the rainfall fluctuation over months of the normal period(1961-90) are shown in Tabl-2 & Figure-2 respectively.

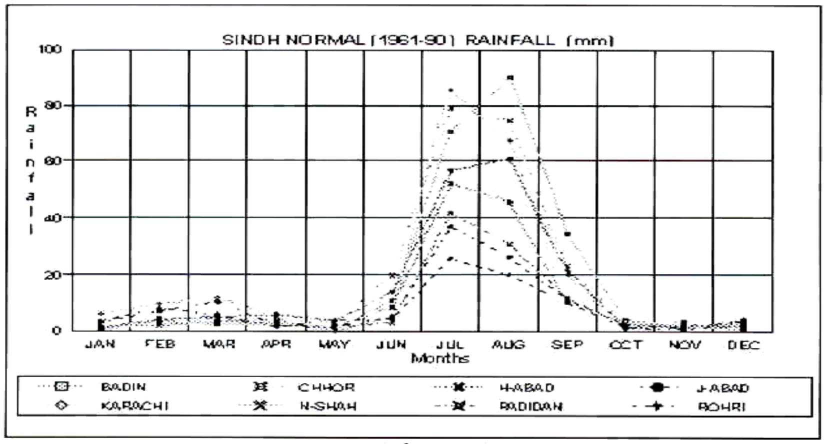

Figure-2

Mean monthly temperature (in degree C) of the following nine stations having good quality of data of Punjab province for the period 1960 to 1998 were taken.

Mean Monthly Station Level Pressure at 1200UTC (in hPa) of nine stations, having good quality of data of Punjab province for the period 1960 to 1998 were used.

Mean monthly temperature (in degree C) of the following eight stations, having good quality of data of Balochistan province for the period of 1960 to 1998 were taken.

Mean Monthly Station Level Pressure at 1200 UTC (in hPa) of all above eight stations, having good quality of data, of Balochistan province for the period 1960 to 1990 were utilized.

Mean Maximum Temperature of Pasni & Jiwani for the period 1960 to 1998 were taken.

Mean Minimum Temperature of Pasni & Jiwani for the period 1960 to 1998 were taken.

Method / Procedure:

Most of the studies in long range forecast are based on the statistical and empirical techniques. Pakistan is divided by four regions, Sindh, Balochistan, Punjab and North West Frontier Province (NWFP). The northern parts (NWFP and Punjab) received total 9293.6 mm normal (JJAS) rainfall and southern parts (Sindh and Balochistan) received total 2605.7 mm normal rainfall during summer (JJAS) monsoon (table-3). Rainfall indices were developed for each year by using following formula:

$$I_j = \frac{1}{N} \sum_{i=1}^{N} \left(\frac{R_{ij} - \overline{R_i}}{\sigma_i} \right)$$

Where:

I_j	=	Rainfall index for year j
R_{ij}	=	amount of the rainfall in the season at station i in the year j
R_i	=	Average rainfall for the years considered at station i.
σ	=	Standard Deviation of rainfall at Station i.
N	=	Number of stations.

Eleven following parameters were selected for the period June 1960 to May 1990 for the examination of significant Correlation coefficient at 95% significance level.

1. Sea Surface temperature, Nino 1+2 (SSTa).
2. Sea Surface temperature, Nino 4 (SSTb)
3. Southern Oscillation Index(SOI)
4. Indian High Pressure (IHP)
5. Northern Hemisphere Temperature (NHT)
6. Mean monthly pressure of Balochistan(BLCH-PP)
7. Mean monthly temperature of Balochistan (BLCH-TM)
8. Mean monthly Pressure of Punjab (PUNJ-TM)
9. Mean monthly temperature of Punjab (PUNJ-PP)
10. Mean Maximum Temperature of Pasni & Jiwani (J-P-TX)
11. Mean Minimum temperature of Pasni & Jiwani (J-P-TN).

The SMRLs for the period 1961 to 1990 were correlated with the above mentioned 12 predictors for the period June 1960 to May 1990. It was observed that out of these twelve predictors have significant correlation coefficients. These nine predictors were retained for developing the required regression equations(s)

1. SOI, last year June (SOL-06)
2. NHT, current year January (NHT-01).
3. IHP, last year August (IHP-08)
4. Mean Pressure of Balochistan, last year June (BLCH-PP6)
5. Mean Pressure of Balochistan, last year July (BLCH-PP7)
6. Mean Temperature of Balochistan, last year September (BLCH-TM9)
7. Mean Pressure of Punjab, current year May (PUNJ-PP5)
8. Mean Temperature of Punjab, May (PUNJ-TM5)
9. Mean Maximum Temperature of Pasni & Jiwani, last year December (J-P-TX12)

In this study all calculations are based on the normalized value of rainfall of the selected stations. For other predictors their anomalies have been taken into the consideration.

Two approaches have been made in developing the prediction equation.

Approch-1:

SMRIs developed using data (average. & standard deviation) for the period 1961-90

These predictors were further screened out by forward stepwise regression method. The model gave only five predictors (Table 4b)

Following are the multiple regression results of forward stepwise regression by taking SMRIs as dependent variables.

1:	SOI_06	2:	NHT_01	3:	LHP_08
4:	BLCH_PP6	5:	BLCH_PP7	6:	BLCH_TM9
7:	PUNJ_PP5	8:	PUNJ_TM5	9:	J_P_TX12
10:	SMRIs				

BASIC REGRESSION EQUATION FOR THE YEAR 1991 & ONWARD

STAT. MULTIPLE REGRESS. Regression Summary for Dependent Variable: SMRI90 (smris2.sta)
R= .76665779 R2= .58776417 Adjusted R2= .50188170
F(5,24)=6.8438 p<.00043 Std.Error of estimate: .55277

N=30	BETA	St. Err. of BETA	B	St. Err. of B	t(25)	p-level
Intercpt			189.1508	107.2445	1.76373	0.090505
SOI_06	-0.23898	0.145492	-0.1445	0.088	-1.6426	0.113513
J_P_TX12	0.325962	0.135859	0.2497	0.1041	2.39927	0.024549
BLCH_PP7	0.359549	0.135371	0.0292	0.011	2.65604	0.013829
IHP_08	-0.285419	0.133267	-0.2209	0.1032	-2.1417	0.042574
PUNJ_TM5	0.227124	0.147475	0.1086	0.0705	1.54008	0.136623

Table-4b

The regression equation was used to predict SMRLs for the period 1991-98. The graph is shown to figure-4a & predicted SMRLs value in table-4c.

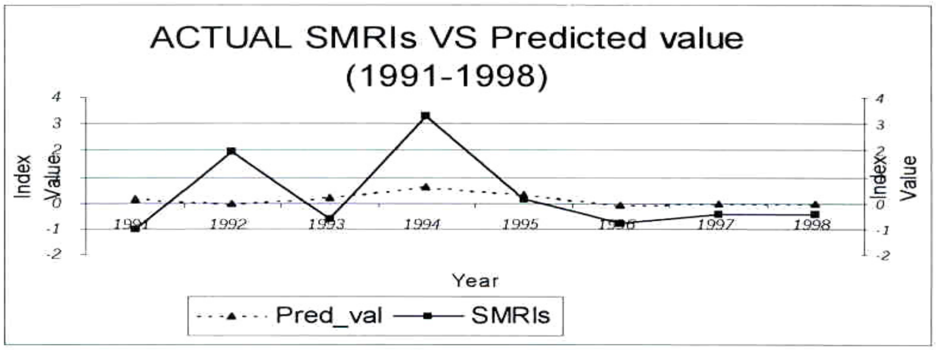

Figure-4a

YEAR	SMRIs	Pred_val
1991	-1.01689	0.149027
1992	1.94887	-0.03662
1993	-0.57459	0.238922
1994	3.294223	0.592539
1995	0.163186	0.322447
1996	-0.77352	-0.07496
1997	-0.41226	-0.00655
1998	-0.41321	-0.01621

Table-4c

Approach-2:

In this approach SMRIs were developed using data (i.e.average &SD) of the rain period 1961-90, 1961-91, 1961-92----,1961-98

The regression equation developed in this model uses the same nine predictors for screening of potential predictors. For each year previous year SMRI and current year predictors data were used. For example, for calculating the rainfall for the year 1991 prediction equation was developed using the SMRIs values of 1961-90 and all the other nine predictors up to the may 1991 were put for screening by the stepwise forward multiple regression method. The model out put is given in table-4d.

REGRESSION EQUATION FOR THE YEAR 1991

STAT. Regression Summary for Dependent Variable: SMRI 61-90 (smri91.sta)
MULTIPLE R= .69681476 R2= .48555081 Adjusted R2= .40323894
REGRESS. F(4,25)=5.8989 p<.00174 Std.Error of estimate: .60438

		St. Err.		St. Err.		
N=30	BETA	of BETA	B	of B	t(25)	p-level
Intercpt			-41.313	13.7945	-2.9949	0.00611
J_P_TX12	0.50646	0.151653	0.3875	0.11602	3.3396	0.00263
BLCH_TM9	0.57285	0.192036	0.4319	0.14478	2.983	0.00629
NHT_01	-0.56556	0.192021	-1.4002	0.47541	-2.9453	0.00688
BLCH_PP6	0.25687	0.169683	0.0215	0.01422	1.5138	0.14262

Table-4d

Similarly for predicting the rainfall of the year 1992 actual rainfall for the year 1991 (JJAS) of the selected stations were taken into account to calculate the SMRIs 1961-91 and new prediction equation for the year 1992was developed by means of all the other nine predictors up to the year1991, Putting them for screening by the stepwise forward multiple regression method. The model output is given in table-4e.

REGRESSION EQUATION FOR THE YEAR 1992

STAT. Regression Summary for Dependent Variable: SMRI 61-91 (smri91.sta)
MULTIPLE R= .70959346 R2= .50352288 Adjusted R2= .42714178
REGRESS. F(4,26)=6.5922 p<.00084 Std.Error of estimate: .59829

		St. Err.		St. Err.		
N=31	BETA	of BETA	B	of B	T(25)	p-level
Intercpt			-41.813	13.6367	-3.0662	0.00501
J_P_TX12	0.487	0.147364	0.3748	0.11342	3.3048	0.00278
BLCH_TM9	0.60288	0.175188	0.4652	0.13517	3.4413	0.00197
NHT_01	-0.63301	0.177265	-1.5344	0.42969	-3.571	0.00142

Table-4e

For the years 1993-98 separate regression equations for the required year were developed. The model output is given in table-4f to table-4k.

REGRESSION EQUATION FOR THE YEAR 1993

STAT. Regression Summary for Dependent Variable: SMRI 61-92 (smri92.sta)
MULTIPLE R= .56378620 R2= .31785488 Adjusted R2= .21679635
REGRESS. F(4,27)=3.1453 p<.03026 Std.Error of estimate: .70593

		St. Err.		St. Err.		
N=32	BETA	of BETA	B	of B	T(25)	p-level
Intercpt			-35.381	16.0484	-2.2046	0.03618
J_P_TX12	0.49208	0.170472	0.3854	0.13351	2.8866	0.00757
BLCH_TM9	0.35783	0.193999	0.2795	0.15154	1.8445	0.07611
NHT_01	-0.3727	0.197211	-0.9056	0.4792	-1.8898	0.06956
BLCH_PP6	0.22188	0.188058	0.0196	0.01661	1.1799	0.24835

Table-4f

REGRESSION EQUATION FOR THE YEAR 1994

STAT. Regression Summary for Dependent Variable: SMRI 61-93 (smri9
MULTIPLE R= .55672410 R2= .30994173 Adjusted R2= .2113619
REGRESS. F(4,28)=3.1441 p<.02964 Std.Error of estimate: .70

		St. Err.		St. Err.		
N=33	BETA	of BETA	B	of B	T(25)	p-level
Intercpt			-39.292	16.0256	-2.4518	0.02071
J_P_TX12	0.47905	0.169018	0.3749	0.13228	2.8343	0.00843
BLCH_PP7	0.27164	0.18279	0.0248	0.01667	1.4861	0.14843
NHT_01	-0.38849	0.193585	-0.9517	0.47423	-2.0068	0.05451
BLCH_TM9	0.33105	0.192528	0.2617	0.15223	1.7195	0.09657

Table-4g

REGRESSION EQUATION FOR THE YEAR 1995

STAT. Regression Summary for Dependent Variable: SMRI 61-94 (smri94.sta)
MULTIPLE R= .53913483 R2= .29066636 Adjusted R2= .24490290
REGRESS. F(2,31)=6.3515 p<.00488 Std.Error of estimate: .72938

		St. Err.		St. Err.		
N=34	BETA	of BETA	B	of B	T(25)	p-level
Intercpt			-32.716	14.7557	-2.2172	0.03408
J_P_TX12	0.53733	0.155187	0.4139	0.11954	3.4625	0.00158
BLCH_PP7	0.24785	0.155187	0.0241	0.01512	1.5971	0.12039

Table-4h

REGRESSION EQUATION FOR THE YEAR 1996

STAT. Regression Summary for Dependent Variable: SMRI 61-95 (smri95.sta)
MULTIPLE R= .53716435 R2= .28854554 Adjusted R2= .24407963
REGRESS. F(2,32)=6.4891 p<.00431 Std.Error of estimate: .72708

		St. Err.		St. Err.		
N=35	BETA	of BETA	B	of B	T(25)	p-level
Intercpt			-32.941	14.7024	-2.2405	0.03213
J_P_TX12	0.53523	0.152958	0.4154	0.11871	3.4992	0.0014
BLCH_PP7	0.2471	0.152958	0.0243	0.01507	1.6155	0.11603

Table-4 I

REGRESSION EQUATION FOR THE YEAR 1997

STAT. Regression Summary for Dependent Variable: SMRI 81-96 (smri96.sta)
MULTIPLE R= .54186192 R2= .29361434 Adjusted R2= .25080308
REGRESS. F(2,33)=6.8583 p<.00323 Std.Error of estimate: .72493

		St. Err.		St. Err.		
N=36	BETA	of BETA	B	of B	T(25)	p-level
Intercpt			-33.274	14.656	-2.2704	0.02984
J_P_TX12	0.54151	0.150122	0.4251	0.11784	3.6071	0.00101
BLCH_PP7	0.24421	0.150122	0.0244	0.01503	1.6267	0.11331

Table-4j

REGRESSION EQUATION FOR THE YEAR 1998

STAT. Regression Summary for Dependent Variable: SMRI 61-97 (smri97.sta)
MULTIPLE R= .53247559 R2= .28353025 Adjusted R2= .24138497
REGRESS. F(2,34)=6.7274 p<.00345 Std.Error of estimate: .72702

		St. Err.		St. Err.		
N=37	BETA	of BETA	B	of B	T(25)	p-level
Intercpt			-33.112	14.6905	-2.254	0.03076
J_P_TX12	0.53166	0.148925	0.4205	0.1178	3.57	0.00109
BLCH_PP7	0.24105	0.148925	0.0244	0.01507	1.6186	0.11478

Table-k

The comparative graph for actual and predicted values of SMRIs is given figure-4b and the values of above SMRIs for the period 1991-98 is given in table-41.

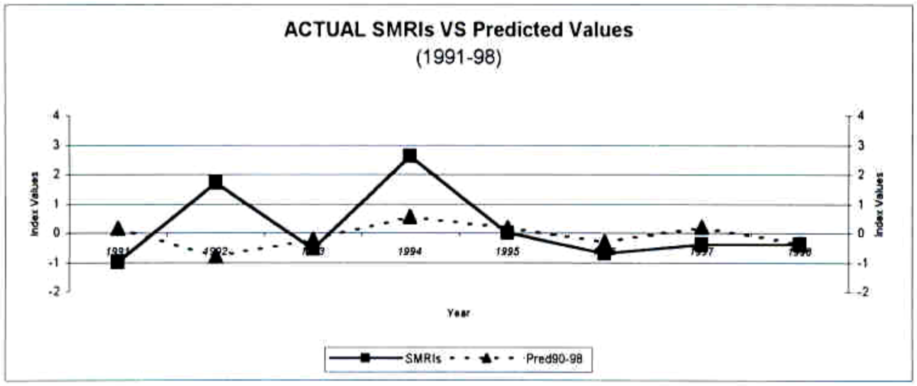

Figure-4b

YEAR	SMRIs	Pred91-98
1991	-0.98110379	0.145380286
1992	1.716682066	-0.799089143
1993	-0.5585368	-0.209747333
1994	2.617179473	0.546805
1995	0.003411549	0.173159286
1996	-0.71365421	-0.301881429
1997	-0.38534969	0.203115714
1998	-0.38523572	-0.370727143

Table-41

Result and Conclusions:

The root mean square error for approach-1 & approach-2 are 1.327495 and 1.25255 respectively. The values of the two errors are very close to each other. Hence the equations derived from above two approaches are equally good.

This study explores the relationship of several global and local parameters (predictors) with Sindh Monsoon Rainfall. The parameters specially SOI (last year June), IHP (last year August) and Jiwani-Pasni maximum temperature (last year December) are significantly correlated with the Sindh Monsoon Rainfall Index, preceding the onset of the monsoon. The predicted values, using the two approaches for the years 1992 and 1994 are not very satisfactory because of the occurrence of abnormal rainfall in these two years. Whereas, for the years 1995 up to 1998 the predicted values are highly satisfactory.

Acknowledgement:

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TABLE-1

AMOUNT OF ANNUAL MEAN NORMAL PRECIPITATION

Station	Amount	Station	Amount	Station	Amount
Punjab & NWFP		Sindh & Balochistan		Gilgit & AJK	
Bahawalnagar	196.6	Badin	222.2	Astor	477.9
Bahawalpur	172.6	Chhor	216.5	Bunji	144.3
Faisalabad	367.4	Hyderabad	177.9	Chilas	173.2
Islamabad	1142.2	Jacobabad	110.4	G Dupatta	1611.2
Jhelum	853.4	Karachi (AP)	217.5	Gilgit	129
Khanpur	97.3	Nawabshah	134.3	Gupis	119.1
Lahore(AP)	663.9	Padidan	108.5	Kotli	1300.4
Lahore(PBO)	628.8	Rohri/Sukkur	88.3	Muzafarabad	1526.7
Multan(PBO)	187	Barkhan	393.3	Skardu(PBO)	204.4
Murree	1789.2	Dalbandin	80.8	Mean	631.8
Sargodha	434.9	Jiwani	114		
Sialkot	957.9	Kalat	119.7		
Balakot	1671.2	Khuzdar	244.1		
Cherat	630	Nokkundi	35.4		
Chitral	442.9	Panjgur	108.7		
D I Khan	268.8	Pasni	99.6		
Dir	1416.1	Quetta	260.9		
Drosh	588.2	Sibbi	144.4		
Kakul	1366.2	Zhob(PBO)	285.1		
Kohat	546	Mean	166.4		
Mianwali	454.3				
Parachinar	850.5				
Peshawar	403.9				
Rafique	296.7				
Risalpur	597.7				
Saidu Sharif	1053.8				
Mean	695.288				

TABLE-2

Amount of Precipitation in (mm) of SINDH during 1961-90

STATION	JUN	JUL	AUG	SEP	TOT
Badin	10.8	70.5	89.9	34.4	205.6
Chhor	19.7	79	74.5	23	196.2
Hyderabad	13.9	56.7	60.8	21.4	152.8
Jacobabad	4.7	36.8	26.3	11.2	79
Karachi (AP)	5.5	85.5	67.4	19.9	178.3
Nawabshah	8.4	51.8	45.4	10.4	116
Padidan	3.2	41.7	30.7	11.8	87.4
Rohri/Sukkur	4.4	25.7	19.8	10	59.9

TABLE-3
Amount Of Precipitation in (mm)

Station	Period	Jun	Jul	Aug	Sep	Tot	Station	Period	Jun	Jul	Aug	Sep	Tot
Sindh & Balochistan							Punjab & NWFP						
Badin	61-90	10.8	70.5	89.9	34.4	205.6	Balakot	61-90	98.4	359.4	292.5	100.8	851.1
Chhor	61-90	19.7	79	74.5	23	196.2	Cherat	61-90	17.7	91.4	96.8	35	240.9
Hyderabad	61-90	13.9	56.7	60.8	21.4	152.8	Chitral	64-90	5.5	6.2	6.5	7.7	25.9
Jacobabad	61-90	4.7	36.8	26.3	11.2	79	D I Khan	61-90	14.4	60.8	57.5	17.6	150.3
Karachi (AP)	61-90	5.5	85.5	67.4	19.9	178.3	Dir	67-90	51.3	145.8	159.8	81.8	438.7
Karachi(Man)	61-87	3.9	66.4	44.8	22.8	137.9	Drosh	61-90	14.4	21.9	22.3	22.4	81
Karachi (Ms)	61-90	5	92.5	56.1	19	172.6	Kakul	61-90	85.3	258.3	261.3	96.9	701.8
S-E-Faisal	67-90	13.9	109	82	11.7	217	Kohat	61-90	20.3	69.6	111.4	40.3	241.6
Larkana	88-90	1.2	115	46.8	0	162.8	Parachinar	61-90	43.8	118.6	105.4	58.3	326.1
MoenJoDaro	79-90	0	47.9	24.7	4.2	76.8	Peshawar	61-90	7.7	42.3	67.7	17.9	135.6
Nawabshah	61-90	8.4	51.8	45.4	10.4	116	Risalpur	61-90	18.4	113.4	125.9	39.9	297.6
Padidan	61-90	3.2	41.7	30.7	11.8	87.4	Saidu Sharif	74-90	41.5	146	143	56.7	387.2
Rohri/Sukkur	61-90	4.4	25.7	19.8	10	59.9	B Nagar	63-90	15.4	81.3	34.3	9.3	140.3
Barkhan	67-90	30.5	100	87.7	45.6	264	Bahawalpur	61-90	16.9	52.6	43.2	12.1	124.8
Dalbandin	61-90	0.8	3.9	0.9	0.4	6	Faisalabad	61-90	28	115	89.8	28.7	261.5
Jiwani	61-90	0.6	7.7	3.6	0.3	12.2	Islamabad	61-90	62.2	267	309.9	98.2	737.3
Kalat	61-90	1.1	12.4	9.8	1.6	24.9	Jhelum	61-90	51.9	237.3	221.2	77.7	588.1
Khuzdar	66-90	11.9	44.7	56.9	6.4	119.9	Khanpur	61-90	2.8	27.5	23	15.5	68.8
Lasbella	-----	----	----	----	----	----	Lahore(AP)	61-90	32.9	217.8	173.5	66.2	490.4
Nokkundi	61-90	0	1.3	1.2	0	2.5	Lahore(PBO)	61-90	36.3	202.1	163.9	61.1	463.4
Ormara	61-90	0.5	26.3	11.6	3.2	41.6	Mianwali	61-90	25.5	98.5	104.5	48.4	276.9
Panjgur	61-90	3.3	25	9.2	1.5	39	Multan	61-90	12.3	61.3	32.6	10.8	117
Pasni	61-90	0.4	5.9	12.3	0.5	19.1	Murree	61-90	130.3	339.9	326.3	146.5	943
Quetta	61-90	1.1	12.7	12.1	0.3	26.2	Rafique(Paf)	72-90	23.3	103.5	58.8	24.7	210.3
Sibbi	61-90	6	35.6	30.3	7.7	79.6	Sargodha	61-90	23.2	108.2	129.1	26.3	286.8
Zhob(Pbo)	61-90	10.5	48.5	58.9	10.5	128.4	Sialkot	61-90	65.6	288.4	259.1	94.1	707.2
Total		161	1203	964	277.8	2605.7	Total		945.3	3634	3419.3	1295	9293.6
Gilgit & AJK													
Astor	61-90	19.9	21	23.5	18.5	82.9	Kotli	61-90	81.9	283	291	94.8	750.2
Bunji	61-90	7.2	14.5	18.4	8.8	48.9	Muzafarabad	61-90	103	328	249	108.1	788.2
Chilas	61-90	7.6	11.6	12.4	3	34.6	Skardu	61-90	8.9	9.1	10.5	7.1	35.6
G- Dupatta	61-90	114	276	254	110.5	753.7	Total		357	970	889	365.8	2581.8
Gilgit	61-90	6.1	15.6	15.5	6.5	43.7							
Gupis	61-90	8.2	11.4	15.9	8.5	44							

TABLE-4a1

SIGNIFICANT CORRELATIONS

MARKED (*) CORRELATIONS ARE SIGNIFICANT AT P < .05000

Variable	SOI_06
SMRI	-.48*

Variable	NHT_01
SMRI	.40*

Variable	IHP_08
SMRI	-.38*

Variable	BLCH_P06
SMRI	.39*

Variable	BLCH_P07
SMRI	.39*

Variable	BLCH_TM9
SMRI	.42*

Variable	PUNJ_P05
SMRI	-.42*

Variable	PUNJ_TM05
SMRI	.40*

Variable	PUNJ_TM05
SMRI	.40*

TABLE-4a2

SIGNIFICANT CORRELATIONS

MARKED (*) CORRELATIONS ARE SIGNIFICANT AT P < .05000

Variable	SOI_06	SOI_07	SOI_08	SOI_09	SOI_10	SOI_11	SOI_12	SOI_01	SOI_02	SOI_03	SOI_04
SMRI	-.48*	-0.13	-0.18	-0.15	-0.25	-0.13	-0.07	-0.09	-0.2	-0.19	0.12

Variable	SOI_05	NHT_06	NHT_07	NHT_08	NHT_09	NHT_10	NHT_11	NHT_12	NHT_01	NHT_02	NHT_03
SMRI	0.34	0.1	0.18	0.11	0.31	-0.1	0.14	-0.08	.40*	0.17	0.17

Variable	NHT_04	NHT_05	IHP_06	IHP_07	IHP_08	IHP_09	IHP_10	IHP_11	IHP_12	IHP_01	IHP_02
SMRI	0.22	0.1	0.24	-0.25	-.38*	0.33	-0.03	-0.04	-0.14	-0.09	-0.23

Variable	IHP_03	IHP_04	IHP_05	SSTA06	SSTA07	SSTA08	SSTA09	SSTA10	SSTA11	SSTA12	SSTA01
SMRI	-0.26	-0.02	0.02	0.12	0.11	0.09	0.03	0.1	0.08	0.08	0.04

Variable	SSTA02	SSTA03	SSTA04	SSTA05	SSTB06	SSTB07	SSTB08	SSTB9	SSTB10	SSTB11	SSTB12
SMRI	0.15	-0.13	-0.1	-0.19	0.02	0.14	0.08	0.18	0.09	0.08	0.11

Variable	SSTB01	SSTB02	SSTB03	SSTB04	SSTB05	BLCH_P06	BLCH_P07	BLCH_P08	BLCH_P09	BLCH_P10	BLCH_P11
SMRI	0.03	-0.09	-0.18	-0.23	-0.2	.39*	.39*	0.27	0.31	0.26	0.36

Variable	BLCH_P12	BLCH_P01	BLCH_P02	BLCH_P03	BLCH_P04	BLCH_P05	BLCH_TM06	BLCH_TM07	BLCH_TM08	BLCH_TM09	BLCH_TM10
SMRI	0.33	0.2	0.25	0.17	0.18	0	0.12	-0.01	0.13	.42*	0.24

Variable	BLCH_TM11	BLCH_TM12	BLCH_TM01	BLCH_TM02	BLCH_TM03	BLCH_TM04	BLCH_TM05	PUNJ_P06	PUNJ_P07	PUNJ_P08	PUNJ_P09
SMRI	0.1	0.21	-0.02	0.06	-0.19	-0.07	-0.05	0.25	0.05	-0.1	0.05

Variable	PUNJ_P10	PUNJ_P11	PUNJ_P12	PUNJ_P01	PUNJ_P02	PUNJ_P03	PUNJ_P04	PUNJ_P05	PUNJ_TM06	PUNJ_TM07	PUNJ_TM08
SMRI	-0.15	-0.14	0.14	0.14	0.13	-0.04	0.19	-.42*	-0.33	0.01	0.22

Variable	PUNJ_TM09	PUNJ_TM10	PUNJ_TM11	PUNJ_TM12	PUNJ_TM01	PUNJ_TM02	PUNJ_TM03	PUNJ_TM04	PUNJ_TM05	J_P_TX06	J_P_TX07
SMRI	0	0.35	0.1	0.1	-0.16	-0.04	-0.25	-0.08	.40*	0.03	-0.09

Variable	J_P_TX08	J_P_TX09	J_P_TX10	J_P_TX11	J_P_TX12	J_P_TX01	J_P_TX02	J_P_TX03	J_P_TX04	J_P_TX05	J_P_TN 06
SMRI	0.08	0.14	0.14	0.2	.41*	-0.16	0.19	-0.1	0.02	0.07	-0.04