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CASE STUDY

PAKISTAN: *FLOOD MANAGEMENT - RIVER CHENAB FROM MARALA TO KHANKI*

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PAKISTAN: FLOOD MANAGEMENT - RIVER CHENAB FROM MARALA TO KHANKI

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1. Location

Chenab River is one of the largest rivers of the Indus basin. The river basin measures 67515 km^2. The source of Chenab is at 77°- 30° E and 32°-50° N and lays in Lahul and Spite district in Himachal Pradesh India. The river forms at the confluence of the two streams called “Bhaga” and “Chandara” which flow along the Baralcha pass at an elevation of 5,000 M and join at a place called Tandi in Jammu and Kashmir State (India). Besides Bhaga and Chandra, Bhut nullah and Manu also enter the river from right above Salal Dam. Chenab is joined near the boarder by two major tributaries, the Munwar Tawi and Jammu Tawi both draining some 2,800 Km^2 of land on both side of the two rivers. Chenab enters Pakistan just upstream of rim station Marala (32°- 40/ N and 76°-29/ E). The total catchment area upstream of Marala is nearly 28,000 Km^2. The distance from Marala Barrage to confluence point with Indus river at Mithankot is 598 Km. The river slopes from the source to the mouth vary strongly, with the steepest part, about 25 m/Km upstream of Tandi. From Tandi to Akhnoor the slop is 5m/Km and it drops to about 0.4 m/km when the river flows out into the plains. Below Akhnoor it becomes wider and the flood plain is enormous. Downstream of Marala the river width varies from 700 to 1400 m whereas the flood plain is about ten times as wide as the river. The layout of the river basin is shown in Fig-1.

1.1 PILOT STUDY AREA

The pilot study area was selected from Marala barrage upper drainage basin to Khanki Headworks lower drainage basin. The total area is 1120 square kilometers. Fig-2 & 2A show the Chenab river basin and the pilot area respectively. Khanki Headworks is the oldest barrage on Chenab River and was completed in 1892. Between Marala and Khanki number of small tributaries like Halsi, Bhimber, Palku and Aik, cover drainage area of 3,437 Km^2, contribute into Chenab River. The average slope is about 0.33 m/km between this area (i.e. Marala to Khanki). Marala Barrage is the rim station at river Chenab and is, therefore of paramount importance in all the water regulatory maters. All downstream stations are directly connected with the information supplied by this station. It is located at 32°-40/ N and 74°-29/ E while the Khanki Headworks is located at 32°-24/ N and 73° -58/ E. The length of the river between Marala and Khaki is 56 Km and the width is 850 m. The average annual rainfall in the area is 950 mm and the mean annual temperature is 30°C. The normal mean temperature and average rainfall at Sialkot and Jhelum are shown in Table-1.

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Table-1 Showing Rainfall And Temperature At Sialkot And Jhelum Form (1971-2001)

STATION	SIALKOT		JHELUM	
LOCATION	32°- 30/ N	74°- 32/ E	32°- 56/ N	73°- 43/ E
YEAR	Rainfall(MM)	Mean Temp.(°C)	Rainfall(MM)	Mean Temp.(°C)
1971	772.6	30.0	622.9	31.3
1972	625.8	30.5	624.4	30.9
1973	1886.7	29.7	983	30.5
1974	569.5	30.1	551.7	31.0
1975	1190.1	29.4	1239.3	30.5
1976	1689	28.9	1043.1	30.0
1977	792.7	29.4	899.6	30.5
1978	1064.9	29.2	1169.5	30.3
1979	614.3	29.4	937.2	30.7
1980	732.1	30.0	955.6	31.0
1981	806.9	29.4	836.7	30.5
1982	948	28.4	1068	29.2
1983	1090.4	28.1	1088.9	29.0
1984	837	29.5	845.4	30.5
1985	1093.8	30.0	618	31.4
1986	1002.1	28.8	932	29.6
1987	661.2	30.0	653	31.0
1988	1374.8	29.8	994	31.4
1989	1059.1	29.1	668.4	30.7
1990	1466.1	28.9	1192.4	30.4
1991	875.4	28.8	986.3	29.9
1992	1454.6	28.7	1134.4	29.5
1993	886.5	30.0	761.7	31.2
1994	1190.8	29.5	999.5	30.5
1995	976	29.4	1157.9	30.0
1996	1642	29.0	989.1	30.1
1997	1387.7	27.8	1335.7	28.8
1998	1036.8	29.3	961.4	30.6
1999	646.3	30.0	628.3	31.4
2000	989.3	29.8	840.4	31.2
2001	792.1	29.9	746.7	31.6

Climate and the mean annual rainfall of the pilot area are shown in Fig-3. The rainfall is more in summer as compared to winter. The main weather system which causes heavy rainfall in this area is due to combined effect of the monsoon incursion from Arabian Sea and Bay of Bengal during active phase of monsoon. The Hydrological features are clearly illustrated in the Fig-4 of the pilot area. The soil is transitory from sediment plains of Pir Punjal Range to flatter flood plains of Punjab. The active flood plain is between old flood plain on left side and alluvial terrace on right side. The lengths, slopes and geomorphological setting of pilot area is given in Table-2.

Table-2. Lengths, Slopes and Geomorphological Setting of Pilot Area.

Reach	Length [km]	Slope [m/km]	River width [m]	Flood plain width [m]	Geomorphological setting
Marala-Alexandra	41	0.42	850	6,800	Transition from piedmont plains of Pir Punjal Range to flatter floodplains of Punjab.
Alexandra-Khanki	15	0.33	850	4,300	Active flood plain between old flood plain on left side and alluvial terrace on right side.

The pilot area mostly comprises of agricultural land and the land use patterns are illustrated in Fig-5. Over the past 30 years the area under cultivation has decreased due to industrialization, urbanization and increase in salinity of irrigated land. There is little impact on the magnitude of the floods as the area under change was outside the riverbanks and there was no encroachments and narrowing or modification of the river channel. To cater for any increase in flood magnitude the pressure (through relocation of breaching section) has been planned to be diverted to lesser populated areas.

The population is approximately 453500 and the annual population growth rate is 2.1%.

Both the barrages play a vital role to manage the surpluses and deficiencies of surface water in the study area. The characteristics of the barrages with their off take and link canals are presented in Table-3 and Table-4.

Since the area brought under industrialization and urbanization was already unutilized and the only avenue for expansion both from population point of view and industry point of view was available in this area though it did lie in the river flood plain from exceptionally high flood point of view, the protected embankments already existed, the vulnerability to floodwater is less because of:

a) The embankment level has also been increased to improve the safety factor.
b) The breaching sections are also so devised and shifted so as to reduce the pressure on the protection bank of this area.

Additionally (Flood Protection Sector Project) FPSP-I & II have also provision for constructions of spurs and strengthening of the banks in their plain to save the area from flood damage. This was necessitated because the vulnerability of the flood damage increased. Though the vulnerability of the flood definitely increased and the same was catered for protection/safety measures as per (a) & (b) above.

Table-3 Summery of barrages in Pilot area.

Name	Length [m]	Crest Level [m]		Pond level [m]	Capacity [m^2/s]
		Under Sluice	Weir		
Marala	1,363	242.32	243.85	247.50	31,148
Khanki	1,337	217.93	221.59	221.89	22,653

Table-4. Tributaries, off takes and link canals of Pilot area.

Reach	Tributaries, off takes and link canals	Discharge			
		Inflow		Withdrawal	
		[10^3 cfs]	[m^3/s]	[10^3 cfs]	[m^3/s]
Marala-Khanki	Bhimber Nullahh Palku Nullahh UJC LCC	7.8	221	11.5	325

The barrages have attendant marginal bunds, guide bunds and river training works. In the marginal bunds designated breaching sections are included to bypass part of the floodwater under extreme circumstances to save the structure.

2. FLOODS

Floods in Chenab result from heavy rainfall in the upper drainage basin, which falls under the most active monsoon belt. Pir Punjal range beyond Akhnoor is ideally located to cause the necessary orographic lifting along its windward slopes. The snow metl contributions on the average 40% of the total flow in July when the peak melt rates are attained. Hence it synchronizes with the early monsoon in July, but not with the peak values occurring in August and September. During the monsoon, particularly the Jammu and Munawar Tawis contribute considerably to the flood flows at Marala. Between Marala and Khaki quite a number of tributaries enter Chenab River, which can aggravate the floods. The total catchment area of these tributaries is about 3,500 Km^2 it is estimated that these tributaries contribute to severe river flooding as much as 30 years of the base flow at Marala. These basins are flood prone, heavy flood damage occurred in September 1988 in the Sialkot district located in between the Aik and Palku nullahs. The historical extreme events in the pilot area were recorded in 1988, 1995, 1996 and 1997. The brief descriptions of historical flood events, flood limits and losses are shown in Table 5, 6 & 7 respectively:

Table 5: Thirty-two Years Historical Data Of River Chenab At Marala & Khanki

MARALA					**KHANKI**			
Years	**Day**	**Month**	**Discharge In Thousand Of (Cusecs)**	**Flood Level**	**Day**	**Month**	**Discharge In Thousand Of (Cusecs)**	**Flood Level**
1970	2	7	203.7	H	1	9	251.9	H
1971	27	8	175.1	M	3	8	293.2	H
1972	10	7	132.9	L	10	7	281.7	H
1973	9	8	769.6	E.H	10	8	100.0	L
1974	17	7	109.7	L	5	7	189.4	M
1975	16	7	582.6	V.H	16	7	666.2	E.H
1976	2	8	549.4	V.H	2	8	615.0	E.H
1977	5	7	437.1	V.H	6	7	472.1	V.H
1978	2	8	460.3	V.H	9	8	433.0	V.H
1979	2	8	248.1	H	3	8	286.8	H
1980	15	8	217.3	H	-	-	195.0	M
1981	25	7	529.3	V.H	26	7	563.5	V.H
1982	5	8	282.9	H	2	8	261.8	H
1983	4	8	232.5	H	26	8	200.0	H

1984	9	8	174.9	M	9	8	165.0	M
1985	7	8	274.1	H	7	8	309.0	H
1986	27	7	308.5	H	5	8	341.0	H
1987	21	7	118.0	L	26	7	108.0	L
1988	25	9	750.9	E.H	26	9	864.2	E.H
1989	30	7	407.8	V.H	31	7	512.2	V.H
1990	9	9	213.3	H	10	9	276.0	H
1991	13	7	138.4	L	21	7	131.0	L
1992	10	9	845.0	E.H	10	9	910.5	E.H
1993	11	7	409.4	V.H	11	7	430.4	V.H
1994	20	7	412.5	V.H	20	7	425.1	V.H
1995	27	7	439.9	V.H	28	7	630.5	E.H
1996	23	8	766.8	E.H	24	8	851.2	E.H
1997	28	8	775.5	E.H	28	8	847.6	E.H
1998	10	7	145.8	L	10	7	130.8	L
1999	19	7	214.7	H	20	7	179.2	M
2000	22	7	247.6	H	23	7	309.2	H
2001	07	8	190.6	M	07	8	162.8	M

L	**LOW FLOOD**
M	**MEDIUM FLOOD**
H	**HIGH FLOOD**
V.H	**VERY HIGH FLOOD**
E.H	**EXCEPTIONALLY HIGH FLOOD**

Table 6: FLOOD LIMITS (IN THOUSANDS CUSECS)

SITE	DESIGN CAPACITY	LOW	MED	HIGH	VERY HIGH	EX. HIGH
MARALA	**1100**	**100**	**150**	**200**	**400**	**600**
KHANKI	**800**	**100**	**150**	**200**	**400**	**600**

LOW FLOOD:- River flowing within deep channel (s) but about to spill over river islands/belas.

MEDIUM FLOOD:- River partly inundating river islands/belas.

HIGH FLOOD:- River almost fully submerging islands/belas and flowing upto high banks/bunds but without encroachment on the freeboard.

VERY HIGH FLOOD:- River flowing between high banks/bunds with encroachment on the freeboard.

EXCEPTIONALLY HIGH FLOOD:- There is imminent danger of overtopping /breaching or a breach has actually occurred or high bank areas become inundated.

The classification of flood limits (High, Very High, Exceptionally High) has actually been devised to indicate the river/channel flow conditions with respect to embankments/spillover scenario, alertness & watch to be maintained by the river management authority and for population awareness. These limits also indicate whether floods are contained within the banks or spillover is expected. These limits also convey:

a) Level of alertness to be maintained by rescue & flood management agencies.
b) Quantum of the expected damage.
c) To issue significant flood forecast/warnings when channel flow is expected to be High or above flood limits.

On receipt of significant forecast, which is issued for high & above flood level and also mentions the range, the following actions are taken for flood management:

a) Relief authorities start preparing relief oriented action.
b) Rescue authorities prepare for any evacuation.
c) District authorities/community members (public representative) are informed to prepare public accordingly for shifting of the population to safe areas as per flood fighting plan of District Government functionaries and ministries etc activate their resources. In case of exceptionally high flood the breaching section is activated on predetermined site to reduce the pressure and save the headworks and to divert the floodwaters to least populated/urbanized/industrialized areas.

There is variety of the land use pattern from unused free areas to cultivated land, industrialized or urbanized areas along the whole length of the river channel and on the both banks. Since all the areas on both sides are not uniformly urbanized/industrialized, therefore the areas of less damage-prone are predetermined for breaching the embankment during exceptionally high floods.

Low and medium floods actually pose no immediate, threat to population, it indicates safe passage of floods within the river channels inviting no significant measure to be taken. However, it is beneficial from the following points:

a) The link canal discharge into the dry river channel is closed at the source so as to compensate for any further increase in the flood level.

b) This results in releasing less water from reservoir/dam and as such results in the conversation of water resources and its use during the meager/low flow period.

The classification of flood limits for each river at different structures established on these rivers have already been calculated and communicated to respective river management authority responsible for different areas. This classification is used in formulation of flood management plan in terms of river/barrage/dam. These classification/limits are associated with different stepwise actions and responsibilities/flood management activities of field staff in that area.

Low Flood: The existing staff for routine maintenance will continue and no additional manpower will not be provided. However, the concerned agency for River Management will be vigilant.

Medium Flood: In this stage the water spill-out inundates the low-lying areas in the riverbed i.e. small islands. The day/night watch is arranged i.e. one man for day and one man for night per kilometer including the existing manpower for watch purpose.

High Flood: The watch establishment will be increased to one man per kilometer per shift for three shifts in a day including existing manpower. The respective river engineers will leave their offices and shift to camp offices on their respective river barrage. The district authorities will arrange the manpower/labour and other necessities for them in their camp office.

Very High Flood: The staff duties for high flood limits will be doubled i.e. watch establishment will be increased to two men per kilometer per shift for three shifts in a day.

Exceptionally High Flood: At this flood stage the Chief Engineer of that area will be the overall in charge of the watch/flood fighting activities. He will manage the activities keeping in view the demand of the site and in consultation with district authorities/public representatives and Army Engineers. The manpower strength will be enhanced to four men per kilometer per shift for three shifts in a day. He will also arrange the record of hourly gauges at one-kilometer interval.

The flood situation and other relevant instant damage will be promptly reported to Chief Engineer Floods.

Table 7: Showing losses and damages

YEAR	TEHSIL	VILLAGES AFFECTED	PERSONS AFFECTED	AREA AFFECTED KM^2	CROPPED AREA AFFECTED KM^2	HOUSES DAMAGED	HOUSES DEMOLISHED/ WASHED AWAY	PERSONS DIED	CATTLE HEADS LOST
1988									
	Wazirabad	265	198723	903.5	579.3	484	16747	1	1009
	Gujrat	145	75390	579.2	387.0	1335	1787	4	1381
	Sialkot	833	187291	1072.5	477.4	31030	19351	49	9389
1995									
	Gujrat	131	8191	109.3	20.2	1163	149	12	22
	Sialkot	612	300000	1079.1	528.3	2926	37	21	11
1996									
	Wazirabad	169	250400	210.9	210.9	1811	3306	8	8
	Sialkot	522	350000	892.6	829.6	-	17725	41	330
	Gujrat	112	5316	50.3	43.2	1244	428	11	266
1997									
	Waziabad	128	13619	499.9	183.1	1877	2320	27	56
	Sialkot	464	305545	814.9	316.3	2136	629	20	2
	Gujrat	165	35000	176.0	110.5	2061	1240	8	76

3. FLOOD MANAGEMENT

The river Chenab above the rim station Marala flows in a rugged and hilly terrain and all its upper drainage basin is situated in Himachal Pradesh (from where it originates) and Indian state of Jammu Kashmir. The river has no major dam or headworks above Marala, therefore it maintains a free flow at Marala headworks. The management strategy used here has two components as given below:

3.1 QUANTITATIVE PRECIPITATION RADAR

Since Pakistan could not get the point-rainfall observations from India, therefore the flood forecasting division Lahore has to depend on the QPM radar observations of Lahore & Sialkot.

3.2 INDIAN DISCHARGE DATA

Because of Indus Treaty agreement between Pakistan and India, the discharge data of Chenab at main Akhnoor (India) and also at Jammu (India) for Jammu Tawi the main tributary of Chenab river is available which gives a good clue of the existing conditions at cross border points. These informations play a vital role for flood forecasting at Marala and river routing down stream upto the confluence of the river, where it enters river Indus and also for stage calculations in the pilot study area.

The structural measure plan has been prepared by the each district authority and Irrigation Department. In pilot study area districts of Sialkot and Gujrat have their own flood fighting plans in which construction of flood dikes, levees to confine flows, and bypass flood ways to divert flows are already worked out. However, no big structural measure like dam is built in the pilot project. Some embankments are built in this area, which usually play a major role in the protection of certain areas from the floodwaters.

Among Non-structural measures the importance of communication in flood forecasting and warning systems to provide information to district, Municipalities level through the press and radio up to citizens for effective flood control and evacuation has been achieved. After 1988 & 1992 floods a lot of improvements in flood forecasting and warning system have been adopted. Flood or no flood information is daily sent through Fax direct to Relief Department, Army Rescue, River Management, Federal, Provincial, District Head of Elected Representatives of Community and each agency which has either minor or any major role to combat flood.

The existing non-structural measures were found inadequate and were required to be strengthened particularly in data acquisition and institutional improvement. This was adequately covered up in FPSP-I & II (Flood Protection Sector Project) part of which is reproduced as below:

"During its early years, Pakistan experienced severe floods in the years 1955 and 1956 in the Indus Basin Rivers. These floods however, could not initiate a national drive for flood protection as the land-use pattern till then was not so flood prone.

Economic growth and population pressure continued building up till it faced the disastrous floods of 1973 and then of 1976. Both these floods resulted in heavy losses to life and property and disrupted the nation's major communication links, especially Lahore-Islamabad road and railways. These events proved to be the driving force for national policy-makers to set up a federal agency for managing the flood problem.

The Federal Flood Commission (FFC) was created in January 1977 with the mandate to:

1. Prepare an integrated Master Flood Protection plan on a Nation-wide basis.
2. Approve Flood Protection Scheme prepared by provincial governments under the plan.
3. Arrange funding for the approved flood protection works and measures.
4. Formulate policies regarding regulation of reservoirs for flood control.
5. Monitor and evaluate the implementation of the National Flood Protection plan.

Immediately after its formation, the FFC appointed a joint-venture of consultants to prepare the National Flood Protection Plan. The consultants completed this comprehensive report in 1978 for flood protection to be completed by the year 1990.

The FFC prepared the National Flood Protection Plan 1978 (NFPP-1978), it comprised of viable future flood protection plan, it is a technically sound and economically feasible engineering plan the main thrusts were:

a) To reduce the flood losses
b) To give priorities to flood protection to the areas of greatest economic risk
c) To provide protection from flood damages to areas out side flood plains i.e. cities & vital infrastructure installations.
d) Improvements in existing flood protection/flood control facilities.

Two major reservoirs of the country can be adequately used for management of severe floods. Tarbela reservoir is located across main river Indus and is less vulnerable to serious flooding because monsoon currents rarely gives heavy rainfall in its sub basins. However the catchment of Mangla reservoir over river Jhelum (a tributary of river Indus) is every year vulnerable to some sought of flooding i.e. light, moderate, and severe because of monsoon rainfall in its sub basins.

A flood warning manual has been prepared to extensively describe the flood categories which can be expected and flood wave routing down stream can be managed to avoid flooding in the vulnerable populated areas and avoid damages to the structures. The working methodology has been evolved along with the reservoir management authority.

The flood mitigation policies includes the following

a. Remodeling the flood embankments
b. River training works
c. Construction of new bunds
d. Feasibilities studies

Flood affected communities are involved in the formulation of flood management plans in the following manner

a. The local representative of the community is associated in each and every activity planned executed or implemented in that area.
b. A District level, sub-district level and at provincial level, the government has assigned each minister a district for flood management. The minister is the head of the elected representative of that district, he coordinates and chairs the flood management activities will all the government functionaries.

During 1988 Pakistan suffered two major flood events, the first in July/August and the second in September/October. The first flood involved the Indus, Swat, Kabul and Jhelum Rivers. This flood caused only minor damage in Punjab, but resulted in significant damage in Sindh, Balochistan and NWFP, where exceptionally heavy rains coincided with the high river flow period.

The second flood was caused by heavy rains in the catchments of the Chenab (Pilot Study Area), Ravi and Sutlej Rivers. In response from an urgent request from the Government of Pakistan for emergency assistance to restore public sector infrastructure a loan was sanctioned worth USD 44.0 million.

Following the severe 1992 floods, Asian Development Bank approved the second Flood Damage Restoration (Sector) Project to re-establish and restore the pre-flood capacities of critical public sector infrastructure in irrigation, drainage flood control, roads, health and education, damaged by these floods. The Government of Pakistan, World Bank and other donors planned to co-finance this USD 396 million project. This project was scheduled to be completed by June 1996, but was extended to December 1997.

The project covered priority flood protection works in the following major areas/reaches:

- Indus River from Chashma Barrage to sea (Sindh).
- Chenab River from Marala Barrage to Qadirabad Barrage (Punjab)
- Ravi River from Kot Naina to Sidhani Barrage (Punjab)
- Flood protection of Quetta city from Kasi Nullah (Balochistan)
- Flood protection along various hill torrents (Balochistan)

The comprehensive programme for strengthening of Pakistan's flood forecasting and warning capability was conceived by Government of Pakistan and Asian Development Bank in 1992/93. By April 1994, Government of Pakistan and Asian Development Bank had decided to increase the scope of the flood forecasting and warning related components of the FPSP (Flood Protection Sector Project) to include:

(i) The procurement and installation of hardware and software for rehabilitation and improvement of the gauging and telemetry system operated by the Water and Power Department Authority (WAPDA).
(ii) The procurement of HF radio equipment for FFC, WAPDA, the provincial Irrigation Department (PIDs) and the Pakistan Meteorological Department (PMD)
(iii) The procurement and installation of a 10cm weather radar for PMD at Lahore.
(iv) The carrying out of a bathymetric survey.

Development Of Indus Flood Forecasting System:

For the development of the Flood Forecasting System (FFS), the Federal Flood Commission engaged international experts under a contract with a join Venture of Consultants. These experts include a Flood Forecasting and warning Expert, a Hydrologist, a Software Expert & Modeller and a Hydro-meteorologist. The services of an international meteorologist for the project have also been arranged by Federal Flood Commission through a contract with University of Reading, England.

Part-I of the flood forecasting and warning has been implemented which includes the following

(i) Procurement and installation of S-Band weather radar, which is functional since 1997.
(ii) Preparation of flood warning manual, which have been prepared in 1997 and is followed.
(iii) Procurement of 69HF Radio sets have been done and sets are installed and are functional since 2001.

Now the FPSP-II is in process under which one S-Band Radar is planned to be installed at Mangla, one C-Band radar is to be installed at Sialkot. The approval has been accorded, funds are available and these to be installed and functional by 2005.

Technical studies have been identified and the funds have been allocated to carry out the studies. They are also to be completed by 2005, some of which are:

(i) An extended analysis of existing radar data from Sialkot to determine storm motion and orographic effects
(ii) Validity of global scale model analyses and forecasts
(iii) Study of spatial and temporal variability of rainfall to determine the ability of gauge measurements to represent area rainfall over a range of time periods and areas.
(iv) Optimum use of satellite data for rainfall estimation and forecasting.
(v) Determination of meteorological situations and type of rain events which give rise to systematic overestimates or underestimates of rainfall by radar.
(vi) Study of radar observed storm characteristics and of the influence of orography under different meteorological situations.
(vii) Determination of the relation ship between river levels and radar rain estimates for the hill torrents and their catchments.
(viii) Survey of meso scale models and their possible utility of the Indus catchments.

Within the framework of the expanded programme for improvement of the country's flood forecasting and warning capability adopted by the Government of Pakistan in 1992, the Study aims at providing (i) a flood forecasting system that will allow full utilization of the flood forecasting capabilities offered by the equipment to be installed under the FPSP and (ii) a decision support system for improved flood management. The scope of the study includes the following major activities:

- Data collection and analysis, and hydrological studies to provide a comprehensive basis for rainfall –runoff modeling and river flow routing.
- Preparation of a system of computer models for rainfall –runoff relations and river flow routing for real time flood forecasting and management. It will provide maximum possible lead times and allow timely evacuation of areas likely to be flooded.
- Preparation of guidelines for improved flood management through breaching sections or adjusted reservoir operation under conditions of improved flood forecasting.

The decision support system is in place and has been used in flood season 15th June to 15th October 2002 & 2003. This includes:

a) Pre-flood season meetings among all concerned agencies to check the preparation status, chaired by Federal Minister.

b) Post flood season meeting to evaluate the performance and to ensure that short comings if any, or additional requirements to be completed before the start of next flood season.

4. FLOOD AND WATER MANAGEMENT INSTRUMENTS

An important part of proper flood forecasting and warning is timely collection of data of river gauges and other relevant details. In the pilot study area precipitation is measured with normal rain gauges every hourly and three hourly and water levels confirmed through visual observation taken at river sites gauges. The six hourly discharge data is received at Flood Forecasting Division (FFD) through police wireless H.F. Radio sets, and in case of any significant situation hourly or half-hourly data can be received at FFD. The observational network is installed and maintained by Pakistan Meteorological Department (PMD), Water And Power Development Authority (WAPDA) and Provincial Irrigation Department (PID). This data is used as input for flood forecast model, flood records and water resource management for integrated flood management of river basin.

Since there is no dam/reservoir in this area to store the floodwaters, therefore floodwater is only used as ground water recharge and as a soil conditioner for the agricultural land to improve land fertility. The over flow from the embankments during the floods is used as ground water recharge plus the additional soil deposit (fertile layer) there are no other physical structure constructed as to control the water resources. There are two major reservoirs/dams, which act as water storage, one on main river Indus i.e. Tarbela Dam and the other is on river Jhelum i.e. Mangla Dam. However, on the Chenab River, the pilot study area there is no reservoir/dam either across the border or within the complete length (598 Km). The barrages only serve to regulate the flow to the link canals for irrigation purposes.

In the pilot study area the water use management system is in place particularly for irrigation purposes & it has a detailed layout of canals and link canals to the agricultural lands operation of which becomes important during exceptionally high flooding (Fig-1).

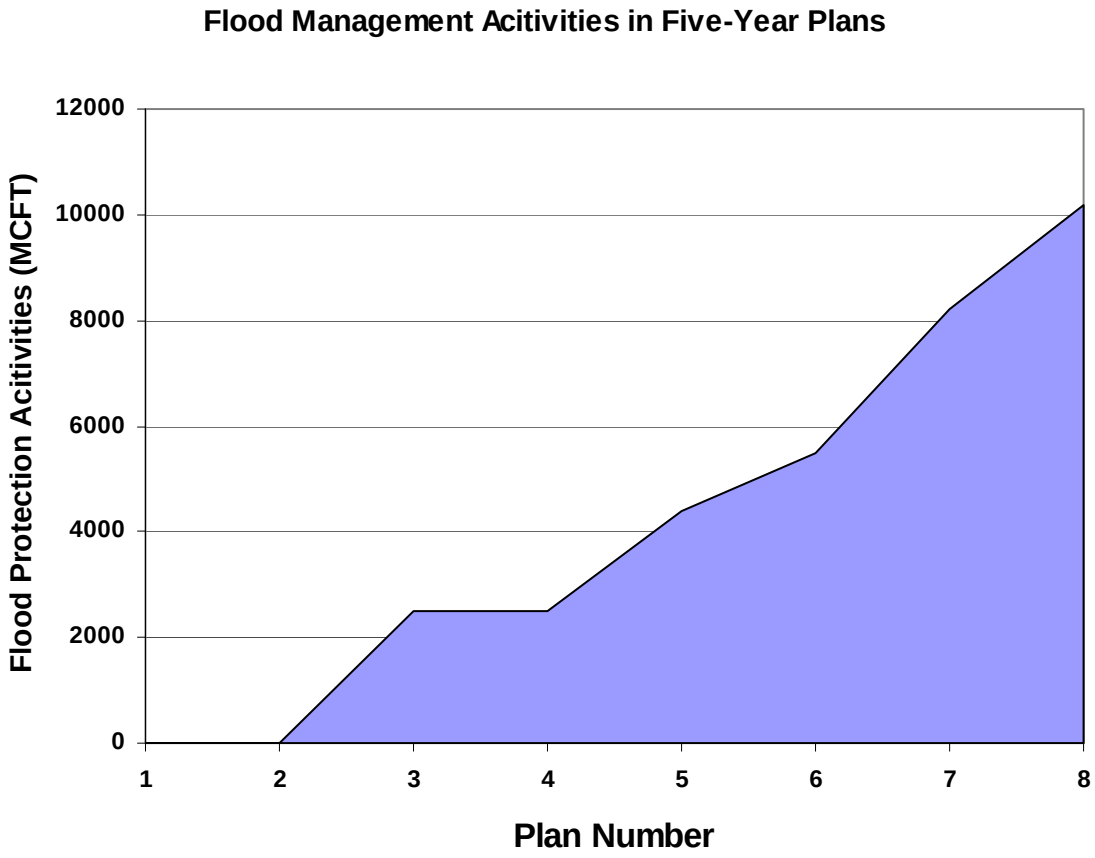
5. POLICY:

The national water policy is under formulation. The contract for the preparation of National Water Policy was awarded to the consultant who presented their proceedings in a workshop in April 2002. The same has been submitted to Ministry of Water & Power, Government of Pakistan. However, at present the first priority is to utilize the available water in equitable and judicious manner to encourage the migrated agrarian population to settle evenly within the Indus basin. An institutionalized planning exercise was carried out in the form of five-year plans which were implemented from 1955 onwards. These five-year plans focused on the extension of irrigation facilities to new areas and to improve the irrigation control and distribution in existing areas. These five-year plans were prepared in response to extreme flood events, as after 1971, 1973 and 1976 floods, a project was formed with the help of WMO and some international donor agencies, which resulted in the establishment of a 5 cm Quantitative Precipitation Measurement Radar at Sialkot to improve the Flood Forecasting and Warning System of Pakistan.

The first priority was to utilize the water in an equitable and judicious manner to encourage the migrated agrarian population settled evenly in Indus Basin and sparsely distribute the benefit of irrigated agriculture. During the first five-year plan (1955-60) more than 80% of water sector expenditures incurred in the improvement of river and canal water regulation and diversions so that additional area could be brought under irrigation. Headworks at Kotri and Tansua on the Indus and at Marala-Ravi on the Chenab were completed during this period. The need to protect fertile land from water logging, salinity and floods was evident but the financial constraints prohibited the execution of in these sectors.

During the second five-year plan (1960-65) the policy of water resource development continued and study was completed to access the potential of water resource development. A number of surface drainage & sub-surface drainage projects were initiated.

During the third five-year (1965-70) plan Mangla Dam was completed. The flood control still remains at low priority and essential flood protection works were completed on a limited scale. The figure given below illustrates the flood management activities in different five-years plans for the area protected against floods.



6. INSTITUTION RESPONSIBLE FOR FLOOD MANAGEMENT

Flood management process in Pakistan is multi-functional involving a number of different organizations. The Government organization, which plays major role in the flood management are briefly discussed below for proper understanding. Federal Flood Commission is the coordinating body at the Federal Government level with all the provinces and technical agencies.

6.1 Flood Forecasting Division (FFD)

FFD of the Pakistan Meteorological Department plays a pivotal role in the entire flood mitigation process. Hydrometeorological data from the various national and international sources is received in this Division, which is then processed to prepare flood forecasts and warnings to be disseminated outwards to various national organizations. Major actions required to be taken by the Division before, during and after the flood season are summarized below.

(i) Ensure serviceability of the meteorological equipment including QPM Radar Lahore, QPM Radar Sialkot, Teleprinter network, FAX, APT, RTT and MDD Equipment.
(ii) Ensure availability of the following items in sufficient to last for the whole of flood season: Surface and upper air meteorological charts, isohyetal maps, various forecast forms, data tabulation sheets stationery etc.
(iii) Update the calibration of the radar and flood forecasting models
(iv) Liaison with telecommunication authorities for timely reception and transmission meteorological and hydrological data and rapid dissemination flood forecast and warning to all the agencies.

The operational setup of Flood Forecasting Division is shown in Fig-6.

6.2 Provincial Irrigation and Drainage Authority (PIDA)

PIDA plays a front line role in the process of flood mitigation. Major flood related functions include.

(i) Flow measurement at the specific sites at rivers, canals and nullahhs.
(ii) Planning, design construction and maintenance of flood protection works.

6.3 Water and Power Development Authority (WAPDA)

WAPDA is involved in the Dam management and the major functions are as under.

(i) Collection of rainfall data from telemetric rain gauge stations and to provide it to Pakistan Meteorological Department.
(ii) To provide the Hydrometric flood data at rim station and on the barrages.

6.4 Provincial Relief organization.

Provincial relief organizations are charged with the responsibility pertaining to disaster preparedness, emergency response, and post disaster activities pertaining to all disasters including floods. Flood preparatory actions required to be taken by the relief Commissioner include:

(i) Arranging inspection of the flood protection.
(ii) To establish flood warning center and the flood centers at the district and Tehsil levels.

6.5 Pakistan Army

Pakistan Army's flood related function encompasses all the three phases of flood operations from the pre-flood to post flood. All the rescue and relief operations during and after floods are carried out by Pakistan Army. Provincial government provides all the support and equipment (boats, life jackets, vehicles, tents etc.).

6.6 Commissioner for Indus Waters (C I W)

Commissioner for Indus waters is a regulatory body to get river flow and rim data from India and then passed on the Chief Meteorologist Flood Forecasting division, Lahore.

6.7 Emergency relief cell (ERC)

Emergency Relief Cell has been established under the cabinet division and is controlled by the Cabinet Secretary. The Director General Relief heads the cell. Main function of the Emergency Relief Cell includes.

(i) Planning and assessment of relief requirements of major disasters.
(ii) Stock pilling of basic necessities needed during emergency such as dry ration, tarpaulins, blankets etc.

6.8 Federal Flood Commission (FFC)

FFC was established in 1977 to provide the necessary infrastructure at the federal level to help the provinces in meeting the technical and financial resources required to carry out the Flood Mitigation Measures.

During the recent past FFC has played a unique role in remodeling the flood mitigation policy of the country on modern lines with the help of the foreign loan mostly obtained from Asian Development bank (ADB).

Situation prior to remodelling:

Prior to remodeling, the rainfall monitoring and prediction relied on traditional methods and communications systems, with limited benefit from technology and techniques, which were available over the last twenty years or so. The staff of the F.F.D (Flood Forecasting Division) has many years of experience in using these methods. However, these depended on the timely acquisition of data from within Pakistan and from overseas. A survey of the actual data reception showed that in severe weather conditions only some 10% of the anticipated data was received. Good forecasts cannot be made in these circumstances. In addition, even in favorable communications conditions, there has been a decline in the amount of overseas data transmitted to Pakistan over the international radio links. Other information available to the forecasters were estimated of hourly rainfall from a rather inferior radar set at Sialkot and low quality satellite images. The actual radar observations of the weather could not be viewed by the forecasters, and the satellite imagery was difficult to interpret. Fortunately other data sources are available and should be accessed.

Remodeling under FPSP-1 (Through Federal Flood Commission)

The need for a better database was recognized in FPSP-1 with the provision of new Doppler 10 cm Radar (Quantitative precipitation monitoring) at Lahore, which has became operational in 1997. This provides a valuable source of information for monitoring rainfall over parts of the upper catchments, and will contribute to the forecasting of rainfall a few hours ahead.

Provision was also made in FPSP-1 for the improvement in the acquisition of data from within Pakistan. A network of about thirty telemetred rain and river gauges installed during 1997, using the meteorburst transmission technique. Also, 12 SSB HF radio sets provided to the PMD (Pakistan Meteorological Department) to improve links between Lahore and synoptic stations in northern Pakistan. Additional HF receivers at 36 WAPDA (Water & Power Development Authority) sites will further contribute to the rainfall data. These will also be used for the transmission of river data and for relaying warnings and advice from WAPDA/FFD to river and dam sites.

Flood Protection Sector Project (FPSP)-II (Through Federal Flood Commission)

Advanced flood warning centres are now using rainfall forecasting systems that automatically combine data from radar, satellites and numerical atmospheric prediction models adapted to their locality. Given the gravity and financial importance of flooding in Pakistan such a system should be envisaged here. Significant progress in many aspects can be made within FPSP-II.

Real time radar data is the best achievable method of estimating the current rainfall within a catchment and also contributes to the short range, up to 6 hour, forecasts of rainfall. It is not possible to give full radar coverage of all the catchments because of the terrain and international boundaries. However satellite data can cover the whole area and give indications of the intensity of rainfall not only over the catchments but also within the approaching depressions. This gives an extended forecast capability that can be further enhanced by the products from global scale numerical models. These products, in the form of digital or graphical charts, identify and forecast the position and intensity of monsoon depressions. To exploit these technical capabilities it is necessary to have a detailed knowledge of the typical behavior and rainfall yield of the depressions and of the circumstances that give rise to variations from the typical state. These considerations imply not only a significant input of equipment but

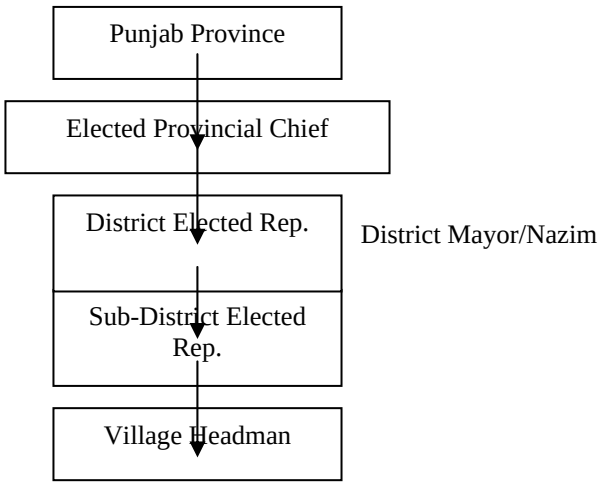
corresponding programmes of applied research and of staff development. Each of these areas is addressed in FPSP-II. Also with the rapid developments in communications methods a review of the requirements of the whole flood warning system and best ways of satisfying them in the next three to five years will be undertaken.

The radar coverage of the upper catchments of River Jhelum will be further improved by the provision of 10cm radar at Mangla. The data from this and the other radar sets in Pakistan will be relayed to the Flood Forecasting Division where data processing equipment will all it to be integrated into the forecasting procedures and to be saved for further studies.

The meteorological data acquisition systems at the Flood Forecasting Division will be expanded and upgraded to give improved reception of traditional data and allow the capture of frequent and high resolution satellite data together with meteorological charts from the global numerical models.

The flow sheet diagram (Annex-I) indicates the involvement of the flood affected communities. District flood fighting plan also includes the role of community. The breaching section and breaching decision requires the involvement of elected representatives of the public. In District flood management the community involvement is at the following levels: During and post flood situation the elected representatives of the community of the flood affected areas are involved for relief and rehabilitation and shifting the public to pre-designated safety shelter, arrangement of food distribution, provision of emergency health facilities and settlement, rehabilitation and distribution of relief goods.

The organigraph has been prepared from the concept point of Federal & Provincial Government authorities to disseminate and receive flood forecast & warning. Each province has its own setup to outreach to community through elected representatives, minister & town/district public elected representatives. One example is given below:



LESSON LEARNT:

To have a better coordination and quick flow of information, representatives of various users of flood mitigation agencies such as Army, Relief, Irrigation Department and Reservoir Management Authorities have been position in the premises of Flood Forecasting building, so that incase of any flood situation better liaison can be made.

During the year 1988, 1992 which were massive flood years, though a forecast was issued but its impact was lost and it could not be received in time by the reservoir management authorities. This lapse necessitated amendments in the existing procedure and afterwards a more proactive method was adopted rather then previous passive approach.

This did increase some telephone billing but it has now contributed a lot in forecast issuance and its receipt by the users agencies and its quick response. A personal follow up is also done for more effective and failsafe and correct appraisal, particularly twice during any typical situation or during any real time flood situation.

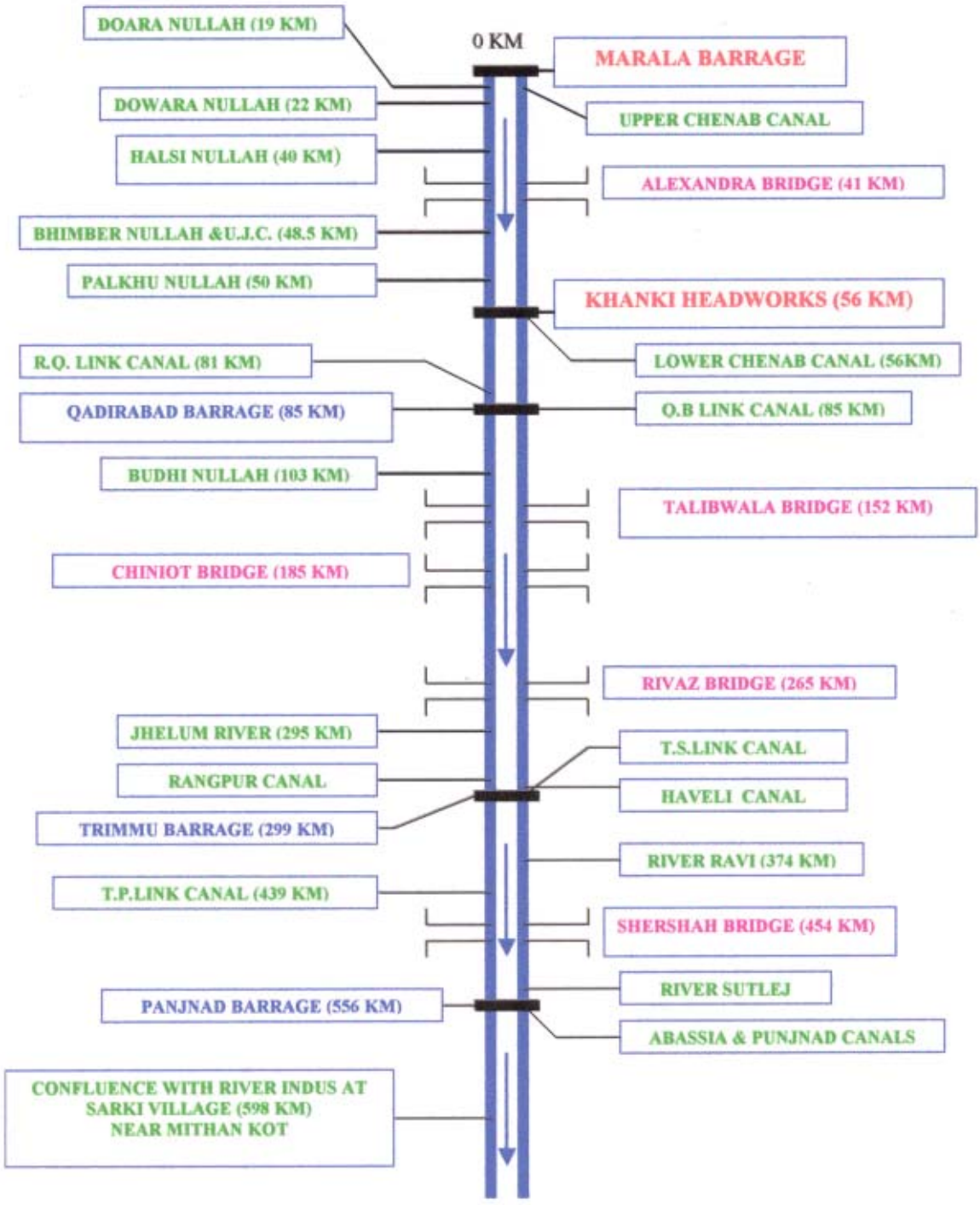
To further increase coordination and integrated effort at a broader level Federal Flood Commission organizes pre-flood and post flood meetings every year at national level, as a follow up action to review the lapses and shortcomings during each previous flood season. This helps in further tuning of the existing network and coordination system.

The pre-flood meetings are arranged at:

1. Relief Commissioner level (Province wise)
2. Army Rescue level (Province wise)
3. Provincial Governor level and at the Federal level to oversee the existing arrangements followed by a post flood meeting.

In addition there was no model for quantitative and qualitative flood peak estimation as a consequence of this new strategies have been planned and put in operation.

1. Procurement and Installation of radar of S-band radar with extended range 450 Km was established at Lahore in order to track down the tropical storm and its movement.
2. Coordination between the Dam management and irrigation authorities, through direct communication has been established at least twice in a day.
3. Operational coverage on T.V, during pre-flood season, for public awareness is in place and covered up is also through newspapers daily report.
4. Close liaisons by F.F.D with all the agency Heads is ensured for confusion free and timely flow of forecast and warning.
5. A Manual (official document) listing role of each and every organization and details of action to be taken for an integrated flood forecasting and management has been prepared. An abstract of the manual is attached as (Annex-II). Flood warning manual, which was prepared under the FPSP-I covers, flood mechanics type of flood forecasting responsibilities of concerned departments, forecast and flood warning dissemination.
6. An integrated network of Weather Radars have also been put in operation covering the country for rainfall monitoring in river basin both in upper and lower drainage basins.



LAYOUT OF THE CHENAB RIVER BASIN

FIG-1

CHENAB RIVER DRAINAGE BASIN

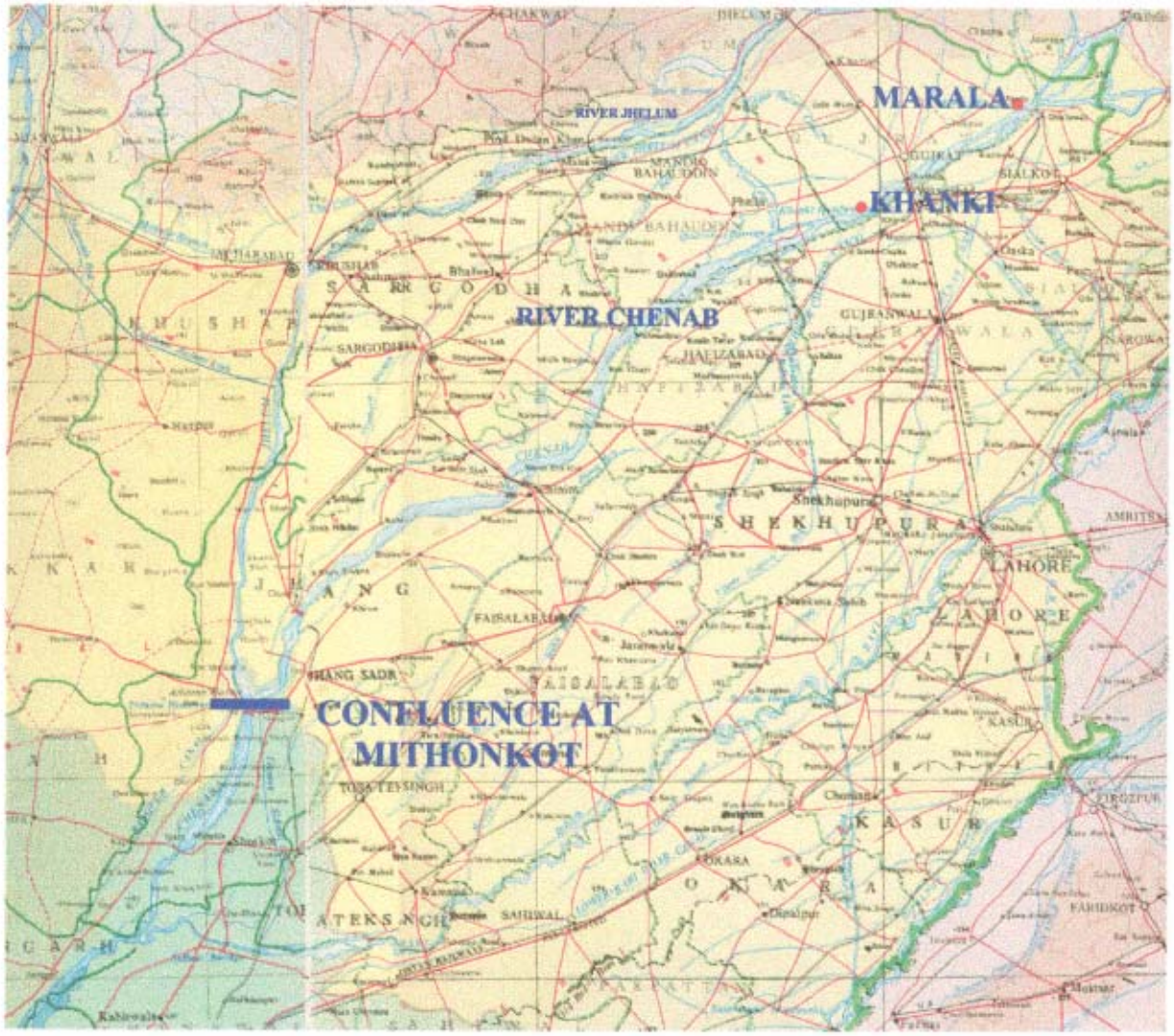


Fig.2

PILOT AREA FOR STUDY

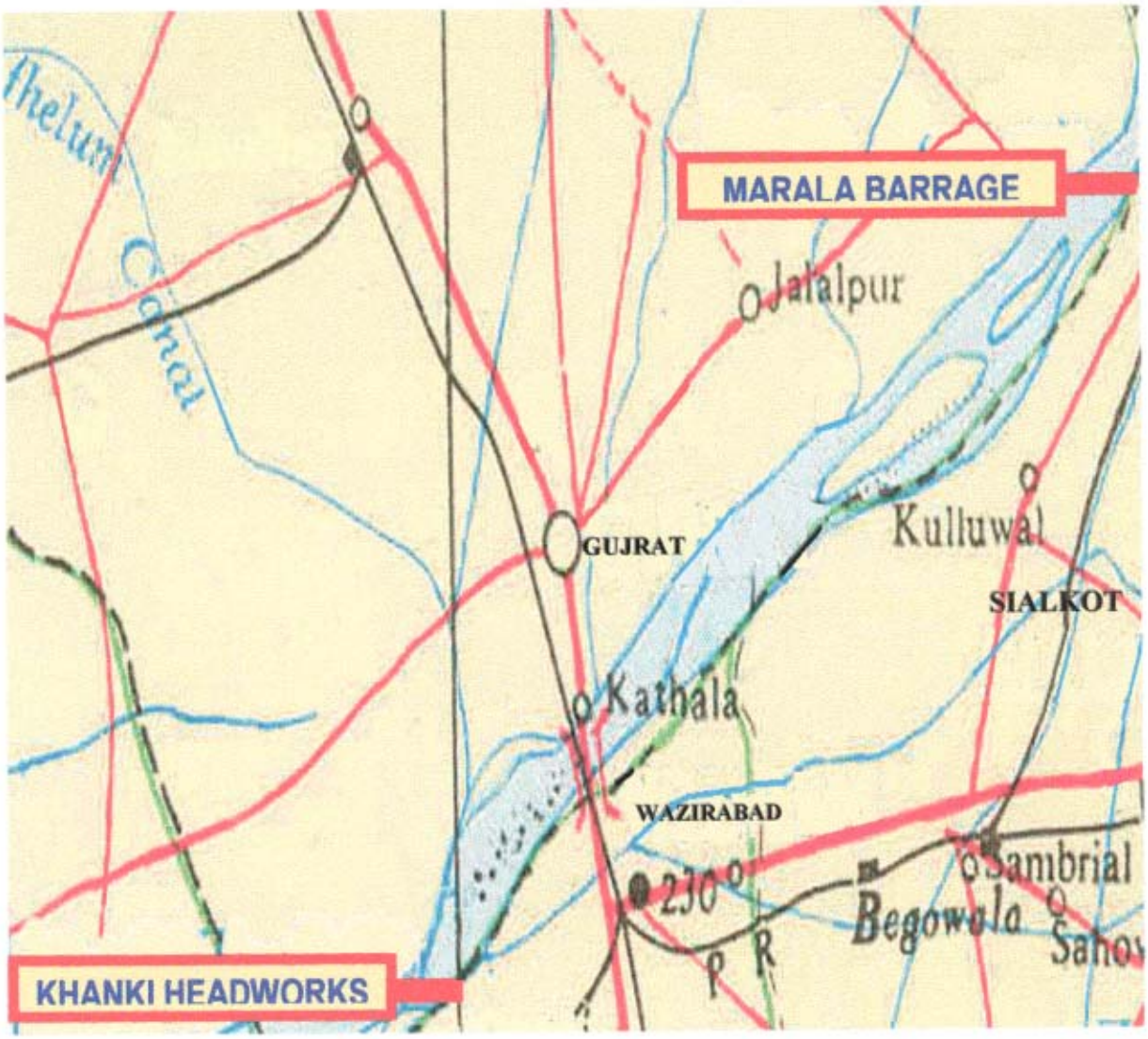
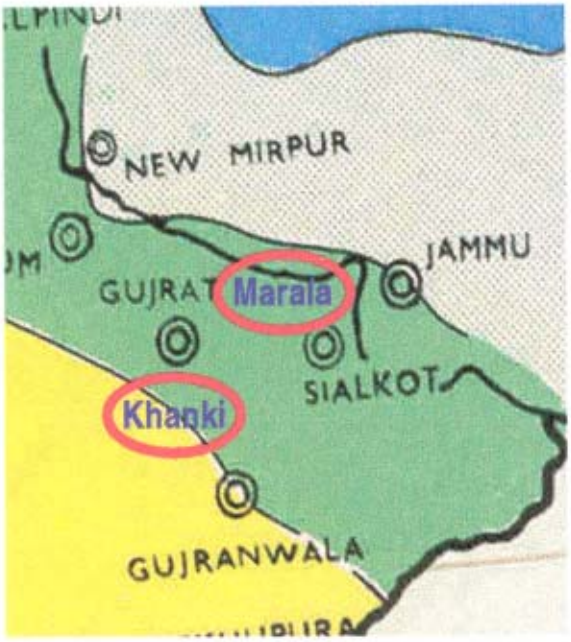


Fig.2A

CLIMATE AND MEAN ANNUAL RAINFALL IN PILOT STUDY AREA



CLIMATE

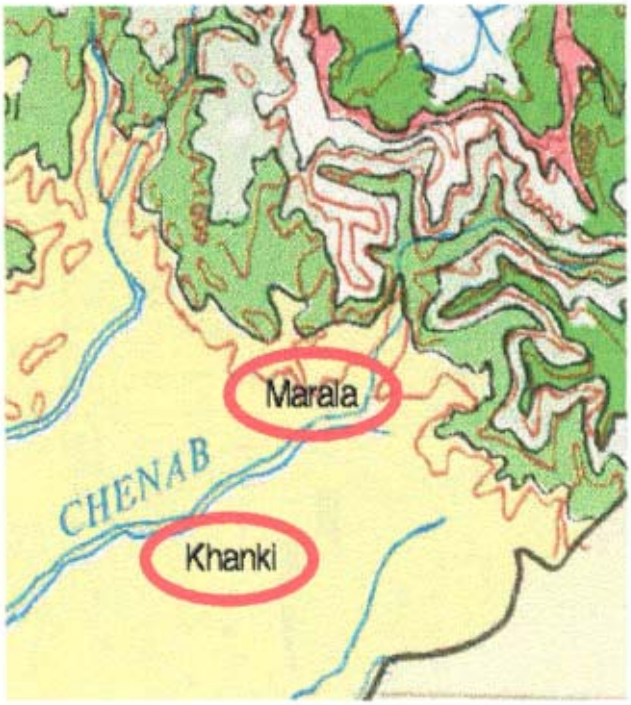
CLASSIFICATION	SYMBOL	ASSOCIATED MEAN ANNUAL RAINFALL
COLD, Humid		1000 mm, or more
VERY COLD,Sub-Humid		1000 mm, or more summer rain
COOL,Sub-Humid		500-1000 mm rain in summer & winter
WARM, Sami-Arid		250-500 mm, maximum summer rain

MEAN ANNUAL RAINFALL

INCHES	MM
80	2000
40	1000
20	500
10	250

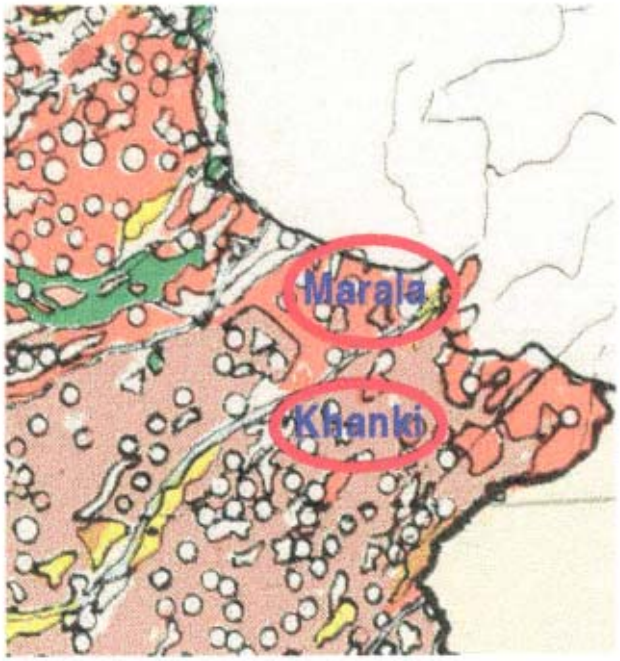
FIG-3

LAND USE PATTERN IN PILOT STUDY AREA



NATURAL VEGETATION

- Desertic and semi-desertic vegetation
- Thorny
- Subtropical dry evergreen forest
- Subtropical pine forest
- Temperate latifoliate forest
- Temperate Coniferous forest



LAND USE

- ARABLE & IRRIGATED
- ARABLE & UNIRRIGATED
- WOODS & FORESTS
- ROUGH GRAZING LAND

FIG-5

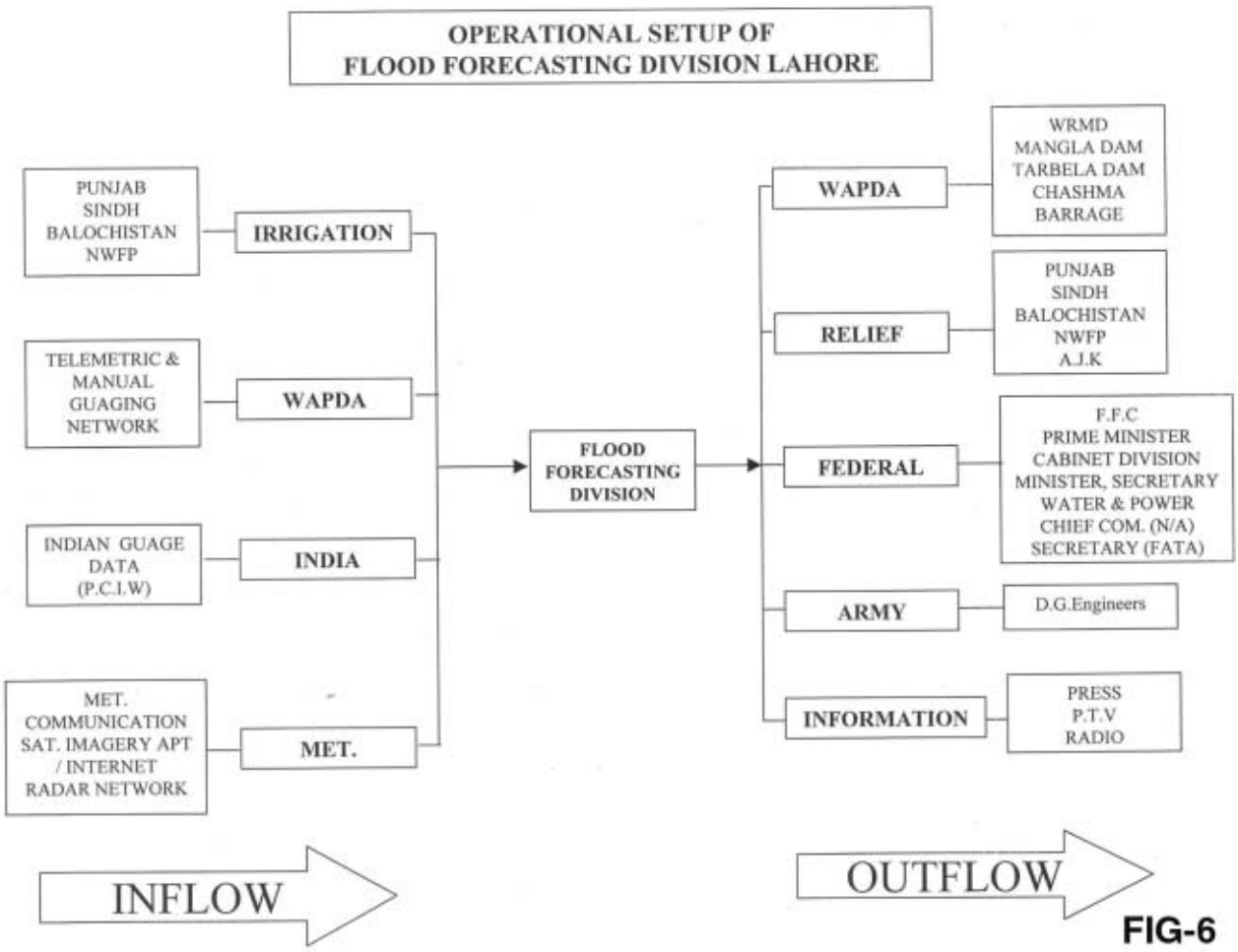
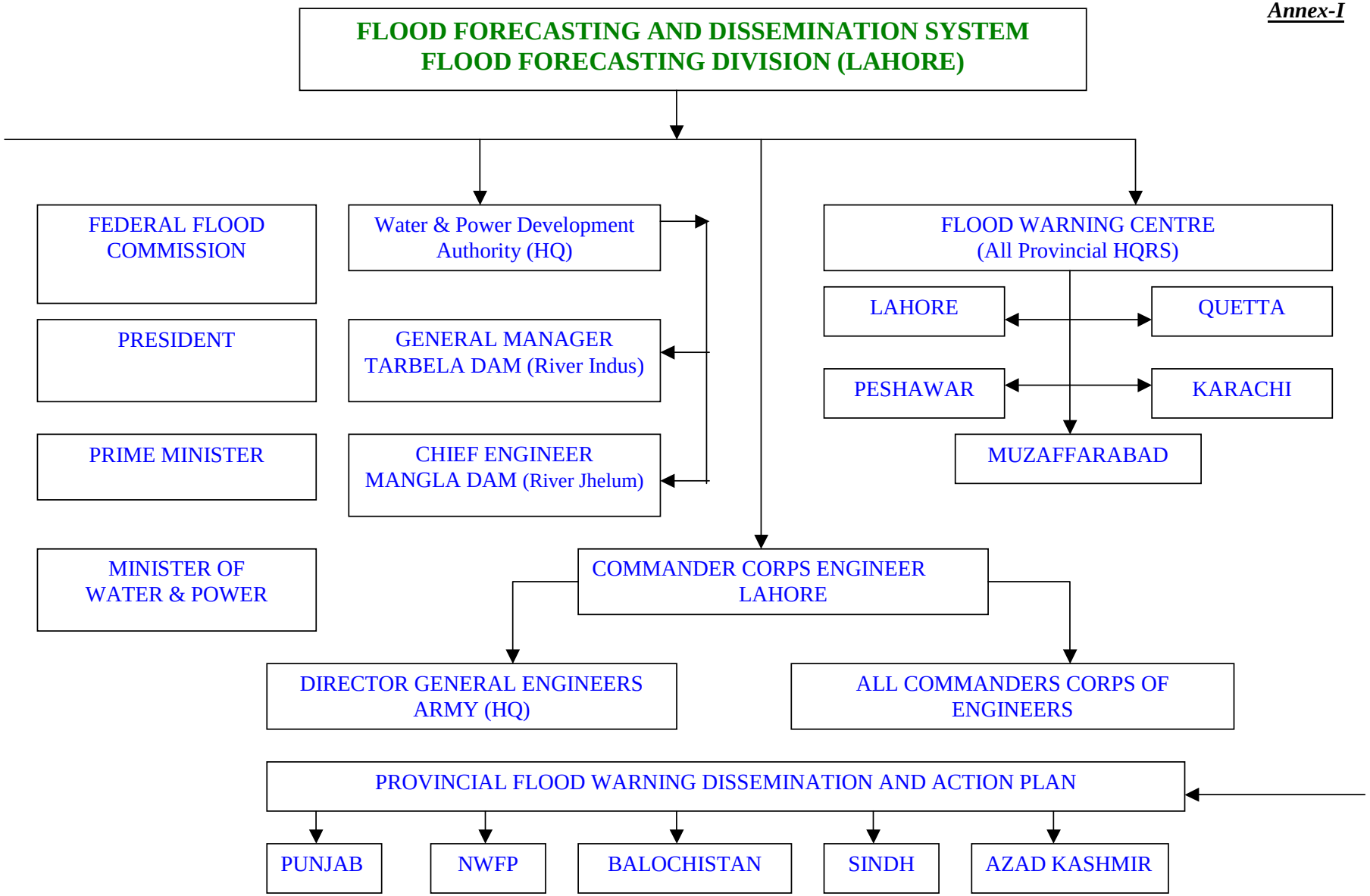

OPERATIONAL SETUP OF
FLOOD FORECASTING DIVISION LAHORE
PUNJAB
SINDH
BALOCHISTAN
NWFP
IRRIGATION
TELEMETRIC & MANUAL GUAGING NETWORK
WAPDA
INDIAN GUAGE DATA (P.C.I.W)
INDIA
MET. COMMUNICATION SAT. IMAGERY APT / INTERNET RADAR NETWORK
MET.
FLOOD FORECASTING DIVISION
WAPDA
WRMD
MANGLA DAM
TARBELA DAM
CHASHMA BARRAGE
RELIEF
PUNJAB
SINDH
BALOCHISTAN
NWFP
A.J.K
FEDERAL
F.F.C
PRIME MINISTER
CABINET DIVISION
MINISTER, SECRETARY WATER & POWER
CHIEF COM. (N/A)
SECRETARY (FATA)
ARMY
D.G.Engineers
INFORMATION
PRESS
P.T.V
RADIO
INFLOW
OUTFLOW

FIG-6

Annex-I


FLOOD FORECASTING AND DISSEMINATION SYSTEM
FLOOD FORECASTING DIVISION (LAHORE)
FEDERAL FLOOD COMMISSION
PRESIDENT
PRIME MINISTER
MINISTER OF WATER & POWER
Water & Power Development Authority (HQ)
GENERAL MANAGER TARBELA DAM (River Indus)
CHIEF ENGINEER MANGLA DAM (River Jhelum)
FLOOD WARNING CENTRE (All Provincial HQRS)
LAHORE
QUETTA
PESHAWAR
KARACHI
MUZAFFARABAD
COMMANDER CORPS ENGINEER LAHORE
DIRECTOR GENERAL ENGINEERS ARMY (HQ)
ALL COMMANDERS CORPS OF ENGINEERS
PROVINCIAL FLOOD WARNING DISSEMINATION AND ACTION PLAN
PUNJAB
NWFP
BALOCHISTAN
SINDH
AZAD KASHMIR

Annex-II

Flood Warning Manual

Abstract

Flood warning manual clearly defines the approved text of the Flood warnings to be issued at different stages such as qualitative and quantitative forecasts with appropriate colour coding prior to the approach of the floods alongwith the movement of the flood generating systems within the possibility of one to three days. In addition to this miscellaneous information which contains rainfall meteorological situation, forecast, expected levels of each river indicating the classification of the flood and its numerical values. The list of recipients has also been identified receiving routine forecast, qualitative forecast and colour-coded forecast and significant forecasts (high - very high - exceptionally high flood limits).

Based on the previous historical data meteorological situations responsible for category-1, category-2 and category-3 floods have been identified. These categories are indicative of the depressional/non-depressional rainfall, depression passing close by and directly affecting the river discharge basin. It also highlights the committee responsible for press/T.V and radio briefing alongwith coordinating members designated under the chairmanship of Chief Meteorologist Flood Forecasting Division. This is meant to remove the confusion creating statements from many agencies on one issue. The manual also defines the role of each and every organization connected with the flood management and specifies the responsibilities so as to create a quick response, feedback and action oriented approach. In order to cater for previous shortcomings specified list of the authorities who are to receive the forecast/warnings has been prepared. An exclusive detailed forecast/warning dissemination methodology utilizing all the latest modes of communication is prepared which is updated yearly in pre and post flood meetings/conferences both at Provincial/Federal level.

Based on past historical data the manual also indicates the most vulnerable and critical sites and with regards to flashy/sloppy behavior and also the catch-area generating the flood wave.

Function And Responsibilities Of Flood Related Government Organizations.

1 General

Flood management is a multifunctional process involving organizations. The Government Organization, which plays major role in the flood management, is PIDA, WAPDA, provincial relief Organization, Pakistan Army, CIW, Emergency Relief cell, FFC and FFD. Proper understanding of functions of these organizations is briefly described below.

2 Provincial Irrigation and Drainage Authority (PIDA)

PIDA plays a front line role in the process of flood forecasting as well as flood mitigation. Major flood related functions include.

i) Flow measurement at the specific sites at rivers, canals and nuallahs.
ii) Planning, design construction and maintenance of flood protection works.
iii) Maintenance of data communication network to provide the river flow data to FFD.
iv) Supervision of the flood warning center (on behalf of Relief Commissioner) to ensure timely dissemination of the flood forecasts/warning.

v) Director (floods), PIDA, in his capacity as member FFD to maintain close coordination with Chief Met FFD for the issuance and dissemination of the flood forecasts/warning.
vi) Occasional updating of the divisional flood fighting plans and execution of such plans during flood emergency.
vii) Implementation of the divisional flood fighting plans for the actions required to be taken before, during and after the flood emergency.

3 WAPDA

WAPDA is actively involved in the Flood Forecasting process by providing the much needed river and rain data from its telemetric gauge sites within the upper catchments of Indus and Jhelum rivers. During the pervious flood forecasting project (from 1977 to 1987), WAPDA was assigned the responsibility to establish and maintain a telemetric network of river and rain stations to support the flood forecasting models. A total of about forty such stations were established. The number was gradually reduced to about twenty due to maintenance problems, specially in respect of the river gauging equipment which developed frequent problems. It was decided to assign three categories to the telemetric stations in relation to their relative importance in flood forecasting. WAPDA maintained only fifteen category-1 stations during the last few years. The system is being replaced now with a new set of equipment using the meteorburst based communication system. A map showing the telemetric sites is given in Fig 4.2 WAPDA supports another Hydrometric data measurement and transmission system by the surface water Hydrology project. An overlap of the two systems also exists at a number of sites, most of which are within the Mangla catchment.

WAPDA 's telemetric network is directly linked to FFD and is looked after by and officer of the level of research officer whose office is located within the premised of FFD.

Beside WAPDA 's involvement in providing the Hydrometric flood data, it is also involved in providing the data from such hydraulic structures as Mangla and Tarbela dams and the chashma barrage.

A great scope exists in future in assigning the flood mitigation role to Mangla and Tarbela reservoirs by linking up to operation of the two reservoirs with the flood forecasting system. Resorting to pre-flood releases on the basis of the flood forecasts can create necessary flood storage.

Coordination between FFD and WAPDA sharply improved after the 1992 flood disaster. Daily meeting in the office of General Manager (planning) was held and as a result suitable advice was rendered to Tarbela and Mangla organizations. Such coordination is necessary specially when a serious flood situation is feared pertaining to any one of the three flood categories i.e., Category-1, 11,or 111. Pre-flood released may become necessary to create required flood storage incase of Category-11 and Category-111 floods. This will however need a reliable flood forecast, which is now available due to the newly established flood forecasting facilities provided under the Flood protection Sector project.

4 Provincial Relief organization.

Ultimate aim of flood warning is to reduce the potential loss to the life and property of the community living in the flood liable areas. Provincial relief organizations are charged with the responsibility pertaining to disaster preparedness, emergency response, and post disaster

activities pertaining to all disasters including floods. Consequently, under the present set up the flood Warning Center has been placed under the Relief Commissioner in addition to his normal duties. Relief Department primarily function through control and coordination of the personnel and resources of other government Departments generally organized as committees like flood commission and flood Warning Center. Relief functions at the district and Tehsil level are performed through the deputy Commissioner, who coordinate with the other departments to execute the flood mitigation function at the district level.

Flood preparatory actions required to be taken by the relief Commissioner include:

i) Arranging inspection of the flood protection works by the irrigation Department and Pakistan army to ensure that all vital flood protection bounds etc are in a satisfactory state of maintenance.
ii) To establish flood warning center and the flood centers at the district and Tehsil levels.
iii) To ensure that all flood related agencies/department involved in the process of flood mitigation are fully geared to perform the functions pertaining to their respective areas in the process of the flood mitigation.
iv) To ensure that flood forecasts/warnings are disseminated without loss of time to all concerned and that they are fully aware of the action to be taken under each situation.

These are some of the major actions required to be taken by the relief Commissioner before the onset of the flood season. During the flood emergency however he is to supervise the flood relief functions carried out by the district administration with the help of Pakistan Army and other government Departments.

5 Pakistan Army

Pakistan Army's corps of engineers under the common and control of Engineer-in-chief (E-IN-C) is charged with the responsibility to provide the necessary help to he civil authority to carry out the rescue and relief operations during and after the floods. It is the responsibility of the provincial government to provide all the support equipment (boats, life jackets, vehicles, tents etc) to the Army for such operation.

Pakistan Army's flood related function encompasses all the three phases of flood operations from the pre-flood to post flood phased including the all important flood phase. Pre-flood phase is the flood preparatory phase during which the adequacy and the serviceability of the flood fighting equipment are ensured. A number of pre-flood meetings are held at the level of E-IN-C to help coordinate the activities of the other organizations/agencies in providing the required support to the Army. Since Punjab is the most flood prone province, it is the Relief Commissioner Punjab, who provides the bulk of the flood fighting equipment to the Army. The CC Engineers 4 Corps of the Army that is stationed at Lahore acts as a liaison officer for the purpose. Pre-flood inspections of the flood protection structures are also carried out by the respective commander corps of engineers for their respective areas to ensure that the structures (bunds, barrages, spurs etc) are in satisfactory state of maintenance. Discrepancy, if any, is brought to the notice of the Relief Commissioner and PIDA. Sometimes joint inspections with PIDA are carried out to save time. Availability of sufficient stock of explosives to activate the breaches, if required, is ensured. However, due to many problems arising on account of purchase, storing and transporting of the explosives to the breaching sites, it has now been decide to do away with the explosives and instead to use bull-dozers for activating the breaches.

Pakistan Army's major flood related function starts after the flood occurs. An officer of the 4 corps engineers is placed on duty in the flood warning center to keep a close watch on the flood situation All flood forecasts and warnings are communicated to the CC Engineers 4Corps in time to be transmitted to the D.G. Engineers and all other CC Corps of the Engineers. Lack of understanding of the flood forecasts has been a major problem faced by the Army in the past, since they are not acquainted with the commonly used Hydrometeorological terms and no arrangement of the pre-flood training of the concerned CC Engineers Corps has so far been made. As the flood arrives, units of the Army move out to their respective areas of responsibility and carry out the relief and rescue operations in coordination with the civil administration. A major post flood meeting is held under the chairmanship of E-IN-C to discuss the performance of all the flood related agencies with the view to bring about the necessary improvement in future.

6 Commissioner for Indus Waters (C I W)

Pakistan has a unique flood-forecasting problem in the sense that greater part of the flood producing upper catchments of the Sutlej, Ravi and Chenab rivers lie across the border in India/held Kashmir. Further more a number of control structures like dams and barrages etc exist over the rivers across the border with the result that the free flow conditions are destroyed making the operation of the rainfall/runoff model extremely difficult. The situation underlines the need for the river flow data from across the border in respect of the important sites over the rivers in India/held Kashmir. Consequently, an agreement has been signed between the two countries through their respective 5-3 Commissioners for Indus waters, which includes a provision to receive from India such river flow and rain data as is considered important for flood forecasting in Pakistan.
A number of river flow stations are specified for this purpose. Normally once a day the data is received by the Pakistan Commissioner for Indus waters through a cable. The data is then passed on to the Chief Met FFD. Frequency of data reception is increased to six hourly and even to hourly in relation to the prevailing flood situation. Pakistan Commissioner for Indus waters is thus responsible to provide to the Chief Met FFD the much-needed data from India for use in the flood forecasting models.

Many problems have occurred in the past when the India data in respect of river Ravi was passed on to the press which resulted in the issuance of false alarm to the public. This is because large-scale attenuation of the flood wave occurs between Madhopur (India) and Jassar due to the physiographic characteristic of the catchment and the riverbed. Incidences are not uncommon when the flood peak at Jassar is reduced to 1/4th of its size at Madhopur. It has thus been decided that the India data as received through the Commissioner for Indus waters must not be public to avoid false alarm arising out of the wrong interpretation of the data. Leakage of this data to the press must be specially guarded since the press may publish threatening front line news of the approach of severe flood mentioning the same amount of the flood wave as given in the India report for Madhopur. Eventually when nothing arrives as compared to what was reported. Press may start to criticize India for providing the incorrect flood information. This puts Pakistan Commissioner for Indus waters in an embarrassing situation viz. a viz. his Indian counterpart.

It has therefore been decided that flood forecast as issued by Chief Met FFD only be given to the press

Pakistan Commissioner for Indus waters is the only forum through which any clarification or further information can be obtained from India with regard to flood data or the flood control structures etc.

7 Emergency relief cell (ERC)

Emergency Relief Cell has been established under the cabinet division and is controlled by the Cabinet Secretary. The Director General Relief heads the cell. Main function of the Emergency Relief Cell includes.

i) Planning and assessment of relief requirements of major disasters.
ii) Stock pilling of basic necessities needed during emergency such as dry ration, tarpaulins, blankets etc.
iii) Establishing emergency fund upon declaration of any part of the country as calamity affected.
iv) Maintaining contact with UNDP and other intentional aid giving agencies.
v) Making arrangements of disaster relief assistance from other countries.

ERC maintains two warehouses for stocking relief goods and the cell also maintains relief goods dispatch organization for the dispatch of the relief goods ERC maintains a fleet of helicopters which are given under the control of Army aviation base Dhamal and are flown by the Army pilots for the relief missions under the instructions of ERC.

Located at Islamabad ERC maintains contact with the Federal Flood Commission (FFC) and is one of the recipients of the daily flood report issued by FFC.

8 Federal Flood Commission (FFC)

FFC was established in 1977 to provide the necessary infrastructure at the federal level to help the provinces in meeting the technical and financial resources required to carry out the Flood Mitigation Measures.

During the recent past FFC has played a unique role in remodeling the flood mitigation policy of the country on modern lines with the help of the foreign loan mostly obtained from Asian Development bank (ADB)

The policy being implemented by the FFC encompasses both the engineering as well as the non-engineering measures. Non-engineering measures mainly pertain to establishment of a modern flood forecasting and warning system to provide timely and reliable flood information to the concerned flood mitigation agencies and the public in general. One big step towards this end is establishment of the 10 cm 's' band QPM Doppler radar at Lahore to afford the acquisition of the much needed rainfall data from across the border over Sutlej, Beas, Ravi and Chenab catchment through the process of remote sensing. The other big step is the establishment of improved flood forecasting models, which are to be operational at FFD after real- testing during 1997 flood. Improvement in the measurement and transmission of the Hydrometric data based up to the meteorburst communication system is also a part of the new project. The hydrodynamic flood routing model is a physically based model accounting for the hydrodynamical changes in the flood wave. The model calls for the survey of the channel geometry to determine the channel parameters at suitable intervals of the channel length. it has, therefore, built-in discharge elevation relationship which should readily yield the flood levels at any point along the channel.

A brief on the model is placed as annedure-1. This is of great advantage in the area of flood warning since it shall allow the estimation of the areas of inundation along the channel. Flood inundation maps shall be prepared to facilitate the identification of the villages likely to be inundated as against those considered safe, for a specific level of flood to be determined on the basis of running the hydrodynamic model.

A number of flood protection works have been executed and some are still in the process of implementation by the provinces through financial and technical support provided by the FFC.

In the context of flood warning dissemination, Chairman FFC (being also the Chief Engineering Advisor to the Federal Government) renders suitable advice to the president and the Prime Minister as and when the situation so demands. He carries out this function either directly or through the Minister of water & Power.

9 Flood Forecasting Division (FFD)

FFD of the Pakistan Meteorological Department plays a pivotal role in the entire flood mitigation process. Hydrometeorological data from the various national and international source is received in this Office which is then processed to produce flood forecasts and warnings to be disseminated outwards to various national organizations.

Major actions required to be taken by the Office before, during and after the flood season are summarized below.

a) Flood preparatory Measures

i) Ensure serviceability of the meteorological equipment including QPM Radar Lahore, QPM Radar Sialkot, Teleprinter network, FAX, APT, RTT and MDD Equipment.
ii) Ensure availability of the following items in sufficient to last for the whole of flood season: Surface and upper air meteorological charts, isohyetal maps, various forecast forms, data tabulation sheets stationery etc.
iii) Update the calibration of the radar and flood forecasting models
iv) Ensure availability of sufficient staff strength to maintain round the clock roster of duties for the meteorological and hydrological work.
v) Lilies with PTC's Coordination officer provide for 24hours maintenance services for the teleprinters, Internet and the office and residential telephones of all the flood-related functionaries.
vi) Conduct a familiarization training of the senior cadre and junior cadre govt. functionaries actively involved in the process of flood mitigation. Senior cadre training may be limited to one day only and must include such functionaries as the Relief Commissioner, Director General (Relief), Chief Engineer, Hydrology WAPDA, Chief Engineer FFC, Chief Engineer Hydrology and Drainage PIDA, Director Flood PIDA.

Training for the junior cadre may extend to a period of one week for the persons from various provincial and federal departments actually posted on flood duties.

Functions During the Flood Season

Direct FFD is personally responsible for the issuance of timely and reliable flood forecasts/warning to afford pre-flood initiation measures to reduce damage to the life and

property due to floods. He is required to remain in touch with his office even outside the worming hours to maintain a close watch on the flood generating weather situations. In case situation for Category-11 or category-111 floods develop he is to give advance verbal briefings to R.C. Punjab, Chairman FFC, D.G. Engineers (Army), D.G.Met and Member (water) WAPDA. Such briefing should be over and above the written qualitative forecasts issued when the approaching monsoon low/depressions draws closer. in order to avoid undue public panic, flood forecasts to the public should be given, only when the possibility of floods has positively developed, in which case suitably tailored flood forecasts must be provided to the press and the electronic media in time The argument that the false alarm to the public need be strictly avoided, must not be construed to mean that even the reliable flood forecasts, (when the flood situation becomes imminent) should be denied to the public. The benefit of the improved flood forecasting system must to the public by way of more reliable and more advanced flood information to them. It is also important that the necessary trust be placed in the forecasts issued by Chief Met FFD and under no circumstances the forecast issued by him allowed to be amended without his consent. This is because the flood forecasting is the sole prerogative of the Chief Met. FFD and no one else in the present set-up has the necessary technical means or the know-how to make any change. Violation of this basic principle has been the cause of depriving the nation of the timely and correct flood warnings in the past on a number of occasions.
Under a serious pre-flood situation Chief Meteorologist FFD may invite other members of the FFD (which include Director Floods of Irrigation Department, Chief Engineer (H & WM) of WAPDA and a representative of CIW) to an emergency meeting in his office to discuss the necessary flood related actions. Additionally, daily press briefings may be commenced in consultation with the Relief Commissioner Punjab. Special flood briefing may be conducted by the R.C.Punjab or the Minister or Revenue & Relief Government of Punjab.

In case of Category-111 flood situations a forecast of PMF in respect of Mangla/Tarbela be issued in yes/no terms and Member (water) WAPDA be personally informed of it by Chief Meteorologist, FFD.