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Development of National Flood Protection Plan-IV (NFPP-IV) and Related Studies to Enhance Capacity Building of Federal Flood Commission-FFC

DEVELOPMENT OF NATIONAL FLOOD PROTECTION PLAN-IV (NFPP-IV)

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LIST OF ABBREVIATIONS/ACRONYMS

ADB	Asian Development Bank
ADP	Annual Development Programme
AJ&K	Azad Jammu and Kashmir
AMSL	Above Mean Sea Level
AWB	Area Water Board
CCD	Climate Change Division
CCI	Council of Common Interests
DDMA	District Disaster Management Authorities
DEM	Digital Elevation Model
DR	Discount Rate
DTM	Digital Terrain Model
EIRR	Economic Internal Rate of Return
ERC	Emergency Relief Cell
FATA	Federally Administrated Tribal Areas
FDRP	Flood Damages Restoration Project
FEWS	Flood Early Warning System
FFC	Federal Flood Commission
FFD	Flood Forecasting Division
FLA	Federal Line Agencies
FoDP	Friends of Democratic Pakistan
FPL	Flood Protection Levee
FPM	Floodplain Map
FPSP	Flood Protection Sector Project
FR	Frontier Region
GB	Gilgit Baltistan
GIS	Geographical Information System
GLOF	Glacial Lake Outburst Flood
GoP	Government of Pakistan
GPS	Global Positioning System
HEC-HMS	Hydrological Engineering Centre - Hydrologic Modeling System
IDe	Irrigation Directorate
IDB	Islamic Development Bank
IFM	Integrated Flood Management
IMF	International Monetary Fund
IPOE	International Panel of Experts
ISDO	Irrigation and Small Dams Organization
JCRS	Jhelum Chenab Ravi Sutlej
JICA	Japan International Cooperation Agency
KP	Khyber Pakhtunkhwa
LiDAR	Laser Illuminated Detection and Ranging
LS	Lump Sum
M&R	Maintenance and Repairing
MBCS	Meteor-burst Based Communication System

MDO	Mangla Dam Organization
MIS	Management Information Systems
NASA	National Aeronautics and Space Administration
NDMA	National Disaster Management Authority
NESPAK	National Engineering Services Pakistan
NFPP	National Flood Protection Plan
NGO	Non-Governmental Organization
NHA	National Highway Authority
NTWC	National Tsunami Warning Center
O&M	Operation and Maintenance
PC	Planning Commission
PCIW	Pakistan Commissioner for Indus Waters
PDMA	Provincial Disaster Management Authority
PID	Provincial Irrigation Department
PMD	Pakistan Meteorological Department
PMPIU	Project Management and Policy Implementation Unit
PST	Pakistan Standard Time
PWD	Public Works Department
QPF	Quantitative Precipitation Forecast
RS	Remote Sensing
RTUs	Remote Terminal Units
SDLC	Software Development Lifecycle
SOP	Standard Operating Procedure
SoP	Survey of Pakistan
SRTM	Shuttle Radar Topography Mission
SWH	Surface Water Hydrology
TIN	Triangular Irregular Network
ToR	Terms of Reference
UNO	United Nations Organization
WAPDA	Water and Power Development Authority
WB	World Bank
WCAP	Water Sector Capacity Building and Advisory Services Project
WMO	World Meteorological Organization
WRD	Water Resources Division of NESPAK

TASK-A: DEVELOPMENT OF NATIONAL FLOOD PROTECTION PLAN-IV (NFPP-IV)

EXECUTIVE SUMMARY

ES.1 Introduction

Ministry of Water Resources, Government of Pakistan through Federal Flood Commission (FFC) under Water Sector Capacity Building and Advisory Services Project (WCAP) program engaged National Engineering Services of Pakistan (NESPAK) in association with Deltares of The Netherlands for 'Development of National Flood Protection Plan-IV with the following objectives:

i. Task-A: Develop 'National Flood Protection Plan-IV to be implemented during next 10 years based on innovative and integrated approach incorporating structural and non-structural measures for reducing floods, reducing susceptibility to flood damages and mitigating the flood impacts keeping in view constraints, gaps and lapses in the previous Flood Protection Plans, technical shortcomings and lessons learnt from past major flood events.
ii. Task-B: Develop a comprehensive inventory of the existing flood protection infrastructure of all regions of Pakistan (four provinces, Gilgit-Baltistan, FATA and AJ&K) constructed so far through various resources (Federal/ Provincial/Foreign Aided) and carry out benefit monitoring and evaluation of flood protection works, constructed under FPSP-I and II.
iii. Task-C: Carry out Floodplain Mapping and Zoning along all the Indus River and its major tributaries including Kabul and Swat Rivers, identify high, medium and low flood risk areas up to district level and prepare River Act for restricting/prohibiting permanent settlements in high and medium flood risk areas.
iv. Task-D: For the capacity building of Federal Flood Commission, develop a reliable database/information system to store and retrieve required data and enhance data processing techniques for preparation and dissemination of Flood Reports, as approved by the FFC, among the concerned organizations and design a web based interface for effective data sharing with all stakeholders at the federal and provincial levels, including public.

The Consultants commenced their work in June 2013 and submitted Draft reports on Task-A, B and C on January, 2015 and Task-D in February 2015. Thereafter, detailed discussions were held with WCAP, FFC, Provincial Irrigation Departments, PMD, WAPDA, NDMA and other stakeholders to obtain their suggestions for incorporation in the National Flood Protection Plan-IV. The Plan consisting of the following set of reports was submitted by incorporating the comments of Clients:

- National Flood Protection Plan-IV (*Executive Report*)
- Task-A: Development of National Flood Protection Plan-IV (NFPP-IV) and PC-I
- Task-B: Development of Inventory of Flood Works, and Benefit Monitoring and Evaluation of Flood Protection Works
- Task-C: Floodplain Mapping and Zoning
- Task-D: Automation of Flood Situation Monitoring and Reporting

ES.2 Planning Strategy for Developing Integrated Flood Management Plan

The planning strategy for development of National Flood Protection Plan-IV, in line with the current practices worldwide, has been focused on integrated flood management planning giving more emphasis to the non-structural measures like floodplain mapping, flood risk zoning, strict policymaking and legislation (River Act) to avoid encroachments on floodplains for agricultural purposes and housing settlements, watershed management measures in the uplands of rivers, strengthening of river gauging network and flood early warning and forecasting system and mitigation of floods through reservoir management besides structural measures like construction of storages, rehabilitation/strengthening of barrages/bridges and rehabilitation of existing protection works and building new protection bunds, dikes etc., wherever required in the various reaches of rivers. The main features of ‘Integrated Flood Management Plan’ are:

ES.3 Integrated Flood Management Plan

Integrated flood management has two distinct components i.e. structural measures and non-structural measures for flood management. Integrated flood management is a fusion of different strategies. Structural and non-structural measures help in accomplishing different strategies involved in integrated flood management as given in Table ES-1.

Table ES-1: Structural and Non-structural Measures in Integrated Flood Management

Strategy	Options	Category
Reducing Flood	Watershed management	Non-structural Measure
	Dams and reservoirs	Structural & Non-structural Measure
	High flow diversions	Structural & Non-structural Measure
	Channel improvement	Structural & Non-structural Measure
Reducing Susceptibility to Damage	Flood Forecasting and Early Warning	Non-structural Measure
	Strengthening of existing rain and river gauging network	Non-structural Measure
	Floodplain regulation	Non-structural Measure
	Construction of flood protection and river training works i.e. levees, dikes, spurs etc	Structural Measure
Mitigating the Flood Impacts	Information and education	Non-structural Measure
	Disaster preparedness	Non-structural Measure
	Post- flood recovery	Non-structural Measure
	Flood insurance	Non-structural Measure

The construction of dams, dikes levees etc., reduce the flooding and flood early warning can reduce the extent of damage caused by floods. An effective integrated flood management plan involves coherence and coordination between different strategies and departments responsible for respective tasks. Both integrated flood management components are included and are discussed in detail in the present Task-A Report.

ES.4 Category-wise Investment Plan for Next 10-Years

Flood Management Investment Plan has been prepared in detail, keeping in view the needs/requirements, with respect to flood protection, of four (4) provinces, FATA, Gilgit-Baltistan, Azad Jammu & Kashmir and various departments/organizations of the country. The important aspect in development of NFPP-IV is the contribution and consent of all stakeholders (Provinces/ Federal Line Agencies/ Organizations). After the 18th Amendment, it was necessary that NFPP-IV be presented in the meeting of Council of Common Interest (CCI) for approval and decision on implementation. During approval process in CCI meetings, Ministry of Water & Power proposed implementation for financing of NFPP-IV in two phases as; Phase-I: the first five (5) years and Phase-II: in next 5 years after financial closure of first phase. The total cost of next 10 years Flood Protection Plan is proposed to be Rs. 332,246 million with Rs. 290,919 million for structural measures and Rs. 41,327 million for non-structural measures. A category-wise summary is presented in Table ES-2.

Table ES-2: Category-wise Summary of Cost for Structural and Non-Structural Measures

Description		Cost in Million Rupees
I. Structural Measures		
1.	Construction of Proposed Flood Protection Works.	193,936
2.	Flood Management Structures Across Hill Torrents and Flood Generating Nullahs.	56,697
3.	Feasibility & Detailed Design Studies of Barrages and Hydraulic Structures.	1,500
4.	Master Planning, Feasibility Studies, and Detailed Designing Studies.	3,751
5	Physical Hydraulic Model Study for Major Railway Bridges and Improvements of Existing Flood Protection Facilities of Pakistan Railway.	450
6	Physical Hydraulic Model Study for Selected Reaches of Major Rivers.	200
7	Measures for GLOFs & Land Sliding in Hilly Areas.	1,000
8	Remodeling & Proper Maintenance of Drainage System in Lower Indus.	9,763
9	Coastal Flood Protection Works.	1,622
10	Flood Mitigation, Channelization and Execution of the Lai Nullah Project (Only Flood Component).	16,000
11	Studies for Proper Town Planning in Future and Improving the Existing Storm Drainage System of Urban Areas.	1,000
12.	Provision of Annual Funds under Provincial ADPs for Flood Fighting Activities during Flood Season and Procurement & Repair of Flood Fighting Equipment & Machinery under PIDs.	5,000
Sub-Total (I)		**290,919**
II. Non-structural Measures		
1.	Up-gradation & Expansion in the Existing Flood Forecasting and Warning System of PMD.	14,000
2.	Up-gradation, Installation and Expansion in the Existing Gauging System of WAPDA.	2,297
3.	Study to be Conducted for Removal of Encroachments in major Rivers & Hill Torrents and Procurement of LiDAR's.	750
4.	Study and Implementation Cost for Development of Watershed Management in Upper Catchment Areas of Rivers & Hill Torrents.	4,500
5	Disaster Management Activities by NDMA, Rescue and Relief.	18,320
6	Study for Drought Management	50
7	Feasibility/Technical Studies for Ramsar Sites.	30
8	Capacity Building for All Institutions Dealing with Flood Management in the Country.	1,380
Sub-Total (II)		**41,327**
Grand Total (I+II)		**332,246**

ES.5 Department/Area-wise Selected Number of Schemes and Estimated Costs

As a part of Flood Protection Investment Plan for next 10 years, out of total 908 flood protection schemes/works proposed by the provincial and federal departments/agencies for, 583 schemes have been selected after passing through a scrutiny process for their selection based on technical and economic details like location map, layout plan, engineering details, flood mitigation impact, capital costs, O&M costs, benefits, etc. Department/Area-wise selected schemes and their cost estimates for Phase-I are provided in Table ES-3.

Table ES-3: Summary of Selected Projects/Schemes for NFPP-IV (Phase-I)

Sr. No.	Departments / Federal Line Agencies	Number of Schemes	Estimated Cost (Rs. Million)
1	Punjab Irrigation Department	53	23,350
2	Sindh Irrigation Department	51	21,351
3	Khyber Pakhtunkhwa Irrigation Department	72	20,000
4	Balochistan Irrigation Department	259	17,700
5	Gilgit-Baltistan Region	29	1,932
6	FATA Irrigation & Hydel Power	72	3,098
7	AJ&K Irrigation & Small Dams	47	3,561
	Sub-Total	**583**	**90,992**
8	PMD (6 Nos. Projects/Studies)	-	4,505
9	WAPDA (6 Nos. Projects/Studies)	-	2,297
10	NHA (8 Nos. Studies)	-	-
11	Climate Change Division (4 Nos. Studies)	-	30
12	Pakistan Railways (Bridges + Bunds Improvements)	-	450
	Total		**98,274**

ES.6 Short Term, Medium Term and Long Term Measures

There are certain flood protection projects/schemes/studies that need to be implemented on top priority basis in order to achieve the objective of country-wide flood management at the earliest possible time. Thus, an implementation plan based on best managerial judgment and engineering skill, assigning priority to each of selected schemes as Top Priority to achieve Short term goals, High Priority to achieve Medium term goals, and Medium Priority to achieve Long term goals, has been developed.

ES.7 Yearly Funding Requirements for Implementation of National Flood Protection Plan-IV

Keeping in view the priority of works, expected initiation and completion of projects/ schemes/studies etc., phasing of investment over next 10 years has been determined for implementation of NFPP-IV. The cost for each activity during each of 10 years has been summed up to determine financial requirements to be arranged for each of next 10 years. These are presented in Figure ES.1.

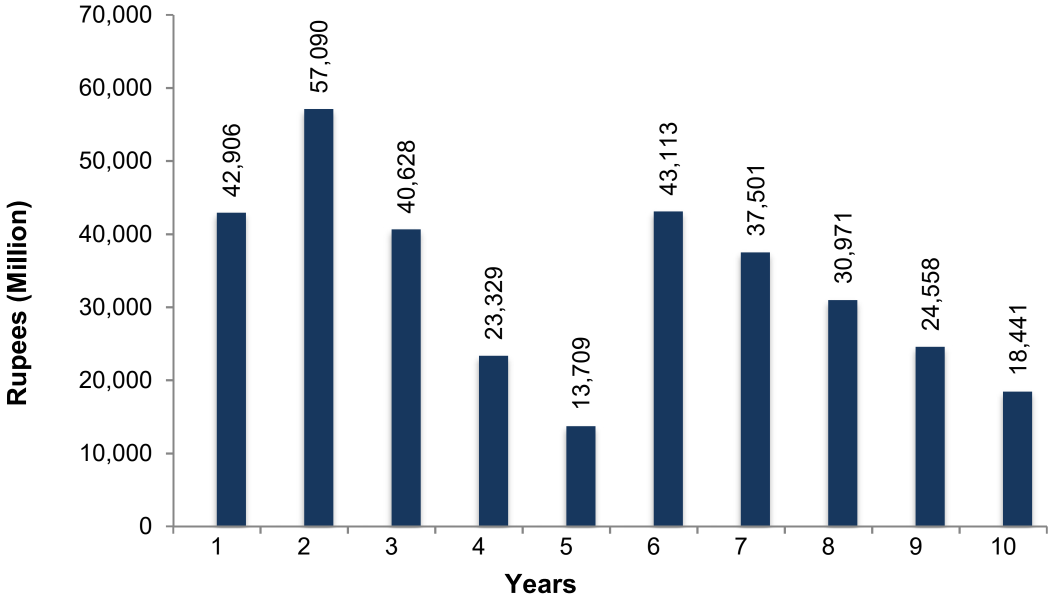

Figure ES.1: Yearly Funding Requirements for Next 10 Years

ES.8 Important Recommendations

Some of the important recommendations are given below for effective implementation of National Flood Protection Plan-IV for the next 10 Years:

i. Major reservoirs need to be constructed on priority basis to help in flood mitigation, preserve the flood water for overall irrigation system but for control releases downstream of Kotri to check seawater intrusion besides many other benefits.

ii. Existing reservoir Standing Operating Procedures (Revised in 2015 by FFC) for major reservoir to be implemented to ensure efficient control of floods in order to provide maximum relief to downstream areas.

iii. Rehabilitation and enhancement of flood passing capacity of barrages and bridges needs special attention for their immediate execution.

iv. Adequate conveyance capacity within the river and urban channels needs to be restored by removing bottle necks and encroachments.

v. Analysis indicate that small dams have substantial potential in mitigating flood peaks from their respective catchments. It is recommended to consider construction of various small dams in KP, AJ&K, Punjab and Balochistan for cumulative impact on flood mitigation from flash flooding. The pre-feasibility/feasibility studies on these dams may be taken-up by the provincial governments from their own resources.

vi. Flood Early Warning System needs to be up-graded on immediate basis for inclusion of catchment area upstream of Tarbela dam, updating of existing river and floodplain geometry, study on Radar calibrations, enhancement in reliability of Quantitative Precipitation Forecast (QPF) through meteorological studies and training of PMD professionals. Reliable and accurate QPF estimate can enhance lead times for forecast of flash floods.

vii. Expansion and up-gradation of existing gauging network, Radar network, telemetry network under PMD and WAPDA should be undertaken.

viii. Repairing, strengthening and up-gradation of existing flood protection works need to be carried out on immediate basis through provincial resources to protect the population and infrastructure against flood threat. Operation and Maintenance (O&M) of existing flood infrastructure is a key issue which is sole responsibility of provinces. It is highly recommended that provinces take concrete steps towards O&M by providing adequate and timely resources. Water charges may be enhanced initially to at least Rs. 1,500 per acre (as recommended by Friends of Democratic Pakistan (FoDP) assembled after 2010 floods), yielding an annual revenue of Rs. 33 billion for 22 million acres of Punjab alone.

ix. Conduct comprehensive studies for all existing breaching sections to ascertain their effectiveness and possible flow paths, flow depths, velocities and inundation extents of breach flood flows.

x. Formulate and implement watershed management policy for re-forestation, soil conservation and improvement in land use in the watersheds and carry out necessary legislation at national level as well as provincial level.

xi. ‘River Act’ for the rivers floodplains has been formulated during current NFPP-IV studies keeping relevant stakeholders on board and there is strong need to implement the 'River Act' in its real sense and spirit for removing encroachments, permanent settlements and undue developments in the floodplains so that flood damages can be reduced.

xii. Provinces, NDMA, PDMAs and DDMAs etc., should play active role through workshops, electronic and print media to create awareness in flood prone communities for preparing them to fight against floods. Awareness campaigns for removal of encroachments and un-planned developments in floodplain areas should be initiated.

xiii. Institutional reforms, capacity building and training of FFC, PIDs, NDMA, PDMAs, and other related departments/agencies/organizations is recommended on priority basis.

1. INTRODUCTION

1.1 PREAMBLE

The super flood of 2010 in Indus River corresponding to a highest return period at Tarbela, caused unprecedented damage of US$10 billion which is nearly half of the cumulative damage of US$19 billion in the past64 years period from 1950 to 2014. This event coupled with successive flood events in 2011, 2012, 2013 & 2014 and equally disastrous flood events globally not only raised the deep concerns about the perceived effects of Global Warming and Climate Change but also exposed the inadequacy and ineffectiveness of traditional approaches alone to control floods, flood management and mitigation of flood damages. It is now an established fact that flood control structures (levees, flood walls, bunds), embankments etc., designed for specific return periods (50,100 years) encourage increased economic activity in adjoining areas resulting in higher flood damages wherever the design capacity of such structures in exceeded.

This realization has evolved the idea of an integrated flood management approach which emphasizes, in addition to structural measures, the use of a broad range of non-structural measures consisting of flood warning, floodplain land use legislation, organizational roles down to local level, flood insurance, community participation etc., with the sole purpose of minimizing of flood damages from future unavoidable flood events of greater magnitudes.

1.2 BACKGROUND

History of flood events in Pakistan from 1950-2014 indicates direct losses of about US$ 38,055 million. Only during 2010 flood, about 1,985 people lost their lives, 1.6 million houses were destroyed, 17,553 villages and a total area of 160,000 km^2 were affected. Consequent to disastrous 1973 & 1976 floods, the need of a central planning and coordinating agency was felt and Federal Flood Commission (FFC) was established under Ministry of Water & Power. Since its creation FFC has greatly contributed in integrating the planning measures at the national level and providing financial resources for the flood management projects.

FFC formulated National Flood Protection Plans (NFPPs) I, II and III in years 1978, 1988 and 1998, respectively in recognition of the impact of floods on the socio-economic conditions and the need for continuous and uninterrupted efforts for solution of the problems. The primary focus of NFPP-I (1978) and NFPP-II (1988) was on construction of flood protection embankments, bunds, spurs etc in vulnerable reaches in rivers, cities and locations of key installations and infrastructure. NFPP-III (1998), to some extent shifted the focus to non-structural measures which included institutional reforms and strengthening (Component-A), development of Flood Protection Works (Component-B) and development of Flood Early Warning Systems (FEWS) and floodplain mapping and zoning (Component-C). In view of huge flood damages of 2010 flood, the focus of NFPP-IV on non-structural measures with provision for restoration and maintenance of existing flood protection works. However, key area where need of flood protection works is identified, those will be considered for construction.

1.3 OBJECTIVES OF NFPP-IV

The formulation of NFPP-IV is aimed at improving country-wide comprehensive flood management planning, implementation and monitoring to essentially achieve flood management objectives. For this purpose, required detailed studies were planned and it was planned to conduct these under the World Bank fund for ‘Water Sector Capacity Building and Advisory Services Project (WCAP). The present project studies are also being executed in collaboration with FFC under WCAP.

The main objective of the overall study is the development of comprehensive flood protection plan and to chalk out an investment schedule based on the lessons learnt in perspective of 2010-2014 floods. In addition, there is a strong need for updating of floodplain mapping and zoning for identification of high, medium and low flood risk areas so that emergency evacuation and relief plans can be formulated and implemented as well as restricting developments/construction of permanent settlements in high risk zones through legislation. As FFC is empowered to monitor the requirement and implementation of flood protection works across Pakistan, there was an essential need for capacity building and scrutinizing existing and planned flood protection structures/schemes through a detailed inventory and web based information/data management. Accordingly, overall project has been distributed into the following tasks:

Task-A: Development of National Flood Protection Plan -IV (NFPP-IV) and PC-I
Develop a National Flood Protection Plan-IV (NFPP-IV) and umbrella PC-I for next 10 years based on integrated and innovative approaches and technical shortcomings and lessons learnt in the past major flood events.

Task-B: Development of Inventory of Flood Works, and Benefit Monitoring and Evaluation of Flood Protection Works
Develop a comprehensive inventory of the existing flood protection infrastructure of all regions of Pakistan (four provinces, Gilgit-Baltistan, FATA & AJ&K) constructed so far through various resources (Federal/ Provincial/Foreign Aided) and carry out benefit monitoring and evaluation of flood protection works, constructed under FPSP-I and II.

Task-C: Floodplain Mapping and Zoning
Carry out Floodplain Mapping & Zoning along all the Indus River and its major tributaries (Kabul, Swat, Jhelum, Chenab, Ravi & Sutlej) and prepare River Act for restricting/prohibiting permanent settlements in high and medium flood risk areas (Provinces to enact River Act).

Task-D: Automation of Flood Situation Monitoring and Reporting
Develop a reliable database/information system to store and retrieve required data and enhance data processing techniques for preparation and dissemination of Flood Reports, as approved by the FFC, among the concerned organizations and design a web interface for effective data sharing with all stakeholders at the federal and provincial levels, including public.

1.4 SCOPE OF SERVICESAND CONSULTANT'S TOR

The scope of consultancy services for four (4) major Tasks; A to D and their sub-tasks are detailed below:

Task-A: Development of National Flood Protection Plan-IV (NFPP-IV) and PC-I

i) Review the previous National Flood Protection Plans and other Flood Management related documents in view of lessons learnt from major flood events occurred in past in the country, especially 2010 and 2011 Flood Events.

ii) Identify gaps and shortcomings with reference to effectiveness for flood protection/ management keeping in view of major flood events, especially 2010 and 2011 Flood Events.

iii) Review of existing structural and non-structural flood protection and management interventions including but not limited to; spurs, bunds, flood protection walls, dykes, flood embankments, Flood Forecasting and Warning system etc. and identify cost-effective and sustainable, structural and non-structural measures in the context of integrated flood management.

iv) Review and assess possible flood paths/escape channels to divert flood water to desert areas or/and off channel storages/retention to reduce/absorb peak flood discharges in Indus River System and give recommendations in the context of integrated flood management.

v) Give recommendations for integrated flood management including but not limited to; watershed management/flash flood management, up-gradation of existing Flood Forecasting and Warning System, implementation of structural flood protection measures (spurs, bunds, flood protection walls, dykes, flood embankments etc.) along major and other rivers including Hill Torrents/flood flows generating nullahs in vulnerable reaches.

vi) Review previous studies carried out for capacity building of FFC dealing with flood management, and give consolidated recommendations for implementation on the findings of previous studies.

vii) Formulate a National Flood Protection Plan (NFPP-IV) for next 10 years based on integrated and innovative approaches in light of findings of activities (i) to (vi) above and recommend comprehensive short-term and long-term management and implementation plans for the integrated flood management in consultation with FFC and Client.

viii) Prepare umbrella PC-I for 10 years for the entire investments to be recommended under NFPP-IV in consultation with FFC.

Task-B: Development of Inventory of Flood Works and Benefit Monitoring and Evaluation of Flood Protection Works

i) Review all available data/information on existing flood protection works carried out so far through Federal/Provincial/Foreign resources all along the Indus River and its major tributaries including Hill Torrents/flood flows generating nullahs but not limited to; Flood Protection Sector Projects.

ii) Develop a comprehensive inventory of the existing flood protection infrastructure of all regions of Pakistan (four Provinces, Gilgit-Baltistan, FATA & AJ&K) providing description/information including but not limited to; reference/code number, name of river/stream/nullah, name of district, type of structure, length, height, name of the program, name of the flood protection scheme, cost, year of completion, executing agency (Federal/Provincial), etc.

iii) Prepare current status of flood protection infrastructure including but not limited to; physical intact, damaged (minor/major), washed away etc. in consultation with Federal/Provincial Departments for each region of Pakistan (four Provinces, Gilgit-Baltistan, FATA & AJ&K).

iv) Review all available data/information on flood works executed under "Flood Sector Projects" but not limited to; completion reports, and carry out benefit monitoring and evaluation of flood protection works carried out under Flood Sector Project I & II in compliance with Planning Commission's reporting format as per FFC requirements and give recommendations for effective implementation of future flood protection works.

v) Revisit mandate Cell of FFC, its requirements and give recommendations for capacity building to perform its functions effectively for monitoring of flood protection/management works/projects.

Task-C: Floodplain Mapping and Zoning

i) Review all previous available data/information on Floodplain mapping and zoning all along the Indus River and its major tributaries but not limited to; Flood Protection Sector Projects and identify gaps and shortcoming with reference to their effectiveness and flood management, especially in the context of 2010 and 2011 Flood Events.

ii) Prepare Floodplain maps for additional reaches and update existing Floodplain maps/risk maps showing extents of inundated areas in view of most severe floods occurred in past, especially, 2010 and 2011 flood events. These maps shall cover Indus River and its major tributaries downstream of Tarbela reservoir up to Arabian Sea, besides Kabul and Swat Rivers upstream Nowshehra Bridge, to provide coverage to Peshawar and Charsadda Districts and Swat Valley.

iii) Prepare submergence plans on district level for critical reaches/flood plains along flood embankments on rivers and identify high & medium flood risk areas.

iv) Identify and recommend low flood risk areas for future developments such as towns, villages, industrial areas etc.

v) Review current relevant policies, laws and acts and prepare river act for restricting/prohibiting permanent settlements in high and medium flood risk areas in light of recommendations of Floodplain mapping/zoning studies (Provinces to enact river acts).

Task-D: Automation of Flood Situation and Reporting

i) Reviewing the existing FFC data requirements for flood situation monitoring and reporting.

ii) Review existing database, data/information receiving/collection, storage, retrieval, processing system and transmission of data.

iii) Design and develop an integrated database structure for efficient data/ information collection, processing, storage and retrieval of required data as per FFC requirements.

iv) Develop a reporting procedure and reporting format to assist the FFC and provide information to all stakeholders as per FFC requirements.

v) Design a networking system for sharing information within FFC.

vi) Design and develop detailed Terms of Reference (TORs) including hardware and software with complete specifications to be required to setup a Flood Situation Monitoring and Reporting Cell, with the consultation of FFC.

vii) Prepare procurement/bidding documents and cost estimates for supply and installation of hardware and software as per the World Bank Guidelines in coordination with FFC and Client.

viii) Supervise supply and installation of hardware and software, testing and final checks before handing/taking over the final supplied and installed facilities by the FFC. The Consultant shall also submit the satisfactory completion certificate(s), beside the Project Completion Report.

ix) Upgrading existing website of FFC and establish its links for effective data/information sharing among all stakeholders as per FFC requirements.

x) Develop linkages of FFC database with Flood Forecasting Division Lahore database and other stations and databases as per FFC requirements for data/information receiving and transfer for flood situation monitoring and flood reporting.

xi) Prepare training manuals and conduct training programs of the relevant staff of FFC for use of database, networking system and web-based applications.

1.5 REPORTSTRUCTURE

The present report pertains to the Task-A: Development of National Flood Protection Plan-IV (NFPP-IV) and its related issues. This report provides information on history of floods in Pakistan in Chapter-2. A comprehensive review of previous Flood Protection Plans and related documents is provided in Chapter-3. A detailed discussion on existing flood management practices including structural and non-structural measures is provided in Chapter-4. Future challenges in view of Global Warming and Climate change, Trans-boundary water management, Environmental management and financial resource management is discussed in Chapter-5. Chapter-6 provides information on planning strategy, objectives and goals under NFPP-IV. Integrated Flood Management being the focus of next ten years planning has been comprehensively discussed in Chapter-7. The procedure for identification, evaluation and selection of flood protection schemes for inclusion in NFPP-IV has been provided in Chapter-8. Flood protection investment plan for next 10 years including phasing and details on investments is provided in Chapter-9 of this report. Economic Appraisal of proposed Flood Protection Schemes is given in Chapter-10 and Conclusion and Recommendations is provided in Chapter-11.

Various important inter-linked activities carried out during NFPP-IV studies to conclude at investment plan have been discussed in separate reports. Necessary references to separate reports have been made for reader facilitation at appropriate places in report.

A total of seven (7) Annexures and thirteen (13) Exhibits have been provided in the present report to assist reader in grasping necessary information on activities carried out during preparation of NFPP-IV.

PC-I has been submitted as separate document for approval of different stakeholders/ ministries.

2. HISTORY OF FLOODS IN PAKISTAN

2.1 MAJOR RIVERS- THE SOURCE OF FLOODS

2.1.1 Origin and Geography of Major Rivers

Pakistan's major rivers originate from the northern mountains of Himalaya, Karakoram, Hindukush and Kashmir ranges and drain one by one into another and finally fall into Indus river creating the Indus River Basin (IRB). Indus river is the twelfth largest river in the world and a major trans-boundary river in Asia.

<u>Indus River</u>

The Indus river originates from the Tibetan plateau and it first flows in north-westerly direction till Gilgit from where it takes a south-westerly course and finally debouches in the Arabian sea south-east of Karachi city. The basin covers an area of about 1 million km^2 and touches six countries (China, India, Afghanistan, Nepal, Bhutan and Pakistan). A number of large and small tributaries join the Indus river. Snow and glacier melt is the main water input for this river system as rainfall is low in this region, and is generally concentrated to the monsoon season of July to September. Its five large tributaries on the left bank are Jhelum, Chenab, Ravi, Beas and Sutlej. Ravi, Beas and Sutlej are trans-boundary Rivers, with upper catchments in India. The main right bank tributaries are Swat, Kabul, Kurram, Gomal, Sanghar and Kaha. Kabul River is also trans-boundary River that flows through Afghanistan and Pakistan. Pakistan's major rivers & their tributaries are shown in Figure 2-1.

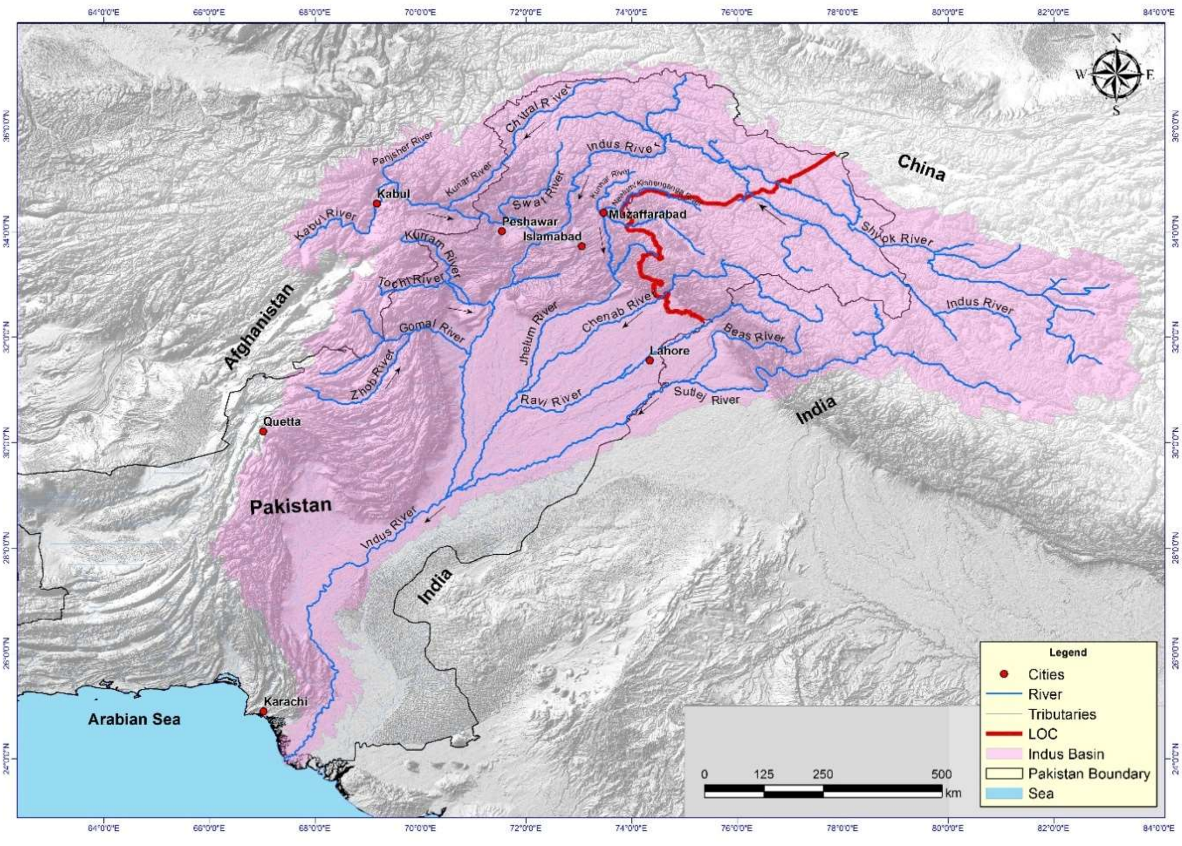

Figure 2-1: Indus River Basin-Map of Major Rivers in Pakistan

River slope in the upper reaches till Kalabagh are steep, with an average slope of 3.7 m/km. At Kalabagh, Indus flows out into the plains, becoming a wide braided river with mild slopes, ranging from 0.24 m/km up to Mithankot to 0.11 m/km in its lower reach. The climate of the upper basin is dominated by westerly air masses, which contribute late winter snowfall to massive glaciers and snowfields, whose melt-waters define the annual and long-term hydrologic regime of the Indus. The Indus receives runoff from number of ranges of Pakistan before it falls in the sea. Its annual runoff is about 200 cubic km and sediment discharge is approximately 200 billion km yearly[1].

Jhelum River

The Jhelum River is one of the major tributaries of Indus River System. The source of the river is at Anantnag in Kashmir valley. The basin map of the Jhelum River is shown in Figure 2-2. It is located between Indus and Chenab River catchments, draining a basin area of 63,500 km^2 (25,520 $mile^2$). The river takes its rise in Kashmir, about 100 km (62 mile) south-east of Srinagar.

Downstream of Srinagar, the river traverses marshy land until it falls in Wularlake 165 km (103 mile) from its source. The downstream of Wular lake, near Sopor, Pohru river, joins the Jhelum River draining a basin of 1,905 km^2(735 $mile^2$). The Jhelum River flows roughly in westerly direction downstream of Baramula, until it joins its largest tributary Neelum River (Kishan Ganga) near Muzaffarabad. The Neelam River originates from Krishansar lake runs northwards to Badoab village where it meets a tributory from the Dras side and runs westwards along the Line of Control in Jammu and Kashmir, enters Azad Kashmir and then runs west until it meets the Jhelumat Muzaffarabad. Neelum river drains an area of 7,356 km^2(2,840 $mile^2$). About 12 km (7.5 mile) downstream of the confluence with Neelum, Jhelum River is joined by Kunhar river, another tributary with basin area of 2,435 km^2 (940 $mile^2$). From here river at Muzaffarabad turns and flows for about 142 km (89 mile) to Mangla reservoir. On its way, it is joined by Mahl and Gun rivers near Azad Pattan. Kanshi and Poonch rivers directly drain into Mangla reservoir.

Poonch river, which drains nearly 4,222 km^2(1,630 $mile^2$) steeply sloped land on the western flanks of the Pir Panjal range, is a very fast responding river producing flashy flood. Kanshi river drains an area of 1,658 km^2(640 $mile^2$). When entering the plains downstream of Mangla, the cross-sectional geometry of Jhelum river changes from a deep single channel to a shallow compound one with wide flood plain, particularly downstream of Rasul barrage. Jhelum is joined by Suketar and Jabbanullahs between Mangla and Jhelum city, draining some 720 km^2 (281 $mile^2$) of area south-east of Mangla reservoir. Kahan and Bunhanullahs, with catchment areas of 1,070 km^2 (413 $mile^2$) and 1,175 km^2(459 $mile^2$) enter Jhelum on the right side u/s of Rasul barrage. After travelling about 820 km (512 mile), it joins Chenab River u/s of Trimmu barrage.

[1]*Indus Basin Floods, ADB Report, 2013*

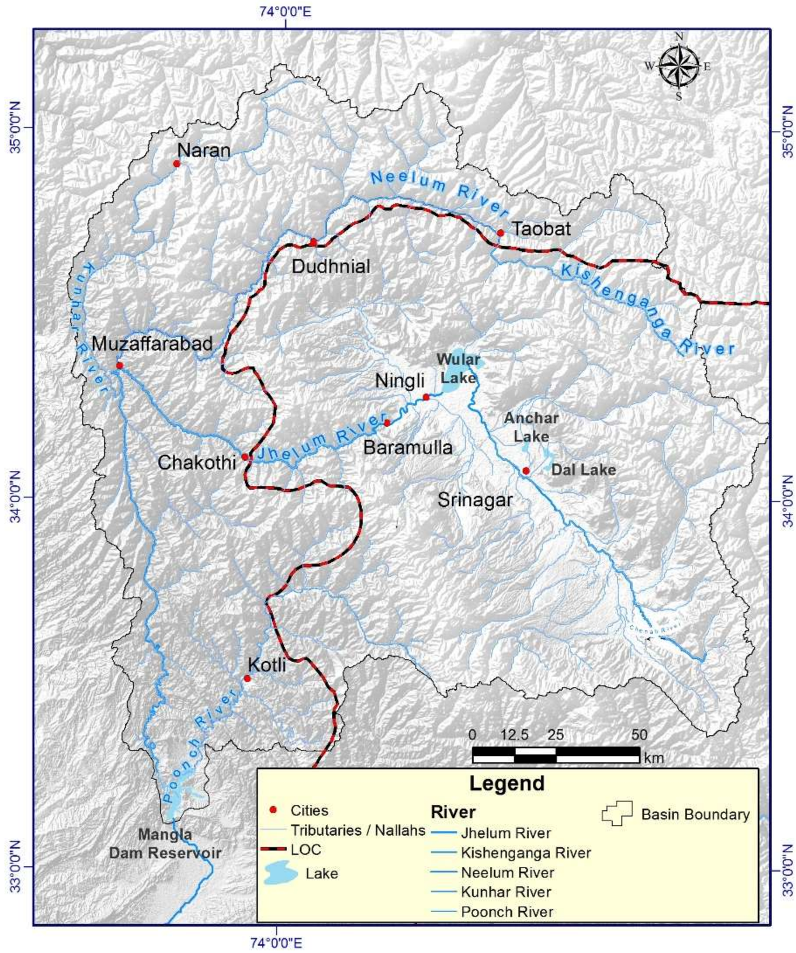

Figure 2-2: Jhelum River Basin

<u>Chenab River</u>

The Chenab River is a major river flowing through India and Pakistan. It originates in the upper Himalayas in the Lahaul and Spiti districts of Himachal Pradesh, India and flows through the Jammu region of Jammu and Kashmir into the plains of the Punjab, Pakistan near Diawara village in Sialkot district, as shown in Figure 2-3. In the upper reach, the river first flows in north-westerly direction till Benswar, where it is joined by Maru River. Downstream of Benswar the River takes a sharp turn to the south while traversing the Pir Panjal Range. Here, it again turns to the south till it flows out into the plains at Akhnoor, 34 km (21.25 mile) from the line of control, to change its course into south-westerly direction. Near the line of control in Pakistan territory, Chenab is joined by two major tributaries, Munawar tawi and Jammu tawi about 2 km (1.25 mile) upstream of Marala barrage. Chenab enters Pakistan about 11 km (7 mile) upstream of Marala barrage, which is a rim station on Chenab River.

Marala barrage is the first important structure on Chenab River in Pakistan from where water is diverted into Upper Chenab Canal and Marala Ravi Link Canal. Below Marala barrage, the river passes through an alluvial plain of Punjab province for a distance of 637 km (398 mile). It is joined by the Jhelum River upstream of Trimmu barrage, 64 km (40 mile) further downstream by the Ravi River and upstream of Panjnad by the Sutlej River. The Chenab River basin measures 67,515 km^2 (26,079 mile^2), which makes it the largest of the Punjab rivers. From its source in Himachal Pradesh in India till the confluence with Indus River at Sarki village, some 35 km (21 mile) up-stream of Mithankot, Chenab traverses a length of about 1,235 km (772 mile).

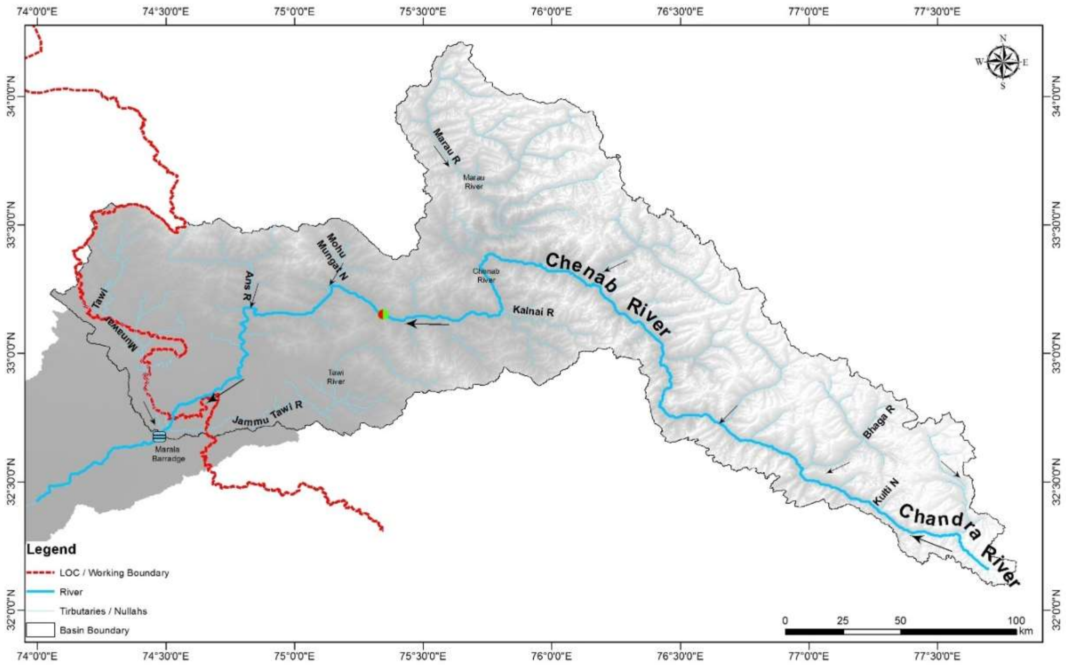

Figure 2-3: Chenab River Basin

Ravi River

The river originates in the Himalayan Mountains in the centre of the Indian state of Himachal Pradesh. The basin map of the Ravi River is shown in Figure 2-4. The river drains a catchment area of over 40,000 km^2 (15,444 mile^2) from its source to the confluence with Chenab River. The river enters Pakistan at Kot Naina, about 33 km (21 mile) upstream of the rim station of Jassar Bridge. Then, for more than 100 km (63 mile) all the way down to Ravi syphon, the Ravi forms the border between Pakistan and India. From Jassar bridge, it traverses through 385 km (241 mile) before joining Chenab River, about 75 km (47 mile) below Trimmu barrage. Sidhnai barrage is the last structure on Ravi River, which is located 27 km (17 mile) upstream of its confluence with Chenab River.

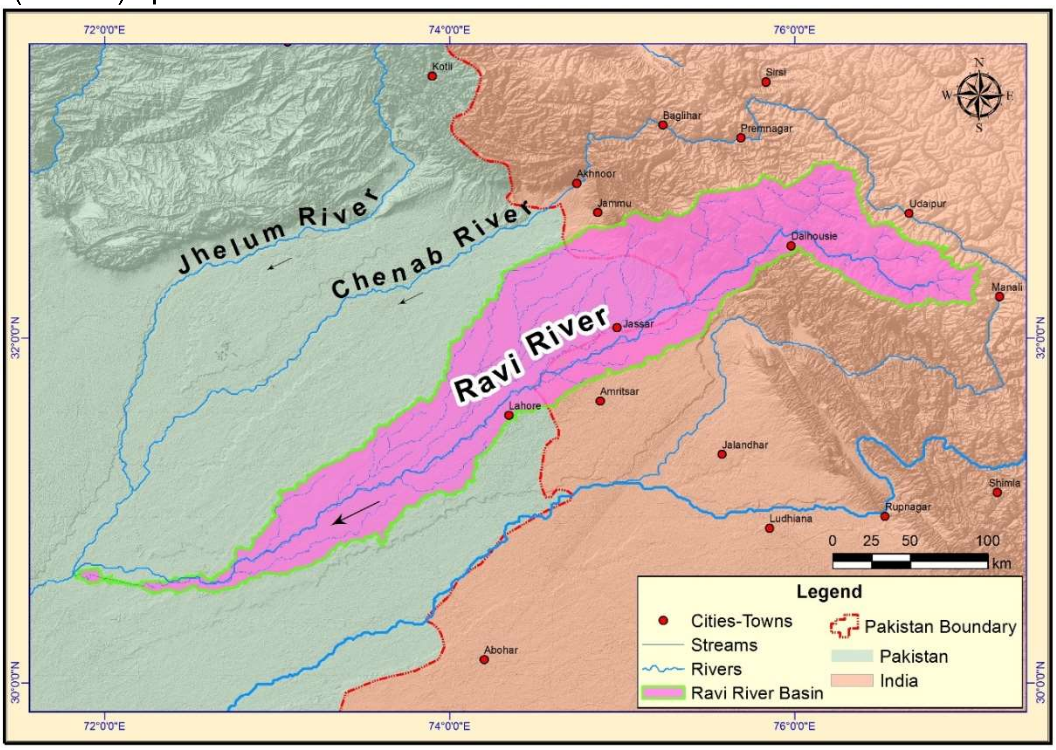

Figure 2-4: Ravi River Basin

<u>Sutlej River</u>

Sutlej River originates in western Tibet, south of the Kailash Mountain Range. The basin map of the Sutlej River is shown in Figure 2-5. The river flows first in north-westerly direction, crossing the Manasarovar and Rakas Lakes north of the Tibet-India-Nepal triple point, and drains the northern slopes of the Great Himalayas Range with mountain peaks rising up to 7,800 m (25,600 ft). Near the Tibetan-Indian border, the river is joined by Spiti and Beas Rivers. These two are the major tributaries of Sutlej. Thereafter, Sutlej River crosses the Great Himalayas Range and while leaving the Himalayas to enter the plains of Indian Punjab, Sutlej shifts southward to regain its westerly course at Rupnagar. The river enters Pakistan downstream of the Ferozepur barrage.

Its main tributary, Beas river, with a catchment area of 15,251 km^2 (5,890 mile^2) joins Sutlej river on the right bank, about 51 km (32 mile) upstream of Ferozepur, just above Harike barrage. The Sutlej River reaches Pakistan about 10 km (6 mile) downstream of Ferozepur barrage, where the borderline mingles with the river alignment. Thereafter, it becomes border line for some kilometers and only from Bakerke onward, some 15 km (9 mile) downstream of Ferozepur, Sutlej River runs entirely in Pakistani territory. The rim station Ganda Singh Wala is located a few hundred meters downstream of Ferozepur barrage.

Downstream of barrage, it flows down in the same south-westerly direction for about127 km (79 mile) till it reaches Suleimanki barrage. Below Suleimanki barrage, it further flows in a south westerly direction covering a distance of about 193 km (121 mile) before reaching Islam barrage, which is another important structure on the river. It further flows down for about 238 km (149 mile) to join Chenab River upstream of Panjnad barrage. During its course in Pakistan, no significant tributary joins the river. The total length of river Sutlej is about 1,552 km (964 mile) and the catchment area is 122,000 km^2(47,100 mile^2).

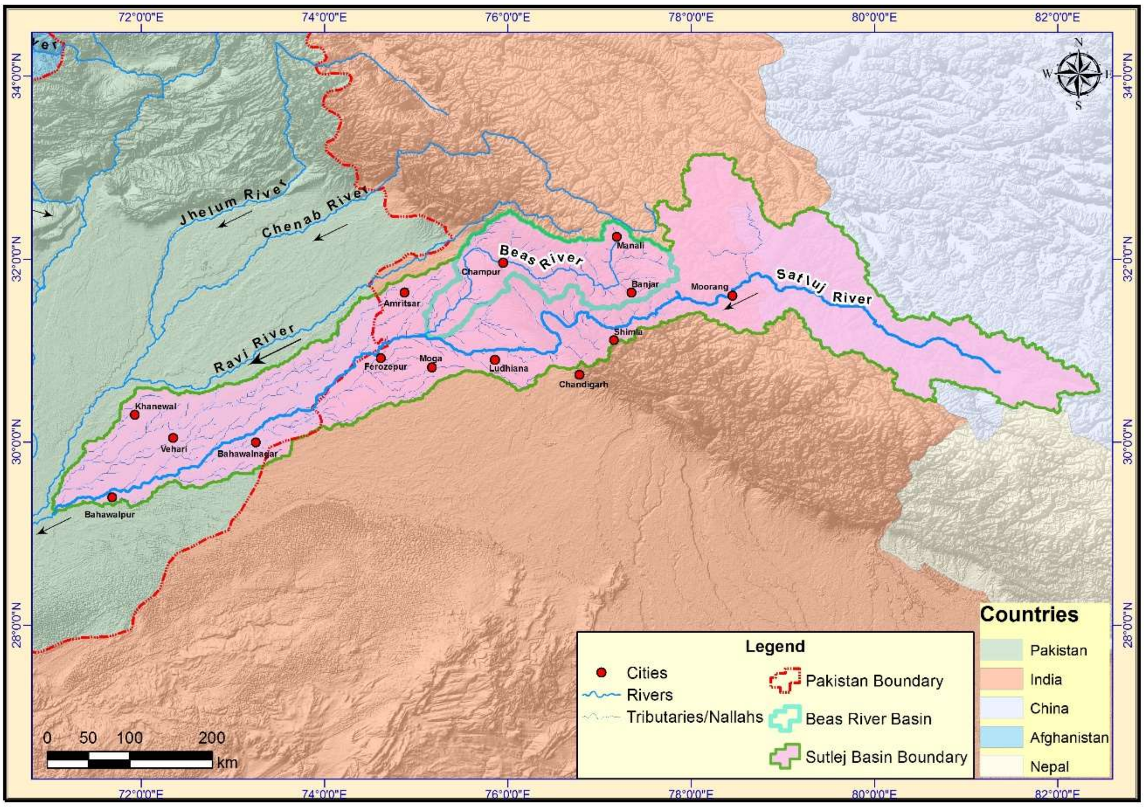

Figure 2-5: Sutlej River Basin

2.1.2 Indus Basin Irrigation System

The Indus and its tributaries enter the plains downstream of ‘rim stations’. Below these stations water is measured, and diverted into an extensive network of canals, as shown in Figure 2-6. From the rim stations to the sea, the irrigation system is managed more or less as an integrated system. Since partition of India and Pakistan in 1947, river water use and distribution remained an important issue. In 1960, the Indus Water Treaty (IWT) was signed between India and Pakistan, according to which India was allocated the water from three eastern rivers (Sutlej, Beas, and Ravi) and the three western rivers (Chenab, Jhelum and Indus) to Pakistan.

The Indus irrigation system consists of three major reservoirs (Tarbela, Chashma, and Mangla); 16 barrages (Ferozepur, Suleimanki, Islam, Balloki, Sidhnai, Marala, Khanki, Qadirabad, Trimmu, Panjnad, Rasul, Jinnah, Taunsa, Guddu, Sukkur, and Kotri); 12 inter river link canals; 45 irrigation canals; and over 107,000 water courses and millions of farm channels & field ditches. The total length of main canal system is estimated at about 585,000 km (36,930 miles).

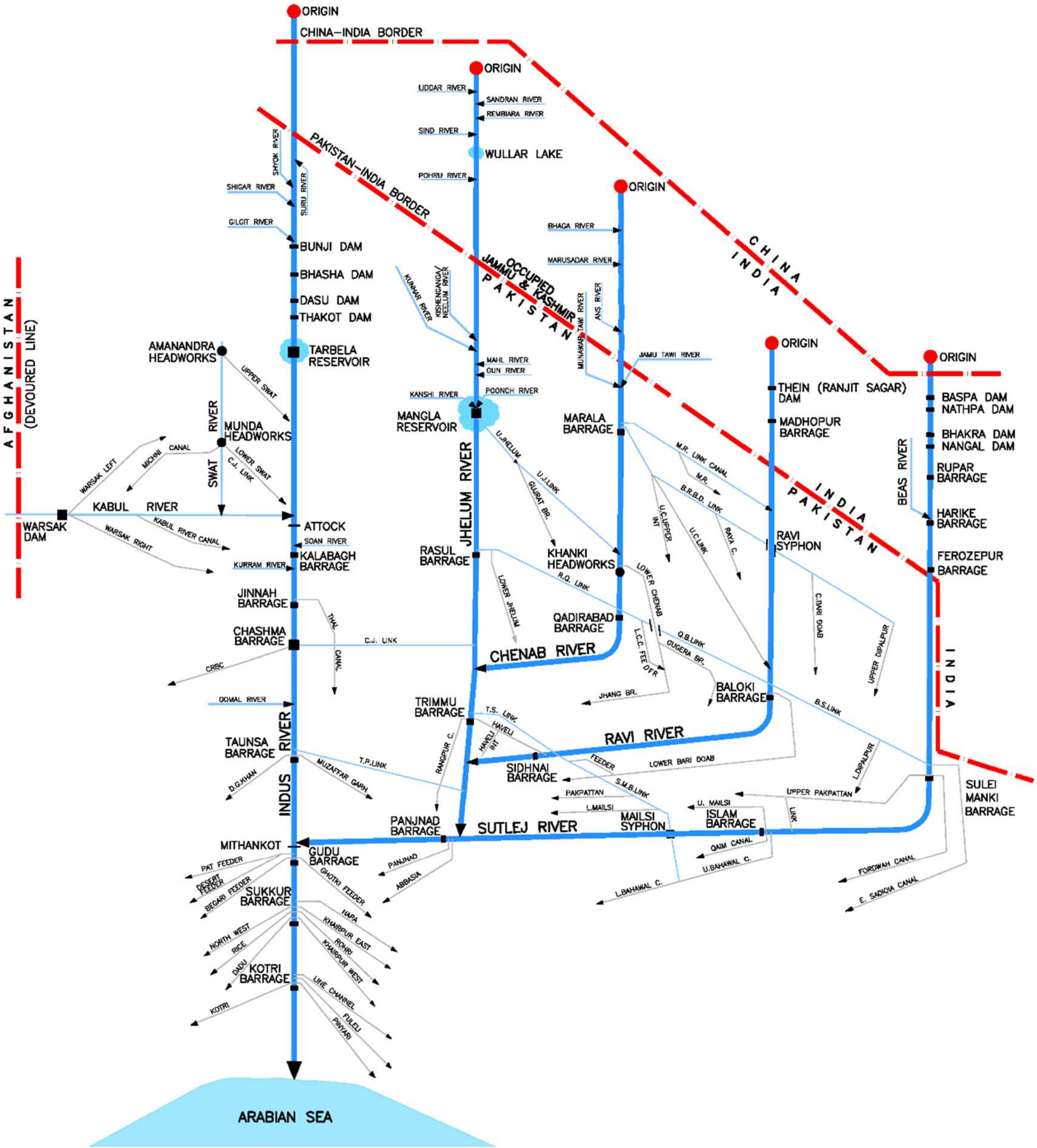

Figure 2-6: Schematic Diagram of Indus Basin Irrigation System

2.1.3 Climatic Norms of Indus River Basin

The Upper Indus River basin is a high mountain region and the mountains limit the intrusion of the monsoon, the influence of which weakens northwestwards. Most of the precipitation falls in winter and spring and originates from the west. Monsoonal incursions bring occasional rain to trans-Himalayan areas but, even during summer months, not all precipitation derives from monsoon sources. Climatic variables are strongly influenced by altitude and are not uniform over the Indus River basin. It varies from sub-tropical arid and semi-arid to temperate sub-humid on the plains of Sindh and Punjab provinces to alpine in the mountainous highlands of the north. Annual precipitation ranges between 100 and 500 mm in the lowlands to a maximum of 2,000 mm on mountain slopes. Average annual rainfall on the Indus plains is about 230 mm. On the lower plains, Larkana and Jacobabad areas, receive, on average about 90 mm of rainfall annually. On the upper plain, Multan receives 150 mm and Lahore about 450 mm of rain. Northern valley floors are arid with annual precipitation from 100 to 200 mm. Snowfall at higher altitudes (above 2,500 m) accounts for most of the river runoff.

The climate of Pakistan is classified as arid or semi-arid. Figure 2-7[2] shows average annual precipitation over Pakistan. The axis of maximum rainfall is located along the foothills of Himalaya and Hindukush mountains, indicating the strong orographic effect on rainfall distribution. Rainfall decreases in westerly direction across the Indus Plains. Heavy rainfall can cover vast areas in the eastern rivers catchments. Rainfall occurs mostly during the monsoon season (July through September) and the cold weather season (December through March). Occasionally, however, heavy rainfall can occur in the other dry months of the year.

The monsoon season is characterized by the occurrence of general south-west monsoon current. A series of tropical depressions develop at the head of the Bay of Bengal and move in a north-westerly direction over northern India and enter Pakistan. The monsoons gain strength until July, remain constant to the end of August, and then begin to slacken. The monsoon-current reaches Pakistan in beginning of July and is well established by the middle of that month. In some years, the monsoon remains active even in September. The Sutlej and Ravi rivers are the first to be affected and generally receive the heaviest rains in their catchments. The intensity decreases steadily to the north-west along the foot-hills of the Western Himalayas. The upper part of the Indus River basin receives the least contribution from the monsoon rains.

[2] http://www.rrcap.ait.asia/lc/cd/html/countryrep/pakistan/studyarea.html

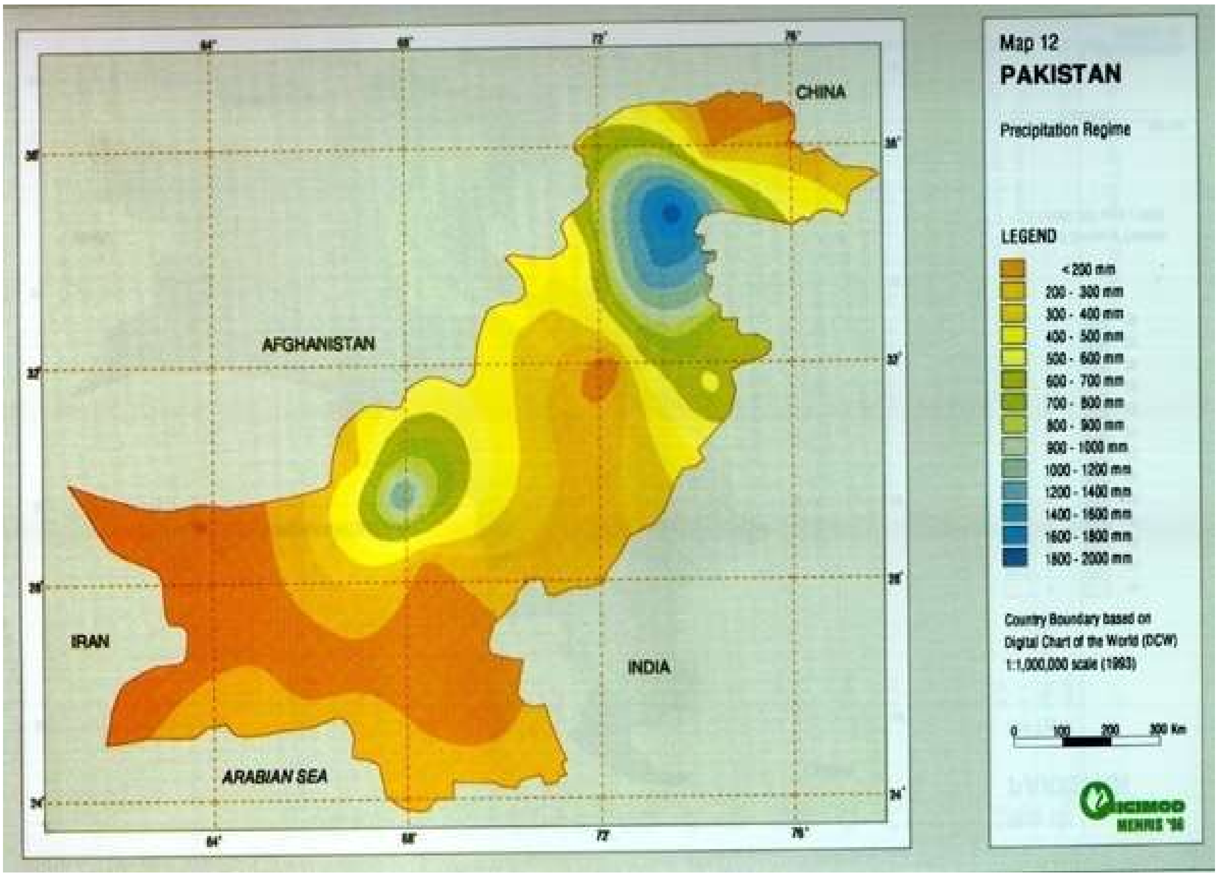

Figure 2-7: Average Annual Rainfall of Pakistan

2.2 PAKISTAN FLOOD MECHANICS AND HISTORY OF FLOODS

Physiographic variation in Pakistan results in different types of flooding like flash, riverine, GLOF, coastal and urban flooding. Northern areas of Pakistan are distinguished by high slopes and elevations associated with Himalayan and Karakorum ranges which lead to flash flooding in foothills and Glacial Lake Outburst Flood (GLOF) in upper areas. The western extents of Pakistan with Afghanistan and Iran also experience flash flooding due to Suleiman ranges in Potowar Plateau and many other mountain ranges in Balochistan Plateau.

The flood mechanics for different types of floods in country are briefly defined below:

2.2.1 Riverine Floods

The floods in rivers are generally caused by heavy concentrated rainfall in the upper catchments, during the monsoon season (July through September), which is sometimes augmented by snow melt flows. Monsoon currents originating in the Bay of Bengal and resultant depressions often result in heavy downpour in the Western Himalayan foothills, which occasionally produce destructive floods in one or more of the main rivers of the Indus system.

All the rivers of the Indus system are perennial. In terms of peak flows and flood hazards, the left bank tributaries are the most critical. The right bank tributaries up to Attock bridge, do not significantly increase flood hazards in the Indus Plains since flood peaks on these rivers usually occur during the May-June period, when the Indus and its left bank tributaries are not in flood.

Floods occurring in the Indus plain normally are generated in the mountain and foothill areas, where either snowmelt, rainfall superimposed on snowmelt or runoff from intense rainfall draining into flashy hill torrents builds up high discharges. Glacier and snow melt causes a general rise in river stages. The glaciers serve as natural storage reservoirs that provide perennial supplies to the Indus River and some of its tributaries. When combined with heavy rainfall, sudden rise to very high flood stages often occur in the Indus River. Snowmelt contributions to flood peaks on the Chenab River are not great and are even less significant for the Jhelum, Ravi and Sutlej rivers. These rivers often experience heavy floods due to intense rainfall.

In the plains area, where channel slopes are flat, floodwaters spread over vast areas, when river stages are only slightly above the banks. There are numerous hill torrents along the borders of the Indus plains that cause serious problems after intense rainfall over the foothills. The affected areas usually are localized. These torrents, however, occasionally contribute to general inundation over large areas.

2.2.2 Flash Floods in Hill Torrents

Flash floods in the hill torrents occur primarily in mountainous, semi-mountainous regions and in adjoining piedmont. It can also be described as sudden severe increase in the flow of river/stream water within short interval of time. Flash floods are short-term events, occurring within six (6) hours of the causative event (NWS, 2002) (heavy rain, dam break, levee failure, rapid snowmelt and ice jams) and often within 2 hours of the start of high intensity rainfall. A flash flood is characterized by a rapid stream rise with depths of water that can reach well above the banks of the creek. Flash flood damage and most fatalities tend to occur in areas immediately adjacent to a stream. Flash floods are exemplified by a swift rise in water, velocities, and large amounts of debris. Factors involving the flash flooding in the country are rainfall intensity, duration of rainfall and the gradient of watershed and streams. In Pakistan flash flooding areas are Khyber Pakhtunkhwa (KP), Gilgit-Baltistan (GB), Azad Jammu & Kashmir (AJ&K) and some districts of Punjab, Balochistan & Sindh.

2.2.3 Coastal Floods and Seawater Intrusion

2.2.3.1 Coastal Floods

Weather and tidal conditions can increase sea levels that result in flooding along coastal areas. The cause of such a surge is generally a severe storm or cyclonic activity in Arabian Sea. The storm wind pushes the water up and creates high waves. Winds generated from tropical storms and hurricanes or intense offshore low pressure systems can drive sea water inland and cause significant flooding. The Makran Coast of Balochistan and south-eastern Sindh experienced such coastal floods from tropical cyclones from Arabian Sea. Historic coastal storms are given in Table 2-1.

Table 2-1: Historic Coastal Flood Events in Pakistan

Storm	Year	Location
Phet Storm	2010	Gwadar Area
BOB 03 Storm	2009	Karachi Area
BOB 06 Storm	2007	Karachi Area
Yemyin Storm	2007	Karachi Area
Onil Storm	2004	Thatta Area
Cyclone Storm	1999	Keti Bandar

Pakistan has about 1,046 km (650 miles) coastline along the Arabian Sea and the Gulf of Oman in the extreme south western part of the country. Though cyclones are rare in the

Arabian Sea, cyclones that form in this sea mostly move towards Indian state of Gujrat rather than Pakistan.

Cyclones in the Arabian Sea mostly occur from May to June and then from September to October. Monsoon season plays a vital role for the formation of cyclones in this basin. Tropical storms that hit Pakistan are mostly remnants by the time they reach Pakistan or make landfall in south eastern Sindh which is not very much populated and rarely move towards the Balochistan coast.

Each year before the onset of monsoon from mid of April to mid July and also after its withdrawal from mid September to mid December, there is always a distinct possibility of the cyclonic storm to develop in the north Arabian Sea. There is a 98 per cent chance of cyclones to turn towards the Indian state of Gujrat, one per cent chance of moving towards the Gulf and one per cent chance of moving towards the Pakistani coast.

Pakistan lies in the temperate zone. The climate is generally arid, characterized by hot summers and cool or cold winters, and there are wide variations between extremes of temperature. The upper parts of Pakistan sometimes get rain from the Western Disturbance almost every month and from June till September almost whole country is lashed by South West Monsoon rain. Pakistan is a country where extreme weather events are not a yearly event therefore tornadoes are highly uncommon in the country, but cyclones are not uncommon.

Cyclones mostly hit the Sindh coast than the Balochistan coast in Pakistan. During the last 100 years a number of cyclonic storms have struck Pakistan's coastal areas. The years involved were 1895, 1902, 1907, 1944, 1948, 1964, 1985, 1999, 2007 and 2010. Other cyclones that are listed below caused rains as remnants.

- In 1895, a cyclonic storm hit the Makran coast in Balochistan province.
- In May 1902, a cyclonic storm struck the coast in the vicinity of Karachi.
- Again in June 1902, a cyclone hit the coast near Karachi.
- In June 1907, a tropical storm struck the coast near Karachi.
- On 27th July 1944, a cyclone left some 10,000 people homeless in Karachi.
- In 1948, a tropical storm made landfall along the Makran coast in Balochistan province.
- On 12th June 1964, Indus valley cyclone made landfall in Tharparkar, Hyderabad and Karachi districts in Sindh province. It caused a great loss of life and property in the province. About 460 people were killed and left some 400,000 people homeless in south eastern Sindh.
- On 15th December 1965, a powerful cyclone slammed Karachi with 10,000 casualties. It is the deadliest tropical cyclone in the history of Pakistan.
- In 1984, there are unconfirmed reports that a cyclone hit Makran coast.
- In May 1985, a cyclonic storm made a landfall in the eastern direction of Karachi. The cyclonic storm which was moving towards Karachi had weakened over the sea, when it was still a few 100 kilometers away south of Karachi. However, it did cause concern and panic in Karachi.
- In November 1993, a category-1 Indo-Pak cyclone approached the Sindh-Gujrat border, but dissipated due to high vertical wind shear over open waters. However, it caused massive rainfall and flooding in Karachi. Thatta and Badin districts were the

worst affected where the cyclone killed about 600 people in coastal Sindh and displaced some 200,000 people.

- In June 1998, remnants of the category-3 Gujarat cyclone (the 5th strongest cyclone of the Arabian Sea) killed 12 people in Karachi.
- In May 1999, again a category-3 Pakistan cyclone (the 4th strongest cyclone of Arabian Sea) hit Keti Bandar near Karachi at peak intensity in Sindh province. This Cyclone killed 6,400 people in Sindh. It was the strongest and most intense cyclone recorded in Pakistan.
- In May 2001, the powerful category-3 India cyclone (the 3rd strongest cyclone of the Arabian Sea) hit the Indian border of Gujarat. It caused rain along the Sindh coast, but no damage was reported.
- In October 2004, a severe cyclonic storm, Cyclone Onil, approached the Sindh coast but later re-curved back to the sea. It caused heavy rain that killed 9 people in Karachi.
- In early June 2007, a category-5 Cyclone Gonu (the strongest cyclone in the Arabian Sea) passed near the city of Gwadar in Balochistan province as a cyclonic storm with torrential rain and strong winds; it caused damage to dozens of boats and school buildings in the area. It also caused high winds with light rainfall in Karachi and other coastal areas.
- In late June 2007, a cyclonic storm, Cyclone Yemyin, passed near Karachi and hit between the towns of Pasni and Ormara in Balochistan Province. It killed 200 people alone in Karachi city on 23rd June due to heavy rainfall and intense windstorm of 70 mph. Due to the landfall near the town of Ormara and Pasni on 26th June, 300 people were killed and lives of 2 million were affected. It is ranked as the third deadliest cyclone in the history of Pakistan.
- In November 2009, remnants of Cyclone Phyan caused gusty winds along the Sindh coast including Karachi.
- In June 2010, Cyclone Phet (the 2nd strongest cyclone in the Arabian Sea), a powerful category-4 cyclone, made landfall in Keti Bandar as a weak tropical depression, with a total of 14 casualties in Pakistan. Before that it wreaked havoc in Gwadar, Balochistan province as a category-1 cyclone.
- In November 2010, remnants of Cyclone Jal caused dusty winds in Karachi, while it caused light to moderate rainfall in southeastern Sindh.
- In early November 2011, moisture from Cyclone Keila that was moving towards Oman, caused drizzle in Karachi.

A summary of the wettest tropical storms in Pakistan have been summarized in Table 2-2.

Table 2-2: Wettest Tropical Cyclones in Pakistan

	Precipitation		Storm	Measurement Station
Rank	(mm)	(inch)		
1	370	14.57	Cyclone Phet 2010	Gwadar
2	285	11.22	Cyclone 2A 1999	Shah Bandar
3	245	9.64	Depression 2009	Karachi
4	191	7.51	Deep depression 2007	Karachi
5	145	5.71	Cyclone Onil 2004	Thatta
6	110	3.94	Cyclone Yemyin 2007	Karachi
7	43	1.69	Deep Depression 2007	Karachi
8	18	0.70	Depression 2009	Karachi

Source: Detailed History of Cyclones in Pakistan, Pakistan Weather Portal.

2.2.3.2 Seawater Intrusion

Another coastal problem is the Seawater intrusion downstream of Kotri Barrage, built in 1955.It is the last downstream barrage on the Indus River, before it discharges into the Arabian Sea. There is about 194 km (121 miles) of river reach from the barrage to the sea.

At present, Indus River discharges in the Arabian Sea at two points: Turshian and Khobar. Indus Delta region marks Sindh's 300km (188 miles) long coast with Arabian Sea. Before the building of barrages, the coastal agriculture areas of Keti Bandar, Kharo-chan and Shah Bandar produced rice as the main crop for export. The sea-borne goods in transit to upper Sindh area used to be transported by river boats. The socio-economy of these areas was very good and people were prosperous. The area was a major producer of milk and ghee (clarified butter) which was exported to cities as far as Bombay. There used to be a rare red rice, millet, gram and vegetables cultivation in both the coastal districts of Badin and Thatta.

Due to the drastic reduction of Indus discharge of freshwater and sediments after the construction of Kotri Barrage, coastal agriculture and the status as a viable sea-river port, both were lost. Keti Bandar has changed thrice its location. Its previous locations are submerged under sea water. Presently, it occupies much lesser geographical area than it used to. Population of Keti Bandar is declining and people live there in poor conditions.

The quantity of water outflow to sea has been progressively reduced, particularly after the construction of barrages, dams and link canals under the Indus Water Treaty, 1960. The Indus Water Treaty (IWT) signed by Pakistan and India in 1960, resulted in an altered distribution of flows in the river system. Due to extensive development of infrastructure including link canals, barrages and reservoirs, the outflow to sea has been drastically reduced.

This gradual depletion in flow of sweet river water and rich silt into sea has led to sea water intrusion in the coastal area that literally kills life in all forms, livestock and vegetation on land and fish and other edible marine varieties and the mangroves forest in the sea. The increase in salinity during the low flow periods has reduced the suitability of the delta for the cultivation of red rice, production of exotic fruit and the raising of livestock.

Under the provisions of the Water Accord, 1991, a quantity of 10 MAF was provisionally earmarked for outflow downstream Kotri pending further studies to be undertaken to establish the needs of minimum releases downstream Kotri. Finally, two studies were carried out on water releases below Kotri Barrage to Check Sea Water Intrusion and to address environmental concerns. Then, a third study on the environment concerns of all the four provinces was conducted.

International Panel of Experts (IPOE) recommended that a total volume of 25 MAF in any five years period (an annual equivalent amount of five (5) MAF) be released in a concentrated way as flood flow (Kharif period), to be adjusted according to the ruling storage in the reservoirs and the volume discharged in the four previous years. IPOE in Para IV of executive summary says: "An escapage at Kotri Barrage of 5,000 cusecs throughout the year is considered to be required to check seawater intrusion, accommodate the needs for fisheries and environmental sustainability, and to maintain the river channel. The IPOE likes to stress that seawater intrusion only concerns problems related to surface water, because salinity in the aquifer is predominantly due to fossil water salinity from geological origin".

The recommendation would require an additional release from storages of 1.26 MAF to 2.20 MAF, depending on the weather, during the low flow months of September to middle of June. This would require additional storage capacity to prevent reduction in water availability for irrigation use. This means that unless additional storage capacity is made available, the required release below Kotri cannot be made. Thus, it seems necessary to build a new storage as it would not only resolve the problem of power shortage in the country but will improve water availability during low flow season.

2.2.4 Urban Floods

Flooding in urban areas can be caused by flash floods, or coastal floods, or river floods, but there is also a specific flood type that is called urban flooding. Urban flooding is specific in the areas that lack drainage of storm water.

High intensity rainfall can cause flooding, when the city drainage system does not have the adequate capacity to drain away the runoff generated through concentrated rains. Urban floods are a great disturbance for daily life in the city. During periods of urban flooding, streets can become swift moving rivers, while basements can become death traps as they fill with water. Urban floods are being experienced in Pakistan cities, especially in monsoon season-having high population density (Karachi, Lahore, Faisalabad, Multan, Hyderabad, etc.) with unplanned, clogged, encroached and undersized drainage systems.

2.2.5 Glacial Lake Outburst Floods (GLOF)

Glacier outburst floods may be broadly defined as the sudden release of water stored either within a glacier or dammed by a glacier. Outburst floods have been reported in all glaciated regions of the world and may be triggered by:

- The sudden drainage of an ice-dammed lake below or through an ice dam;
- Lake water overflow and rapid fluvial incision of ice, bedrock or sediment barriers occur; or
- The growth and collapse of sub-surface reservoirs.

Due to their high and rapid discharge, the outburst floods originating from high mountain glaciers have devastating impacts on downstream communities. Gilgit-Baltistan areas experience glacier outburst floods. A list of historic GLOF events is given in Table 2-3.

Table 2-3: List of Historic GLOF Events in Gilgit-Baltistan, Pakistan

Sr. No.	Year	Glacier	River
1	1533	Human	Upper Shyok
2	1750	Biafo Gl.	Braldu River
3	1780	Khumdan	Upper Shyok
4	1826	Khumdan	Upper Shyok
5	1833		Upper Shyok
6	1833	YashkukYaz	Chapursan [Hunza]
7	1835	Sultan Chussky	Shyok
8	1839	Khumdan	Upper Shyok
9	1842		Upper Shyok
10	1844		Ishkoman/ Ghizer/Gilgit
11	1848	Aktash or Khumdan	Upper Shyok
12	1851	Chungphar	Tarshing/ Astore
13	1855	Khumdan	Upper Shyok
14	1861	Karambar	Ishkoman
15	1865		Ishkoman
16	1871		Gilgit Hunza
17	1882	Chong or KichikKhumdan	Upper Shyok
18	1884		Shimshall
19	1892		Ishkoman, Shyok

Sr. No.	Year	Glacier	River
20	1893	Karambar, Chhateboi	Ishkoman/ Ghizer
21	1893		Shimshall
22	1898		Upper Shyok
23	1901	Khumdan	Upper Shyok
24	1903	KichikKhumdan	Upper Shyok
25	1905	KichikKhumdan	Upper Shyok
26	1905	Khurdopin	Shimshall/ Hunza
27	1905	Karumbar	Iskoman/Gilgit
28	1906	Khurdopin	Shimshall/ Hunza
29	1907	Khurdopin	Shimshall/ Hunza
30	1924	Chong Khumdan	Upper Shyok
31	1926	Chong Khumdan	Upper Shyok
32	1927	KazYaz	Chapursan/ Hunza
33	1927	Khurdopin	Shimshall/ Hunza
34	1928	Kilik Valley	Hunza
35	1929	Chong Khumdan	Upper Shyok
36	1932	Chong Khumdan	Upper Shyok
37	1933	Chong Khumdan	Upper Shyok
38	1942	Khordopin	Shimshall/ Hunza
39	1959/60,1964	Khordopin	Shimshall/ Hunza
40	1967		Hunza
41	1972	Batura Gl.	Hunza
42	1973	Batura Gl.	Hunza
43	1974	Balt Bare	Baltar/Hunza
44	1979	Kvagar	Shagsgam
45	1980	Un-named or Khalti	Ghizer/Gilgit
46	1984	Gulagab	Iskoman
47	1990	Lokpar/Alling Tributary	Shyok-Hushe
48	1995	Sosat Glacier, Sosat Valley	Ghizer
49	1997	Kande	Kande/Hushe/Shyok
50	1999	Charti	Ghizer/Gilgit
51	2000	Khordopin or YukshinGardan Glaciers	Shimshall/ Hunza
52	2000	Kande	Kande/Hushe/Shyok

2.2.6 2010 Super Flood

In 2010, Pakistan was hit by its worst natural disaster - floodwater inundated up to one fifth of the country (approximately 160,000 km^2) and affected an estimated 20 million people, mostly by destruction of property, infrastructure and lands of livelihood, with a death toll close to 2,000. This flood event began in late July 2010, resulting from heavy monsoon rains in Khyber Pakhtunkhwa, Lower Punjab, Sindh and Balochistan regions. The heavy monsoon rain in the catchment area of the Indus River was the immediate cause of this catastrophic flood. 2010 flood was caused by a freak combination of disastrous weather events. Keeping in view the topographic features and atmospheric circulation patterns, jet stream with easterly monsoon trough resulted in prolonged wet spell over northern KP and upper parts of Punjab. Hot & very humid weather prevailed over upper parts of the country during four days (July 24th – 27th, 2010) resulting high degree of instability over the area.

With the interaction of western cold air-mass, the occlusion took place. The vortex formation was further accentuated by the topographical features like north-west and south-eastern Himalayan range on one side and north-east and south-west Suleiman range on the other, allowing the air mass to be trapped and rise vertically due to orography. The monsoon storm track of 2010 super flood is shown in Figure 2-8.

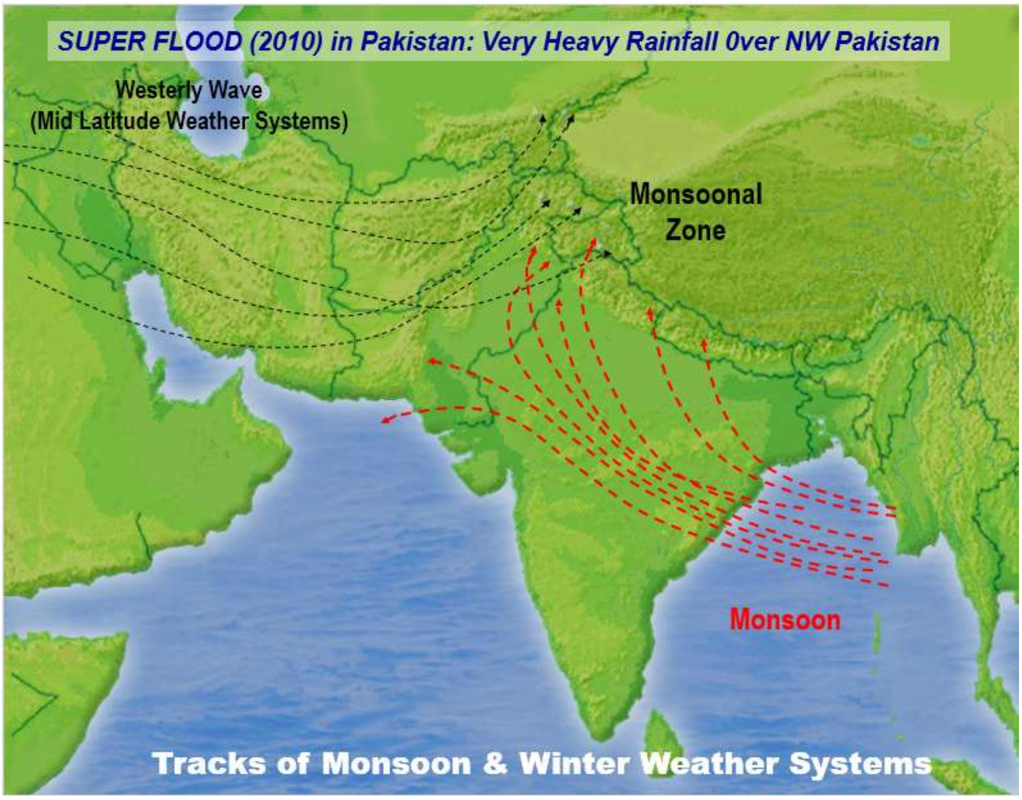

Figure 2-8: Storm Track of 2010 Super Flood[3]

The ridges of the northern Khyber Pakhtunkhwa were completely saturated by torrential rains. The heaviest rains were recorded during night time on 27thand 28thJuly 2010 over most of the places as given in Table 2-4. Pakistan Meteorological Department (PMD) had started issuing warnings of this disastrous event from 24thJuly 2010. First Advisory was issued at 1500 Pakistan Standard Time (PST) on 24thJuly 2010. It was updated on 26thJuly at 1800 PST. The Advisories were disseminated to all concerned agencies and media. The rain began falling in upper KP and northern Punjab at 2100 PST on 26thJuly 2010 and continued till 0900 AM next morning. During this period, moderate to heavy rainfall was also recorded in Kashmir and adjoining areas of Khyber Pakhtunkhwa.

Second flood wave initially started due to a cloud burst in the catchments of Indus in Jammu and Kashmir around 0100–0300 PST on 6thAugust, 2010 leading to flash flood and mud slides over the region. According to synoptic analysis, the monsoon trough at the mean sea level lay to the south of its normal position on 4thand 5thAugust 2010. There was a cyclonic circulation in lower levels over west Rajasthan and neighborhood. A well-marked low pressure area lay over northwest Bay of Bengal on 5thand over north Orissa and neighborhood on 6thAugust. Under the influence of these systems, strong southeasterly winds with speed of 15-20 knots (28-30 km/hr) prevailed over western Himalayan region causing influx of moisture over the region.

Similar heavy rainfall was also recorded in the months of July and August in GB and AJ&K areas. Thunderstorm resulted in floods which caused widespread damages to roads/ highways, bridges, cropped areas, power houses, etc. During the flash flooding about 183 and 71 deaths were reported in GB and AJ&K, respectively. Table 2-4shows the comparison

[3] *Source: Pakistan Meteorological Department (PMD)*

of rainfall recorded in this area with the mean rainfall at various stations of northern parts of Pakistan.

Table 2-4: Comparison of 2010 Monsoon Rainfall with Mean Rainfall in Northern Parts of Pakistan

Northern Parts Station	Mean July Rainfall (mm)	Total July 2010 Rainfall (mm)	Daily Rainfall July 2010 (mm)			Total Rainfall for Three Days (mm)	% of July Rainfall over Three Days
			28th	29th	30th		
1	2	3	4	5	6	7	8
Cherat	97	388	33	257	81	371	96
Chitral	152	63	6	41	13	60	95
Dir	154	317	57	149	0	206	65
Lower Dir	93	295	0	192	71	263	89
Drosh	372	101	23	61	15	99	98
Kalam	56	105	14	84	0	98	93
Kohat	N/A	345	0	233	29	262	76
Mirkhani	364	44	0	27	15	42	95
Parachinar	117	245	20	21	20	61	25
Peshawar A/P	46	402	N/A	274	59	333	83
Peshawar City	58.3	294	N/A	204	22	226	77
Risalpur	37	433	5	280	121	406	94
Saidu Sharif	124	471	44	187	103	334	71

Source: Pakistan Meteorological Department, G/O Pakistan N/A= not available mm= millimeter ratio col 8 = col 7/col 3

A continuous interaction of westerly wave with monsoon system resulted in extreme precipitation in the form of rain that continued to fall till 30th July and then in August, which produced huge runoff so much that the rivers and hill torrents swelled out of their flood channels and inundated the nearby populated areas, destroyed houses, infrastructure and agriculture lands. Resultantly, the Swat and Kabul rivers swelled to such heights that every bridge on these rivers and its tributaries was overtopped. The approach roads too many bridges were also washed away.

The roaring waters swept everything in its path. Due to continuous rains, during the next few days, the rescue operations could not be launched as most of the road approaches were destroyed and helicopter flights were not possible due to bad weather. More than 200 mm of rainfall was recorded within a period of 24 hours over a number of places of Khyber Pakhtunkhwa. A record-breaking 274 mm rainfall in Peshawar during 24 hours surpassing the 187 mm rain recorded in April 2009. In the wake of the above mentioned severe weather system, Saidu Sharif in Swat valley (Malakand Division) and Cherat in Nowshera (Nowshera Division) received 334 mm and 371 mm of rainfall during three days. Because of the hilly terrain, these rains caused flash floods in the local nullahs and rivers. Speedy flood waters and striking lightning had its toll of life and property in Swat and Mansehra, where the people in their sound slumber, were swept away before they could sense the approaching disaster.

The Indus River experienced two distinct back-to-back flood peaks in the reach between Jinnah and Taunsa barrages, with an average lag time of about 5–6 days. The lag time between the peaks varied from 10 days in the upper river reaches to 3 days in the lower river reaches. The two peaks merged at Kotri barrage, the most downstream structure on the Indus River. From upstream to downstream, the lag time of the first flood wave was 2 days between Tarbela Reservoir and Chashma Barrage, 1 day between Chashma and Taunsa barrages, 7 days between Taunsa and Guddu, 4 days between Guddu and Sukkur, and 17 days between Sukkur and Kotri. The 2010 Flood inundation areas are shown in Figure 2-9.

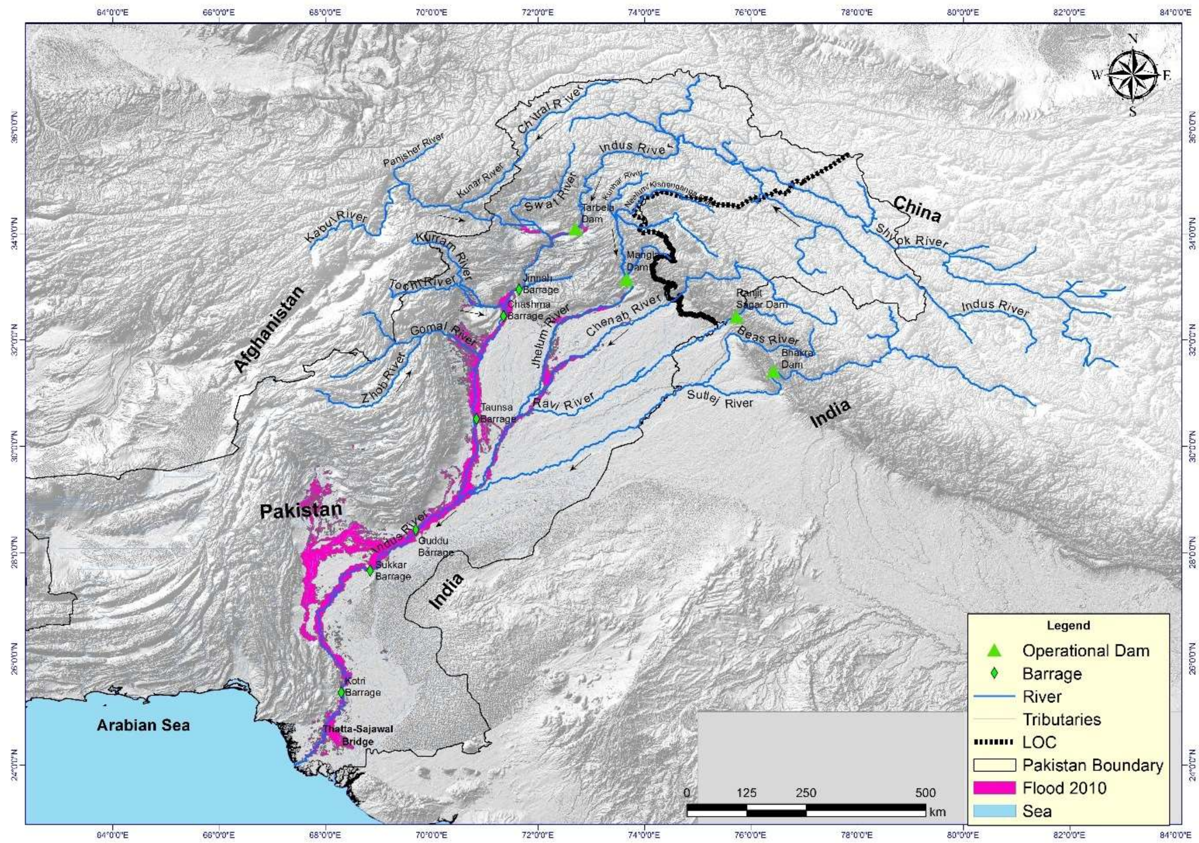

Figure 2-9: Inundation Areas during 2010 Flood in Indus River System

The peak discharges recorded in western rivers during 2010 flood season were very high as compared to highest recorded floods. A comparison of historical maximum flood peaks viz-a-viz 2010 maximum flood peaks at control structures are given in Table 2-5. On the Swat river, a flood peak of 7,646 m^3/sec (270,000 ft^3/sec was estimated, (as gauge had washed away) at the Amandara Headworks. The flood peak was about 60% higher than its design discharge capacity of 4,813 m^3/sec (170,000 ft^3/sec). Downstream, at the Munda Headworks, a flood peak of 8,495 m^3/sec (300,000 ft^3/sec) was estimated as gauge had washed away. It was almost 71% higher than its design capacity of 4,955 m^3/sec (175,000 ft^3/sec). This flooding at the Amandara and Munda Headworks was unprecedented, which severely damaged the Amandara Headworks and washed away the Munda Headworks altogether. Downstream of the Munda Headworks, a flood peak of 4,248 m^3/sec (150,000 ft^3/sec) from the Kabul river, combined with the flood peak from the Swat river, increased the total peak flow of the Kabul river at Nowshera to 12,708 m^3/sec (448,560 ft^3/sec). This exceptionally high flow in the Kabul severely damaged the Nowshera city area and further contributed to the flooding of the Indus river downstream.

Table 2-5: Comparison of Historic Flood Peaks during 2010 with Highest Records

River	Irrigation Control Structure	Peak Discharge 2010 (m^3/sec)	Historic Highest Discharge (m^3/sec)
Swat **	Amandara Headworks	7,646	4,813
	Munda Headworks	8,495	4,955
Chitral	Chitral	2,266	1,633 *
Kabul	Nowshehra	12,708	9,808
Indus	Tarbela Dam	23,585	22,653
	Jinnah	26,541	25,966
	Chashma	29,351	22,115

River	Irrigation Control Structure	Peak Discharge 2010 (m^3/sec)	Historic Highest Discharge (m^3/sec)
	Taunsa	27,180	22,330
	Guddu	32,523	33,300
	Sukkur	32,022	32,875
	Kotri	27,319	27,778
Bara	Jhansi Post	447	233 *
Kurram	Thal	414	315 *
Gomal	KhajuriKatch	941	900 *
	KotMurtaza	1,460	992 *
Kaha	Darrah	2,265	3,355 *

Source: Federal Flood Commission and WAPDA *: Daily Maximum **: Indus Basin Floods, ADB Report, 2013

Propagation of 2010 Flood Wave

On the Indus River, the water flow into the Tarbela Reservoir was 23,585 m^3/sec (833,000 ft^3/sec) equivalent to a flood event with a return period estimated at more than 3,000[4] years. However, the flood inflow was within the design capacity of the dam, which was constructed to handle the Probable Maximum Flood (PMF). The observed peak outflow of 17,104 m^3/sec at Tarbela indicates that the reservoir-routing effect had reduced the flood peaks by 28% (6,541 m^3/sec). At Jinnah barrage, a flood peak of 26,541 m^3/sec was observed, and an estimated 4,287 m^3/sec of discharge passed through the designed breach section upstream of the barrage. These figures indicate a total flood peak of 30,828 m^3/sec at Jinnah barrage, which corresponds to 117 years return period flood and is about 15% higher than the barrage's design capacity of 26,900 m^3/sec.

At Chashma barrage, the flood peak of 29,351 m^3/sec (a return period of 170 years) topped the barrage's design capacity of 26,990 m^3/sec. This flood peak at the barrage was the highest since its construction in 1971, and nearly 10% higher than its design capacity. However, the flood passed through the structure without significant damage. Further downstream, Taunsa barrage sustained the worst flood damage in Punjab province. Out of a total flood peak of 30,724 m^3/sec (1,085,160 ft^3/sec), 27,185 m^3/sec passed through the barrage structure. An estimated additional discharge of about 3,539 m^3/sec (125,000 ft^3/sec) passed through the natural breach section. This was higher than 100 years return period flood by about 14%; however, it was lower than the barrage's design capacity of 31,149 m^3/sec (1,100,000 ft^3/sec). The flood peak at Guddu barrage remained within the design capacity as well, but the design capacity of Sukkur barrage was exceeded by about 26% and that of Kotri barrage by 10%.

During the 2010 flood, Tarbela Reservoir attenuated its peak inflow discharge of 23,585 m3/sec to 17,104 m^3/sec (833,000 ft^3/sec to 604,100 ft^3/sec) at outlets. A review of SOPs for operation of Tarbela reservoir is needed to see if more attenuation than 28% was possible. Similarly, Mangla Reservoir, on the Jhelum River, attenuated its peak inflow of 8,665 m^3/sec to 6,428 m^3/sec at the outlet. Tarbela Reservoir reduced its flood peak by 28% and Mangla Reservoir by 25%, thereby playing a major role in lowering the downstream flood peaks.

[4] *Estimated during NFPP-IV studies*

2.2.7 2011 Flood

The flood of 2011 occurred during the monsoon season in mid-August mainly in Sindh, surrounding areas of Balochistan and Punjab. The extraordinary rain event caused colossal damages to human settlements, infrastructure and agricultural lands.

In July 2011, precipitation remained below normal monsoon; however, from August 2011 to September 2011 the rainfall significantly exceeded the monsoon historic norms. A heavy rain occurred over the areas of Sindh across the Indian Territory and continued for three weeks in spells. This continuous rainfall over flat areas resulted in abnormal water depths and inundated a large area away from the Indus left bank stretching from Shaheed Benazirabad (Nawabshah) to coastal areas. An important damaging factor was the long duration of ponding of un-drained water due to restricted drainage of the area. Runoff generated from continuous rain spells was ten times more than the drainage capacity of Left Bank Outfall Drain (LBOD) and Kotri drainage systems in Sindh that resulted in overflow of drains and flooding of area outside the drain system.

Maximum rainfall that occurred in second spell of monsoon (during September) was more than 600 mm. It affected the private and public properties of districts Mirpurkhas, Badin, Shaheed Benazirabad (Nawabshah), Sanghar, Tando Muhammad Khan, Umerkot, Tharparker, Tando Allah Yar and adjoining areas. Table 2-6shows the summary of rainfall recorded in the months of August and September in different cities of Sindh Province.

Table 2-6: Rainfall Recorded in Sindh Province during 2011 Monsoon

City	Rainfall (mm)		Total (mm)
	August	September	
Mithi	530.0	760.0	1290.0
Mirpur Khas	231.1	603.0	834.1
Shaheed Benazirabad	353.2	268.4	621.6
Badin	331.2	628.4	959.6
Chor	276.0	268.0	544.0
Dadu	134.1	341.1	475.2
Padidan	251.2	172.0	423.2
Hyderabad	162.2	244.2	406.4
Karachi	61.2	212.2	273.4

“Annual Flood Report 2011” by FFC indicates that 23 districts in Sindh, 12 in Punjab and 1 in AJ&K covering about 6.8 million acres were affected by 2011 rains/floods across the country. This particular event claimed 516 human lives, damaged about 1.6 million houses and about 2.3 million acres of cropped area.

The major problems for slow delivery of drainage system were;

i) In-efficient performance of natural drainage due to encroachments and obstructions,
ii) Overtopping at number of places due to in-adequate capacity of drains,
iii) Submergence of drains at out fall points,
iv) Backflow in Mirpur Khas Main Drain,
v) Limited capacity of the entire drainage network to cope with heavy storms,
vi) Roads, canals, built up areas and drains caused compartmentalization of the area, and
vii) In-adequate capacity of culverts/bridges at crossing points of drains.

Post flood management activities provided relief to the population through distributing necessary food items, health facilities and drinking water. However, no immediate steps towards the drainage of flood water were considered.

2.2.8 2012 Flood

Monsoon started across Pakistan in the third week of August 2012 which affected Khyber Pakhtunkhwa, Gilgit-Baltistan and Azad Jammu and Kashmir. The second spell of the monsoon started from the first week of September, over southern parts of the country. The torrential rains on 9thand 10th September hit the upper parts of Sindh (Districts Kashmore, Jacobabad & Shikarpur), Northeastern Balochistan (Districts Nasirabad, Jaffarabad, Killa Saifullah, Jhal Magsi and Loralai) and Southern Punjab (Districts Rajanpur & Dera Ghazi Khan). The unprecedented rains and flash floods flows of hill torrents emerging from Kirther and Koh-e-Suleman hill ranges led to flooding. The worst affected districts were Rajanpur, Dera Ghazi Khan (Punjab), Kashmore, Jacobabad, Shikarpur (Sindh), Nasirabad and Jaffarabad, Killa Saifullah, Jhal Magsi and Loralai (Balochistan).

During 2012 rains/floods, about 571 people lost their lives, 636,438 houses were damaged/ destroyed, 14,159 villages were affected and a total area of 4,746 km^2 was affected.

2.2.9 2013 Flood

The monsoon remained comparatively more active during the month of August 2013. Overall, five rain spells of heavy to very heavy intensity were experienced during the month of August. As a consequence of heavy rains in catchment areas, River Chenab attained very high stage at Marala, Khanki & Qadirabad barrages. Flood flow levels in other main rivers also increased. Indus River at Chashma, Kabul River at Nowshera and Jhelum River at Mangla (upstream) also attained high flood stage during that period.

The rains/floods during 2013 affected cropped area of about 1.107 million acres affecting 8,297 villages claimed about 333 lives, fully damaged 33,763 houses and partially damaged 46,180 houses. Population of about 1.489 million was also affected.

2.2.10 2014 Flood

In September 2014, the monsoonal low across northern India and Pakistan produced extreme amounts of rainfall in 48 hours, causing deadly floods in both countries. The Kashmir region witnessed disastrous floods across majority of its districts caused by torrential rainfall. The Indian occupied Jammu and Kashmir, as well as Azad Kashmir, Gilgit-Baltistan and Punjab in Pakistan, were affected by these floods. By September 24, 2014, 367[5]people in Pakistan had died due to the floods.

The strongest post monsoon storm took place in Pakistan's recorded history when on 3rd of September a very low pressure system developed in parts of Jammu and Kashmir and north-east districts of Sialkot, Lahore, Kasur, Okara, Gujrat, Gujranwala, Jhelum. By the 4th of September, the rains became more widespread in the northern Punjab, AJ&K and KP including the twin cities of Rawalpindi and Islamabad, Mangla, Rawalakot, Kotli and Jhelum. The heaviest amounts of rainfall however were recorded on 4th and 5th of September as several weather stations broke their 24 hour, 48 hour and total monthly rainfall records for the month of September.

The total amount of rainfall recorded between 3rd and 5th of September 2014 at various locations is as under:

- Rawalakot, Azad Kashmir – 464 mm
- Kotli, Azad Kashmir – 410 mm

[5]Source: NDMA web retrieved on 21-10-2014 and Seminar on Flood event 2014

- Lahore: Airport – 498 mm, Shahi Qila – 466 mm, Misri Shah – 453 mm, Shahdara Upper Mall – 389 mm, Jail Road – 379 mm
- Sialkot: Cantt – 471 mm, Airport – 346 mm
- Rawalpindi: Islamabad Airport – 336 mm, Shamsabad – 311 mm, Bokra – 208 mm
- Gujranwala: 286 mm
- Kasur: 280 mm
- Islamabad: (Zero Point) – 274 mm, Saidpur – 268 mm, Golra Sharif – 209 mm
- Okara: 257 mm
- Gujrat: 231 mm
- Murree: 204 mm
- Jhelum: 202 mm

Based on the lessons learnt from the previous floods, Flood Forecasting Division of Pakistan made better predictions this time. A comparison of forecasts and actual observed peaks on Jhelum and Chenab Rivers is presented in Figure 2-10.

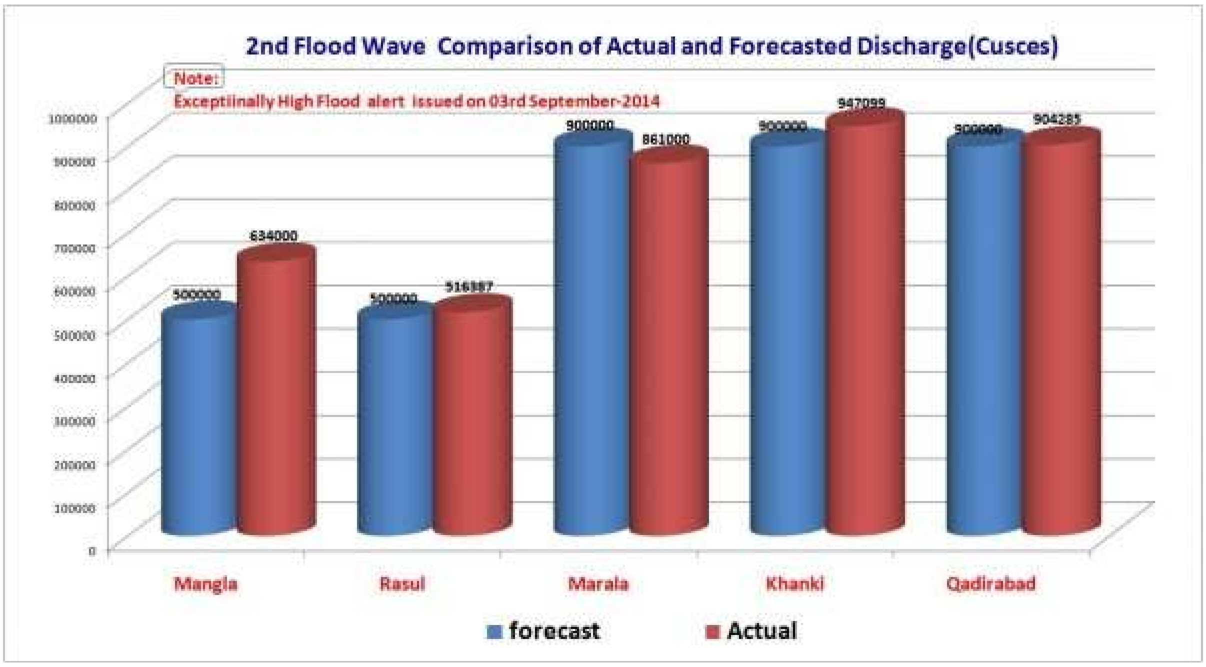

Figure 2-10:Forecast of Second Flood Peak by PMD (Source PMD)

A peak flood of 17,953 m^3/s (634,000 ft^3/s) at Mangla dam and 24,380 m^3/s (861,000 ft^3/s) at Marala barrage was recorded during September 2014 flood. Further downstream of Marala barrage, about 26,816m^3/s (947,100 ft^3/s) and 25,606m^3/s (904,290 ft^3/s) of flood peaks were observed at Khanki and Qadirabad barrages, respectively. Breaches were made in Atbara Hazard dyke upstream of Trimmu barrage to save it. According to reports, the Trimmu Head works safely passed 650,000 cusecs of water resulting in the water levels to recede. More than 350 villages in Jhang District were flooded due to above mentioned breaches leaving trail of destruction behind. As the floodwater moved further south, water level started increasing at Panjnad and it flooded areas in Mithan Kot and 300 villages in Multan District.

According to an estimate[6], 367 people died in the disaster. Over 2.5 million people were affected by the flooding in over 4,000 villages. Nearly 700,000 people were evacuated and

[6] *NDMA website accessed on 21-10-2014 ,*

100,000 homes damaged. In Punjab, AJ&K and GB, more than 2.4 million acres of crops were damaged and 9,000 cattle lost.

2.3 HISTORIC FLOOD DAMAGES SINCE 1950

The floods of 1950, 1955, 1973, 1976, 1978, 1988, 1992, 1994, 1995, 2010, 2011, 2012, 2013 and 2014 were the events that caused tremendous damages to the economic growth. Heaviest direct flood damage to agricultural crops, followed by damage to urban and rural property and public utilities occurred. As per report of Federal Flood Commission Islamabad, more than 12,300 people lost their lives and the country suffered a cumulative financial loss of about US $ 38 billion. About 197,200 villages were reportedly damaged/ destroyed and a total area of 616,500 km^2 was affected due to the past 24 major flood events. Table 2-7 provides details of financial and human life losses in these historical floods.

Table 2-7: Historical Flood Damages in Pakistan, 1950-2016

Year	Direct Losses (US$ Million) 1US$=86 PKRs	Lost Lives (number)	Affected Villages (number)	Flooded Area (km^2)
1950	488	2,190	10,000	17,920
1955	378	679	6,945	20,480
1956	319	160	11,609	74,406
1957	301	83	4,498	16,003
1959	234	88	3,902	10,424
1973	5,134	474	9,719	41,472
1975	684	126	8,628	34,931
1976	3,845	425	18,390	81,920
1977	338	848	2,185	4,657
1978	2,227	393	9,199	30,597
1981	299	82	2,071	4,191
1983	135	39	643	1,882
1984	75	42	251	1,093
1988	858	508	100	6,144
1992	3,010	1,008	13,208	38,758
1994	843	431	1,622	5,568
1995	376	591	6,852	16,686
2010	10,000 (@1US$=86 PKR)	1,985	17,553	38,600[a]
2011	3,730 (@1US$=94 PKR)	516	38,700	27,581
2012	2,640 (@1US$=95 PKR)	571	14,159	4,746
2013	2,000 (@1US$=98 PKR)	333	8,297	4,483
2014	500 (@1US$=100.9 PKR)	367	4065	9779
2015	170 (@1US$=105.0 PKR)	238	4,634	2,877
2016	6 (@1US$=104.81 PKR)	153	45	-
Total	38,171	12,330	197,275	616,598

Source: (i) 2016-Annual Flood Report of Federal Flood Commission, Islamabad.
[a] The figure quoted by FFC is 160,000 which is not supported by satellite data reported by NASA as 38,600.

Among the extreme flood events, 2010 flood was the most destructive one, which significantly added to the figures of losses. The damage caused by 2010 flood is estimated at US$10 billion which is more than 50% of the cumulative damage of US$19 billion in the 60 years period of 1950-2009.

The phenomenon like this is observed worldwide that construction of flood protection structures like bunds, dykes etc., to provide protection against low floods (upto 25 years return period) encourages economic activities in the protected areas and some permanent structures are built. In some cases, the waterway is curtailed to reclaim area for agriculture. These areas suffer maximum damages when high flood occurs. Thus, there is need to legislate land-use in floodplain areas through river act and its strict implementation so as not to construct permanent structures in those areas.

3. REVIEW OF THE PREVIOUS FLOOD PROTECTION PLANS AND STUDIES

3.1 GENERAL

Major floods occur infrequently and therefore recede from public memory until they re-occur with greater fury catching the concerned organizations by surprise. Over the 'non-flood' period, lack of resources lead to poor maintenance of flood protection works thereby increasing their risk of failure. From North to South, Pakistan has a contiguous river system, cutting the areas provincial, administrative, social and cultural boundaries. The flows increase as they move south. Eighty percent of flows at Sukkur are those accumulated below Tarbela and Mangla Reservoirs.

Such, a system automatically raises the need for Integrated Water Resource Management (IWRM) and consequently Integrated Flood Management (IFM). The proactive and integrated flood management requires a full-time, basin-scale, and effective organization that could prepare and implement flood policy, lay down a plan for the Indus Basin, implement effective interventions, and coordinate efforts to minimize flood risks with the provincial governments and other stakeholders.

Although the Federal as well as provincial governments oversees the flood management problems, disaster response is constitutionally a provincial area of responsibility, and the Federal government has no constitutional basis for intervening in disaster response unless requested by a provincial government. Nevertheless, the Federal government did receive considerable criticism for its slow response to the flood of year 2010.

3.2 REVIEW OF PREVIOUS NATIONAL FLOOD PROTECTION PLANS

Immediately upon its inception, FFC focused on the preparation of first National Flood Protection Plan (NFPP-I) with an investment schedule to be implemented during the decade 1978-88. Consequently, three NFPPs and other flood management documents were prepared for the specific time durations as given below:

i. National Flood Protection Plan - I for the period 1978 – 1988 as NFPP-I
ii. National Flood Protection Plan – II for the period of 1988 – 1998 as NFPP-II
iii. National Flood Protection Plan – III for the period of 1998 – 2008 as NFPP-III
iv. First Flood Protection Sector Project as FPSP-I
v. Second Flood Protection Sector Project as FPSP-II
vi. 1988-Flood Damage Restoration Project
vii. 1992-Flood Damage Restoration Project
viii. Other Flood Related Reports

National Flood Protection Plans I, II and III for periods 1978-1988, 1988-1998 and 1998-2008, respectively have been completed successfully, while the preparation of NFPP-IV (this plan) is in process. It may be mentioned here that some leftover works of NFPP-III are still in progress and included as ‘On-going’ Projects in the current NFPP-IV. The summary of Federal Investment on flood protection works is given in Table 3-1.

A review of investments in previous NFPPs as given in Table 3-1indicates that PIDs and Federal Agencies have proposed more than 2,000 flood protection schemes/projects with estimated cost of about Rs. 29,650 million, apart from the foreign funded/aided projects (FPSP-I & II and 1988 & 1992 FDRPs). However, only 1,013 flood protection schemes of the three Plan Periods (1978-2008) could be executed. During these three decades foreign loans were also spent on flood protection works/flood protection schemes. Although since establishment of FFC in 1977, huge amount has been spent on flood sector projects, which includes various structural and non-structural investments, yet the spatial variability and severity of the flood events from 2010 to 2013 caused a wide spread damages. These floods were the worst in which about 3,405 people lost their lives.

Table 3-1: Summary of Federal Investment on Flood Protection Works/Schemes

Cost Million Rupees

Sr. No.	Plan/Project	Period	Proposed Schemes[7]		Executed Schemes[8]		Remarks
			No.	Estimated Cost	No.	Estimated Cost	
1	2	3	4	5	6	7	8
1	NFPP-I	1978-1988	840	9,500	311	1,730	100% by GoP
2	NFPP-II	1988-1998	735	8,500	180	1,419	100% by GoP
2A	FPSP-I	1989-1997	256	4,556	256	4,735	80% by ADB & 20% by GoP
2B	1988-FDRP	1988-1993	2,028	1,926	2,028	1,926	90% by IDA & ADB 10% by GoP
2C	1992-FDRP	1992-1998	1,980	6,659	1,980	6,659	80% by IDA, ADB, EU & KfW and 20% by GoP
3	NFPP-III	1998-2008	439	11,703	383	4,292	100% by GoP
3A	FPSP-II	1998-2007	391	13,877	101	4,165	80% by ADB & 20% by GoP
3B	Lai Nullah Flood Forecasting & Warning System		1	348	1	348	97% by Japanese Grant & 3% by GoP
4	Normal/ Emergent Flood Programme (2009-2014)		1,151	44,407	271	4,012	100 % by GoP
Total			7,821	101,476	5,511	29,286	
NFPP-I, II, III			2,014	29,703	874	7,441	

Note: Sr. No. 2C - also Include 1994 Rain/Flood Restoration Works Cost
ADB: Asian Development Bank IDA: International Development Agency GoP: Government of Pakistan
KfW: Kreditanstalt Fur Wiederaufbau EU: European Union

Keeping in view the gaps and shortcomings identified in flood protection/management, O&M of works (previous & new) have to be done on continuous basis on priority before start of every flood season. Also, new critical flood projects must be completed as soon as possible. Encroachments in flood plains should be removed on priority basis and at the same time, strengthening/improvements of the flood forecasting system should be ensured. The review of documents, mentioned earlier in this section is presented in the following sections.

3.2.1 National Flood Protection Plan-I

Immediately after its establishment, FFC engaged M/s National Engineering Services of Pakistan (PVT) Limited (NESPAK) and HARZA International to prepare the NFPP-I (1978-1988), which provided a consistent and economically appropriate flood protection plan for the different areas of Punjab, Sindh, Khyber Pakhtunkhwa and Balochistan. The NFPP-I aimed at preparation of the first ever flood control investment plan establishing priorities and sequence of development for the next decade. The plan was derived from the proposals of the provincial and federal agencies mainly for the four provinces of Pakistan. This covered

[7] NFPP-III, June 2001, FFC, Islamabad.

[8] Annual Flood Report, 2013 & 2014, FFC, Islamabad.

two 5-year plan periods; fifth plan for the period 1978-83 and sixth plan for the period 1983-88. In view of competing demands and limitations of financial resources, a basic criteria was developed to work out a feasible system of priorities for the projects to be undertaken in the next 10 to 12 years. Towards this end, the flood situation was evaluated on river by river basis. Detailed hydrologic studies were carried out and flood flow estimates were made for each critical point. Major problems were identified and prioritized considering the flood hazards, economic benefits, alternative solutions and justification for implementation. The major objectives followed by NFPP-I are given below:

1) Reduce flood losses and sufferings in an economically sound manner such that the benefits of floods damage/reduction measures exceed their cost, as far as possible.
2) Give priority for flood protection to areas of greatest economic flood damage hazard and/or greatest potential for human suffering, as far as possible.
3) Provide, as far as possible, adequate protection from flood damages to developed areas lying outside active Floodplain of the rivers, in particular to protect cities, irrigation works, communications and other vital infrastructural installations.
4) Make maximum use of existing flood control / protection facilities by improvement, where necessary, to bring them to the level of functional capability and reliability to conform to adopted standards.
5) Obtain maximum flood control utilization of multi-purpose facilities without adversely affecting other functions or compromising the safety of the facility.
6) Promote appropriate land use by avoiding the growth of flood vulnerable developments in flood hazard areas and adjusting land use, where possible, to be compatible with the frequency and duration of flooding.

The NFPP-I proposed following implementation plan:

i. Recommended improvements in flood management, present and proposed capacities of structures on Rivers and their return period;
ii. High priority projects and feasibility studies;
iii. Recommended investment schedule (1978-1988);
iv. Recommended maximum outflows at Tarbela;
v. Co-operation with India;
vi. Education and training of technical staff; and
vii. Improvement of Flood Forecasting and Warning System.

Under NFPP-I, high priority projects requiring immediate attention were recommended for implementation. The investment schedule contained the plan for the structural measures, which comprised the evaluation and prioritization of 840 projects costing about Rs. 9,462 million, primarily proposed by the provinces. Due to financial constraints, many proposed projects could not be executed. Under NFPP-I, budget of Rs. 1,949 million was allocated for some 350 flood protection schemes of the four provinces and federal line agencies. Of this amount, the actual provided amount was about Rs. 1,730 million (need based), which led the completion of 311 flood protection and river training works/flood protection schemes.

The financial constraints/problems affect the level of investment, which directly determines the degree of protection being ensured. As mentioned above, 840 projects were proposed, but executed projects were only 311, which indicates that about 37% of planned projects were implemented in the ten years (two five-year plans). Some flood vulnerable projects that were classified most urgent for execution in NFPP-I were shifted to NFPP-II.

3.2.2 National Flood Protection Plan-II

National Flood Protection Plan-II (also prepared by NESPAK) included updating of NFPP-I incorporating the priority projects and flood protection schemes proposed for implementation during the 6thFive Year Plan (1983-1988). NFPP-II included flood management planning for the entire country. Efforts were made to evolve a unified flood control plan so that planning and execution of projects is carried out to achieve maximum benefits. Modern prevailing concepts comprising the use of risk analysis, probability estimation of stochastic events and sensitivity analysis for flood management planning had been carried out to study the interaction of key sensitive indicators likely to influence the economic viability of the projects.

Flood routing, stability analysis of flow regulating structures and flood management works, updating of design criteria of proposed infrastructure and fixing of free board on scientific basis were the innovative procedures evolved and adopted during NFPP-II. The major objectives followed in NFPP-II are given below:

1) Updating of the National Flood Protection Plan 1978 incorporating the priority projects and flood protection schemes proposed to be implemented during the 6th Plan.
2) Included in the National Flood Protection Plan Phase-II, were the areas left out in NFPP-I i.e. Makran Coastal areas, AJ&K, FATA and GB to make it a realistic flood protection plan for the entire country.
3) To update all analytical studies carried out in NFPP-I i.e. flood frequency analyses, stage frequency analyses, flood damage factors etc.
4) In the case of hill torrents, to make maximum efforts to utilize flood waters in the areas where there flows are generated.
5) To give priority to potentially higher economic flood hazard areas or whose human sufferings exceed tolerable limits like cities, irrigation works or other vital infrastructure; and
6) To apply structural and non-structural flood management measures in combination, as far as these are technically and economically viable.

The NFPP-II proposed following implementation plan:

i. Under NFPP-II, proposed implementation plan was presented in three categories i.e. Appraisal studies (costing Rs. 10-30 million), Feasibility studies (costing more than Rs. 30 million) and Master planning studies.
ii. Updating of the National Flood Protection Plan-I incorporating the priority projects and flood protection schemes proposed to be implemented during the 6th Five Year Plan.
iii. To update all analytical studies carried out in NFPP-I i.e. flood frequency analyses, stage frequency analyses, flood damage factors etc.

Under NFPP-II investment plan, a total number of 735 projects, estimated to cost Rs. 8,486 million were proposed for the four Provinces and Federal Agencies as presented below in Table 3-2.

Table 3-2:Proposed Projects for NFPP-II by Provinces and Federal Agencies

Sr. No.	Province/Agency	Projects	
		Number	Estimate Cost (Rs. Million)
1	Punjab	265	5,549
2	Sindh	28	1,573
3	Khyber Pakhtunkhwa (NWFP)	61	596
4	Balochistan	31	207
5	FATA	27	128
6	AJ&K	7	83
7	Gilgit-Baltistan Region	256	120
8	Karachi Development Authority	1	230
	Total	735	8,486

Source: NESPAK Report NFPP-II, Executive Summary.

However, for NFPP-II, inception investment was envisaged for Rs. 14,915 million, a summary of which is presented in Table 3-3. The inception projects included the liabilities of ongoing projects. In 1985, Government of Pakistan requested Asian Development Bank to examine the technical and economic feasibility of a number of high priority flood protection projects/proposals in order to assess the suitability for Bank Funding of these projects. In Table 3-3, Sr. No. 2 FPSP-I, ADB approved soft loan to identify 17 flood protection projects (256 flood protection schemes) estimated to cost Rs. 4,735 million, in addition to the other Provincial projects. In addition to NFPP-II, two major projects (Sr. Nos. 4 & 5) relating to the restoration and rehabilitation of irrigation infrastructure, damaged as result of 1988 & 1992 floods, were also successfully implemented during the NFPP-II Period.

Table 3-3: Inception Projects under NFPP-II

1. Normal / Emergent Flood Program		
	Funding Agency	100% by GoP
	No. of Schemes Completed	170
	Cost (Need Based)	Rs. 806 million
2. Flood Protection Sector Project-I		
	Foreign Funding	20% by GoP + 80% ADB
	No. of Schemes Completed	256
	Approved Cost	Rs. 4,735 million
3. Prime Minister's River Management Programme		
	Funding Agency	100% by GoP
	No. of Schemes Completed	10
	Project Cost	Rs. 613 million
4. 1988 - Flood Damage Restoration Project		
	Foreign Funding	90% by IDA&ADB + 10% GoP
	No. of Schemes Completed	2,028
	Approved Cost	Rs. 1,874 million
5. 1992 - Flood Damage Restoration Project		
	Foreign Funding	80% by IDA, EU, KFW, ADB +20% GoP
	No. of Schemes Completed	1,980
	Approved Cost	Rs. 6,888 million
Total Cost (Sr. Nos. 1 to 5) = Rs. 14,915 Million		

Source: Annual Flood Report, 2014, FFC, Islamabad.

During NFPP-II, 'Master Planning Studies of Hill Torrents of Pakistan' was conducted by FFC with NESPAK as Consultants. The Consultants proposed 1,204 water conservation sites estimated to cost Rs. 20,785 million (1998 Price Level) for entire Pakistan and recommended these for implementation during the next 20 years. The number of flood protection scheme in each of 4 provinces and federal areas are given in Table 3-4.

Table 3-4: Master Planning Studies of Hill Torrents of Pakistan

Sr. No.	Agency / Province	Number of Flood Protection Schemes	Feasibility Studies Carried out on
1.	Federal Areas	383	- Gilgit Baltistan (N. Areas) - FATA - AJ & K
2.	Punjab	211	- D.G. Khan - Potohar Area - Rachna and Chaj Doabs
3.	Sindh	33	- Khirthar Range Area - Karachi Area - Sehwan Pataro Area
4.	Khyber Pakhtunkhwa (NWFP)	154	- D.I. Khan Area - Hazara, Kabul & Bannu Basins - FATA
5.	Balochistan	423	- Indus Basin Component including Quetta Region - Kharan Coastal Desert Basin - Makran Coastal Area
	Total	**1,204**	

The rains and floods in years 1988, 1992 and 1994 inflicted colossal damages to irrigation infrastructure. Two major projects (1988-FDRP & 1992-FDRP) relating to the restoration and rehabilitation of damaged infrastructure were successfully implemented during the NFPP-II period. Due to these projects, the Government of Pakistan allocated funds over and above the requirements of NFPP-II projects, by curtailing some of the projects, amounting to about Rs 2,900 million, with a view to accommodate these under the 3rd National Flood Protection Plan (NFPP-III) and other isolated projects. Some of the salient features of these restoration projects are given in Table 3-4 above.

Under NFPP-II, following non-structural management improvements were undertaken:

- Procurement & installation of a 10-CM Weather Radar for PMD at Lahore;
- Development of Flood Early Warning System (FEWS);
- Procurement of equipment for improvement of the gauging and telemetry system operated in real time by WAPDA;
- Procurement of HF Radio equipment for PIDs, FFC, PMD, WAPDA, ERC etc.;
- Preparation of Floodplain Maps of Indus River Basin;
- Pre-feasibility studies for four barrages for increasing their design discharge capacities, and
- Flood Management through Mangla Reservoir.

Lessons learnt from projects implemented under NFPP-II and proposed improvements are given below:

- Alternative flood protection measures for flood management proposal must be studied,
- There should be same / similar set of standards for all provinces, but with specific rules and recommendations for flood management of each river reach,
- GIS techniques and remote sensing tools should be adopted for planning and designing,
- Use of appropriate software would improve accuracy and ease out analysis of complex situations,
- For flood protection works, cost benefit analyses should be carried out,

- Accurate topographic information and maps should be prepared. Alternatively, for flood protection purposes, remote sensing images could be used for identification, analysis, planning and design, and
- Modifications are required in the prevailing financial procedures.

3.2.3 National Flood Protection Plan-III

The NFPP-II's major achievement comprised successful implementation of FPSP-I in the provinces through the execution of 256 flood protection schemes after feasibility studies and substantial improvements in country's flood forecasting & warning system as well as through Normal Annual Development Program (NADP). However, many important flood protection schemes and projects were left out, which were included in National Flood Protection Plan-III (NFPP-III) during eighth and ninth five years plans for the periods, 1998-2003 & 2003-2008, respectively.

An ADB mission visited Pakistan in October/November 1995 and prepared draft ToR's for Technical Assistance (TA) for a follow-up project to the then on-going FPSP-I under ADB Loan No. 837-PAK(SF). This follow-up project to FPSP-I was in the perspective that by the time the new Project (FPSP-II) would be ready for execution, the implementation of NFPP-II would be close to completion and by that time priorities for NFPP-III would be formulated in line with the lessons learnt from FPSP-I under NFPP-II. Hence, the mission facilitated formulation of overall scope of NFPP-III and FPSP-II.

The FFC initially received a list of some 830 flood protection schemes from the four Provinces& Federal Agencies with an out-lay of Rs. 25,152 million, for implementation during the NFPP-III period mainly through foreign loans. This included some 391 flood protection schemes for physical execution under FPSP-II, at an estimated cost of Rs. 13,877 million. Proposed number of flood protection schemes and corresponding indicative costs for NFPP-III at its inception are given in Table 3-5, whereas a list of river wise/reach of proposed flood protection schemes under FPSP-II is given in Table 3-6.

Table 3-5: Initial Proposed Flood Protection Schemes under NFPP-III

Sr. No.	Province / Agency	Proposed Number of Schemes	Estimated Cost (Rs. Million)
1.	Punjab	352	13,817
2.	Sindh	159	6,294
3.	Khyber Pakhtunkhwa (NWFP)	82	1,965
4.	Balochistan	138	1,126
5.	Gilgit-Baltistan, FATA & AJ&K	99	1,950
	Total	830	25,152

Table 3-6: Proposed Flood Protection Projects for FPSP-II under NFPP-III

Province	Name of River	Stretch / River Reach	Number of Schemes	Estimated Cost (Rs Million)
Punjab	Jhelum	Mangla-Rasul	7	254.47
		Rasul-Khushab	3	125.61
		Khushab-Trimmu	3	195.13
	Chenab	Qadirabad-Trimmu	19	1,579.80
		Trimmu-Panjnad	11	630.02
	Ravi	Kot Nainan- Balloki	1	6.50
		Balloki-Sidhnai	24	553.72
	Sutlej	Sehjra-BS Link Outfall	16	284.92
		BS Link Outfalls-Suleimanki	4	150.68
		Suleimanki-Islam	6	341.90
	Indus	Chashma-Taunsa	11	566.44

Province	Name of River	Stretch / River Reach	Number of Schemes	Estimated Cost (Rs Million)
		Taunsa-Guddu	24	1,381.42
	Hill Torrents	Rajanpur	1	1,256.00
Total Punjab			130	7,326.61
Sindh	Indus	Sukkur-Kotri	55	1,750.31
		Kotri-Sea	40	1,788.34
	Hill Torrents		5	619.62
Total Sindh			100	4,158.27
Khyber Pakhtunkhwa (KP)	Hill Torrents	Hazara and Kohistan	5	85.50
	Kabul Basin	Adezai	5	124.80
		Kabul RD 12,5000 - Outfall Indus	4	173.40
		Naguman RD 0-90,000	3	69.40
		Shah Alam RD 0-1,23000	2	46.20
	Swat Basin	Adezai/Jindi	1	86.70
		Khiali	2	68.70
		Bara	2	57.80
	Bannu		10	164.20
	Kohat & D.I.Khan		11	566.40
Total Khyber Pakhtunkhwa			44	1,461.20
Balochistan	Hill Torrents	Indus Basin	88	581.74
		Makran Basin	8	69.90
		Makran Costal Basil	21	279.43
Total Balochistan			117	931.07
All Provinces Total			391	13,877.15

Under FPSP-I, works were undertaken by the provinces for constructing flood embankments, spurs and dykes etc. The flood forecasting and warning system of the country had also been improved considerably. In order to complete the left over works/sub-projects and the remaining activities of FEWS including some new flood protection schemes emerged during the course of FPSP-I, as indicated in Table 3-6, additional funds were required. Due to the successful completion of FPSP-I, ADB and OECF (now JBIC of Japan) offered soft term loan to the tune of US $ 100 million & US $ 50 million respectively. This became the basis for appraisal and inception of FPSP-II with overall estimated cost of Rs. 8,000 million and envisaged scope of work in conformance with the emerging requirements of NFPP-III.

Against the planned investment of Rs. 11,703 million for the Provinces and Federal Agencies, on actual a sum of Rs. 5,539 million was spent for physical implementation of 232 flood protection schemes under NADP and 93 flood protection schemes under ADB's assisted FPSP-II. Therefore, in the NFPP-III plan period, a total of 362 flood protection schemes could be completed under NADP with a cost of Rs. 3,415 million. A total of 101 flood protection schemes were completed under FPSP II with a cost of Rs. 4,165 million as well as development of Flood Early Warning System with a cost of Rs. 432.12 million. Overall details of expenses under NFPP-III are as below:

i. Planned Investment under NFPP-III (1998-2008) — Rs. 11,703 million
ii. Actual Expenditure under NADP — Rs. 6,441 million
iii. Total Expenditure under FPSP-II — Rs. 4,165 million

In addition to above, through grant of Government of Japan, a 'Master Plan Study' on Lai Nullah flood problem was completed in September 2003 with a cost of Rs. 200 million. A short-term project relating to improvements in the FEWS for Lai Nullah in Rawalpindi-Islamabad was completed by March 2007 through Japanese grant of Rs. 337 million and GoP share of Rs. 11 million. Overall total cost for Lai Nullah Master Plan was Rs. 537 million.

3.2.3.1 Second Flood Protection Sector Project under NFPP-III

The Umbrella PC-I of the project amounting to Rs. 8,000 million was approved by ECNEC on January 22, 1998 for implementation. It was originally planned to be completed within a period of seven (7) years i.e. 1998-2004. Due to delay in signing of loan agreement and engagement of international consultants, the project could not be started well in time; therefore, the implementation period of the project was reduced. For financing of the project, loan agreement worth SDR 73.249 million (approx. US $ 100 million) was signed between the Government of Pakistan and the Asian Development Bank on February 10, 1999, which became effective on October 01, 1999. The Project started in April 2000 on signing of Consultancy Services Agreement with Package-B and Package-C consultants. Later on due to the project reformulation, ADB curtailed the Project loan by SDR 29.617 million (approx. US $ 40 million) from the original loan of SDR 73.249 million (approx. US $ 100 million). The loan amount available was thus SDR 43.632 million (approx. US $ 60 million).

Status of flood protection schemes/sub-projects approved by the Scrutinizing Committee of FFC for implementation is given below in Table 3-7.

Table 3-7: Proposed FPSP-II Flood Protection Schemes under NFPP-III

Name of Agencies/ Provinces	Number of Flood Protection Schemes Approved by FFC, Islamabad	Estimated Cost (Rs Million)	Allocation
WAPDA	i) H.F Radio Communication System = 01	9.69	100% financing by ADB excluding taxes & duties.
	ii) Telemetry Network = 01	96.72	
Pakistan Meteorological Department (FF & W Component)	iii) Up-gradation of Sialkot Radar = 01	68.85	100% financing by ADB excluding taxes & duties.
	iv) Up-gradation of Lahore Radar = 01	19.40	
	v) Procurement and installation of 10 CM Radar at Mangla= 01	237.46	
Punjab	Individual flood protection schemes = 34	1,598.28	- 75% of civil work by ADB loan. - 25% by GoP.
Sindh	Individual flood protection schemes = 21	1,098.48	
KP (NWFP)	Individual flood protection schemes = 22	612.28	
Balochistan	Individual flood protection schemes = 19	274.17	
	Total Schemes 101 and Cost	4,015.34	

3.2.3.2 Flood Mitigation/Environmental Improvement Plan of Lai Nullah Project under NFPP-III

A comprehensive 'Master Planning Study' was undertaken in 2003 to address flood and environmental issues of Lai Nullah on permanent basis after 2001 rainfall in Islamabad-Rawalpindi, which resulted in loss of 74 human lives besides colossal damage to public and private property. This study was carried out through Grant-in-Aid of Government of Japan under the auspices of Japan International Cooperation Agency (JICA) for which FFC was the main coordinating and counterpart agency.

Overall findings of the study, finalized with the consensus of all local, provincial, federal and international stake holders, included the following two major components.

I. Urgent Emergency Projects (Two Parts);

   a. Lai Nullah Flood Forecasting & Warning System
   b. Construction of flood retarding basin/community pond in Sector F-9 Park for mitigation of flood of 25 years return period

II. Short Term & Long Term Project relating to Construction of Diversion Channel.

Thereby, the following structural and non-structural measures emerged out of the study:

3.2.3.3 Structural Measures

- Community Pond:

  A community pond was proposed in the compound of Fatima Jinnah Park F-9, Islamabad with a catchment area of 26.5 square kilometers and effective storage capacity of 2.9 million cubic meters capable of impounding all the peak flood runoff of 25 - year recurrence interval.

- Flood Diversion Channel:

  It was proposed to divert flood discharge of 100 years return period from the upper reaches of Lai Nullah to the adjacent Korang River.
- Supplementary River Channel Improvement Works:

  Proposed works included:

  i. Improvement of about 1 km stretch of Lai Nullah below Chaklala Road Bridge in Rawalpindi.
  ii. Side slope protection works of the Lai Nullah channel prism.

3.2.3.4 Non-Structural Measures

Following non-structural measures were also proposed under the 'Master Plan Study' including:

- Establishment of FF&WS in Islamabad-Rawalpindi
- Preparation of a flood risk map
- Control of encroachments, solid waste disposal into Lai nullah& improvement of drainage & sewerage
- Establishment of a management committee for integrated Lai nullah administration, establishment of a Task Force for implementation of flood mitigation plan, demarcation of roles of relevant land administrators, strengthening of legal setup and capacity building etc.

The total expenditure incurred was Rs. 348 million (JICA loan amount Rs. 337 million + GoP Share Rs. 11 million) for above mentioned projects.

3.3 REVIEW OF FLOOD RELATED REPORTS

3.3.1 Indus Basin Floods by Asian Development Bank

With an emphasis on Indus basin, this report encompasses a critical analysis of Pakistan's water resource policy, flood management methodology and future challenges. This report states a different flood management approach. According to the report 21 floods occurred between 1950 and 2010 in the Indus Basin, causing cumulative direct economic losses of about US $19 billion (in 2010), killing 8,887 people, and damaging or destroying a total of 109,822 villages (within an area of around 446,000 km^2).

The document highlights that Pakistan does not have an approved water policy or a comprehensive flood management law, or river-plains regulatory laws. Pakistan's draft national water policy seems to comprise a plan rather than a policy. There is a gap between the issues and recommended actions to address the issues. The draft policy focuses on a few traditional actions, and provides no guiding principles.

The traditional flood management approach lacks preemptive solutions, operating only when danger becomes real and imminent. It is ad hoc in nature, and does not comprehensively consider the basin's hydro-climatic realities, physical settings, and development needs. Moreover, it lacks effective policies, planning, and institutional backing.

The world is in transition, undergoing demographic changes, rapid urbanization, accelerated economic development, changes in lifestyle, quests for renewable energy, and climate change. For instance, Pakistan's population is projected to double by 2050, unless serious population control measures which is need of the time are not considered. Correspondingly, the economy is expected to expand, and climate change is likely to increase the frequency of extreme events. High rainfall variability and flooding will make the population and infrastructure more vulnerable. Overall, these changes will aggravate the looming water, food, and energy crises, as well as water related disasters.

The limitations of the traditional flood management approach and the overwhelming effects of the change drivers (including likely climate change impacts) necessitate the adoption of a contemporary flood management approach (CFMA). However, in order to work, the CFMA must be incorporated into government policy and strategy, and embedded in appropriate legislation and institutional arrangements.

Indus Basin floods contain large volumes of freshwater that, if properly managed, could be used beneficially. Pakistan is a water-scarce country in the midst of an energy crisis, and is potentially facing a food crisis as well. It should therefore not allow such a precious resource to be wasted. For this reason, the CFMA recommended here would require that flood management be integrated into the management of water resources in general, following a framework based on integrated water resources management (IWRM) at the basin scale, and linking it with economic development and social and environmental welfare. The CFMA would aim to transform the flood burden into a water asset through basin-scale planning and effective implementation. Pakistan did not include large dams in its priority agenda in the past. However, recent water and energy crises have demonstrated the need for large reservoirs, and the government is considering large reservoirs as one solution. It is highly desirable that any effort to build large reservoirs be linked to flood management.

3.3.2 Annual Flood Report 2010 by Federal Flood Commission

A detailed study to assess the losses due to the catastrophic flood was undertaken by FFC, which is responsible for integrated planning for flood control at the national level and arranges financial resources for the implementation of flood management projects on country wide basis. Under emergent flood program, all the four provinces and federal agencies submit their flood related flood protection schemes which are technically scrutinized and submitted to ministry of Water & Power for approval of Departmental Development Working Party (DDWP/CDWP). Flood Communication Cell of Federal Flood Commission remains in operation on round-the-clock basis for the entire flood season and flood situation report is issued on daily basis to all the concerned.

The monsoon of the Year 2010 brought with it the worst flooding in the past 80 years in the region. Heavy monsoon rains in the Khyber Pakhtunkhwa, lower Punjab, Sindh, and Balochistan regions made the rivers surge and overflow which devastated areas from Gilgit-Baltistan to Kotri. During 2010 flood season, flows in western rivers were very high and some of the discharge levels recorded were comparable to those observed during the floods of 1956, 1973, 1976, 1988 and 1992. Asian Development Bank (ADB) has estimated the cost of flood damages to irrigation, drainage & flood protection infrastructure as Rs. 23.60 billion and their reconstruction/rehabilitation cost as around Rs. 83.00 billion, which includes remodeling cost of some structures for building back safer. For the flood season 2011, FFC advised provinces and federal agencies to mobilize all resources to repair/restore the damaged infrastructure, streamline the procedures and update the standard operating procedures (SOPs) of dams and barrages in order to ensure safety of all the structures and manage any future floods with a much better state of preparedness.

3.3.3 The 2010 Flood – Flood Enquiry Commission – Supreme Court of Pakistan

The Honorable Supreme Court of Pakistan constituted a commission to inquire into the pleadings of various petitioners regarding the 2010 flood which resulted in large scale flooding in the whole country and caused unprecedented damage to life and property. Flood Enquiry Commission prepared its findings in light of the Terms of Reference contained in the thirteen formulations of the Honorable Supreme Court of Pakistan in its order dated 15th December, 2010. Flood enquiry commission investigated various questions laid out in the ToR's of the Honorable Supreme Court of Pakistan.

Some of the facts reported by Flood Enquiry Commission are presented in the following paragraphs. It is stated by Flood Enquiry Commission that some gates of Sukkur barrage remain closed due to issues resulting from changes in the Indus River course since 1930s which reduced its capacity from 1.5 million cusecs to 900,000 cusecs. It is reported that thousands of acres of land encroached upon by the local influential land lords in the Katcha area of Sindh, blocks the natural water flows and create additional hazards during flood season.

The commission referred to the Damage and Need Assessment (DNA) survey that has revealed several weaknesses in the irrigation sectors: (i) deferred maintenance of flood embankments; (ii) insufficient reservoir/storage capacity to absorb flood peaks; (iii) lack of response mechanisms to early warnings; (iv) need for expanding flood early warning system (FEWS); and (v) encroachment of flood plains and riverine areas.

The commission reported that the historical evidence in Sindh Bund Manual shows that Guddu, Sukkur and Kotri barrages had withstood higher flood water flows than the 2010 flows; the performance of these three barrage structures and training works designed to sustain flood pressures and retain the bigger volumes may also have been beyond expectations of many. But what was lacking is the thorough and regular inspections of the bunds, particularly the main bunds on which the allied and secondary loop bunds and structures depend.

The heaviest damage to public sector infrastructure was suffered by the transport and communication sector. Complaints of human interventions have also been voiced and the NHA was directed to apprise the commission about such breaches in road network in various provinces and the estimated losses including the reasons for overtopping of M-1 motorway.

In its interaction with public and private sector institutions, the Commission noted with concern that major damages occurred due to lack of maintenance and repair of river embankments, canals and obstructions by major highways/motorways constructed by the Provincial Irrigation Departments and the National Highway Authority (NHA) and others across the country.

Flood Enquiry Commission gave various recommendations for the expansion of flood early warning systems, flood mitigation, barrages and bunds, encroachments and motorways/ highways. It was brought to the notice of the Commission that the major reason for inundation of lands and dwellings on the northern side of the Islamabad-Peshawar Motorway (M1) was the inadequate capacity of crossing bridges meant for the drainage of the flood flows in rivers. The motorway acted like a bund obstructing the natural course of water flows in the area. In addition to this, Flood Enquiry Commission also recommended to carry out detailed study of all NHA road network to identify areas of possible flooding as a result of obstruction caused by these roads.

3.3.4 Flood 2010: The Event, Issues and Way Forward – Irrigation & Power Department, Punjab

Punjab Irrigation Department is responsible for the operation and maintenance of one of the largest Irrigation networks in the world. Irrigation Department prepared 2010 Flood report by addressing the events, issues and way forward. The report also addresses its role for the flood fighting plans at Canal Division level after obtaining information for flood forecasting/ warnings and disseminates it in timely manner. It addresses the need for prior identification and demarcation of river water routes escaping from the breaching section and required relief cuts on designated route for keeping the damages to the minimum and the importance of model studies for the river training works.

3.3.5 Symposium on International Workshop on “Floods in Pakistan 2010” – Pakistan Engineering Congress

The report presents the combined efforts of the various researchers on the flood of 2010. It discusses the Flood event of 2010 right from occurrence to its mitigation and future strategies for future development and its impacts on all the stakeholders of the country. It discusses the primary objective to focus on the reduction of flood losses in an economically sound manner; prioritizing areas of greater economic concerns; protecting the possible use of existing flood control facilities; promoting appropriate land use in flood hazard areas; minimizing adverse impact on national ecosystem and environment; reviewing design of hydraulic structures and flood protection infrastructure in all provinces/agencies; reviewing of breaching sections and areas inundated as a consequence of breaches; hill torrent management; upgrading the flood protection facilities/ bunds that provide protection to the cities and towns and important installations such as power stations, oil refineries, industries etc.

3.3.6 Flood Action Program – International Commission for the Protection of Danube River

This report does not describe flood problems/issues, but describes that how to protect the individual river basin from the floods like as Balochistan and Khyber Pakhtunkhwa hill torrents/rivers basins. The methods, approaches, planning, measures, etc., are useful for formulation of NFPP-IV project.

Historically, and most recently in August 2002, disastrous flood events occurred in Danube River basin. In response to the damages, the International Commission for the Protection of Danube River (ICPDR) decided to establish the long-term Action Program for Sustainable Flood Prevention in the Danube river basin.

The first step is the development of a framework action program which is based on the sustainable flood protection program developed in the various Danube countries as well as on networking existing structures and using the future-oriented knowledge base accumulated through a wide range of activities over the past decade. The overall goal of the

Action Program is to achieve a long term and sustainable approach for managing the risks of floods to protect human life and property, while encouraging conservation and improvement of water related ecosystems. In addition, the Action Program needs to be specified in further detail for sub-basins.

At the beginning of the Action Program there is a description of the general hydrological and climate characteristics of the Danube River Basin as well as an overview of floods and flood protection. The section on “General considerations, basic principles and approaches” of the Action Program refer primarily to UN-ECE Guidelines on Sustainable Flood Prevention, EU Best Practices on Flood Prevention, Protection and Mitigation and to EU Communication on flood risk management, COM (2004) 472. The major principles advocated are: (i) the shift from defensive action against hazards to management of the risk and living with floods (ii) the river basin approach taking into account the Water Framework Directive, (iii) joint action of government, municipalities and stakeholders towards flood risk management and awareness raising, (iv) reduction of flood risks via natural retention, structural flood protection and hazard reduction, and (v) solidarity.

The four major basin-wide targets of the Action Program, that will be further defined and elaborated by the Flood Protection Expert Group of the ICPDR:

- Improvement of flood forecasting and early flood warning systems; interlinking national or regional systems.
- Support for the preparation of and coordination between sub-basin-wide flood action plans.
- Creating forums for exchange of expert knowledge.
- Recommendation for a common approach in assessment of flood-prone areas and evaluation of flood risk.

At the sub-basin level, six targets have been identified in the Action Program:

- To reduce the adverse impact and the likelihood of floods in each sub-basin through the development and implementation of a long-term flood protection and retention strategy based on the enhancement of natural retention as far as possible.
- To improve flood forecasting and warning suited to local and regional needs as necessary.
- To increase the capacity building and raise the level of preparedness of the organizations responsible for flood mitigation.
- To develop flood risk maps.
- To harmonize design criteria and safety regulations along and across border sections.
- To prevent and mitigate pollution of water caused by floods.

For sub-basin measures, the Action Program provides a recommended structure of the flood action.

Plans give an overview of activities to be considered during their preparation. Decisions on the framework of implementation of the sub-basin Action Plans is the task and responsibility of the countries affected, according to their national legislation as well as their bilateral and multilateral agreements.

Financial resources necessary for the implementation of the Action Program should be based on the national budgets and other national sources, on EU funds, including new cohesion policy funds, and on the loans from International Financing Institutions.

3.3.7 National Flood Reconstruction Plan 2010 by Flood Reconstruction Unit

Flood reconstruction unit (FRU) of Planning Commission, Government of Pakistan prepared its reconstruction plan for the whole of Pakistan. The report described the destruction caused by 2010 Flood and the reconstruction plan. The reconstruction works and costs were gigantic compared with available resources and institutional capacities, which are relatively weak. Preliminary estimates prepared under the Disaster and Need Assessment (DNA) survey assessed the sector damage to the physical infrastructure at Rs. 113 billion, 93% of which is in the road sector. The damage to NHA network was extensive throughout Pakistan. Roads, bridges, culverts, retaining walls and causeways were mostly damaged. The flood damaged 793 km of the NHA network, including 410 km completely damaged and 383 km partially damaged. Because of the severe flood damages, some sections had to be closed for traffic, cutting off large parts of the country from the highways network which brought misery to the people and created difficulties in rescue and relief operations.

3.3.8 Post Flood Report – 2010, Pakistan Army Corps of Engineers

Comprehensive report on the pros and cons of 2010 flood was prepared by the Pakistan Army Corps of Engineers. The report describes the facts, issues, reasoning of flood 2010, extent, remedial measures and management of such events in future. Notwithstanding exceptional severity of floods, there is absence in our planning process for disaster management at national as well as provincial and district levels.

Though nation as a whole stood united in handling this disaster to a large extent, there were a number of shortcomings in response at local, provincial and national level. There is, therefore a need to chalk out a comprehensive Flood Management Strategy at national level in the light of lessons of current floods to combat such situations in a cohesive and institutional manner.

3.4 NATIONAL WATER POLICY (NWP) AND ITS IMPLEMENTATION

Water has the recognized sectors laying demand for consumptive and non-consumptive use of water as it is used for drinking and sanitation, Irrigation, hydropower, Industry, environment, river system, wetlands, aquatic life, forestry, recreation and sports, and navigation. Thus, it was deemed prudent to ensure water security for the People of Pakistan; through a National Water Policy laying down the outlines of an integrated water management strategy that aims at maximizing the sustainable economic, social and environmental returns. For the purpose, an integrated and unified River Basin Development policy needs to be adopted. Presently, National Water Policy is in the process of formulation and approval.

National Water Policy covers vast areas of interests pertaining to integrated water resources management from generation of water from its source, its optimized uses and impacts and its safe disposal. The salient points on National Water Policy related to floods are given below.

i. The Flood Protection Plans (National as well as Local) shall be updated on a periodic basis using integrated and innovative approaches and technical shortcomings and lessons learnt in the past major flood events;

ii. Flood zoning shall be established and appropriate land use would be enforced by avoiding growth of vulnerable developments in flood hazard areas. Where feasible, land use shall be adjusted to ensure compatibility with the frequency and duration of flooding;

iii. Floodplain Mapping and Zoning shall be carried out along River Indus and its tributaries (Kabul, Swat, Jhelum, Chenab, Ravi & Sutlej) and a River Act shall be prepared for restricting/ prohibiting permanent settlements in high and medium flood risk areas;

iv. Reservoir operational rules shall be reviewed and optimized to ensure efficient and prudent decisions to control floods provided, however, that the safety of the dam, embankments, spillways, dam abutments, foundations and all other hydraulic structures is under no condition placed at risk;

v. Effective use shall be made of non-structural measures like flood forecasting and early warning systems to minimize flood losses through better forecasts and warning especially for flash floods, through additional forecasting facilities, e.g.,Radars, and other monitoring equipment;

vi. The construction of additional flood protection facilities and improvement of existing infrastructure shall continue where needed, concurrently with development of other measures specified here. Greater emphasis shall be laid on proper maintenance of the existing infrastructure;

vii. The design and maintenance standards of existing barrages and flood protection structures shall be reviewed and changes made where necessary to bring them to the level of functional capability and reliability;

viii. Hill torrent management for mitigation of floods shall be given due priority;

ix. Drainage system of major cities shall be rehabilitated/ upgraded keeping in view likely increase in short duration intense rainfall events due to climate change.

x. Community based flood disaster management initiatives shall be encouraged for effective mitigation of flood hazards.

4. EXISTING FLOOD MANAGEMENT PRACTICES

4.1 ORGANIZATIONAL ROLESAND RESPONSIBILITIES

4.1.1 Federal Flood Commission

Federal Flood Commission was established in 1977 to manage the issues of flood management on country-wide basis. It is a federal body headed by a Chairman working under ministry of Water Resources. The role and responsibility of FFC includes:

i. Preparation of National Flood Protection Plans,
ii. Approval of flood control schemes prepared by provincial governments and concerned federal agencies,
iii. Review of flood damages to flood protection infrastructure and review of plans for restoration and reconstruction works,
iv. Measures for improvements in Flood Forecasting and Warning System (FEWS),
v. Standardization of designs and specifications for flood protection works,
vi. Evaluation and monitoring relating to progress of implementation of National Flood Protection Plans,
vii. Preparation of research program for flood control and protection, and
viii. Recommendations regarding SOPs of reservoir for flood control.

4.1.2 National Disaster Management Authority

The National Disaster Management Authority (NDMA) was established under the Act – 2010 as a federal institution to deal with whole spectrum of disaster management and preparedness in the country.

The NDMA has been given wide spectrum role in managing disasters like floods, earthquake etc. The NDMA formulates and enforces disaster policies at federal and provisional levels and collaborates closely with various government ministries, military forces, and United Nation-based organizations to jointly coordinate efforts to conduct its disaster management, search and rescue, and wide range of humanitarian operations in the country and abroad. The NDMA aims to develop sustainable operational capacity and professional competence to undertake its humanitarian operations at its full capacity.

Codified under the Article 89(1) of the Constitution of Pakistan, the institution is chaired by the appointed chairman, either civilian or military officer, and directly reports to the Prime Minister of Pakistan as its chief operations coordinator.

The functions and duties are defined and set by the Constitution of Pakistan in Article 239I in Chapter1. The Authority charged with the following duties:

i. Act as the implementing, coordinating and monitoring body for disaster management;
ii. Prepare the National Plan to be approved by the National Commission;
iii. Implement coordinate and monitor the implementation of the National policy;
iv. Lay down guidelines for preparing disaster management plans by different Ministries or Departments and the Provincial Authorities;
v. Provide necessary technical assistance to the Provincial Governments and the Provincial Authorities for preparing their disaster management plans in accordance with the guidelines laid down by the National Commission;

vi. Coordinate response in the event of any threatening disaster situation or disaster;
vii. Lay down guidelines for or give directions to the concerned Ministries or Provincial Governments and the Provincial Authorities regarding measures to be taken by them in response to any threatening disaster situation or disaster;
viii. For any specific purpose or for general assistance requisition the services for any person and such person shall be a co-opted member and exercise such power as conferred upon him by the Authority in writing;
ix. Promote general education and awareness in relation to disaster management; and
x. Perform such other functions as the National Commission may require it to perform.

4.1.3 Provincial Irrigation Departments

At present, Irrigation Departments (PIDs) are the provincial entities headed by Secretaries under provincial Ministers of Irrigation. It is mainly responsible for operation and maintenance of one of the biggest canal systems in the world that includes 16 barrages and more than 6,000 kilometers of main canals and many thousands of kilometers of distributaries and minors.

PID’s main functions include; river survey and hydrological data, operation and maintenance of barrages, operation and maintenance of canals, distribution of water, installation of tube wells, flood protection works, drainage schemes, land reclamation, construction of small dams, irrigation research, administration of canal and drainage works and assessment of water charges.

Irrigation Department is one of the major departments, which play an active role in the management of floods. Its responsibilities are multi-dimensional. Another important responsibility of PID is construction and maintenance of flood protection works like flood protection bunds, guide bunds, spurs dikes etc. The barrages and flood protection works play a vital role in protecting human life, property and infrastructure. PID takes-up these works from preliminary assessment, feasibility, design stage, approval and allocation of funds till their completion. The maintenance of all these structures is the sole responsibility of PID.

4.1.4 Pakistan Meteorological Department

The Pakistan Meteorological Department (PMD), is an autonomous and independent institution under the Cabinet Secretariat (Aviation Division) tasked with providing forecasts and public warnings, for the purposes of protection, safety, and general information.

Apart from meteorology, it is also involved in monitoring as well as investigating weather phenomenon, astronomical events, hydrology, and research in astrophysics, climate changes, and studies on aeronautical engineering, renewable energy resources across various parts of the country.

Headquartered in Islamabad, it has offices and research facilities in all over the four provinces of the country.

Due to its resourcefulness and capable scientific staff, the PMD has become a reliable government agency for providing accurate data and forecast in the country. Since 1974, the Meteorological Department has introduced a seismic detection system to acquire scientific data on nuclear explosion and natural earthquake activities. Furthermore, its modern flood forecasting system has assisted the other government agencies and related organizations to improve Radar, satellite, computer technology, flight safety, consultancy services in seismic design of dams, buildings and other development and disaster relief schemes.

Pakistan Meteorological Department has key role in collecting precipitation data through precipitation gauging network in the entire country and sophisticated radars installed at Lahore, Sialkot and Mangla. PMD is responsible to issue meteorological and flood forecasts and warnings. An accurate early warning of the flood increases the reaction time for evacuation of population and adopting precautions against floods. Currently, statistical methods are used to forecast peak discharges at barrages. Rivers flow models (SOBEK) are being inducted as part of FEWS in order to improve accuracy as well as providing warning of expected inundation areas through GIS maps.

4.1.5 Water and Power Development Authority

The Pakistan Water and Power Development Authority (WAPDA), was created in 1958 as a Semi-Autonomous Body for the purpose of coordinating and giving a unified direction to the development of schemes in Water and Power Sectors. The Charter of Duties[9] of WAPDA is to investigate, plan and execute schemes for the following fields:

i. Generation, Transmission and Distribution of Power.
ii. Irrigation, Water Supply and Drainage.
iii. Prevention of Water logging and Reclamation of Waterlogged and Saline Lands.
iv. Flood Management.
v. Inland Navigation.

WAPDA has lead role in providing hydrologic data from whole river network in Pakistan. Besides, WAPDA is responsible for installation and maintenance of staff gauges and telemetry network along various rivers. Real-time transmittal of data from telemetry system which is extremely important in flood warnings is responsibility of WAPDA. The operation of major reservoirs; Tarbela Dam and Mangla Dam, which plays significant role in mitigating floods, is the responsibility of WAPDA.

4.1.6 Pakistan Army

Pakistan Army invariably is called upon to facilitate Civil administration for undertaking relief and rescue operations for protection of life and property during flood season. Over the period, army has developed a comprehensive organizational setup to fight any challenges resulting from floods in the country. The setup is named as 'Army Flood Protection and Relief Organization'.

General Headquarters Flood Relief Centre was established in 1977 and is functioning under General Staff Branch (Engineering Directorate) since then. Corps Flood Control Centers work under respective Corp Headquarters. Commanders Corps of Engineers at Lahore, Karachi, Peshawar and Quetta function as the Army liaison/coordinating officers with the respective Provincial Governments.

Before onset of flood season, certain precautionary and prep-measures are initiated and completed before May 30. These include; inspection of all flood protection works by the Corps Headquarters and, preparation of necessary contingency plans after coordination with civil authorities. Major activities at this stage include; allocation of deployment areas to units/formations, allocation and testing of equipment for flood relief operations, setting up of operation rooms and communications at all levels and finalization of move plans and logistic

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[9] *http://www.wapda.gov.pk/htmls/auth-index.html*

support. Army Pre-Flood Season Coordination Conference is held in Engineers Directorate every year to coordinate various aspects with civil agencies. The conference is chaired by the Engineer-in-Chief and attended by all Commanders Corps of Engineers, Chairman Federal Flood Commission, Secretaries of Provincial Irrigation and Power Departments and representatives of other concerned departments.

Army flood relief center established at Engineers Directorate General Headquarters functions round the clock during flood period with the assigned duties to keep watch on daily weather forecasts and flood situation in the different rivers.

Equipment for flood relief operations are procured through Irrigation and Power Department according to the requirement of different formations. Explosive for the breaching sections is also provided by Irrigation and Power Departments/concerned department and further issued to formations and maintained by respective Army units on behalf of Provincial Governments.

Post flood conference for the postmortem of current year flood activities is held at the end of flood season during November/December at Engineers Directorate attended by all concerned military and civil authorities.

4.1.7 Emergency Relief Cell, Cabinet Division

Emergency Relief Cell (ERC) exists under the Cabinet Division and is controlled by the Cabinet Division. The Cell is headed by a Director General. The main functions of the Emergency Relief Cell include:

i. Planning and assessment of relief requirements for major disasters;
ii. Stock piling of basic need items during emergency such as dry food, tents, blankets etc;
iii. Establishing emergency fund upon declaration of any part of the country as calamity affected; and
iv. Maintaining contact with UNO and its related organizations, besides other international aid giving agencies.

4.1.8 Pakistan Commissioner for Indus Waters (PCIW)

For the purpose of cooperation in matters related to the Indus Water Treaty (IWT-1960), the Permanent Indus Commission was established, with a commissioner appointed by each country. In follow-up of IWT, an agreement was signed between India and Pakistan in 1989 through their respective Commissioners for Indus Waters, which includes provision to share rivers flow data as considered important for flood forecasting in Pakistan. A number of river flow stations are specified for this purpose as described under another section of this report.

The Pakistan Commissioner for Indus Waters receives the Indian data normally once in a day. The data is then passed on to the FFD, Lahore for preparation and issuance of flood forecast to concerned organizations. Frequency of data reception is increased to six hourly and even to hourly in case of severe flood situation. Pakistan Commissioner for Indus Waters is thus responsible to provide to the Chief Meteorologist, FFD, Lahore, the much-needed data obtained from India for use in the flood forecasting models to ensure accurate forecasts for Rivers Sutlej, Ravi, Jhelum and Chenab. 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 flows data or the flood control structures in India.

4.1.9 Provincial Relief Organization/Provincial Disaster Management/District Administration Authorities (District Disaster Management Authority)

Provincial Relief Organizations (now Provincial Disaster Management Authorities) are responsible for disaster preparedness, preparation of emergency response plan, rescue and relief measures and rehabilitation plan and its approval from Provincial Government before implementation; examine the vulnerability of different parts of the province to different disasters and specify prevention or mitigation measures; lay down guidelines for preparation of disaster management plans by the Provincial Department and District Authorities; evaluate preparedness at governmental & non-governmental levels to respond to disaster and enhance preparedness; coordinate response in the event of disaster; give directions to District Disaster Management Authorities (DDMAs) regarding actions to be taken in response to disaster; and promote general education, awareness and community training etc. pertaining to all disasters including floods. Relief functions at the District and Tehsil/Union Council level are now performed through DDMA, who coordinate with the other departments to execute the disaster management functions at the district level.

4.2 REVIEW OF EXISTING FLOOD MANAGEMENT MEASURES

4.2.1 Existing Structural Measures

4.2.1.1 Indus River

Indus plains have been extensively developed for irrigated agriculture. Protection of valuable irrigation facilities, agricultural lands, and major population centers against flood inundation and bank erosion have been accomplished through construction of flood protection embankments and river channel erosion structures. With the development of major irrigation structures on the Indus River flood protection facilities, mainly bunds, evolved. These bunds have been raised and strengthened in response to the most recent flood of record. Presently there are 1311.67 km of bunds on the Upper Indus River. These flood bunds mainly exist along the upstream and downstream sides of the structures on the upper Indus River.

Existing flood protection works along Upper and Lower Indus have been shown in Exhibit-1(included in CD) and Exhibit-2 (included in CD), respectively. The name of the flood protection structures, length, type, river reach, province and district are given in separate report on “Development of Inventory of Flood Protection Works and Benefit Monitoring and Evaluation”. Details on various structures along Indus River are provided as follows;

Tarbela Dam
Tarbela Dam is one of the world’s largest earth and rock filled Dam and greatest water resources development project which was completed in 1976 as a component of Indus Basin Project. The Dam is built on one of the World’s largest rivers the Indus known as the “Abbasin” or the father of rivers.

In addition to fulfilling primary purpose of the Dam i.e. supplying water for Irrigation, Tarbela Power Station has generated 341.139 Billion KWh of cheap hydel energy since commissioning. A record annual generation of 16.463 Billion KWh was recorded during 1998-99. Annual generation during 2007~08 was 14.959 Billion KWh while the Station shared peak load of 3,702 MW during the year which was about 23% of total WAPDA System Peak.

Jinnah Barrage
The Jinnah Barrage is on the Indus River near Kalabagh. It is part of the Thal Project which helps irrigate 770,000 ha (1,900,000 acres) in the Sindh Sagar Doab east of the Indus River. Planning for the project dates back to the nineteenth century but final plans for the barrage

was made in 1919 and it was constructed between 1939 and 1946. The barrage diverts an average of 283 m^3/s (10,000 ft^3/s) of water into the 51.5 km (32 mile) long Thal canal where it serves areas in Bhakkar, Khushab, Layyah, Mianwali and Muzaffargarh districts with 3,362 km (2,089 mile) of additional canal branches and distributaries. It spans 1,152 m (3,780 ft) over the river. The barrage can discharge up to 26,898 m^3/s (950,000 ft^3/s) downstream with 42 gates each 18.2 m (60 ft) wide.

Chashma Barrage

Chashma Barrage is one of the six river structures provided under Indus Basin Project and is the highest amongst all. Chashma barrage is located on river Indus about 56 km (35 miles) downstream of Jinnah Barrage. Its purpose is to supply water to CJ-Link Canal on the left and Chashma Right Bank Canal (CRBC) on the right. The design discharge capacity of barrage is 26,901 m^3/s (950,000 ft^3/s) plus 20% concentration/additional allowance. To pass anticipated maximum design flood discharge of 26,901 m^3/s (950,000 ft^3/s), 52 Gates each 18m (60 ft) wide have been provided in the Barrage. A fish ladder and navigation lock have also been provided. Two head regulators, one for CJ-Link Canal and the other for CRBC exist on the left and right banks, respectively. A low head hydel power station has been recently constructed on the right side of Chashma Barrage.Chashma barrage has a very wide and shallow reservoir on it's upstream, the surface area of which is about 360 km^2 (139 $mile^2$). The initial capacity of Chashma reservoir was 0.870 MAF as per survey carried out in 1971-72. Maximum flood passed through Barrage gates was 22,274 m^3/s (786,600 ft^3/s) in 1976. Maximum outflow passed through Chashma Barrage is 29,418 m^3/s (1,038,873ft^3/s) at reservoir level of El. 640.50 on August 01, 2010.

Taunsa Barrage

The Taunsa barrage, built across Indus River is located at about 16 km (10 miles) west of Kot Addu, with location coordinates of 30º 31 N 70º 51 E. The Barrage has 65 bays with a total width of 1,325 m (4,346 ft) between the abutments. Width of each bay is 18 m (60 ft) except for bay No. 8 which is 7m (22 ft) wide and serves as navigation lock. Bays No. 9 to 61 constitute main weir and there are two sets of undersluices (bays No. 1 to 7 and 62 to 65) separated from the weir by two divide walls at left and right flanks. The barrage has 2 fish ladders each 11 ft wide alongside these divide walls. This Barrage serves 2.351 million acres (951,400 hectares) besides diverting flows from Indus River to the Chenab river through Taunsa-Panjnad (TP) Link Canal. The barrage also serves as an arterial road bridge, a railway bridge, and crossing for gas and oil pipelines, telephone line and EHV transmission lines.

Taunsa barrage is the most important barrage amongst those built across the mighty Indus and it commands large areas in Punjab and Balochistan provinces. Muzaffargarh and TP Link canals offtake from the left flank of the Barrage, while DG Khan is on the right flank. Recent construction of head regulator of Kachhi canal on right flank will enable a withdrawal of 170 m^3/s (6,000 ft^3/s) for irrigation of Kachhi plain in Balochistan. TP Link conveys Indus river water to Chenab river to supplement irrigation in Panjnad command during shortage period.

Guddu Barrage

Guddu barrage is located on Indus River near Kashmore in the Sindh province. The foundation-stone of Guddu barrage was laid on 2 February 1957. The barrage was completed in 1962 at a cost of Rs.474.8 million. Guddu barrage is used to control water flow in the Indus river for irrigation and flood control purposes.

It has a discharge capacity of 33,980 m^3/s (1,200,000 ft^3/s). It is a gate-controlled weir type barrage with a navigation lock. The barrage has 64 bays, each 18 m (60 ft) wide. The maximum flood level height of Guddu barrage is 8 m (26 ft). It controls irrigation supplies to 12,000 km^2 (4,633 $mile^2$) of agricultural land in the Jacobabad, Larkana and Sukkur districts of Sindh province and the Naseerabad district of Balochistan province, by feeding the Ghotki Feeder and Rainee canals on the left (east) side and the Begari Sindh (BS) Feeder and Desert Pat Feeder canals on the right (west) side. The barrage incorporates two fish ladders. The barrage is also used for river control and flood management. It has been designed to pass a super-flood discharge of up to 33,980 m^3/s(1,200,000 ft^3/s). The barrage is also an important transport link across the Indus river and provides cooling water for the thermal power station at Guddu. Two major gas lines cross the barrage.

Sukkur Barrage

Sukkur Barrage is located about 616 km (385 mile) north east of Karachi (68° 55'E, 27° 41'N) in the Sindh province of Pakistan. The Barrage is about 160 km (100 mile) downstream of Guddu barrage and about 480 km (300 mile) upstream of Kotri barrage. The historic Lansdowne Bridge is located about 3 miles upstream of Sukkur barrage. The cities of Sukkur and Rohri lie on the right and left banks of the river, respectively. Sukkur barrage comprises of a 66 spans, approximately 1.4 km (4,725 ft) long, constructed across the Indus River. The structure is mainly of stone masonry construction with reinforced concrete arches spanning 18.29m (60 ft) openings for the two bridges; an upper deck used for operating the gates and a lower road deck. The canal head regulator structures on both the banks control flow in the three right bank canals of Dadu, Rice and North Western canals and four left bank canals of Khairpur Feeder East, Rohri, Khairpur Feeder West and Nara Canals. The canal regulators are low level structures carrying a deck area for operating the gates and a road bridge. The training works upstream of the main barrage comprise divide walls, a submerged weir and approach/tail channel with outer and middle banks within the river and an inner bank adjacent with the right guide bank. An island also exists between the middle bank and approach channel.

Kotri Barrage

Kotri barrage, the last barrage on the Indus river, is located about 176 km (110 mile) upstream of its sea mouth. Kotri barrage, also known as Ghulam Muhammad Barrage, was constructed on the Indus river near Hyderabad in 1955, wherefrom an area of 1.126 million hectares (2.78 million acres) was supplied will regular irrigation supplies. Kotri barrage was constructed to pass a maximum discharge of about 24,780 m^3/s (875,000 ft^3/s) but the flood peak passing through the barrage exceeded the designed discharge capacity in 1956. Flood peaks passing Sukkur barrage are greatly reduced by the valley storage effects along the 480 km (300 mile) reach to Kotri barrage. Kotri barrage is used to control water flow in the Indus River for irrigation and flood control purposes. Four canals off take from kotri barrage, one from right and three from left side.

Most of the canal command area lies in districts of Thatta, Badin and Hyderabad.

4.2.1.2 Jhelum River

There are two major structures; Mangla dam and Rasul barrage on the Jhelum River upstream of confluence of Jhelum River with Chenab River. Mangla dam, constructed in 1967 with top of embankment at El.1234 ft (maximum conservation level as El. 1202 ft), was raised by 30 ft with top embankment at El. 1264 ft (maximum conservation level at El. 1242 ft). It plays a vital role in the mitigation of floods in Jhelum River. More details are presented under Section 5.4 of this report.

Existing flood protection works along Jhelum River are shown in Exhibit-3 (included in CD). The name of the flood protection structures, length, type, river reach, province and district are given in separate report on "Development of Inventory of Flood Protection Works and Benefit Monitoring and Evaluation". The details on structure along Jhelum River is provided as follows:

Rasul Barrage

The only barrage on Jhelum River is at Rasul. The old Rasul headworks was constructed on the Jhelum River in 1901 to feed Lower Jhelum Canal (LJC). Later a new barrage, about 5.0 km (3 mile) downstream of old headworks, was constructed in 1967 to transfer water from Mangla reservoir on Jhelum River to Chenab, Ravi and Sutlej Rivers through Rasul-Qadirabad Link, Qadirabad-Balloki Link and Balloki-Suleimanki Link, respectively.

Rasul barrage is located at about 71 km downstream of Mangla dam. The designed flood passing capacity of the barrage is 24,070 m^3/s (850,000 ft^3/s). Rasul-Qadirabad Link and Lower Jhelum Canal off-take from the left flank of the barrage with maximum capacity of 540 m^3/s (19,000 ft^3/s) and 187 m^3/s (6,600 ft^3/s), respectively.

In addition to d/s releases from Mangla reservoir, Rasul barrage receives flows in between Mangla and Rasul from numerous hill torrents named Koterra, Darapur, Bunha, Chahan, Suketar, JabaKas and others originating from Pabbi hills on left side of river.

4.2.1.3 Chenab River

Existing flood protection works along Chenab River are shown in Exhibit-4 (included in CD). The name of the flood protection structures, length, type, river reach, province and district are given in separate report on “Development of Inventory of Flood Protection Works and Benefit Monitoring and Evaluation”. Details on various structures along Chenab River are provided as follows;

Marala Barrage

Marala barrage is the first structure on Chenab in Pakistan. It is located at 23 km (14 mile) towards, the northeast of Sialkot city. The capacity of the old weir (constructed in 1910-12) was 19,800 m^3/s (700,000 ft^3/s) with an upstream pond level of RL 246.28 m (808 ft). The weir experienced its highest flood on record in 1957 with discharge of 31,150 m^3/s (1,100,000 ft^3/s). The left and right bunds were allowed to breach resulting in a catastrophic inundation of lands and dwellings.

Marala weir was abandoned in 1968, when it was replaced by a new barrage under the Indus Basin Replacement Works. The new barrage has been constructed at 344 m (1,130 ft) downstream of the old weir. The discharge capacity of the left pocket was enhanced to accommodate a huge canal diversion of 1,100 m^3/s (38,850 ft^3/s). The new barrage experienced an exceptionally high flood of 23,930 m^3/s (845,090 ft^3/s) in 1992, when a flood level of 248 m (814 ft) at weir crest was attained.

The pond level of the new barrage was raised by four feet in order to improve the performance of the off-taking channels. The pond level was thus fixed at 247.5 m (812 ft). This reduced the approach velocity and considerably reduced the erosion of “belas” (sand bars). The old weir crest in the normal bays was at RL 244 m (800 ft). The same crest level was kept for the new barrage. The barrage has a left marginal bund, a right closure bund, guide banks and numerous river training works. The weir comprises three sections: a left section with 13 bays, a right section with 7 bays and central section with 46 bays, each having width of 18.3 m (60 ft).

Khanki Barrage

Khanki barrage is located on the Chenab river at 16 km (10 mile) downstream of Alexandra bridge and about 60 km (37 mile) d/s of Marala barrage. The headwork was constructed in 1890-92 and it is the oldest major irrigation diversion structure in Pakistan. The headworks consist of three under-sluices and six bays controlled by shutters. Khanki headworks has a design discharge capacity of 22,654 m^3/s (800,000 ft^3/s). Commissioning of Qadirabad Barrage, at about 30 km (19 mile) downstream of the headworks, has accreted the river bed between Khanki and Qadirabad by 0.6 to 1.2m (2 to 4 ft) rendering the former non-modular during high floods. This raises the stage through the weir resulting in frequent breaching of the marginal bunds.

To replace existing 122 years old headworks with new barrage located about 274 m (900 ft) d/s of old weir, enhancing flood passage capacity from 22,653 m^3/s to 31,148 m^3/s (800,000 ft^3/s to 1,100,000 ft^3/s) and to ensure sustainable irrigation supplies to about 3.3 million acres of fertile lands of seven districts of central Punjab (Gujranwala, Hafizabad, Sheikhupura, Nankana, Faisalabad, Tobatak Singh and Jhang), a New Khanki Barrage Construction Project is in progress. The salient features of this project are

- New barrage with left and right under sluices;
- New head regulator of L.C.C;
- Improvement of roads on both river banks, and other infrastructure.

Qadirabad Barrage

Qadirabad barrage is located in Gujranwala district, 16 km (10 mile) west of Alipur Chatha town and 30 km (19 mile) d/s of old Khanki weir. Qadirabad barrage was commissioned in 1968. It has a design discharge capacity of 25,485 m^3/s (900,000 ft^3/s). The Chenab River is bounded by marginal bunds between Khanki headworks and Qadirabad barrage. The river, while flowing in its alluvial bed (“Khadir”), meanders widely between the marginal bunds. To cope with the situation river training works have been provided. In 1992 a peak discharge of 26,844 m^3/s (948,000 ft^3/s) was recorded, which is more than its capacity. This high flood peak caused high pressure on the left marginal bund and damaged the river training works.

Trimmu Barrage

Trimmu barrage is located about 3 km (2 mile) downstream of the confluence of Jhelum and Chenab Rivers. The barrage is about 320 km (200mile) downstream of Mangla dam on Jhelum River and 291 km (182mile) downstream of Marala barrage on Chenab River. It falls in the semi-arid zone with desert on its right and Rechna Doab on its left.

The barrage is designed for 18,265 m^3/s (645,000 ft^3/s) discharge. Flows approach the barrage at an angle of 55 degrees from the normal and the safe discharge capacity is estimated to be 16, 800 m^3/s (592,000 ft^3/s). In 1959 an exceptionally high flood peak of 26,700 m^3/s (943,000 ft^3/s) was recorded, which was more than its capacity.

The main weir of the barrage consists of 37 normal bays, six under-sluices on the right and eight under-sluices on the left of the main weir. The width of each normal bay is 18.3 m (60 ft), whereas the under-sluice bays are 9.1 m (30 ft) wide each. Three canals named Haveli main line, Trimmu-Sidhnai link (TS Link) and Rangpur canal are off-taking from the barrage. Haveli main line and TS Link off-take from the left flank, whereas the Rangpur canal off-takes from right flank of the barrage. Rehabilitating the existing barrage to safely pass the 100- year return period flood discharge and avoiding possible colossal damages, a project is in pipeline. This project has the following specific objectives

- Addition of 13 bays with road bridge on right to accommodate the discharge in addition of existing capacity of the barrage 18,265 m^3/s(645,000 ft^3/s)to 24,777 m^3/s(875,000 ft^3/s);
- Relocation of existing Head Regulator of Rangpur Canal and Right Guide Bank;
- Partial removal of Bela; and
- Rehabilitation and upgrading of gates and hoisting system.

Panjnad Barrage

Panjnad barrage is situated just below the confluence of Sutlej and Chenab Rivers in the south-eastern part of Muzaffargarh district. The barrage was constructed in 1932 to cater for a discharge of 19,822 m^3/s (700,000 ft^3/s). After passing through Panjnad headworks, the river ultimately joins Indus River at Sarki village, about 160 km (100 mile) downstream of Taunsa barrage and about 125 km (79 mile) upstream of Guddu barrage.

The approach of the river to the barrage is oblique, which partially make the weir un functional and the marginal bunds become unsafe in high floods. General accretion of the river bed downstream of the barrage is reducing the modularity of the barrage. Rehabilitating the existing barrage to perform the designated functions and to ensure reliable irrigation supplies for another 100-year life period; and enhancing the flood capacity of barrage to safely pass the 100-year return period flood discharge avoiding possible colossal damages to agricultural land, infrastructure and public lives due to occurrence of breaches, a project is in pipeline. The specific objectives of this project are:

- Enhancing the Panjnad barrage capacity from 19,822 m^3/s (700,000 ft^3/s) to 24,494m^3/s (865,000 ft^3/s)
- Conversion of island existing between Main and Annexe weir into weir bays to accommodate the flow in addition of existing capacity of the barrage
- Remodeling of existing barrage section
- Raising and strengthening of existing guide banks and marginal bunds
- Rehabilitation and upgrading of gates and hoisting system

4.2.1.4 Ravi River

Existing flood protection works along Ravi River are shown in Exhibit-5 (included in CD). The name of the flood protection structures, length, type, river reach, province and district are given in separate report on “Development of Inventory of Flood Protection Works and Benefit Monitoring and Evaluation”. Details on various structures along Ravi River are provided as follows;

Thein Dam in India
In India, upstream of Jassar bridge (rim station in Pakistan), Thein dam and Madhopur headworks exist on Ravi River. Thein dam is located at 101 km (63 mile) upstream of Jassar bridge, with a live storage capacity of 2,343 MCM (1.9 MAF). The main objectives of the Thein dam are to provide irrigation water to an area of 350,000 ha (865,000 acres) and hydropower generation. The discharge capacity of the spillway is 17,000 m^3/s (600,000 ft^3/s). Madhopur headworks located at 81 km (51 mile) upstream of Jassar Bridge, diverts water to the Upper Bari Doab Canal.

Balloki Barrage
Balloki barrage is located at 160 km (100 mile) downstream of Madhopur headworks. Balloki barrage was constructed in 1913 to divert waters of Ravi River into the Lower Bari Doab canal (LBDC), on the left bank of the river. A regulator for Balloki-Suleimanki Link (BS Link) was added alongside LBDC head regulator during 1954 for feeding canals off-taking from Sutlej River whose control had gone to India in 1947. As a part of Indus Basin Project, the barrage was remodeled in 1964-65 to improve the operational capacity of the structure and to increase capacity of BS Link as per requirement of Indus Basin Works. During 1997-98 a safety evaluation study of this barrage was got done by Provincial Government through consultants which highlighted the necessity of improving the downstream energy dissipation works, controlling retrogression trend and rehabilitation of mechanical works. With the passage of time, the operation of breaching section which had been provided in the Right Marginal Bund (RMB) of the barrage, was not possible because the environmental/social setup has been changed from that of the time of construction of project. Now, a blast of population has broken in the vicinity of barrage and the area previously intended for carrying the waters of breaching sections of the Ravi river have been intercepted by establishing dwelling areas and ploughing the same land for agricultural purposes. Under these circumstances, the Government functionaries are bent upon adopting the other engineering

options to avoid the operation of breaching sections for the safety of the dwelling areas and agricultural lands. The Government of the Punjab engaged a group of intellectuals for consideration of a number of possible options to avoid the conventional operation of breaching sections upstream of the barrage and suggest other alternate arrangement for safety of the structures to pass down the flood waters beyond the designed capacity of the barrage. According to the recommendations of the group the Balloki barrage remodeling is in its final stages. An additional row of friction blocks was added to improve energy dissipation measures. The settled stone apron was recouped with heavy sized stone and open joints of stone masonry layer of floor was filled with rich cement sand mortar. In addition, an annexed weir of 8 bays similar to the existing weir but with depressed crest is constructed alongside the barrage on the right side. The right guide bund of the barrage is relocated to the right side of the annexed weir. The design discharge capacity of the Balloki barrage is enhanced to 10,760 m^3/s (380,000 ft^3/s) which corresponds to 100-year flood discharge.

<u>Sidhnai Barrage</u>
The word Sidhnai means a Straight river. A stretch of 13 km (8 mile) of Ravi River at Sidhnai is nearly straight and does not meander. The present Sidhnai barrage was completed in 1965 as part of the Indus Basin Project, replacing the older weir located about 13 km (8 mile) downstream. Sidhnai barrage is located at 199 km (121 mile) downstream of Balloki Barrage. The weir comprises two sections: a left section with 4 bays (2 under sluices and 2 silt excluders) of width 12.19 m (40 ft) each with crest level at 136.86 m (449 ft) and a right section with 11 bays of width 12.19 m (40 ft) each with the crest level at 138.38 m (454 ft). The barrage width between the abutments is 217.02 m (712 ft) and the pier width is 2.44 m (8 ft). It diverts water from the Ravi river into the Sidhnai Canal and Sidhnai-Mailsi-Bahawal Link Canal. There is an abandoned bye-pass channel on the right bank, which was intended to pass excess flows. These flows are now passed through breaching section in the Right Marginal Bund, into an area between Ravi and Chenab Rivers.

<u>Ravi Syphon</u>
At 73 km (131 mile) downstream of Madhopur headworks, the Bombanwala Ravi-Badian-Dipalpur (BRBD) canal crosses Ravi river through Ravi siphon. Ravi syphon was completed in 1952 to provide about 137 m^3/s (4,850 ft^3/s) to Central Bari Doab (CBD) Canal and other canals that lost their supplies after independence. The structure was repaired and improved after 1955 flood to permit a river discharge of 12,743 m^3/s (450,000 ft^3/s) over the syphon. However, the left side of the channel has silted, reducing the safe discharge capacity.

4.2.1.5 <u>Sutlej River</u>

There are two barrages on Sutlej River (Suleimanki barrage and Islam barrage), five road bridges and one Railway Bridge. One syphon (Mailsi) crosses the Sutlej River below Islam barrage.

Existing flood protection works along Sutlej River are shown in Exhibit-6 (included in CD). The name of the flood protection structures, length, type, river reach, province and district are given in separate report on “Development of Inventory of Flood Protection Works and Benefit Monitoring and Evaluation”. Details on various structures along Sutlej River are provided as follows;

<u>Suleimanki Barrage</u>
Suleimanki barrage was constructed across the Sutlej River during 1924-1926 under the Sutlej Valley Project (SVP). This barrage diverts irrigation supplies into Pakpattan, Fordwah, and Eastern Sadiqia Canals. In consequent of Indus Water Treaty and building up of storages by India, the water availability at the Suleimanki barrage was to be reduced drastically and thus necessitated changes in the diversion arrangements of Pakpattan Canal. Upper reach of the Canal from RD 0+000 to 567+372 now receives supply from Suleimanki

barrage, while the lower command area from RD 568+600 to 667+786 has been shifted to Sidhnai-Mailsi-Bahawal (SMB) Link Canal, and this shortened reach has been now renamed as Pakpattan Canal (Lower) and is being fed through a new head regulator at RD 195+171 of SMB Link Canal.

As the barrage is over 85 years old now, aging process coupled with drastically reduced flows, for greater part of the year have resulted into heavy siltation in the barrage pond. Therefore, examination of the safety parameters of the barrage has become very imperative. Punjab Irrigation Department engaged M/s National Development Consultants (NDC) in June 1998 for evaluation of safety of Suleimanki barrage. This study recommended rehabilitation of the barrage to ensure its safe operation besides additional investigations for sub-surface flows and model studies for evaluating adequacy of river training works. Punjab Irrigation Department awarded the consultancy work of carrying out Feasibility Study for Rehabilitation & Modernization of the Suleimanki barrage to the joint venture (JV) of NDC and NESPAK in association with ATKINS of UK called Punjab Barrages Consultants (PBC). The Consultants submitted the Feasibility Study Report in May 2005.

In 2009, PID entrusted the task of updating the feasibility study of 2005, preparation of detailed engineering design, procurement documents, and PC-I for Rehabilitation and Upgrading (R&U) works of the Suleimanki barrage to a JV of NESPAK, DMC & AAB Private Limited which is known as PIAIP Consultants. The PC-I for rehabilitation of Suleimanki barrage, prepared by PIAIP Consultants is approved by authorities and now this is in its implementation phase. PIAIP Consultants also prepared and submitted a PC-I of 100-year flood management for Suleimanki barrage and submitted to PID.

<u>Islam Barrage</u>
Islam barrage, located about 10 km (6mile) north-west of Hasilpur town, about 195 km (121 mile) downstream of Suleimanki barrage which was constructed across river Sutlej during 1922-1927 as a component of SVP for feeding Bahawal Canal and Qaim Canal on the left bank and Mailsi Canal on the right bank. After the implementation of Indus Water Treaty, the head regulator of Mailsi canal at Islam barrage was abandoned and the canal started receiving supplies from the new Sidhnai-Mailsi Link Canal constructed in 1965.

In June 1998, the consultants were engaged to assess the general health of the hydraulic structures of Islam barrage, who declared that it is unsafe and recommended that rehabilitation of the barrage should be undertaken on a priority basis in order to ensure its safe operation. Based upon this recommendation, the Punjab Government engaged another group of consultants in December 2003 to carry out the feasibility study of the rehabilitation works of the barrage. After the completion of feasibility studies indicating positive outcome, the contract for providing consultancy services to prepare the detailed design of the R & U works for Islam barrage was awarded to a JV comprising NESPAK and NDC in association with Integrated Consulting Services (ICS). Who submitted a PC-I to the PID in 2009.

The PC-I comprises rehabilitation of Islam barrage and its flood protection works. The envisaged project components include repair of cracks, grouting of the subsoil strata underneath the floors, lowering of subsidiary weir crest to increase the barrage capacity, raising of retired embankments (marginal bunds) and provision of wetting channels, rehabilitation of gates and hoisting system including gate motorization, and instrumentation for uplift pressure monitoring. The proposed rehabilitation measures will (i) increase the barrage capacity (from 8,806 m^3/s (311,000 ft^3/s) at present to9,401 m^3/s (332,000 ft^3/s)), (ii) check the leakages through the gates, and (iii) strengthen the embankments thereby safeguarding against occurrence of breaches besides eliminating the need of operating breaching section for floods up to 100-year return period.

Mailsi Syphon

In 1965, about 32 km (20 mile) downstream of Islam barrage, Mailsi syphon was constructed on Sutlej river to carry the irrigation water of Sidhnai-Mailsi-Bahawal (SMB) link canal for the Lower Bahawal canal. The syphon has a length of 439 m (1,440 ft) and its flow capacity is 147 m^3/s (5,200 ft^3/s), passing through four barrels 4.83x4.83 meter (13.5x13.5 ft) each. The Sutlej river over the syphon has a width of 574m (1,601 ft) between the flanks. The design capacity of Sutlej river over the syphon is 12,148 m^3/s (429,000 ft^3/s).

4.2.1.6 Kabul River

Existing flood protection works along Lower Kabul River (Downstream of Warsak dam) are shown in Exhibit-7 (included in CD). The names of the flood protection structures, length, type, river reach, province and district are given in separate report on "Development of Inventory of Flood Protection Works and Benefit Monitoring and Evaluation".

4.2.1.7 Hill Torrents

There are 14 major hill torrent areas in four (4) Provinces, GB Region, FATA and AJ&K in Pakistan. These hill torrent areas are listed below and shown in Figure 4-1.

I. Federal Areas and Azad Jammu & Kashmir
   i. Gilgit – Baltistan (Northern Areas)
   ii. Federally Administrated Tribal Areas (FATA)
   iii. Azad Jammu and Kashmir (AJ&K)

II. Punjab Province
   i. D. G. Khan
   ii. Pothowar Area
   iii. Rachna & Chaj Doabs

III. Sindh Province
   i. Khirthar Range
   ii. Karachi Area
   iii. Sehwan & Petaro Area

IV. Khyber Pakhtonkhwa Province
   i. D. I. Khan
   ii. Hazara, Kabul and Bannu (HKB) Basins

V. Balochistan Province
   ii. Indus Basin Component (including Quetta Region)
   iii. Kharan Closed Desert (KCD) Basin
   iv. Makran Coastal (MC) Area

The hill torrents bring in flashy floods of shorter durations and higher magnitudes. Because of steep gradients, flood flows move with high velocity, which result in the erosion of banks and bed of channels. Presently, major part of flows not only goes waste but also cause untold miseries and further aggravating conditions in the areas which are already most wretched and underdeveloped in the country.

In all hill torrent areas, generally the following types of structures have been constructed:

a) Dispersion Structures;
b) Delay Action Dams;
c) Storage Dams;

d) Diversion Embankments;
e) Flood walls; and
f) Flood Diversion Channels.

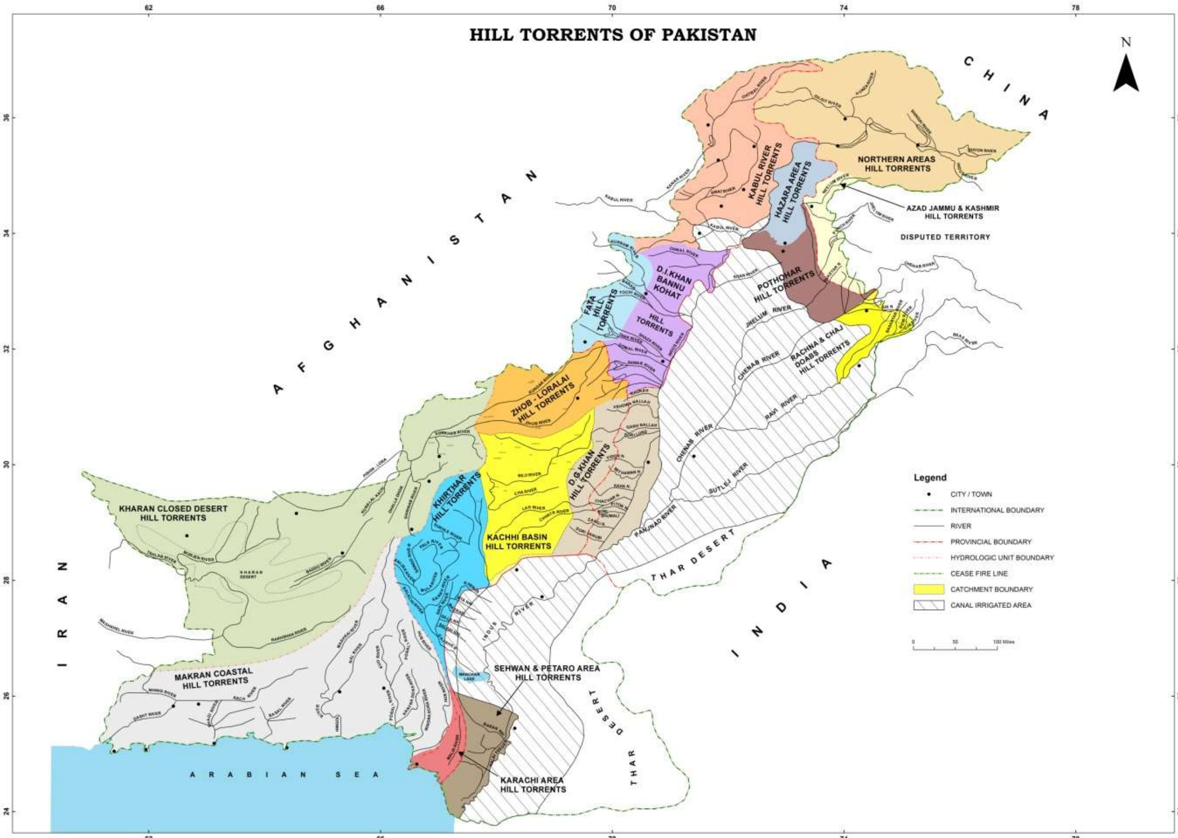


Figure 4-1:Pakistan's Major Hill Torrents Areas

From the point of view of physiographic characteristics of catchment areas and drainage pattern, the hill torrents of Pakistan can be divided into the following three regions:

i. Indus River Basin (IRB) Hill Torrents,
ii. Kharan Closed Desert Basin (KCDB) Hill Torrents, and
iii. Makran Coastal Basin (MCB) Hill Torrents.

<u>Indus Basin Hill Torrents</u>

All hill torrents of Indus Basin finally out-fall into the Indus Basin Rivers. However, before joining the rivers, these inflict serious damages along the route. These hill torrents can be broadly divided into three main regions:

- North & North Western Mountain Hill Torrents
- Suleiman, Kachhi and Khirthar Basin Hill Torrents
- Low Mountain Hill Torrents

North & North Western Mountain hill torrents emerge from high mountains in the north and north western part of Pakistan. The flows of hill torrents in these areas can be generally conserved by constructing low head dams at potential sites. Major hill torrent areas comprehending this category are:

- Gilgit-Baltistan Areas (Northern Areas) Hill Torrents
- AJ&K Hill Torrents
- FATA Hill Torrents

- Hazara, Kabul & Bannu Area Hill Torrents

Suleiman, Kachhi & Khirthar basin hill torrents include following six (6) hill torrent areas:
- D.I. Khan Hill Torrents
- D.G. Khan Hill Torrents
- Kachhi Basin Hill Torrents
- Khirthar Range Hill Torrents
- Karachi Area Hill Torrents, and
- Sehwan & Petaro Area Hill Torrents

Low mountain hill torrents originate in Pothowar, Rachna and Chaj Doabs mountains. The areas are located in north eastern part of Punjab province. Headwaters areas of Rachna and Chaj Doabs are located in Indian held Jammu & Kashmir, while piedmont areas are located in Pakistan. There are no potential sites in Pakistan, where flood-flows could be conserved. Pothowar area also known as Pothowar Plateau is located in the four districts of Punjab - Attock, Rawalpindi, Chakwal and Jhelum with small component in the northern part of Gujrat district. Diversion weirs and low head dams (DA/Storage Dams) can be constructed to conserve flows of hill torrents. So far thirty one (31) small dams have been constructed, while 150 additional sites have been identified for construction of dams which require in for further intervention.

<u>Kharan Closed Desert Basin</u>
Kharan Closed Desert Basin constitutes vast tract of barren lands comprising the north western part of Balochistan. The area is surrounded almost on all sides by overlapping ranges of dry mountains, out of influence of monsoon and westerly disturbances. It encompasses an area of 121,860 km^2 (47,050 miles^2). The area is the minimum rainfall region of Pakistan. It is an area of closed drainage, whereby streams drain into swamps of Murgha and Mushehel that often dry after lows precipitation spells. Nevertheless, heavy rainfalls occasionally produce flash floods. There are about fifty six (56) sites where flood flows can be stored.

<u>Makran Coastal Basin</u>
Makran Coastal Basin forms the south eastern part of Balochistan and is oriented along a 750 km (466 miles) coastal belt of Arabian Sea. It encompasses an area of about 123,025 km^2 (47,500 miles^2). Physiographically, the area possesses a series of mountain ranges, vast alluvial plains and plateaus. The ranges give rise to a number of rivers and hill torrents of various sizes which do not have a common drainage and individually outfall into the Arabian Sea. The area is predominantly under the influence of monsoon, which occasionally generate flash floods causing inundation of large areas and damage to village abadies, agricultural areas and infrastructure. Recent flood during 2010 caused considerable damage in the area. The flood flows can be managed by constructing diversion weirs and delay action dams. There are about eighty two (82) sites where flood flows can be stored.

4.2.1.8 <u>Flood Damages along Makran Coastal Highway in Balochistan</u>

National Highway N-10 (commonly known as Makran Coastal Highway (MCH)), is a 653 km (408 miles) long 4 lanes coastal highway along Pakistan's Arabian Sea coastline. It runs primarily through Balochistan Province between Karachi and Gwadar, passing near the port towns of Ormara and Pasni (Figure 4-2). Although, Balochistan receives less rainfall annually as well as in monsoon period, but sometimes coastal area receives high precipitation from the Sea (Tropical Cyclones from the Arabian Sea). In 2005, 2007 and 2008, very high rainfalls have been recorded in the coastal area, due to which, whole area was flooded and many bridges & road sections of MCH were damaged. Some photos of these floods are shown in Figure 4-3 below.

Figure 4-2: Layout Plan of Makran Coastal Highway N-10

Figure 4-3:Flood Water Inundating the Makran Coastal Highway N-10

4.2.2 Existing Non-structural Measures

4.2.2.1 Floodplain Policies and Legislations

Traditionally, the people living along the rivers built their permanent settlements within the floodplains. They develop their businesses and cultivate lands to earn the money for their livings. The governments are forced politically to construct schools, roads and other infrastructures to facilitate the population. The landlords force governments for construction of bunds within the bunds to reclaim lands for agriculture. As a result, heavy damages are caused by the floods in these areas and the people living within the floodplains suffer the most.

At present, there is no firm policy or river act or legislation to prevent the encroachments in the floodplains. Thus, this is need of present time to formulate policy/river act for each of the rivers and its strict implementation to prevent encroachments in rivers flood plains.

Under the present studies, the formulation of draft River Act has been completed. Details on Draft River Act are provided in Task-C Report on “Floodplain Mapping and Zoning”.

4.2.2.2 Organizations Role towards Preparedness, Response and Relief

Refer to Section 4-1 “Organizational Rolesand Responsibilities”.

4.2.2.3 Flood Forecasting and Early Warnings

Pakistan Meteorological Department has the key responsibility for flood forecasting and early warnings. A special cell namely Flood Forecasting Division (FFD) collects hydro-meteorological data, analyse and dispatch necessary alerts and flood warnings to various stakeholders including provincial and federal flood managing organisations.

Flood Early Warning System of Pakistan (FEWS-Pakistan) was developed under 'Flood Protection Sector Project' with the beginning in 1990s and completion in 2007. It was developed by a joint venture of NESPAK of Pakistan and Deft Hydraulics (now called Deltares) of The Netherlands. FEWS is based on mathematical model composed of two components; hydrological model (SACRAMENTO) and hydraulic model (SOBEK).

Hydrological model is a rainfall-runoff model that computes flood hydrograph at the rim stations from the catchments of Jhelum, Chenab, Ravi and Sutlej Rivers in India and from hill torrents in Pakistan at the entering point to the main rivers. For the purpose to captures rainfall and rainfall forecasts, three 3 radars, one each at Mangla, Lahore and Sialkot were installed and rainfall forecasts and real time rainfall captured is used as an input to the hydrological model. The real time outflow hydrograph from Tarbela reservoir is used as inflow hydrographs from catchment upstream of Tarbela. In the FEWS model developed in 2007, flows of Kabul River at Nowshera were used as an input from Kabul river basin. However, under the present studies, the hydraulic model for lower Kabul basin (downstream of Warsak Dam including Swat river basin) has been developed and included in the FEWS model. FEWS covers flood forecasting along complete Indus River and its major tributaries.

Hydraulic model is a river geometry based mathematical model that simulates hydraulically the flood hydrographs given as an input from the hydrological models (as described above). The flood hydrographs are simulated from the rim stations to the Kotri barrage by the hydraulics model and provide flood peaks and hydrographs at each of downstream bridges and barrages. This information is used as an early warning to the downstream barrages/structures.

FEWS is a useful tool for flood forecasting purpose. However, there are certain constraints in it and certain reservations from the PMD which needs to be addressed. A study to refine and improve the existing FEWS model by up-dating the cross-sectional data used in the existing hydraulics models and by including the catchment upstream of Tarbela as hydrological and hydraulics model is recommended under this National Flood Protection Plan-IV.

Recently in parallel to FEWS, "Integrated Flood Analysis System" (IFAS) has been deployed at FFD. This project was initiated by UNESCO through funding from Government of Japan. IFAS is hydrological modeling software which is used to calculate the river discharge with the help of satellite rainfall data (GS MaP) provided by JAXA and/or ground rainfall data. It uses the Digital Elevation Model (DEM) and land cover/ use data in addition to precipitation data to calculate Run-off. The model covers flood forecasting along Indus River excluding Sutlej, Ravi, Chaneb and Jhelum Rivers. The second phase of this project to extend model for Indus tributaries has been launched.

Japan International Cooperation Agency under a follow-up cooperation worth 13 million PKR has extended equipment to the Pakistan Meteorological Department (PMD), Islamabad for flood forecasting system of Lai Nullah. This follow up cooperation consists of providing equipment and technical assistance in continuation of previous assistance by JICA for mitigating the flood loss from Lai Nullah, which historically has proved fatal, both in life and property.

Tsunami monitoring and early warning is being carried out by PMD through National Tsunami Warning Centers (NTWC) having monitoring capabilities from east coast of Australia to the Atlantic Ocean. PMD has also developed link through special line with Japan and Hawaii warning centers. PMD has improved its capability of digital data processing and analysis and frequency domain within two to three minutes after the occurrence of any earthquake. The digital data recording and processing with international data has greatly improved the evaluation of source parameters.

4.2.2.4 Hydro-meteorological Observation Network

Generally, the hydrologic stations in Pakistan have been installed on the valleys of the main rivers and tributaries and the discharges of the rivers are measured at all the barrages. The observation networks are installed and maintained by the Water and Power Development Authority, the Provincial Irrigation Department and the Pakistan Meteorological Department. The data collected is used for flood forecasts and flood records. Surface Water Hydrology Project (SWHP) of WAPDA measures rainfall and river flow in the upper catchment of rivers. This data is transmitted to reservoir operating agencies and PMD through the High Frequency (HF) radio network of WAPDA. The Hydrology and Research Directorate of WAPDA operates gauges of rainfall and river stage under its telemetry system and, through its telecommunication system, provides data during flood season to PMD for flood forecasts. PID measures river flows at all barrages and rainfall at locations in areas below rim stations. PMD has a network for rainfall and other meteorological observations all over the country.

PMD also has weather radars at many locations. The weather radars at Mangla, Sialkot and Lahore have been installed to provide aerial rainfall estimates of the various sub-basins of Jhelum, Chenab, Ravi and Sutlej rivers.

For providing reliable flood forecasts with longest possible lead times it is essential that the information of rainfall and discharges observed at various locations in the river basins and on the rivers is immediately transmitted to the location where it is to be analysed for determining the flood conditions in the rivers. Flood Forecasting Division of Pakistan Meteorological Department located at Jail Road Lahore receives and analyses all the hydro-meteorological data/information and issues flood forecasts. At present following network provides information to FFD.

The current hydro-meteorological network for flood forecasting and communication systems comprises:

a) High Frequency radio based network,
b) VHF real-time telemetry system,
c) Meteor-burst telemetry system, and
d) Weather Radars at Sialkot, Lahore and Mangla

These systems are briefly described below;

High Frequency Radio Based Network system is operated by WRMD of WAPDA and PID, and transmits the stage and flow data at the barrages and a few other key-stations at every 6hour. Under FPSP-I, 69 HF radios were provided to WAPDA, PID, PMD and civil administration. To upgrade and strengthen the network, 21 more HF radios were provided under FPSP-II.

VHF Real-Time Telemetry System is operated by HRD of WAPDA for transmitting rainfall and river stage information gauged at a number of key-stations. There are 24 telemetry stations and among these 7 are located in Indus river basin, 8 in Jhelum river basin, 5 in Chenab river basin, 3 in Ravi river basin and 1 in Sutlej river basin. The VHF real-time system has not been functioning properly since its installation in 1981. Under FPSP-1 the system was rehabilitated temporarily in 1995. However, the system worked partially but without reliability. Its usefulness during the last three floods has been much below expectation.

Meteor-burst Based Communication System (MBCS) was installed as replacement of VHF telemetry system under FPSP-1. This system, consisting of 24 gauging stations was completed by March 1998. The system consists of; 24 Remote Terminal Units (RTUs), HRD Maintenance Center Lahore for monitoring of sensors for correct operation, 1 Master station at Baddoki (near Lahore) for receiving data from above RTUs and HRD Monitoring Center in FFD premises to receive data from master stations. The system transmits hourly rainfall and river levels data using MBCS. It uses trails of meteors in the troposphere for reflecting radio wave signals to establish data communication. Data is delivered to FFD for making flood forecasts. Under FPSP-II, 20 more new gauging stations have been installed across Indus basin.

4.2.2.5 Community Role

Governmental role in enhancing awareness and preparedness in community to fight against floods is not significant. The people response is quite traditional as they are habitual of reacting when the disaster is over their heads. Despite warnings through electronic media, newspapers and loudspeakers in the local mosques, their attitude is to wait and see till it happens.

Population growth of Pakistan has forced the population to live in/along the riverine areas which resulted in increase in areas needing flood protection. Unplanned development, human resettlements, access road (mostly constructed on political basis), and other infrastructural encroachments have reduced the conveyance capacity of floodplain.

The flood disaster caused huge damages in the recent floods occurred in 2010 to2014. The development resources of the country were transformed to those areas for resettlement and rehabilitation of the displaced communities for their relief. Besides governmental efforts, NGOs also play a vital role in the flood relief works. Traditionally, as soon as the flood is over, after few weeks, the communities go back in their areas to restart their pre-flood leftover activities. They perhaps only think for some time about their losses and disturbances caused by the floods. Even the state have no plan for these communities settled in floodplain areas for their permanent safeguards and no policy to restrict these people to construct permanent infrastructures in the high flood areas.

The past National Flood Protection Plans I, II, and III have been implemented at various times but no policy was made for these communities for their protection. The structural flood protection measures were adopted, while non-structural flood protection measures were neglected during the implementation. As a result, the communities now become habitual to move from the floodplain area during the flood time and resettle again in the floodplain areas after the flood as a common practice. Sometimes, serious damages occurred and they deserve for assistance from the state, NGOs and other welfare institutions, but sometimes, they faced light risk without any or with little damages and losses and the situation is highlighted politically or through media.

In developed countries, there is legal policy that restricts the communities to permanently settle in the floodplains. They manage temporary setup as a shelter to avoid from rains, storm and bad weather to protect themselves and their belongings. When a flood occurs, these people move to highland or protected areas peacefully without any damage or creating problem for the government. They never demand any compensation and relief from the government and or other agencies.

Keeping in view the flood situation, flood events, social problems and government limited resources, there is need to improve the present traditional attitudes of community and concrete steps should be taken to legislate for restriction of permanent settlements in floodplains and enhance the awareness and preparedness to cope the emergency situation.

4.2.2.6 Reservoir Operation Policies

Refer to section 5.4, 'Reservoir Management'.

4.2.2.7 Flood Fighting Plans and Flood Limits

Under current studies, frequency analysis of flood peaks has been carried out at various structures along Indus River and its major tributaries. Existing flood limits along structures have been collected from latest flood fighting plans. Results of frequency analysis and flood limits are provided in Table 4-1.

4.3 ASSESSMENT OF THE EXISTING FLOOD MANAGEMENT PRACTICES

4.3.1 Shortcomings in Policy and Planning

The first hurdle is non availability of an improved policy relating to water sector. Pakistan has tremendous water resource potential but it does not have any water policy to recognize the need for major storage of water to address flood management and deal appropriately with the issue of water scarcity. Without the approved water policy there is no direction and goals of development in the water sector. Without a futuristic approach any haphazard investment made will be without any planning and produce no benefits.

The basic main stay of the present Flood management approach is flood protection levees (FPLs). These Levees were developed in different times and vary in their design methods. There is no practical method of assessing the serviceability status of the structure. Due to this reason they are only tested when some high flood pounds against these structures.

The present flood management approach is reactive rather than proactive. That means the whole idea is to reduce the damages due to floods after they hit the rivers. Floods can be proactively tackled by adopting integrated flood management approach.

Haphazard development of the floodplains without any regulation is a lapse on the part of the government. Government should make Floodplain legislation and bylaws to optimize the Floodplain usage. The non-availability of necessary legislation legalizes the present status of the population living in the flood plains. Government should ban the provision of utilities like electricity, gas, water supply etc., in these areas.

4.3.2 Shortcomings in the Flood Design Limits

During the 2010 flood, the peaks in the Swat River at Munda Headworks, Kabul River at Nowshera, and Indus River at Taunsa Barrage were much higher than the historical peaks, with 100-year return periods. Yet the flood management approach currently in use has no provisions for floods exceeding design limits. Due to changes in the patterns of flooding and in the behavior of streams, the design limits and criteria for major river structures, as well as structures in rural and urban areas, should be reviewed.

Table 4-1: Flood Limits and Flood Frequency Analysis along Indus River and Major Tributaries

(100,000 x cusecs)

River	Structure	Peak Discharges Series	FLOOD LIMITS*					FLOOD FREQUENCY** Return Period					
			Low	Medium	High	Very High	Exceptionally High	2.33 Years	5 Years	10 Years	25 Years	50 Years	100 Years
Indus	**Kalabagh**	Series (1967-2013)	2.50	3.75	5.00	6.50	8.00	4.77	6.13	7.24	8.65	9.68	10.72
	Chashma	Series (1967-2013)	2.50	3.75	5.00	6.50	8.00	4.87	6.05	7.02	8.24	9.15	10.04
	Taunsa	Series (1967-2013)	2.50	3.75	5.00	6.50	8.00	4.56	5.84	6.89	8.21	9.20	10.17
	Guddu	Series (1967-2013)	2.00	3.50	5.00	7.00	9.00	6.01	8.45	10.43	12.94	14.80	16.65
	Sukkur	Series (1967-2013)	2.00	3.50	5.00	7.00	9.00	5.53	8.03	10.07	12.64	14.55	16.45
	Kotri	Series (1967-2013)	2.00	3.50	5.00	7.00	9.00	3.46	5.30	6.80	8.69	10.10	11.49
Jhelum	**Mangla**	Pre Mangla (1928-1966)	0.75	1.10	1.50	2.25	3.00	1.93	3.32	5.68	8.66	10.87	13.06
		Post Mangla (1967-2014)						1.06	1.81	2.97	4.45	5.54	6.62
		Full Series						1.53	2.20	3.98	7.00	9.24	11.46
	Rasul	Pre Mangla (1922-1966)	0.75	1.10	1.50	2.25	3.00	1.87	4.04	6.02	8.52	10.38	12.22
		Post Mangla (1967-2014)						1.04	1.54	3.51	6.34	8.44	10.52
		Full Series						1.63	2.61	4.68	7.31	9.26	11.19
Chenab	**Marala**	Series (1925-2014)	1.00	1.50	2.00	4.00	6.00	2.73	4.78	6.45	8.55	10.11	11.67
	Khanki	Series (1925-2014)	1.00	1.50	2.00	4.00	6.00	2.95	5.30	7.21	9.63	11.43	13.21
	Qadirabad	Series (1970-2014)	1.00	1.50	2.00	4.00	6.00	3.63	5.78	7.54	9.75	11.39	13.02
	Trimmu	Pre Mangla (1922-1966)	1.50	2.00	3.00	4.50	6.00	2.92	4.87	6.64	8.88	10.54	12.19
		Post Mangla (1967-2014)						2.72	4.23	5.46	7.02	8.18	9.32
		Full Series						2.73	4.83	6.09	7.67	8.85	10.01
	Punjnad	Pre Mangla (1928-1966)	1.50	2.00	3.00	4.50	6.00	3.50	4.48	5.29	6.30	7.05	7.80
		Post Mangla (1967-2014)						2.45	4.18	5.59	7.38	8.70	10.02
		Full Series						3.01	4.33	5.40	6.76	7.77	8.77
Ravi	**Balloki**	Pre Thein (1922-2000)	0.40	0.65	0.90	1.35	1.80	0.68	1.37	1.93	2.63	3.16	3.67
		Post Thein (2001-2014)						0.49	0.73	0.93	1.18	1.37	1.55
		Full Series						0.61	1.27	1.81	2.49	3.00	3.50
	Sidhnai	Pre Thein (1922-2000)	0.30	0.45	0.60	0.90	1.20	0.46	1.00	1.45	2.01	2.42	2.83
		Post Thein (2001-2014)						0.28	0.47	0.62	0.81	0.96	1.10
		Full Series						0.41	0.93	1.35	1.89	2.28	2.68
Sutlej	**Suleimanki**	Pre Bhakra (1925-1962)	0.50	0.80	1.20	1.75	2.25	2.25	2.79	3.23	3.78	4.20	4.61
		Post Bhakra (1963-2014)						0.75	1.51	2.14	2.93	3.51	4.09
		Full Series						1.66	2.31	2.83	3.49	3.98	4.47
	Islam	Pre Bhakra (1925-1962)	0.50	0.80	1.20	1.75	2.25	1.72	2.14	2.48	2.91	3.23	3.55
		Post Bhakra (1963-2014)						0.55	1.13	1.60	2.20	2.64	3.07
		Full Series						1.28	1.77	2.16	2.65	3.02	3.39

* Source: Flood Fighting Plans 2013/14
** Results based on frequency analysis carried out under current studies using observed peak discharges upto 2013/14

4.3.3 Shortcomings in Barrage Structures

Some barrages and bridges have limited waterway to pass higher magnitude floods. For this reason, these structures create constrictions, which cause affluxes upstream, that damage flood protection and river-training works. The high seasonal variability of rivers flows due to upstream development (most notably on Trans-boundary Rivers) causes disproportionate sedimentation upstream of barrages, obstructing smooth flows and thus reducing discharge capacity. Most of the purposely built breaching sections which were identified and constructed 50–100 years ago, can no longer operate because of morphological changes in the river channel and economic activities around the flood-disposal channels downstream. Given that a barrage can only be designed for floods of a certain return period, the importance of breaching sections must be emphasized, and alternative solutions must be found for these locations.

4.3.4 Shortcomings in Flood Forecasting System

While Pakistan's flood forecasting and early warning system (FEWS) has demonstrated its usefulness, it has not been beneficially utilized so far either because of its few technical constraints or due to lack of appropriate professional manpower with the department in the past. As regards technical constraints, FEWS does not currently cover the entire basin. For example, Indus River upstream of Tarbela and Swat and Kabul rivers and some of the major hill torrents were not the part of FEWS. As a result, the system's predictive capacity has limitations. Under the present Consultancy services, inclusion of hydrological models of Swat River and Kabul River below Warsak dam in the FEWS is the part of project studies. Still there would be an urgent need to extend the system's coverage to the upper Indus reach and to the major hill torrents.

FEWS can only be utilized with full benefits if meteorological forecast during monsoon season can be made quantitatively besides qualitatively well in time. This would give an adequate lead time to predict floods and their magnitude. The required organizational setup is already in place, so the required studies, procurement, implementation and training of professional staff can be made in near future. An extensive and dedicated effort should be made for its implementation at the earliest to minimize the human sufferings effectively.

4.3.5 Financial Limitations and Constraints

As a universally accepted fact, floods are among those hazards, complete control of which is an ambitious target. Even the top ranking nations of the world like United States, China, and USSR suffer unprecedented recurring losses due to floods. The hydro-meteorological events causing rainfall on various locations of the earth are all beyond the control of human beings. Every oncoming event proves to be a new challenge for the ingenuity of the future forecasts, thereby leading towards improved techniques and models.

The hydro-meteorological events are usually erratic in nature and deceiving in character. Every wet cycle is followed by a dry cycle; and a dry by a wet one with indeterminate and irregular gaps. The repair and rehabilitation expenditures during the entire dry cycle seem to be deceptive and useless lumping of capital. However, a little saving from O & M during an unpredicted wet cycle may lead to the disaster of the entire system and the stake holders.

The financial limitations also affect the level of investment which directly determines the degree of protection against floods. The financial investment can only be materialized within the feasible limits and in terms of specific recurrence interval anticipated on the basis of risk analysis. Any event beyond the safety band will obviously be associated with a warning of risks and losses.

4.3.6 Gaps and Lapses

Flood control/management planning for Pakistan is a complex problem and calls for great ingenuity and experience on the part of the planners. The nature of problems varies at different locations due to varying physiographic, climatic, demo-graphic and socio-economic condones.

Structural measures related to flood protection works in Pakistan are usually in the form of flood protection embankments, guide bunds and spurs along river reaches specifically close to barrages and bridges. The existing flood protection structures include about 5,000 km length of embankments and about 1,000 spurs. Non-structural measures are being implemented through use of Flood Forecasting and Warning Systems, installation of network of gauges and radars, implementation of SOP's for flood passage and use of flood risk maps.

To address flood related issues of the country, three comprehensive NFPPs were prepared from 1978 to 2008. During the same period foreign funded projects (that were part of National flood protection plans) were also implemented all over Pakistan, however, the loss of human lives and infrastructure damages associated with 2010 flood event highlighted many shortcomings and gaps in planning and implementation of flood protection measures.

A thorough review of planning and associated actions has been carried out to identify major gaps and lapses in flood protection measures. These gaps have been categorized as institutional, managerial, technical and of financial nature and are described below;

Institutional Gaps

- Lack of coordination between federal and provincial departments during floods
- Lack of technical data sharing mechanism among departments
- Lack of expertise and specialists in flood handling departments
- Lack of definition of roles and responsibility in departments towards floodplain encroachments.

Managerial Gaps

- Lack of regular inspection/monitoring of flood protection structures
- Lack of technical expertise in operation of water control structures
- Lack of information and real-time instructions at water control structures

Technical Gaps

- Limited real-time data availability
- Low density of hydro-meteorological gauges as compared to International standards
- Limited information on spatial and temporal forecast of Monsoon events
- Limited reaction time for flashy streams
- Non-uniform design standards for embankments and barrages
- Lack of storages for flood peak attenuation
- Poor maintenance, monitoring and repair of flood embankments

Financial Gaps

- Lack of funds for implementation of flood protection schemes highlighted in NFPPs
- Lack of capacity to consume allocated funds
- Limited funding by GoP which results in Securing Loans to address requirements

5. FUTURE CHALLENGES

5.1 INTRODUCTION

Pakistan is the most affected country in the world due to flood disasters in the recent history. Since many decades, it is facing challenges to protect human life, property and infrastructure against devastating floods by spending huge money to construct flood protection works along over spilling rivers, reconstructing its damaged infrastructure and providing relief to flood affected population. Although, the history of floods in Pakistan is not new yet its threat due to global warming is said to be increased. The climate experts are almost unanimous that the increase in the severity of events is due to global warming.

In this context, it is prudent to look in to various aspects that are the likely cause of global warming and long term and short term measures that can be taken to reduce the flashy flood generation from the uplands, to control the flood hazards once these are produced, by operating existing major reservoirs for substantial reduction in flood peaks, by maintenance of existing protection works and barrages, by providing more adequate protection structures at vulnerable locations, by addressing pre and post flood environmental issues and reduce the human sufferings by providing relief with better institutional reforms. These are the future challenges that our nation has to meet in long and short term time for the sake of better future. Some of these are briefly discussed here under this section and various others are discussed in other parts of this report.

5.2 WATERSHED MANAGEMENT

5.2.1 General

Pakistan has been gifted with a unique natural resource i.e., water springs and streams/rivers originating from the Himalayan, Karakoram and Hindukush mountain ranges. These mountains are important watersheds from ecological, social and economic point of view and for the sustained water resource. It has been reported that there are about 250 sub-watersheds which drain to the Indus Basin. Proper management of the watersheds is the topic of discussion over the years. Changes in these upland watersheds have resulted from a range of natural and human intervention factors over the years. These factors include changes in farming systems, over-abstraction of water, over-grazing, deforestation and pollution. Extra magnitude of deforestation has caused production of flashy floods increasing threat to the human life, valuable property and infrastructure. Besides, this over-grazing and deforestation is increasing soil erosion and reducing life of reservoirs. It is fact that although nature cannot be defeated but the floods generated due to the destruction of natural ecosystem is cry of nature.

5.2.2 Deforestation in Pakistan

Pakistan is blessed with forests, less than 5% of its total area is under forest. But unfortunately like many other things we are continuously destructing this blessing. The rate of deforestation of 1.5% is very alarming. Deforestation in Pakistan is rising due to the increasing demand for timber and fuel wood as well as the common practice of uncontrolled grazing.

Trees play a major role in developing good habitats for human and wild life. Deforestation is having threat against ecosystem and weakening the relation between human, nature and ecosystem. It is a contributor to Global Warming and is often cited as one of the major causes enhancing green house effect. Contravention of forest area to accommodate more population makes cutting of trees and this is going on without any idea of reforestation.

There is a wide gap in production and consumption of wood. The ban imposed by government on cutting trees has not prevented the timber mafia from their activities because of political interference, theft, corruption and lack of serious commitment on the part of the government to bring the culprits to book. The timber traders are using all possible means to smuggle wood for short-lived gains. Poor communities consume available natural resources for their immediate survival. For example, in the absence of the provision of gas and electricity or the availability of renewable sources of energy at affordable rates, wood is the only source of energy for communities in hilly areas. Uncertain property rights and insecurity of tenure lead the poor to resort to actions such as cutting of trees. This evidence establishes close correlation between poverty and deforestation. An evidence obtained from Balakot, a sub division of KP Province shows that more than 80% of the population is living below the poverty line. Lack of education, and limited means of transport and communications has exacerbated the problem. In such a socio-economic environment, it is difficult for the people to appreciate the significance of forests and the consequent benefits for sustainable development.

The water cycle is also affected by deforestation. Trees extract groundwater through their roots and release it into the atmosphere. When part of a forest is removed, the trees no longer evaporate away this water, resulting in a much drier climate. Deforestation reduces the content of water in the soil and groundwater as well as atmospheric moisture. Deforestation reduces soil cohesion, resulting erosion, flooding and landslides.

5.2.3 Importance of Watershed Management

Although, watershed management was recognized in Pakistan since many decades, not much significant importance has been given so far. Besides other environmental aspects, watershed management is important in order to regulate the flow of stream water, avoid flash flooding, reduce soil erosion and mitigate sedimentation of our reservoirs. According to a report “sedimentation of Tarbela and Mangla reservoirs”, the average annual sedimentation rate in Tarbela dam is 0.132 BCM (billion cu.m) while in Mangla dam 0.038 BCM. Thus, the storage capacities have been decreased more than 28% for Tarbela dam and 20% for Mangla dam in 30-40 years after their construction. Similarly, grasses, cultivation, plants and forests are likely to reduce flashy floods.

5.2.4 Existing Watershed Management in Pakistan

A series of watershed management studies were carried out and small projects were launched to reduce the quantities of sediments flowing into the reservoir in early 60s as follows;

1. Soil and Water Conservation in Barani Areas (1954)
2. Mangla Dam Watershed Management Program (1959)
3. Tarbela Dam Watershed Management Program (1965)
4. Rawal Dam Watershed Management (1962)

Further, several governmental and non-governmental organizations like forest department, WWF - Pakistan, Agha Khan Rural Support Program, Kalam Integrated Development Project, Pakistan Forest Institute (PFI) etc had conducted several projects in the uplands. WWF – Pakistan is running several projects in Zhob, Galliat, Chitral and flood affected areas of Swat. PFI – Peshawar has also been working in the research sector on this issue. For Mangla dam with traditional approaches in watershed management had a reasonable effect in Mangla dam area compared to the Tarbela dam.

The comprehensive studies conducted by FFC in 1994 through a Swedish consultancy company VBB Viak in association with NESPAK on conservation and development of Upper Kaha hill torrents watershed provided a good basis for GIS based assessment of watershed. The study proposed short term and long term schemes in catchment area of 5,500 km^2 including range / livestock management, flood irrigation / retention and groundwater management. A map showing proposed watershed management along Upper Kaha hill torrent is shown in Figure 5-1. The cost of proposed interventions were estimated to be Rs. 200 million.

5.2.5 Legislation and Recommendation

The first Forest Policy of 1884 was formulated by British rulers, then Land Preservation Act of 1900 and Forest Act of 1927 focused on maintaining the forest in upland watersheds to preserve water flows to irrigate plantation of Indus plains. After creation of Pakistan, a policy directive was issued in 1962 which emphasized that mountains areas should be checked for degradation and ensure watershed reclamation and re-forestation. The 1991 Forest policy recommended watershed planning and coordination as federal function with responsibility of implementation continues to be with provinces. Then in 2001, the participatory approach of forest management was included in the national policy. There is a need for a permanent think tank inside and outside the government and advocacy groups to support forest policy formulation and implementation process on a perpetual basis as reflected in the Forest Policy 2001. However, there is absence of seriousness in implementation of any sort of policy. Without the establishment of proper Watershed Management Department with provincial governments (already exists with Khyber Pakhtunkhwa provincial government), formulating policy to meet the future challenges and allocating funds for its implementation, the hilly uplands shall continue to generate the huge flashy floods causing massive landslides and bringing bulk of sediments to the reservoir reducing their lives at enormous rates.

5.2.6 Recommendations

The recommendations are:

i. Establish Watershed Management Departments or strengthen forestry department with the relevant provincial Governments like Gligit-Baltistan, Azad Jammu and Kashmir and Balochistan and strengthen department in KP,

ii. Formulate watershed management policy and carry out necessary legislation at national level as well as provincial level and implement forcefully,

iii. Allocate/arrange necessary funding, and

iv. Effective enforcement of the existing laws and regulations on forests use and management and involvement of the communities in the policy making process from the very outset enables the government to address and arrest sharp forest decline by creating a feeling of sense of ownership and empowerment among communities.

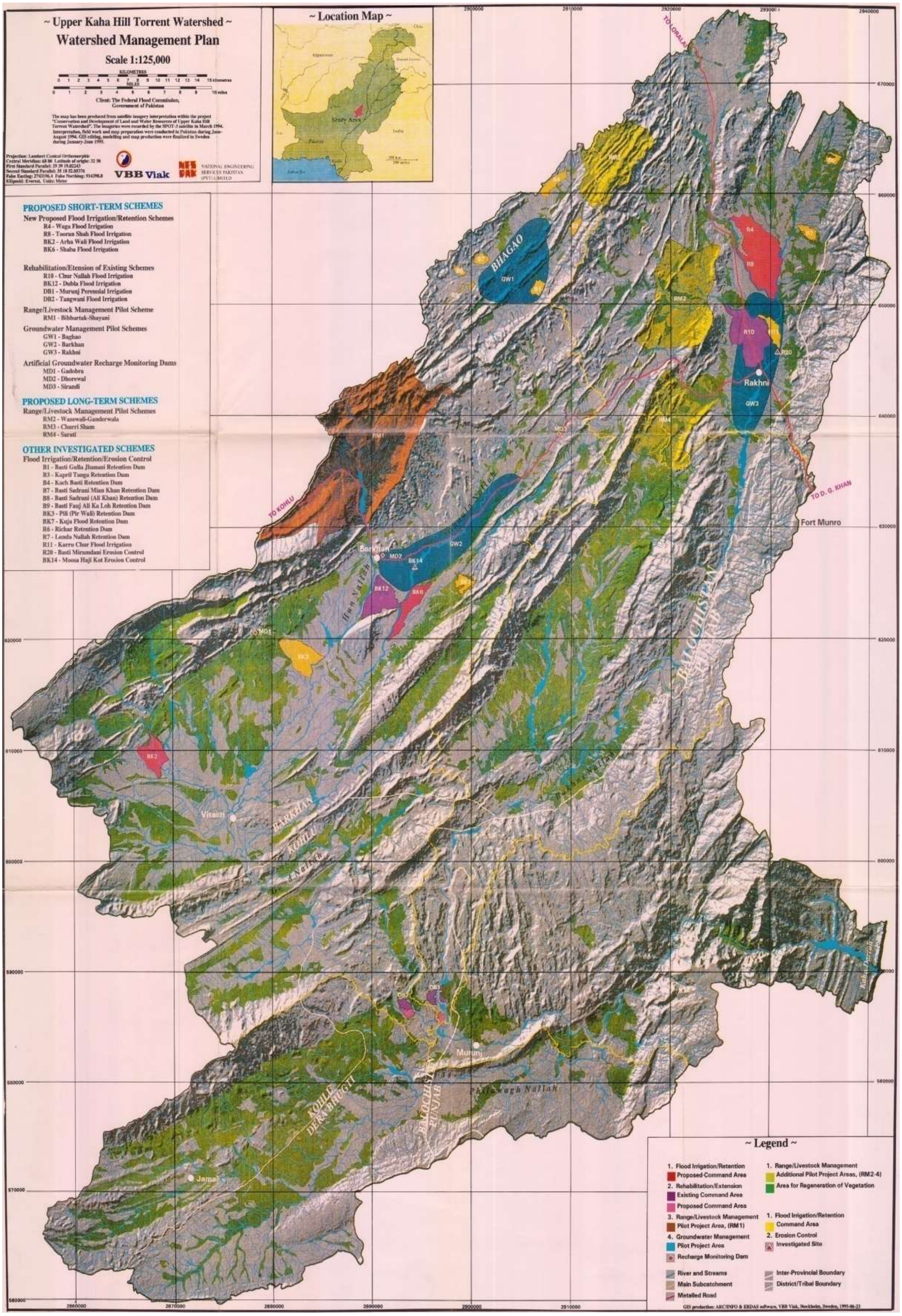


Figure 5-1: Upper Kaha Hill Torrent Watershed Management

5.2.7 Proposed Watershed Management Areas

Seven regions across the country have been selected for proposed investment on watersheds. These include Northern mountain regions, Uplands of Northern Punjab, Western Mountain region, South Western Balochistan Plateau, Coastal zone and the Indus plains. Although the proposed regions exist in the upland areas, but they control the contribution of the total major flows downstream of major rivers and hill torrents. Details on proposed watershed areas along with measures are provided in Section 9 of this report.

5.3 GLOBAL WARMING AND CLIMATE CHANGE

5.3.1 Global Warming

In its most commonly used sense, “global warming” refers to the gradual warming of global-average temperatures due to the slowly increasing concentrations of man-made atmospheric greenhouse gases, primarily carbon dioxide. But global warming can alternatively refer to simply the observation of warming, without implying the cause(s) of that warming.

The most popular explanation for global warming is the burning of fossil fuels, mainly petroleum and coal, which produces carbon dioxide as one of the by-products. As of 2010, the concentration of carbon dioxide is about 50% higher than it was before the start of the industrial revolution in the late 1800's. The potential warming effect of the extra CO_2 is through its ability to absorb and emit infrared radiation, which is the type of radiation the Earth continually looses to outer space in response to heating by sunlight. This makes carbon dioxide a greenhouse gas, although a weaker one in the atmosphere than water vapor.

The net effect of greenhouse gases is to keep the lower layers of the atmosphere warmer that they otherwise would be without those gases. Therefore, it has seemed reasonable to assume that an increase in greenhouse gases would lead to warming.

Deforestation is another reason of increase in global warming. The trees when alive absorb carbon dioxide and release oxygen during day time and absorb oxygen and release carbon dioxide during night time. Till the time of a living tree, nature balances all the releases and absorption. However, when a tree is cut down, it only releases carbon dioxide. The whole ecosystem is disturbed due to this human intervention.

5.3.2 Impact of Global Warming on Climate and Floods

One cannot say that all it is happening is due to the global warming. But the climate experts are almost unanimous that the increase in the severity of events is due to global warming. According to climate change experts, the world weather crisis that caused floods in Pakistan, wildfires in Russia and landslides in China is evidence that global warming predictions are correct. Almost 14 million people have been affected by the torrential rains in Pakistan, making it a more serious humanitarian disaster than the combined effect of South Asian tsunami and recent earthquakes in Kashmir and Haiti.

The recent disaster was driven by a ‘supercharged jet stream’ that has also caused floods in China and a prolonged heat wave in Russia. It comes after flash floods in France and Eastern Europe killed more than 30 people over the summer. Experts from the United Nations (UN) and universities around the world said the recent “extreme weather events” prove global warming is already happening. Jean-Pascal van Ypersele, vice-president of the body set up by the UN to monitor global warming, the Intergovernmental Panel on Climate Change (IPCC), said the ‘dramatic’ weather patterns are consistent with changes in the climate caused by mankind. “These are events which reproduce and intensify in a climate disturbed by greenhouse gas pollution," he said. "Extreme events are one of the ways in which climatic changes become dramatically visible."

The UN has rated the floods in Pakistan as the greatest humanitarian crisis in recent history, with 13.8 million people affected and 1,600 dead. Flooding in China has killed more than 1,100 people this year and caused tens of billions of dollars in damage across 28 provinces and regions. In Russia the morgues are overflowing in Moscow and wildfires are raging in the countryside after the worst heat wave in 130 years.

According to PMD, the rise in global warming is causing a shift in the pattern of monsoon rains increasing the threat of floods which could put a huge dent in an already shrinking economy of Pakistan. Climate change has badly affected the monsoon rainfall pattern in the region. The shifts in the rainfall pattern and its direction of transform are crucial. The changing weather pattern also suggests that western rivers of the country could cause major flooding. On the other hand, rapid melting of glaciers lying in Himalayan Karakoram Hindukush (HKH) region is also worsening the situation. According to experts, the melting will flood the western rivers of the country.

A Climate Change study was conducted, under proposed Munda Dam Project studies by an international consortium of consultants comprising AHT-Group (Germany), Hydroc (Germany) and NESPAK (Pakistan), in year 2013.

The study investigates the possible future effects of climate change in the Swat river basin and how this may impact the feasibility of the proposed dam and other hydro power investments in the Malakand region. The proposed Munda dam will be located at the border of KP and Mohmand agency, about 37km North of Peshawar.

The study mainly dealt with the following questions:

- What are the likely trends on precipitation and temperature in the project area during this century?
- What will be the impact of the rising temperatures on snowmelt and glacier melt? How will the average monthly flow pattern be affected?
- Can a further increase of extreme flood events be expected, what would be its impact on dam safety and flood protection efforts?
- Are there impacts on the catchment, particularly in terms of erosion and land slides / mudflows?
- What recommendations can be given for watershed management, general reservoir operation and flood warning?

The following are brief findings of the study:

i. The development of temperature shows a clear trend. It had been expected, that temperature trends might be different for different project zones, and also significantly stronger in spring than during monsoon. However, the increase is rather uniform of about 5.8°C in 100 years for all months and years. This is equivalent to a change in elevation by 900m. The impact on potential evapo-transpiration in the irrigation area compared to 2012 is an increment of 3.6% for 2050 and 8.2% for 2080 due to increasing temperature.

ii. Monthly Precipitation is much more erratic than monthly temperature. There is no clear trend visible, but the average monthly hydrographs remain rather unchanged to present conditions with two exceptions: extreme precipitation during winter and springs decreases for the upper catchment and extreme precipitation during monsoon increases for the lower catchment and the eastern part of the medium catchment.

iii. In Swat River Catchment, natural runoff has three sources: direct runoff from rainfall, snow melt and, to a lesser extent, glacier melt. Model results indicated that currently the contribution of snow melt is in the order of 48 % of total annual flow. For planning purposes, the foreseen reduction of extreme precipitation in the upper catchment is less relevant, as this does not affect the median (50% probability) conditions. This means, no significant change against present conditions. The rise of temperature results in a gradual reduction of frost days per month and is most prominent in the elevation zones between 2500 and 4000m. This means that rain (unless falling on snow-covered surfaces) would be immediately available as direct runoff. The snow volume later available for retarded melt would be consequently less. Degree days (for areas where there had been frost before) increase significantly for elevations between 2,000m and 4,000m.

iv. Glacier melt in Swat Catchment is already now only of marginal importance, because the catchment is not as high as for instance Upper Indus Basin or Mangla Catchment. Altogether, there are presently 236 glaciers covering 224 km²; they are small (median area 0.45 km²) and can be expected to shrink further. This is indicated by the strong increase of degree-days during summer months for elevations above 4500m.

v. Mean monthly precipitation pattern in warm season will not change significantly during the 21stcentury, which means that the pattern of direct runoff from precipitation during the warm seasons will not change significantly. Autumn season was and will remain dry, and the main difference in the future will be winter and spring, i.e. the Months December to April. During this time, a larger portion of precipitation in the upper and medium catchment east will fall as rain and not as snow, thus becoming immediately available for direct runoff. Furthermore, melting of available snow cover will start earlier. This means, that runoff from snowmelt will add to river discharges at a time when they are most urgently needed. Thus, climate change has a rather positive impact on water availability for Munda Dam Project.

vi. The impact of climate change on extreme flood events during spring would be that floods become less. In the past, spring floods were caused by heavy rains during the melting process. Although the melting may be accelerated in future, extreme rainfall events during that period will become less. Floods during monsoon will increase, as indicated by the increase of extreme precipitation months during monsoon in the irrigation zone and the middle catchment east.

vii. Impact of changes in temperature and precipitation on the Swat River Basin will have impact on vegetation and resilience against erosion. The climate change assessment indicated a significant increase of temperature, which has both a positive and a negative effect:

viii. The tree line will go up, permitting a better potential for natural and man-made forests.

ix. Evapo-transpiration will increase, which will have a negative impact on the vegetation in un-irrigated areas when they lack the protection of a forest cover.

x. The middle catchment west, particularly the sub-catchment of Ambahar River, has highly erodible soils and already now a very poor natural vegetation cover. Without adequate watershed management efforts, this situation my further deteriorate.

xi. The biggest threat is seen from more frequent storms during monsoon period, as the main inflow of sediments takes place during rather short periods of high floods. For most times of the year, suspended sediment concentration in Swat River is rather low, and also bed load is not very high, because the river bed is covered by coarse gravel and large stones.

xii. Land slides and mud flows can be caused by earth quakes, heavy rainfall (particularly when there is no protection by natural vegetation) and quickly falling water levels in the reservoir area.

xiii. Environmental flow is the minimum discharge that should remain in the river to fulfil the needs of aquatic life. It is not only determined by the water depth in the river required for fish, but also by water quality parameters. The single most important variable is available oxygen concentration. It is therefore of utmost importance that the towns that are currently draining their sewage water into Swat and Kabul rivers get sewage treatment that reduce COD and BOD emissions efficiently.

5.3.3 Recommendations

The recommendations to minimize the cause of global warming are:

i. Control the release of carbon dioxide by vehicles through strict implementation of laws and imposing penalties to prevent such vehicles to be on road that produce excessive smoke especially diesel consuming vehicles like buses, trucks etc.

ii. Raise the standard of population living below the line of poverty by proving them electricity and natural gas so that to avoid burning of wood for cooking of their meals and heating of their livings to fight against cold weather, and

iii. Prevent excessive grazing, deforestation and cutting of trees.

iv. Watershed management; Re-forestation, soil conservation and improvement in land use in the watersheds should be promoted.

5.4 RESERVOIR OPERATION AND ITS ROLE IN FLOOD MANAGEMENT

5.4.1 Introduction

There are two major reservoirs in the Indus River basin in Pakistan; Mangla dam on Jhelum River near Mangla and Tarbela dam on Indus River near Tarbela. Both of these were constructed during 1960s and 1970s, respectively for power generation and irrigation with the priority to store/release water for irrigation purposes. At the time of construction, flood mitigation was only possible if the storage was already below the maximum conservation, both of these dams were not meant to mitigate floods. The flood surcharge storage was provided over and above the maximum conservation levels of both the dams to pass the design flood with the operation policy to keep the reservoir level at maximum conservation level by passing outflow equal to inflow till the time inflow exceeds the design outflow capacity and the excessive flood volume to be stored in the flood storage designed for the purpose.

However, due to unprecedented damages occurred during the flood of 1992, it was felt to change the operational policy to mitigate the floods to some extent by lowering the reservoir levels below the maximum conservation levels immediately after receiving flood forecast of a high magnitude flood. After the disastrous super flood of 2010 on Indus River and now 2014 flood on Chenab and Jhelum Rivers, there is strong need to review the existing SOPs so that some relief can be provided to the downstream areas.

A brief description of flood generation and forecasting mechanism of respective rivers and existing operational policy/Standard Standing Operating Procedures (SOPs) for the operation of both the reservoirs are given in the sections below.

5.4.2 Floods and Reservoir Operating Procedures of Existing Major Reservoirs

5.4.2.1 Mangla Dam

Mangla Dam was designed against the Probable Maximum Flood (PMF). In order to safely pass the PMF through Mangla reservoir, surcharge storage of 1.5 MAF up to El. 1228 ft was provided above the maximum conservation level (MCL) at El. 1202 ft, with spillway designed capacity as 900, 000 cusecs. In addition to this, storage of 0.3 MAF above the MCL was also provided for anticipated sedimentation in the flood storage zone between El. 1202 ft and El. 1228 ft.

With the original operation policy, only those flood events would get attenuated which are received when the reservoir is not full, to the extent capacity is available in the reservoir for absorbing these events. At the time of formulation of the above mentioned policy, facilities were not available for good quality and reliable forecasts and response time of the basin was quite short. It was, therefore, prudent to adopt a safe operating policy for the earthfill Mangla dam. The operating policy did not include any provision for lowering of reservoir in advance of floods.

After devastating flood of September 1992, which resulted in severe downstream damages of life and property, Standing Operating Procedures (SOPs) for passage of floods for Mangla dam were revised. The SOPs were oriented towards providing relief to the downstream population as far as possible by lowering the reservoir in advance of flood without compromising safety of the dam. These procedures depend on getting advance information about the weather system and likely floods.

As provision made in the original design, Mangla dam was raised during years 2004-2005 to 2009 by 30 ft with maximum conservation level raised by 40 ft to El. 1242 and maximum flood level from 1228 ft to 1260 ft. Between MCL at 1242 ft and Maximum flood storage level at 1260 ft., the flood storage is 1.5 MAF.

In the raised dam conditions, the SOPs were again updated, keeping in view the updated parameters of design flood and the revised discharge ratings of the two spillways.

<u>Jhelum River Flood Mechanics</u>

Sustained heavy monsoon rains in the catchment areas cause floods in Jhelum River. These monsoon rains are brought by a weather system in which deep low/depressions develop over the Bay of Bengal and move towards catchment areas of the Indus River and its tributaries including the Jhelum River. Part of the basin between Mangla and Muzaffarabad is the region of the heaviest rainfall within the Mangla catchment. During the winter season the precipitation over the higher parts of the basin is in the form of snow, which accumulates until rising air temperatures cause it to melt and deplete from March to June. The snowmelt gives rise to the high-sustained river flows at Mangla, which normally reach their maximum in June.

Discharge and rainfall data of Jhelum River in the Indian held territory is of limited use in the context of real time flood forecasting of Jhelum at Mangla because the flood waves generated in the Kashmir valley get substantially attenuated in the Wular Lake and the surrounding swamp area which continues to expand and may reach up to Baramula under the conditions of high inflows. Thus, the Wular Lake region acts like a big (natural) reservoir, which performs a positive flood mitigation role by dampening down the incoming flood hydrographs.

Two rivers, namely Poonch and Kanshi drain directly into the Mangla reservoir from eastern and western directions, respectively. The catchment of Poonch river is a high rainfall part of the Mangla basin. Because of high rainfall and steep ground slopes, it generates flashy flood peaks that reach Mangla reservoir with very short lag times. Kanshi river basin has a relatively much flatter topography and lower elevations. The rainfall over the basin is lower than on Poonch basin.

Flood Categories

There are three weather situations that can cause floods in the Mangla basin. These are described briefly below.

i) Category-I Storms (300,000 to 500,000 cusecs)

   In Category-I storms, strong south-westerly monsoon incursion reaches the Mangla catchment due to the accentuation of the seasonal low. Category -I storms are more common during the last week of June or up to the end of July, though they may also occur during August, but on fewer occasions. More than 80% of the flood at Mangla under these conditions may be limited to peak discharges within 200,000 cusecs, about 15% of the peaks may range between 200,000 to 400,000 cusecs, while only 5% may exceed 400,000 cusecs.

ii) Category-II Storms (500,000 to 700,000 cusecs)

   In the Category-II storms, a monsoon low/depression approaches from east/southeast traversing across Sutlej, Ravi and Chenab catchments. Under this condition flood peaks at Mangla shall generally range from 300,000 to 600,000 cusecs. In an extremely rare case, when the depression happens to be extremely intense, a peak ranging from 500,000 to 700,000 cusecs may occur.

iii) Category-III Storms (> 700,000 cusecs)

   The Category-III storms are the most critical ones. These storms are produced under the situation when the depression takes a straight northerly path, due to the presence of a strong westerly wave to the north, from its position in Rajasthan and enters Pakistan along Lahore region and then continues to move towards Rawalpindi region, skipping the catchments of Sutlej and Ravi in the east and reaching Chenab and Jhelum catchments with full intensity. Since the northwards movement of the depression is caused by the presence of a strong westerly wave to the north, heavy rains always extend further north to cover lower parts of Tarbela catchment, Hazara region and the whole of Kashmir. The highest floods on record (1928, 1929 and 1992) were generated under this situation. Flood peaks of more than 700,000 cusecs were produced in the Mangla catchment.

Flood Forecasts

Forecasting facilities of Flood Forecasting Division (FFD) have over the last several years improved considerably and after commissioning of the 10 cm radar at Mangla it has improved further. This information is being used along with real time flood warning stations data, computed flood hydrographs and judgment of Flood Management Committee at Mangla to mitigate the abnormal floods.

i) Qualitative Forecast of Rainfall

Flood Forecasting Division, Pakistan Meteorological Department has the capability to provide qualitative forecast minimum 24 hours in advance of actual precipitation indicating the intensity of depression in relation to previous historical floods. Category of floods will also be indicated.

ii) Quantitative Forecast of Rainfall

Flood Forecasting Division, Pakistan Meteorological Department has also capability to provide Quantitative forecast about 12 hours in advance of actual peak describing range of peak and expected minimum and maximum volume of flood hydrograph.

Design Flood

Mangla Dam, being a high dam with large hazard potential, has been designed to withstand against PMF. Binnie & Partners (1959), the original designers of the dam, estimated PMF peak of 2.6 million cusecs with 72-hrs flood volume of 5.53 MAF. During the detailed engineering of Mangla Dam Raising Project, PMF has also been reassessed with improved database. The revised PMF peak is 2.2 million cusecs with corresponding 72-hrs flood volume of 5.77 MAF.

Flood Management Procedures

i) Earlier Flood Management Procedures

Flood Management guidelines have undergone many changes since the first impounding in 1967. As given in the Operation and Maintenance Manual of the project, Mangla reservoir was designed basically to supplement irrigation supplies during the low flow season. The benefit of flood regulation was treated as incidental since no provision was kept to draw down the reservoir in advance of flood or to reduce the outflows intentionally on the basis of forecasts or information received from flood warning stations. However, because of 0.3 MAF additional flood storage kept for future sedimentation between El. 1202 ft and El. 1228 ft, limited flood mitigation capability was available even when the reservoir stood full at maximum conservation level. In addition, the incidental flood benefit can always be had if the flood wave comes at a time when reservoir is below the maximum conservation level.

It was realized for the first time after the flood of 1992, that flood management to some extent is possible, if timely decisions are taken on the basis of rising inflows. After detailed discussions and studies, WAPDA prepared flood management guidelines (1993) to gradually absorb the incoming flood by restricting the outflows to the extent possible. However, because of limitations of flood forecasting facilities and real time information obtained from flood warning stations, lowering of the reservoir in advance of flood was not considered.

Standing Operating Procedures were revised in the light of experience gained in routing of 1997 flood using 1993 guidelines. These guidelines (approved in 1998), provided depletion of the reservoir in advance of Category II and Category III floods on the basis of qualitative/quantitative forecasts. The maximum rate of drawdown was limited to 3 ft/day with maximum discharge of 110,000 cusecs (medium flood).

With the adoption of reservoir lowering procedure approved in 1998 and routing flood of 1992, the lowering up to El. 1197.6 ft was achieved. The reason for not achieving the desired lowering of the reservoir up to El. 1197 ft is well understood as 12 hrs before the first inflow peak of 1992 flood hydrograph (about 725,000 cusecs) the inflow was about 100,000 cusecs only, which increased to 400,000 cusecs within next 8 hrs. The lowering of reservoir was only possible for first 7 hrs, when the inflows were less than 300,000 cusecs. In such situations, by limiting the downstream releases to 300,000 cusecs, the targeted lowering cannot be achieved. Thus, NESPAK recommended lowering of the reservoir by 4 ft from Maximum Conservation Level, on receipt of the qualitative forecast (24 hrs in advance of actual precipitation) and 1 ft on receipt of the quantitative forecast would have been a better option.

In 2003 WAPDA decided to raise the MCL from El. 1202 ft to El. 1206 ft. SOPs were accordingly revised for MCL at El. 1206 ft. Two changes were made in the earlier SOPs for MCL at El. 1202 ft. Lowering of the reservoir for category-I flood was also considered (i.e., lowering to El. 1202 ft in view of qualitative and quantitative forecasts) and drawdown limits for Category-II and –III floods were revised. The drawdown limits for Category-II and III floods were increased from 3 ft/day to 4 ft/day. Drawdown of Category-I flood was considered keeping in view the erodible bund with crest at El. 1208 ft.

ii) Revised Guidelines for Raised Mangla Dam

The analyses for the proposed SOPs for MCL at El. 1242 ft shows that by lowering the reservoir on recommended procedure will not compromise either reservoir filling or dam safety even in the worst case, if assumed, that the flood received at Mangla is different from the forecast of flood by Flood Forecasting Division of Pakistan Meteorological Department. The guidelines for the raised MCL of El. 1242 ft. are reproduced in Table 5-1to Table 5-3.

Detailed flood routing studies were conducted to formulate broad based guidelines for providing flood mitigation to the maximum possible extent for different categories of floods, while ensuring the safety of the project. The approved SOPs have been given due consideration in formulating the SOPs for the raised dam conditions.

Lowering of reservoir level in Category-I flood has not been considered for revised SOPs for MCL of El. 1242 ft. This has been decided keeping in view the frequency of Category-I flood. Almost every year, there is a possibility of Category-I flood and lowering in advance of flood when the reservoir would be at MCL i.e., El. 1242 ft has two disadvantages, (i) loss of water in case no flood is received and (ii) emergency condition each year for lowering of reservoir. The flood routing analysis reveals that there would not be substantial over spills from the control weir which is at El. 1243 ft (only one ft above the MCL) to cause flooding in the approach channel and subsequently inundations in the Bara Kas.

Lowering of the reservoir in Category-II and Category-III floods has been provided in the SOPs. The revised guidelines ensure effective use of flood forecasts during entire flood routing exercise.

Table 5-1: Standing Operating Procedures for Category-I Floods

Sr. No.	Reservoir Condition	Maximum Permissible Outflow
1.	Qualitative Forecast (24 hrs. in advance of actual precipitation); Maintain reservoir at El. 1242 ft	150,000 cusecs
2.	Quantitative Forecast (12 hrs. in advance of actual peak at Mangla); Maintain reservoir at El. 1242 ft	150,000 cusecs
3.	If inflow is rising, maintain outflow to 150,000 cusecs; watch till water level rises to El. 1242.5 ft.	150,000 cusecs
4.	If inflow is still rising increase outflow to 250,000 cusecs; watch till water level rises to El. 1243 ft.	250,000 cusecs
5.	If reservoir level is still rising with: a) Evidence of Flood Recession	Start reducing outflows, gradually, as the situation permits
	b) Evidence of further flood build up	300,000 cusecs until evidence of flood recession is received

Note:

i. Data from Flood Warning Stations and forecasts from Flood Forecasting Division shall be kept in view all the time. As soon as inflow hydrograph recession is confirmed the outflows should be reduced gradually for downstream relief, subject to the safety of the project.

Table 5-2: Standing Operating Procedures for Category-II Floods

Sr. No.	Reservoir Condition	Maximum Permissible Outflow
1.	Qualitative Forecast (24 hrs. in advance of actual precipitation)	Deplete with maximum outflow of 210,000 cusecs @ 4ft/day up to El. 1238 ft.
2.	Quantitative Forecast (12 hrs. in advance of actual peak at Mangla)	Adjust outflow with maximum limit of 300,000 cusecs and drawdown to Reservoir Level 1237 ft.
3.	If inflow is still rising maintain outflow to 300,000 cusecs; watch till water level rises to El. 1238 ft.	300,000 cusecs
4.	If inflow still rising increase outflow to 350,000 cusecs; watch till water level rises to El. 1239 ft	350,000 cusecs
5.	If inflow is still rising increase outflow to 400,000 cusecs; watch till water level rises to El. 1240 ft.	400,000 cusecs
6.	If inflow is still rising increase outflow to 450,000 cusecs; watch till water level rises to El. 1241 ft.	450,000 cusecs
7.	If inflow is still rising increase outflow to 500,000 cusecs; watch till water level rises to 1243 ft.	500,000 cusecs
8.	If reservoir level is still rising with: a) Evidence of Flood Recession	Continue same outflow and then start reducing gradually as the situation permits
	b) Evidence of further flood build up	Operate the main spillway to cater for inflow/outflow.

Note:

i. If reservoir is below conservation level, pre-releases on receipt of forecasts shall be reduced accordingly by Flood Management Committee, Mangla.

ii. Data from Flood Warning Stations and forecasts from Flood Forecasting Division shall be kept in view all the time. As soon as inflow hydrograph recession is confirmed the outflows should be reduced gradually for downstream relief, subject to the safety of the project.

iii. Efforts shall be made to restrict the outflows so that combined peak at Trimmu of (Mangla and Marala) x 0.55 ≤ 650,000 cusecs, if possible, without jeopardizing the safety of the Mangla Dam Project, which is of paramount importance.

iv. Under PMF like conditions if reservoir level rises above El. 1250 ft, the outflows shall be reduced only when the reservoir level starts depleting.

Table 5-3: Standing Operating Procedures for Category-III Floods

Sr. No.	Reservoir Condition	Maximum Permissible Outflow
1.	Qualitative Forecast (24 hrs. in advance of actual precipitation)	Deplete with maximum outflow of 210,000 cusecs @ 4ft/day up to El. 1238 ft.
2.	Quantitative Forecast (12 hrs. in advance of actual peak at Mangla)	Adjust outflow with maximum limit of 300,000 cusecs and drawdown to Reservoir El. 1237 ft.
3.	If inflow is still rising increase outflow to 400,000 cusecs; watch till water level rises to El. 1238 ft.	400,000 cusecs
4.	If inflow is still rising increase outflow to 425,000 cusecs; watch till water level rises to El. 1239 ft.	425,000 cusecs
5.	If inflow still rising increase outflow to 450,000 cusecs; watch till water level rises to El. 1240 ft.	450,000 cusecs
6.	If inflow still rising increase outflow to 475,000 cusecs; watch till water level rises to El. 1241 ft	475,000 cusecs
7.	If inflow still rising increase outflow to 500,000 cusecs; watch till water level rises to El. 1243 ft.	500,000 cusecs
8.	If reservoir level is still rising with: a) Evidence of Flood Recession	Continue same outflow and then start reducing gradually as the situation permits
	b) Evidence of further flood build up	Operate the main spillway to cater for inflow/outflow.

Note:

i. If reservoir is below conservation level, pre-releases on receipt of forecasts shall be reduced accordingly by Flood Management Committee, Mangla.

ii. Data from Flood Warning Stations and forecasts from Flood Forecasting Division shall be kept in view all the time. As soon as inflow hydrograph recession is confirmed the outflows should be reduced gradually for downstream relief, subject to the safety of the project.

iii. Efforts shall be made to restrict the outflows so that combined peak at Trimmu of (Mangla and Marala) x 0.55 ≤ 650,000 cusecs, if possible, without jeopardizing the safety of the Mangla Dam Project, which is of paramount importance.

iv. Under PMF like conditions if reservoir level rises above El. 1250 ft, the outflows shall be reduced only when the reservoir level starts depleting.

5.4.2.2 Tarbela Dam

Tarbela dam spillways are designed against Probable Maximum Flood. The dam was constructed for irrigation supplies on priority basis with generation of power. Tarbela is a small reservoir with respect to the size of Indus River considering that its present active storage of 6.472 MAF is only about 10.11 percent of the average annual inflow at Tarbela which is 64 MAF (79 BCM).

The total capacity of two spillways is 42,475 m^3/s (1,500,000 ft^3/s) which constitute the peak outflow resulting from routing of PMF. The maximum capacity of service spillway is 18,405 m^3/s (650,000 ft^3/s) which is usually operated during almost all the floods.

The existing procedure of reservoir operation is based purely on dam safety requirements against various hydrological considerations and does not include any specific provision to suppress the incoming flood for easement of downstream flooding. Some relief is available automatically when the reservoir is rising from minimum to full pool level and the flood peak is damped but there is no provision for making any deliberate efforts to do so.

Indus Basin Flood Mechanism at Tarbela

During 1992 flood, Indus river did not reach its pre-Tarbela historic high value of 23,220 m^3/s (820,000 ft^3/s) while the peak inflow of 14,725 m^3/s (520,000 ft^3/s) at Tarbela Dam was the highest of its operation history. However, the flood peak during 2010 flood at Tarbela was 23,585 m^3/s (833,000 ft^3/s) which exceeded all floods of the recorded history and caused severe damages in the country. This event has demanded review of existing reservoir operation procedures to mitigate hazard potential in the future.

Location of Tarbela Reservoir is such that about 90% of annual river inflow is derived from snowmelt. The remainder of runoff is derived from rainfall in the catchment area of 10,360 km^2 (4,000 $mile^2$) lying immediately upstream of dam site. Rain in this area is the most critical flood-producing factor of the basin. The minimum and maximum water levels in reservoir for the year 2014 have been established as 1,380 ft. and 1,550ft, respectively.

Flood Forecasting and Warning

Hydrology Section of WAPDA receives hourly information on temperature, rainfall and gauge heights from Skardu, Bunji, Besham, Phulra and Daggar Stations.

Additional rainfall information is received from Oghi and Shinkiari Stations. The communication is through wireless system. Water Resources Management Directorate and Surface Water Hydrology of WAPDA at Lahore share this information through wireless system. The Reservoir Level is recorded round the clock at hourly intervals and this information is passed on to Tarbela Dam Project (TDP) Hydrology office through wireless or V-phone.

Bunji gauging station carries special importance. Its lag time to Tarbela is 48 hours. Flows at Bunji are essentially snowmelt with insignificant contribution of rainfall. Substantially higher or abnormally low flows as compared to normal flows at this station are to be taken as a flood warning. SE (S&H) is responsible to issue Flood Warning on the receipt of inflow data from upstream gauging stations to Government, Civil and Project Authorities as laid down in the Flood Management Procedure.

A flow of 8,495 m^3/s (300,000 ft^3/s) or more at Bunji warrants that depletion of reservoir should be considered. It is proposed that calculated depletion can be started immediately with an outflow not exceeding 14,158 m^3/s (500,000 ft^3/s). Similarly, if Bunji flows are consistently lower than 1,416 m^3/s (50,000 ft^3/s) during June - September period, its cause must be investigated. It is possible that abnormally low flow is due to formation of natural dam (landslide or glacier) in the upstream river or its tributaries. Formation of a natural dam can significantly reduce the flow at Bunji and Tarbela is thus pre warranted of awaiting dam burst flood.

As per SoPs, on confirmation of such a situation, Tarbela reservoir should be depleted to some predetermined elevation. The flow at Bunji predicts the snowmelt component of anticipated flood. If Bunji flow remains below 8,495 m^3/s (300,000 ft^3/s) the anticipated flood would not exceed 39,645 m^3/s (1,400,000 ft^3/s) at that time. To take advantage of flood warning system especially during June-October period the flood warning data should be carefully examined to estimate inflow flood. Depletion of reservoir may also be considered against heavy rainstorm flood if rainfall of 4" or more occurs in 6 hours and continues at any station near Tarbela.

A Fax machine bearing No: (0995) 350001 has been installed in the office of Superintending Engineer Survey & Hydrology Residency Tarbela Dam, for easy transmission / receipt of the messages. Local administrations of adjoining districts were also requested to provide a separate wireless channel for intimating the emergencies (in case of breakdown of telephone system) but it was rejected because of secrecy of provinces. Anyhow the primary responsibility of collecting warning rests with the civil and irrigation authorities.

Probable Maximum Flood

According to the Project Design Report by TAMS, the Probable Maximum Flood (PMF) of 50,205 m^3/s (1,773,000 ft^3/s) constitutes a base flow of snowmelt of 16,990 m^3/s (600,000 ft^3/s) and rest will be generated by rainfall runoff. Maximum reservoir level during this flood will be 1,552.2 ft. The dam burst flood, simultaneously occurring with PMF may reach 60,230 m^3/s (2,127,000 ft^3/s) and resulting reservoir level will be 1,556.5 ft. Although theoretically, dam must be safe if the reservoir level remains at elevation 1,556.5 ft for a few days but in view of uncertain health condition of the embankments and foundations, the reservoir should be operated in a manner that level may not exceed 1,550 ft.

Reservoir Operation and Flood Routing

Flood Management Manual 2014 describes the existing procedures, proposes modification to handle & route the very high floods (Q > 600,000 cusecs), it lays emphasis on the improvement of coordination links between various agencies and the offices at Tarbela.

i. The basic principles for operating the reservoir are, to ensure the safety of the embankment dams against overtopping and to fill the reservoir during high flows season. After attaining elevation of 1510 ft, the reservoir should be further filled at the rate of 1 ft / day so far possible, fulfilling the irrigation requirements during the season.

ii. It would be possible to operate the reservoir in a fashion to ameliorate sharp flood peaks within the above mentioned limits, with vigilant watch on instrumentation network. The reservoir can be lowered in advance of the flood peak on the basis of upstream flood warning information, under the guidelines given in section 3.2 of the manual and flood peak ameliorated by the storage created by the lowering.

iii. Frequent changes in spillways discharges should not be preferred and during high spillway discharges, the downstream river stages should not be increased rapidly.

Routing of Very High Floods

Downstream valley of Tarbela can take about 14,160 m^3/s (500,000 ft^3/s) safely without causing any significant damage. Flows exceeding 16,990 m^3/s (600,000 ft^3/s) will inundate side valleys & villages and bring about damages to life and property. Whereas inundation is unavoidable in the super high floods (say Q> 1,000,000 cusecs.) some hazard mitigation is possible for the intermediate range of floods by allowing a temporary rise of maximum pool level above EL.1550 ft. Temporary holding back of Indus flood peak in the reservoir and controlled releases to prevent synchronization with the peak of other tributaries at various downstream confluences has therefore been considered. It is proposed that at El: 1550 ft reservoir should be operated in such a manner that maximum water levels do not exceed the followings:

i. If flood peak is less than 1,000,000 cusecs permissible Maximum level may be 1,551.50 ft.

ii. If flood peak ranges from 1,000,000 to 1,400,000 cusecs, the permissible maximum level may be as 1,552 ft.

iii. If flood peak ranges from 1,400,000 to 1,773,000 cusecs, the permissible maximum level may be as 1,553.5 ft.

iv. The Dam burst flood simultaneously occurring with PMF will have a peak flow of 21, 27,000 cusecs and the resulting reservoir level may be 1556.5 ft. The above levels would provide some flood mitigation in downstream valley of Tarbela. It is advisable that flood routing of selected peaks be carried out using the latest Reservoir Capacity Tables and results kept handy for reference in the flood management.

5.4.3 Management of 2014 Flood at Mangla

In the normal conditions releases from reservoir are made as per Indus River System Authority (IRSA) indent. In flood situation, when reservoir level is at or above El. 1238 ft., it is operated by as per instructions issued by local flood management committee at Mangla.

Heavy rainfall was reported on September 4, and a forecast of 200,000 cusecs to 600,000 cusecs was issued at 10am by PMD. On the day, the reservoir level was raised at/above El. 1229 ft. and IRSA reduced the indent from 30,000 cusecs to 15,000 cusecs.

On September 5, two (2) forecasts were issued. The 1st forecast was made at 1030 hours with the prediction that well marked low pressure was weakened and likely inflow would be 300,000 cusecs to 500,000 cusecs. The reservoir level was El 1236 ft in the morning which was raised to El.1238 ft. at 1300 hours with inflows to Mangla reservoir as 634,000 cusecs. The 2nd forecast was made on the same day at 1400 hours with prediction that probable inflow would be more than 700,000 cusecs. Immediately afterwards, the SOP for Cat-III Flood were Implemented. The outflows increased gradually from 266,185 cusecs at1500 hours to 499,624 cusecs at 2100 hours to mitigate the affect of expected peak inflows above 700,000 cusecs. The SOP states that increase outflow to 475,000 cusecs after achieving El. 1240 ft and keep watching till elevation rises to 1241 ft. The reservoir level reached at El. 1241 ft. at 1600 hours. The SOP states to Increase outflow to 500,000 cusecs after achieving El.1241 ft. The outflows were increased gradually to 499,624 cusecs. During the period of operation, river gauge data and rainfall data was analyzed on hourly basis. When recession in the flood flows was observed, the outflows were reduced to 200,000 cusecs on September 6 at 0600 hours to give relief to downstream areas. According to WAPDA, the operation helped to avoid synchronization of flood peaks of Mangla and Marala at Trimmu which remained less than 650,000 cusecs as per SOP. Figure 5-2 presented below shows the actual recorded hourly inflow, outflow and reservoir level data.

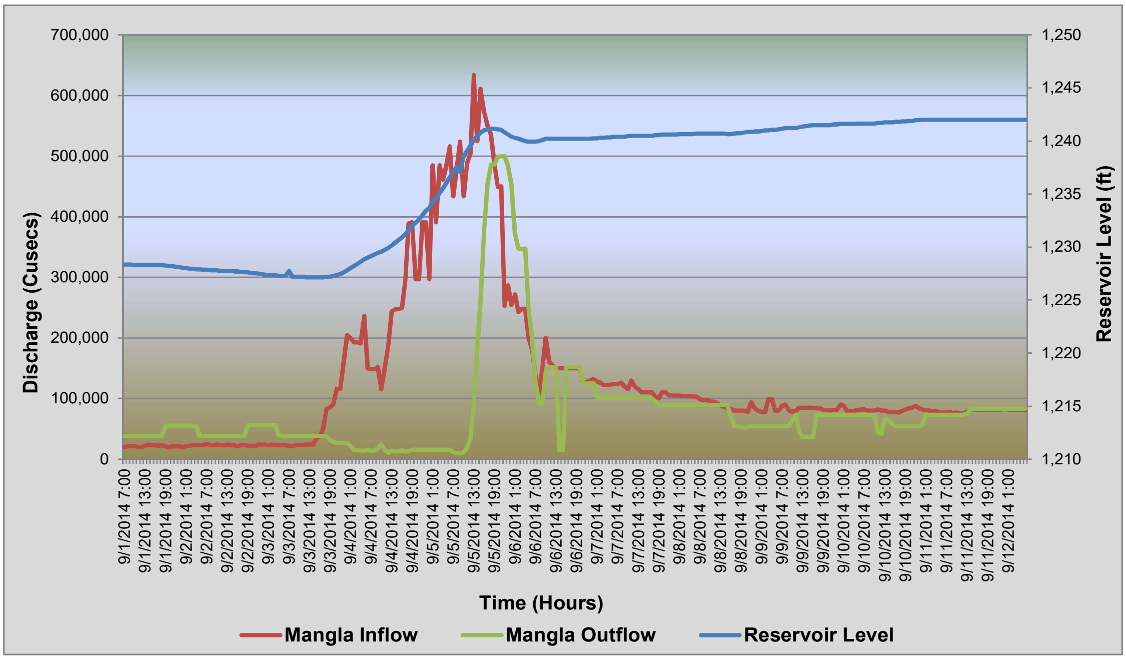


Figure 5-2: Hourly Inflows, Outflows and Reservoir Levels at Mangla during 2014 Flood

A review of Mangla reservoir operation reveals that mostly it was according to the SOPs. Without a better meteorological forecast where inflow and volume of flood can be predicted, it was difficult to operate the reservoir better than this because during such rains and floods the ultimate filling of reservoir up to level El. 1242 ft. is the responsibility of MDO. However, the only question arises, why the reservoir level was not allowed to be raised at or above 1242 ft when there was storage available between El. 1241 ft. and El. 1242 ft. Further there was flood storage available above El. 1242 ft. Perhaps flood could have been mitigated little more in case reservoir level was allowed to be raised up to or above El.1242 ft. This indicates that there were a little flaws in implementing the SOPs to better mitigate the floods.

5.4.4 Recommendations to Meet Future Challenges

Existing reservoir operational rules needs, implementation of SOPs (revised by FFC in 2015) particularly for Tarbela in the light of 2010 and 2014 floods to ensure efficient control of floods in order to provide maximum relief to downstream areas.

5.4.5 Future Storages/Reservoirs on Main Rivers with Flood Mitigation Impact

There are numerous small to large reservoirs planned and proposed on the streams/hill torrents and rivers. The small to medium storages which are proposed on the hill torrents have local impact on the population and lands downstream of these hill torrents. The storages which are proposed to be constructed on the major rivers have wider range of impacts in the flood plains of these rivers depending upon the flood mitigation storage of these dams. Some of these are described briefly in the paragraphs below.

5.4.5.1 Dams and Reservoirs

The role of reservoirs in flood management is very important and historic flood events (2010 & 2014) have highlighted their significance. Pakistan’s western rivers have two major reservoirs, Tarbela and Mangla on Indus and Jhelum rivers, respectively playing significant role in flood mitigation.

Likewise on Indus, future dams upstream of Tarbela would provide relief in terms of reduced flood peaks. i.e., flood peak at Tarbela may get reduced by absorbing flood volumes through future reservoirs.

NFPP-IV recommends the construction of new reservoirs as per WAPDA’s priority list with consensus of all provinces. The provision of cost is however, not made in the plan and is suggested to be undertaken as separate Public Sector Development Projects.

5.4.5.2 Munda Dam

Munda Dam is a proposed multi-purpose concrete-faced rock-filled dam located on the Swat river approximately 37 km north of Peshawar and 5 km upstream of Munda headworks in the Mohmand Agency of Pakistan's Federally Administered Tribal Areas. The gross capacity of dam is 1.29 MAF.

Once completed, the dam will generate 740 MW of hydroelectricity, irrigate 15,100 acres of land and control floods downstream. It is expected to provide numerous estimated annual benefits including Rs. 4.98 billion in annual water storage benefits, Rs. 19.6 billion in power generation benefits by generating 2.4 billion units of electricity annually and Rs. 79 million in annual flood mitigation benefits.

Munda dam is also expected to protect Nowshera and Charsadda districts from seasonal floods by storing peak flood water in its reservoir and releasing it in dry season. In December 2010, in the aftermath of the July 2010 floods in Pakistan, the Pakistan Supreme Court had constituted a flood enquiry commission to investigate the damage caused by the July floods that engulfed the country and caused unprecedented damage to life and property. In its report, the commission noted that if the Munda dam had been constructed, there would have been minimal damage downstream in Charsadda, Peshawar and Nowshera districts and Munda Headworks.

5.4.5.3 Diamer Basha Dam

Diamer Basha dam, gravity dam with a height of 272 meters is in the preliminary stages of construction, on the Indus river in Gilgit-Baltistan area. Upon completion, Diamer Basha dam would be the highest RCC dam in the world. Diamer Basha dam would;

i. Produce 4,500 MW of electricity through environmentally clean hydropower generation;
ii. Store an extra 8,500,000 acre feet (10.5 km^3) of water that would be used for irrigation and drinking;
iii. Extend the life of Tarbela Dam located downstream by 35 years; and
iv. Control flood damage by the River Indus downstream during high floods.

Indus river and its tributaries, un-questionably, are the largest national resources. Besides sizeable surplus water still going out to sea, Indus System has over 30,000 MW of hydropower potential. For effective harnessing of this renewable resource, most of which is run-of-river type, it would be necessary to build multi-purpose storage. This would generate sizeable blocks of cheap electricity and thus check the excessive tariff increases due to anticipated large scale induction of costly thermal power. In particular, this would provide means for; substituting the continuous capacity loss of on line storages to sustain the existing irrigation; development of new irrigation projects, and effective flood control. Taking into account all the above factors, a 25-year (2000-2025) National Water Resources Development Program (NWRDP) has been formulated including multi-purpose projects. It is a package, including multi-purpose dam project, based on the concept of unified approach to tackle the threatening water shortages and anticipated large increase in power tariff due to predominance of thermal power.

5.4.5.4 Chiniot Dam

The Pakistan government has planned to build the Chiniot Dam Project on Chenab river, between Chiniot and Chenab Nagar, to stock up and provide river water for irrigation and to generate power. The power plant will generate 256 Gigawatt hours (GWh) of hydro electricity.

The proposed dam would have a discharge capacity of 1 million cusec and storage capacity of 1.29 MAF. Total length of the dykes will be around 70 km (44 miles) and their height would be 12 m (39 ft).

It is expected that if the reservoir is filled during high floods, it would have positive impact on flood reduction to the downstream reaches of the river. However, filling of reservoir during floods would induce heavy siltation and reduce life of storage. On other hand if it is not filled during floods, it would have low flood mitigation effect.

5.4.5.5 Akhori Dam

The proposed Akhori dam would be located on the Nandna Kas stream in Punjab's northern district of Attock near Akhori village. The dam height would be 130 meters. It would be constructed in five years. The major pond is to be constructed on the Haro and Nandna Kas and Indus-Kabul flows would be diverted through a channel to ensure availability during the dry seasons. While considering all aspects, the Akhori dam has been evaluated to be just like the Kalabagh dam in economic importance. Its construction cost would be three times lower than Kalabagh. Feasibility Study has already been completed and approval of PC-II for Detailed Design and Tender Documents is awaited. The study was submitted to federal authorities in 2012 for addressing the reservations of any of provinces and seeking the PC-II approval for detailed design and tender documents as early as possible.

It would store the water which flows to the sea during every monsoon. In comparison to Kalabagh dam, the Akhori dam would have water storage of 7.6 MAF, equal to the Kalabagh dam but its cost as well as power generation will be extremely low. According to the documents, the total cost on Akhori dam is estimated to be around US$ 4.4 billion against more than US $12 billion for the Kalabagh dam project. About 600 MW of electricity is likely to be generated as compared to Kalabagh dam’s 3,600 MW. Besides other benefits, it would help to mitigate floods.

5.4.5.6 Kurram Tangi Dam

The proposed Kurram Tangi dam is a multipurpose project planned on the Kurram river about 14 km upstream of Kurram Garhi Headworks and 32 km north of Bannu city in North Waziristan Agency. It is designed as a concrete faced rock-fill dam with height of 322 ft. As per revised design, its gross storage capacity will be 1.2 MAF and live storage as 0.9 MAF.

The dam will irrigate a command area of 84,380 acres and will have hydro-power generation capacity of 83.4 MW. The dam will also supplement 278,000 acres of existing system of Civil and Marwat canals. By constructing dam, the life standard of about more than 11,000 people will be improved. It will increase agriculture production, generate power and expected to help in flood mitigation.

5.5 TRANS-BOUNDARY WATER MANAGEMENT

5.5.1 Introduction

As floods do not recognize borders, trans-boundary flood risk management is imperative in shared river basins, involving both Governments. However, trans-boundary flood management is not easy to implement, as joint monitoring, forecasting and early warning, coordinated risk assessment and joint planning of measures, and appropriate legal and institutional frameworks are all necessary. The tool on trans-boundary aspects of flood management focuses on common problems, objectives and approaches of flood management in trans-boundary basins, outlines major steps in arranging trans-boundary cooperation for flood management and presents approaches in sharing knowledge for the management of trans-boundary flood risks.

All the major rivers that run through Pakistan, originate from uplands in India except Kabul river which enters from Afghanistan. There exists Indus Water Treaty between India and Pakistan since 1960 for sharing of waters between both the countries along with mechanism for transmission of flood data/information during monsoon period. No such agreement or arrangement exists with Afghanistan.

Trans-boundary water sharing mechanism under Indus Waters Treaty, as a whole, is not in the scope of present flood related studies and only a review of existing trans-boundary flood management arrangements under Indus Water Treaty are briefed in the paragraphs below.

5.5.2 Treaty Clauses for Exchange of Data

Under Article VI of Indus Water Treaty, there is an arrangement between India and Pakistan for exchange of gauge and flow data of the rivers. The text of above mentioned Article is reproduced as below.

(1) The following data with respect to the flow in, and utilization of the waters of the rivers shall be exchanged regularly between the parties:

a) Daily (or as observed or estimated less frequently) gauge and discharge data relating to flow of the Rivers at all observation sites.
b) Daily extractions for or release from reservoirs.
c) Daily withdrawals at the head of all canals operated by government or by a government agency (hereafter in this Article called canal), including link canal.
d) Daily escapages from all canals, including link canals.
e) Daily deliveries from link canals.

These data shall be transmitted monthly by each Party to the other as soon as the data for a calendar month have been collected and tabulated, but not later than three months after the end of month to which they relate. Provided that such of the data specified above as are considered by either Party to be necessary for operational purposes shall be supplied daily or at less frequent interval, as may be requested. Should one Party request the supply of data by telegram, telephone, or wireless, it shall reimburse the other Party for the cost of transmission.

(2) If in addition to the data specified in Paragraph (1) of this Article, either Party requests the supply of any data relating to the hydrology of the river, or to canal or reservoir operation connected with the rivers, or to any provision to this Treaty, such data shall be supplied by the other Party to the extent that these are available."

5.5.3 Present Set-Up of Data Exchange

A meeting between Indus Water Commissioners of Pakistan and India was held in Lahore from 19th to 22nd May, 1989 and besides other matters, they discussed and agreed on the arrangements for the communication of information about flood flows during the period 1st July to 10th October, 1989. The agreement is intact and extended for the further period till now.

The agreed arrangements are following:

(a) India will continue to make arrangements for the broadcast of certain meteorological and flood data on the same lines as of last year, free of cost for the following discharge sites on the rivers:

i. Akhnoor on the Chenab Main,
ii. Jammu on the Jammu Tawi, and
iii. Madhopur below on the Ravi Main.

(b) India will also continue to communicate, through priority flood telegrams, free of cost, information about flood flows for the following discharge sites on the rivers, as was being communicated hitherto fore:

i. Ropar (Rupar) below, Harike below and Ferozepur below on the Sutlej Main,
ii. Nowshera (Mirthal) on the Beas Main,
iii. Madhopur below on the Ravi Main,
iv. Akhnoor on the Chenab Main,

v. Jammu on the Jammu Tawi, and
vi. Baramula on the Jhelum Main.

(c) In addition to the arrangements at (a) and (b) above, India will make arrangements for the Communication of the flood data listed below, to Pakistan on telephone.

Madhopur Below on the Ravi Main

i. Six hourly discharges at 06.00, 12.00, 18.00 and 24.00 hours (IST) for the discharges between 30,000 and 100,000 cusecs,
ii. Three hourly discharges at 03.00, 06.00, 09.00, 12.00, 15.00, 18.00, 21.00 and 24.00 hours (IST) for the discharges between 100,000 and 200,000 cusecs,
iii. Hourly discharges exceeding 200,000 cusecs,
iv. During the flood falling stages discharges at intervals mentioned at S.Nos. (i) to (iii) above.

Sutlej River

i. Six hourly discharges at Ropar (Rupar) below at 06.00, 12.00, 18:00, and 24.00 hours (IST) for discharges between 50,000 and 150,000 cusecs,
ii. Three hourly discharges at Ropar (Rupar) below at 03.00, 06.00, 09.00, 12.00, 15.00, 18.00, 21.00 and 24.00 hours (IST) for discharges between 150,000 and 250,000 cusecs, hourly discharges at Ropar (Rupar) below for discharges exceeding 250,000 cusecs,
iii. Six hourly discharges at Harike below and Ferozepur below at 06.00, 12.00, 18.00 and 24.00 hours (IST) for discharges between 50,000 and 100,000 cusecs.

5.5.4 Importance of Indian Data for Flood Warning Purpose

Meteorological forecast and flood forecast main alerts that are issued by the PMD prior to the flood in any area in Pakistan in general and in Indus River system in particular. These forecasts are qualitative and quantitative. FEWS-Pakistan is model that is used for quantitative flood forecast. It comprises two distinct components; hydrological model (SACRAMANTO) and hydraulics model (SOBEK). The catchment areas of Chenab, Jhelum, Ravi and Sutlej Rivers lying in Indian side are covered through hydrological models to predict or estimate flood hydrographs at rim stations in Pakistan using catchment's parameters and rainfall forecast or measured rainfall. Hydraulic models are used to simulate the flood inflow hydrograph at rim stations to the downstream reaches including inflows from the downstream catchment areas.

The composition of FEWS model is such that gauge and flood information received from Indian side is not used as an input to the model. However, the information is very useful firstly to confirm the forecast from the hydrological component of the model at rim stations and secondly very important to issue instant warning to the populations living downstream of the rim stations in Pakistan. Although, the lead time is too short yet it helps in making arrangements for evacuation and flood preparedness. Real time information of reservoir levels on eastern streams is squarely important for flood forecasting and warnings. Despite many requests as per Treaty Clause, the required data is not provided by Indian side. This issue needs to be highlighted at higher political forums.

5.5.5 Trans-boundary Issues with Afghanistan

Kabul river basin covers about 53,000 km^2(20,460 $mile^2$) within Afghanistan and about 14,000 km^2(5,405 $mile^2$) within Pakistan before the confluence with the Indus River. The basin has numerous small rivers and seasonal streams.

Being a lower riparian state, Pakistan's water dispute started just after its independence with India and Afghanistan. Afghanistan is planning for construction of dams and facilities on its rivers for flood control, electricity generation and irrigation expansion with the help of India. Once implemented, such projects would impact the flow of water and timing of peak runoff in Pakistan. Afghanistan's initiative for construction of multi-purpose water projects on the tributaries of Kabul River would adversely impact Pakistan. It is estimated that Pakistan would suffer 16 to 17 percent reduction in water supply from Afghanistan after construction of 13 dams on the Kabul River.

Pakistan is one of the most water-stressed countries, a situation likely to worsen into outright water scarcity owing to high population growth. There is no additional water that can be injected into the system. Pakistan is dependent on a single river system and lacks the robustness that many countries enjoy by virtue of having a multiplicity of river basins and diversity of water resources. This situation will not reduce the water availability but give rise to morphological changes with creation of sedimentation problems on major hydraulic structures like Jinnah Barrage.

Unfortunately, there is no water sharing agreement between Afghanistan and Pakistan. In the past, Pakistan did try to bring Afghanistan to the negotiating table to work out some mechanism to ensure a win-win situation for both sides. The World Bank agreed to facilitate a bilateral water treaty but refused to become the guarantor as it is the guarantor of the Indus Waters Treaty. The Afghan administration, however, excused itself by saying it was working on its own national water policy and it was not possible to initiate talks until that policy is ready.

5.6 ENVIRONMENTAL MANAGEMENT[10]

5.6.1 Introduction

Floods cause major destruction to infrastructure, natural environment and ruins human settlements. Widespread affected 20 million people during 2010 flood in Pakistan. Flood disasters occur when it flood waters affects human population and environment. Flash and other severe floods, all have adverse impacts of disasters which lead to disruption in biodiversity and ecological balance. In the light of gradual climatic changes likely to increase flooding in the future, there is need to pay special attention to reduce the flood disasters.

5.6.2 Floods and Subsequent Environmental Issues

Floods create devastating effect on Floodplain ecosystem. During phase of low flow, river occupies natural waterways. During rainy season, river spills in flood plain, so ultimate effect on crops, animals and plant that causes ecosystem disturbance. The environmental issues include:

i. Loss of natural vegetation and cutting of trees,
ii. Poor drainage,
iii. Increased air and water pollution,
iv. Increased litter and waste,
v. Loss of plants and wildlife,
vi. Loss of aquatic habitats, and
vii. Reduced water quality.

[10](Reference: IOSR Journal Of Environmental Science, Toxicology And Food Technology (IOSR-JESTFT) e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 6, Issue 1 (Sep. - Oct. 2013), PP 32-35 www.Iosrjournals.Org www.iosrjournals.org 32 | Page Implications of Environmental Considerations for Floods in Pakistan.)

Current environmental issues in Pakistan have emerged from on-going land degradation, depletion of natural resources, marginal settlements, unplanned settlements, disposal of waste, shortage of irrigation water, variable melting pattern of glaciers and control of water regulatory system over rivers by India.

The causes of environmental degradation includes excessive grazing and unplanned deforestation, shortage of timberland due to increased population, water declining at alarming rate and change in climate due to global warming. Natural disasters like flood, landslide and increasing erosion etc are main causes of impacts associated with environmental degradation.

Currently deforestation is one of major cause responsible for flashy floods. The cutting and depletion of forests at enormous rate needs preventive measures keeping in view its productive, preventive, regulatory and accessory benefits. It is causing ultimate disturbance to environment and more vulnerable to flooding environment.

Flooding washes away the solid wastes and various contaminants which lead to water and air pollution. Flooding leads to many diseases like malaria, hepatitis and others because of poor sanitation conditions. Researches also indicate that oxygen concentration in flooding soil approaches to zero. Without oxygen, certain plants cannot survive. Many non-agricultural plants are submerged under water. Numerous cases have been reported from recent 2010 floods indicating that many deaths occurred due to diarrhea, cholera and other diseases.

The environmental impacts of extreme flooding are complex interesting, and largely unused in policy making. In recent times, the focus of water management has changed from the need to dominate and control water resources to a more appropriate philosophy that seeks a balance between the structural flow control required to support and protect growing populations and environmental well-being. There are certain structural challenges due to floods hazards. Rebuilding challenges include reconstruction of destroyed or damaged housing and infrastructure, including electrical generation and distribution, roads, bridges, rail lines, levees, dams/barrages, and irrigation works. Floods shut down some electricity, oil, and gas facilities. According to various media reports, floods closed approximately 3 GWh of power generation capacity.

While the floods are causing severe negative effects on agricultural production in the current season, the damage and impacts will likely have broader implications for future agricultural production and food security in Pakistan.

5.6.3 Environmental Aspects of Integrated Flood Management in Pakistan

Since many decades, flood is engineering centered, with reliance on structural measures like embankments, dams, dykes with no consideration on environmental aspect. As regular occurrence of floods and their adverse impacts and concerns for sustainable development there is need of flood control from integrated flood management. It includes following considerations:

- Why ecosystem protection is important?
- How can sound ecosystem contribute to flood mitigation?
- What are the environmental consequences of structural flood management measures?
- What is needed to factor environmental consideration in decision making?

Flooding causes erratic flow from sewerage and shallow water outfall lead to hostile effects on water quality. These impacts reduce dissolved oxygen leads to degradation and also cause increase in concentrations of ammonia and bacteria which are harmful for health. If the flood measures are not put in place that will lead to increased risk. Bacteriological contamination caused by wastewater after floods and vegetables grown in that area leads to health related problems.

5.6.4 Recommendations

The following recommendations are drawn from implications of environmental considerations for floods in Pakistan:

i. Environmental problems vary from area to area within country and even from within city as well, so need is to investigate it locally.
ii. Rules and laws are required to be formulated and implemented at Government level to improve the environmental resilience.
iii. Particular attention should be given to deforestation in Pakistan.
iv. Awareness and trainings to community strengthen resilience.
v. Education curriculum at university levels should have some space for environmental related issues related to disasters in general and floods in particular.
vi. Institutional framework for environmental issues in Pakistan is the need of time. Government organizations/institutions at local level should be equipped to deal with environmental degradation caused by adverse impacts of floods.
vii. Ministry of Climate change and Pakistan Meteorological department should play role for awareness of the environmental degradation to the communities.
viii. There is a need to involve all the stakeholders (Army, NDMA, PDMA, PID's, DCO's etc.,) for better planning and execution of plans made for environmental resilience.

5.7 FINANCIAL RESOURCES MANAGEMENT

5.7.1 Understanding

Financial resources management is the process of procuring, allocating and controlling financial resource of a country at the least cost with maximum benefits. Besides country's own resources, Pakistan has been getting billions and billions of dollars in the form aid, loans and investments in all the sectors of life since its creation. This money was not used in a well-planned and organized way. Therefore, there is need to utilize these funds in a scientific manner to achieve maximum benefits.

Financial resources management means putting together the economic resources at hand to make efficient use of them and taking decisions that can successfully culminate in acquiring more assets for the country. With effective utilization of funds, more financing can be attracted to meet the short-term and long-term requirements.

Financial management analysis should be involved which includes calculation of risk, cost and control, and maintenance of the cost of funds at minimum. This is done with the intent of establishing a proper balance between the involved risk and optimized control.

Financial resource management involves the raising of funds through the domestic and foreign market. When considering overseas solutions, direct and foreign institutional investments are major resources to tap, in order to raise the required funds. This whole mechanism designed for effective procurement of funds has to be periodically reviewed and modified, understanding the changing requirements of foreign investors.

The ultimate goal cannot be addressed or achieved without first designing a strategy to ensure the proper utilization of funds. This helps to evade situations in which the funds remain idle or lack of profitable utilization of funds in hand. When availing of funds, it is important to understand the involved cost and risk factors. Any sort of wastage of funds needs to be avoided.

For each of the flood protection scheme, cost-benefit ratio and economic rate of return is computed before its implementation. Economic rate of return (ERR) is defined as interest rate at which the cost and benefits of a project, discounted over its life, are equal. ERR differs from the financial rate in that it takes into account the effects of factors such as price controls, subsidies, and tax breaks to compute the actual cost of the project to the economy.

5.7.2 Funding Agencies in Flood Sector

There are numerous funding agencies in the flood protection sector besides Government of Pakistan. Some of these agencies are World Bank (WB), Asian Development Bank (ADB), Islamic Development Bank (IDB), USAID, International Monitoring Fund (IMF), Japan International Cooperation Agency (JICA), etc. These funding agencies offer short-term and or long-term loans usually at soft interest rate. Investments are also offered by some of these banks or agencies particularly for construction of dams. Funds in the form of aid are also offered by USAID, friendly countries and other charity organizations for the flood relief purpose.

5.7.3 Accountability

Pakistan is a country with rich natural resources but financially poor. Corruption remains a substantial obstacle for Pakistan where it is still perceived to be widespread and systemic prevailing in law enforcement, procurement and the provision of public services. As a result, Pakistan has not grown up to the expectations. Therefore, there is need to strengthen the existing accountability laws and ensure implementation forcefully without any of interference, political or otherwise. The responsibility for mismanagement of funds should be fixed lawfully at any cost and corrupt mafia should be punished without any discount.

5.7.4 Funding for Flood Management

River management, particularly, flood management requires substantial financial resources of different varieties, which, at some times, are urgently needed to cope with the emergencies. Accordingly, a well planned and workable financial road map is essential for developing any river management framework. An attempt has been made, to look at the issue and to explore the financial demands and the potential sources for creating a viable and sustainable financial set up.

5.7.4.1 Flood Protection & Relief (Cost)

(a) The implementation cost of the structural flood management schemes includes:

- Civil works;
- Land acquisition;
- Physical contingencies; and
- Engineering and administrative charges.

(b) The flood fighting expenditure covers-

- Evacuation;
- Relocation;
- Provision of necessities of life; and
- Health support;

(c) Rehabilitation of flood victims may extend to-

- Relief grants;

- Adjustment of loans;
- Provision of new loans;
- Abiana / land revenue remission;
- Exemption from specified local taxes;
- Exemption from market fee on Agricultural Produce;
- Incentive for relocation to safe areas; and
- Non profit insurance schemes by Government.

5.7.5 Possible Revenue Sources

The huge amount of resources is required for the river management at various levels. Therefore, it is important to explore all possible means of gathering these resources. Some of the possible sources for the financial sustainability of flood management are indicated as under:

- Federal grants;
- Donations from local and international donors;
- Cess on irrigated land in general;
- Cess on areas / land benefitting from development schemes;
- Cess on big cities under protection, may be a part of utility bills
- Cess on commercial activity in the river areas;
- Property tax collected from the flood protected commercial establishments;
- Proceeds of sand excavation leases;
- Proceeds of sale / auction of timber collected from river;
- Licensing / registration fees of commercial activities on river bank areas;
- Licensing / registration fees of navigational activities of rivers;
- Contributions by Provincial Governments and Local Governments; and
- Contributions by high income groups in vulnerable areas.

5.8 Conclusions

The most viable option to cope with the challenges of river management in a federal system is the role of all the tiers of the governments and that higher level of government will have more role than the lower level. Thus, the Federal Government should have very large role in the river management activities. Similarly, the Provincial Governments may be entrusted with a medium role and the Local Governments with a small role.

In view of above, it is suggested that the overall division of responsibilities may be fixed as under;

(i)	Coordination	Federal Government
(ii)	Surveys, data bank	Federal Government
(iii)	Flood information	Federal Government
(iv)	River Management Commission	Federal Government
(v)	Others	Provincial/Local Government
(vi)	Financial Contributions[11]:	

Federal Government ---------------- 10%
Provincial Government---------------80%
Local Government--------------------10%

[11]Federal, Provincial and Local Government financial contributions would be finalized after stakeholder consultation in view of 18th Constitutional Amendment and latest NFC Award.

6. PLANNING STRATEGY, OBJECTIVES AND GOALS

6.1 PLANNING STRATEGY

Managing the rivers to minimize the impacts of floods is essential to ensure the long-term survival of communities living near rivers and mainstreams. Following the super flood of 2010, the Government of Pakistan planned to have a comprehensive flood management plan for the next 10 years so that people living in the vicinity of rivers can be saved from the flood hazards and their miseries can be reduced in the real sense. For the purpose, there is a requirement of devising planning strategy to fulfill the objective and goals of the flood management planning.

In the past, except NFPP-II and NFPP-III, more emphasis had been given on the structural measures by constructing protection bunds, dikes, spurs etc., ignoring some of the important non-structural measures. Without denying the need of structural measures, it is not needless to mention that unlike structural measures there are no environmental impacts of non-structural measures. Further, the investments on non-structural measures as compared to structural measures are minimal on a short term basis and are extremely important in the long term to make structural measures more effective and purposeful.

Encroachments on floodplains for agricultural purposes and housing settlements are regarded as the main reasons for the increasing devastation caused by heavy rains and floods. For the purpose there is need for collective action to mitigate environmental hazards with thorough planning which includes strict policymaking and legislation to avoid any sort of development which may threaten the balance of nature. Judicial Flood Enquiry Report following the flood of 2010 also highlighted the need to setup and effectively manage the floodplain management plan. Well informed community role is also required in this perspective so that permanent settlements in the floodplain areas are avoided.

Deforestation in the uplands of rivers at an alarming rate needs to be addressed immediately. This is one of the causes of global warming/climate change, silt erosion and landslides. Another cause of global warming/climate change is the excessive release of carbon dioxide from the factories, vehicles etc., due to non-implementation of laws and regulations. Improper disposal of solid waste in the towns and cities is one of the main causes that result in outburst of diseases immediately after the floods. Thus, formulation of a comprehensive program for watershed management and environmental management is the need of time.

Above mentioned aspects have been kept in view as planning strategy besides strengthening of flood early warning and forecasting system, flood mitigation through reservoir management, and structural measures like construction of storages and protection bunds, dikes etc., in various reaches of rivers.

6.2 PLANNING OBJECTIVES

The formulation of comprehensive integrated and innovative National Flood Protection Plan is the main objective of the present project studies that would lead to improve country-wide flood management planning, implementation and monitoring to essentially achieve flood management objectives. This needs to chalk out an investment schedule based on the lessons learnt in perspective of 2010-2014 floods that includes construction of protection works, rehabilitation of barrages and non-structural measures including but not limited to up-gradation and strengthening of meteorological and flood forecasting system, updating of floodplain mapping and zoning for identification of high, medium and low flood risk areas so that emergency evacuation and relief plans can be formulated and implemented as well as restricting developments/construction of permanent settlements in high risk zones through legislation.

6.3 PLANNING GOALS

The objectives of the Flood Protection Plan-IV are to take effective measures for providing long term protection to the community living near the threat of rivers floods. By implementing National Flood Protection Plan-IV in its real sense, it is expected that the main goal of saving the population from flood hazards would be achieved. There are certain short term and long term goals that are anticipated to be met through proper implementation of this plan.

6.3.1 Short Term Goals

i. Completion of on-going projects,
ii. Strengthening and re-modeling of existing flood protection works in the most vulnerable or problematic areas,
iii. Up-gradation/strengthening of river gauging network and flood early warning and forecasting system,
iv. Revision of SOPs for existing reservoirs,
v. Implementation of floodplain legislation (River Act), and
vi. Many studies for structural and non-structural measures are recommended and should be completed essentially within 1-3 years of implementation of NFPP-IV,

6.3.2 Medium Term Goals

i. To revive the original capacity of barrages/bridges and enhance the existing system capacity of river reaches, hydraulic structures, embankment (top levels) to bear floods above their existing design magnitudes,
ii. Strengthening and re-modeling of existing flood protection works (not covered under Top Priority) in all over the country,
iii. Design/construction of new works as per unique design standards with respect to hydrologic, hydraulic, structural, geotechnical investigations, etc,
iv. Watershed management/land use control in the uplands of all the concerned rivers.

6.3.3 Long Term Goals

i) Implementation of watershed management plans in the uplands of rivers within 10 years of implementation of NFPP-IV,
ii) Implementation of environmental management plans within 10 years,
iii) Construction of small storages in the areas away from the main rivers can be accomplished within 10 years,
iv) Overall complete implementation of NFPP-IV in 10 years.

7. INTEGRATED FLOOD MANAGEMENT

7.1 GENERAL

Integrated Flood Management (IFM) is the process which promotes the coordinated management and development of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. This approach recognizes that a single intervention has implications for the system as a whole, and that the integration of development and flood management can yield multiple benefits from a single intervention. Integrated Flood Management addresses issues concerning human security and sustainable development from the perspective of flood management.

Floods are part of a natural cycle that can never be fully controlled. “Flood Control” is therefore a futile terminology and a counterproductive mandate. It is time to move towards an integrated approach for flood management to save lives and increase resilience towards flood impacts. Flooding of floodplains supports ecosystems which promotes an environment essential to human livelihoods. While flood managers in the past have mainly focused on structural measures to protect and mitigate flood impacts, a broader set of objectives need to be put on the agenda. While structural safety of the barrages and training works is critical, human safety, protection of human shelters, safeguards for agriculture and fisheries, roads, ecosystems, health, and biodiversity need equal attention. This further requires a more holistic and integrated approach involving a number of connected departments and agencies.

Integrated Flood Management expands the focus of flood management and brings more stakeholders and issues to the attention. It includes switching from simple flood control to an integrated flood management approach. Integrated, multi-disciplinary actions are needed to revisit traditional flood management to effectively use flood water for livelihoods and groundwater recharge in addition to safely disposing of extra floodwater.

In Pakistan, flood fighting is more a reaction than pre-emption. Flood management in various parts of Pakistan is fairly a complex issue, due to the varying physiographic, climatic, demographic and socio-economic conditions. In order to protect the threatened areas, different types of structures have been constructed for providing protection against floods.

7.2 COMPONENTS OF INTEGRATED FLOOD MANAGEMENT

Integrated flood management has two distinct components i.e. structural measures and non-structural measures for flood management. Integrated flood management is a fusion of different strategies. Structural and non-structural measures help in accomplishing different strategies involved in IFM as shown in Table 7-1. Construction of dams, dikes levees etc., reduce the flooding and flood forecasting and warning can reduce the extent of damage caused by floods. An effective integrated flood management plan involves coherence and coordination between different strategies and departments responsible for respective tasks. Both IFM components are included in NFPP-IV and are discussed in the subsequent sections.

Table 7-1: Structural and Non-structural Measures in IFM

Strategy	Options	Category
Reducing Flood	Watershed management	Non-structural Measure
	Dams and reservoirs	Structural & Non-structural Measure
	High flow diversions	Structural & Non-structural Measure
	Channel improvement	Structural & Non-structural Measure
Reducing Susceptibility to	Flood Forecasting and Early Warning	Non-structural Measure
	Strengthening of existing rain and river	Non-structural Measure

Strategy	Options	Category
Damage	gauging network	
	Floodplain regulation	Non-structural Measure
	Construction of flood protection and river training works i.e. levees, dikes, spurs etc	Structural Measure
Mitigating the Flood Impacts	Information and education	Non-structural Measure
	Disaster preparedness	Non-structural Measure
	Post- flood recovery	Non-structural Measure
	Flood insurance	Non-structural Measure

7.2.1 Structural Measures

It is well recognized that complete prevention of floods or any other natural hazard is a physical impossibility, but protection from flood and its management is possible and is of vital necessity. The flood management practice regarding structural and non- structural measures taken by management of major rivers for Pakistan mainly comprises flood protection embankments /bunds, spurs, studs and protection walls. These protective measures have been constructed as a result of specific requirements to solve the local flood problems.

The nature and need of flood protection works vary due to physiographic characteristics and local conditions in different parts of Pakistan. Flood protection embankments have been constructed, wherever over-bank flooding is the major problem, while spurs have been constructed to encounter the land erosion, where this phenomenon is predominant. The existing flood management works are described briefly in the following sections and total number of facilities in the four Provinces of Pakistan and AJ&K are given in Table 7-2.

Table 7-2: Existing Flood Protection Facilities

Province	Embankments (km)	Spurs (No.)
Punjab	3,334	496
Sindh	2,424	46
Khyber Pakhtunkhwa	352	186
Balochistan	697	682
Azad Jammu & Kashmir	13	-
Total	**6,820**	**1,410**

Source: 2015-Annual Flood Report of Federal Flood Commission, Islamabad.

In addition to above, after the submission of Task-B Report under NFPP-IV, the number of facilities existing in the Provinces and FLAs are given below:

Number of Existing Flood Protection Facilities

Province / Federal Agency / Department	Type of Structure (No's)			
	Embankment / Bund / Flood Protection Wall	Spur / Stud / Flood Dispersion Structure	Inlet Outlet Structure	Watershed Management Interventions
Punjab	394	791	-	-
Sindh	257	4	-	-
Khyber Pakhtunkhwa	560	224	-	-
Balochistan	257	3	-	-
FATA	205	4	-	-
Gilgit-Baltistan Region	28	2	-	-
AJ&K	0	13	-	-
Pakistan Railways	7	1	-	-
Sub Total	**1708**	**1042**	**0**	**0**
NGOs	183	8	9	7
Total	**1891**	**1050**	**9**	**7**

Source: Task-B Report, Development of Inventory of Flood Works and Benefit Monitoring & Evaluation of Flood Protection Works

7.2.1.1 Dams and Reservoirs

The role of reservoirs in flood management is very important and historic flood events (2010 & 2014) have highlighted their significance. Pakistan's western rivers have two major reservoirs Tarbela and Mangla on Indus and Jhelum Rivers, respectively. There is no major reservoir on Chenab River which can significantly play a role in flood peak attenuation. Chiniot dam has been identified with 1.29 MAF gross capacity. Thein dam and Bhakra dam on Ravi and Sutlej Rivers in Indian part of catchment are already playing effective role in dampening of flood peak magnitudes in these rivers. The location of existing major reservoirs is shown in Figure 7-1.

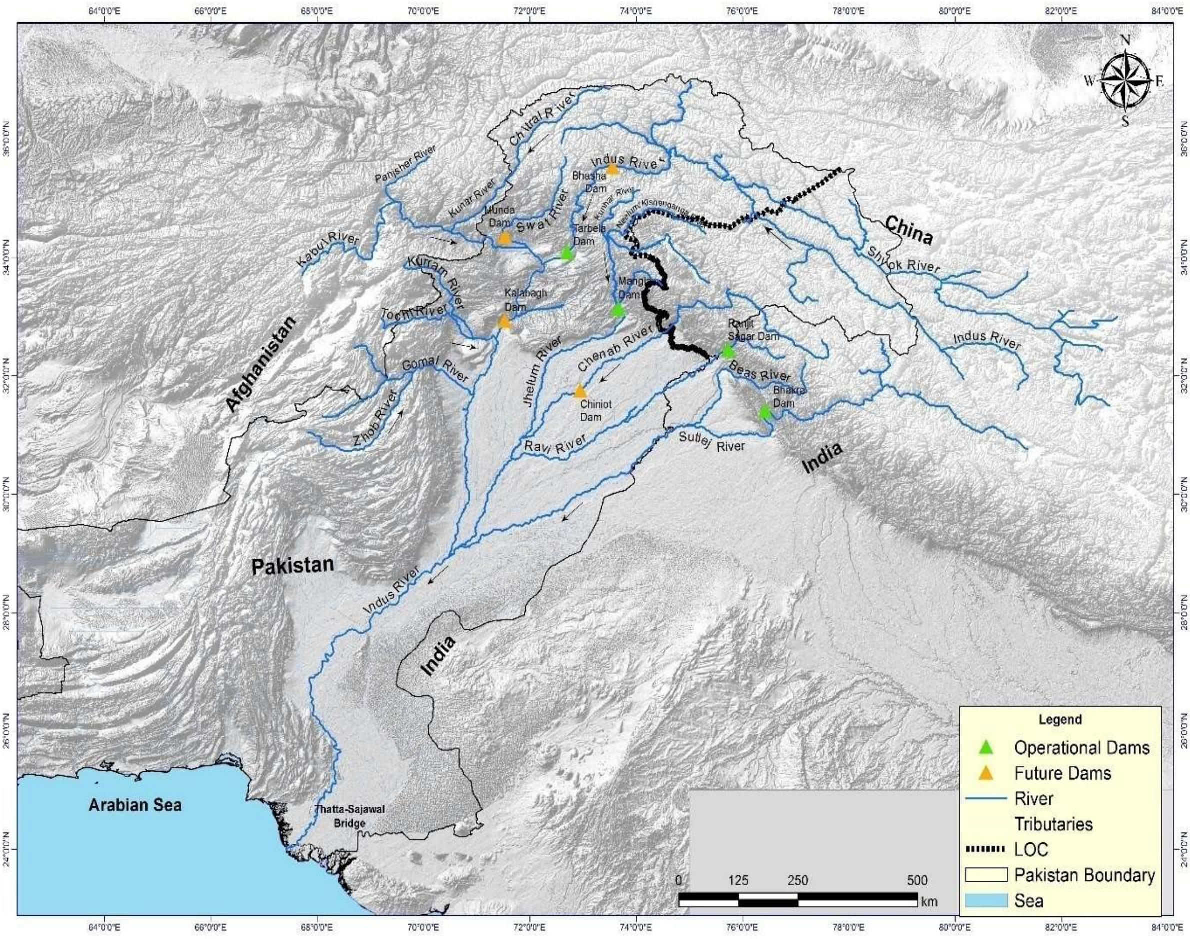


Figure 7-1: Existing and Future Dams

Consultant's analysis indicate that construction of Mangla Dam has reduced the intensity of large floods (about 100-year recurrence interval) by about 20%. The flood peak of 2014 flood released from Mangla could have been reduced by about 40%, if the reservoir had been filled up to 1,242 ft instead of 1,241 ft.

Similarly, India's Thein and Bhakra dams on Ravi and Sutlej rivers significantly lower the magnitude of frequent (low and medium) floods and are able to shave the peaks of large floods (about 100-year interval) by about 20%.

Likewise on Indus, Diamir Basha and other dams (WAPDA Vision) would further provide relief in terms of reduced flood peaks. i.e. 14,158 m^3/s (500,000 ft^3/s) flood at Tarbela at a rate of 20% reduction would be dampened to 8,495 m^3/s (300,000 ft^3/s) with Kalabagh and it would be further reduced with Diamer-Basha dam.

NFPP-IV strongly recommends the construction of new dams and reservoirs. The provision of cost is however not made in the plan and is suggested to be undertaken as separate Public Sector Development Projects. WAPDA's priority list consists of Diamer-Basha, Kurram Tangi and Munda dam with estimated cost of US $ 25 billion.

A detailed discussion on non-structural role of dams through effective reservoir operation, application of Standing Operating Procedures of existing major reservoirs and future reservoirs on main rivers with flood mitigation impact is provided in Section5.4of this report.

7.2.1.2 Embankments/Bunds

The existing embankments/bunds along the rivers in Pakistan are the key element of flood protection. In order to safeguard the areas from inundation, about 6,807 km of embankments have been constructed along major rivers and its tributaries. The bund system has gradually improved with the development of barrage controlled irrigation and has expanded to protect irrigated agriculture and population. Embankments along the rivers are the vital infrastructure that provides protection to the surrounding areas from the flood hazard.

In order to have a clear perspective of flood problems of each river basin, a comprehensive evaluation of existing flood protection facilities is necessary. Out of 6,807 km of existing bunds, 1,525 km are first line of defence in Sindh, and 899 km are second defence bunds including loop bunds, while Punjab has about 3,334 km of bunds. In Khyber Pakhtunkhwa, 352 km of embankments have been constructed along major river system, while in Balochistan 697 km long bunds have been constructed to safeguard areas from the onslaught of hill torrents. The bund system has developed in a period extending over a century in face of exigencies of the situation from time to time. There are fully documented manuals for continuous maintenance of these bunds.

7.2.1.3 Spurs and Studs

The spurs along the rivers of Pakistan have been constructed to encounter the problem of land erosion, which results due to changes in river morphology. This phenomenon occurs during floods with varying intensities. Sometimes erosion is more pronounced during low floods, when undercutting of erodible banks occurs. During the last few decades, about 283,500 ha of land have been lost due to erosion.

In order to protect the areas from erosion, 242 spurs were constructed prior to the start of Flood Protection Sector Project in 1987. Of these, about 120 were for the channelization of flows to the barrages and bridges and 122 for flood management in the areas. 1,168 new spurs have been constructed after 1987. The aggregate number of spurs in the country has accordingly increased to 1,410.

Studs are short bar-spurs used as protection against spill flow causing erosion along a river bank or flood embankment. They reduce erosion by deflecting the high velocity currents away from the eroding bank. The studs are often used in lieu of direct bank protection, because they are more economical and do not disturb the near-bank environment.

7.2.1.4 Gabions and Protection/Retaining Walls

In hilly areas the rivers usually have high velocity flows. There, it is not practicable to provide stone protection against bank erosion. For such locations, the most stable structural measure is the provision of stone retaining wall (with or without gabions). Gabions are well suited for retaining walls because of their flexibility and also to make full use of readily available local stone. These retaining walls are mostly used in hill torrents areas like Balochistan, KP, AJ&K and Gilgit Baltistan.

7.2.1.5 Diversions of High Flows Through Breaching Sections

In monsoon season, when maximum rainfall occurs and snow melts from the glaciers, it causes the maximum flow in rivers, when these flows reach to exceptionally high level, embankments have to be breached to escape the excess water, resulting in damage to standing crops, loss of human and animal life, destruction of properties, dislocation of communication and unimaginable suffering of people which cannot be measured in terms of money. In this section of report, a review of breaches in flood embankments has been made. Proper investigation of such breaches is essential to avoid them and to take appropriate measures to minimize/control such breaches in future. A brief overview of existing breaching sections and possible escape/ diversion paths being studied by provinces is provided in next section.

Normally two types of breaches exist such as natural and artificial. Natural breach in rivers is accompanied by the numbers of factors, which endanger the safety of the banks of rivers. Erosion of the surface of an embankment is usually caused by the action of wind, rodent holes, poor maintenance of wetting channel, etc. Failure of the subsurface of an embankment may be the reason of breach in rivers. Breaches at Taunsa barrage, Jampur Flood bund & Jinnah barrage (2 No's) in Punjab and Guddu barrage & Tori bund in Sindh during 2010 flood may be categorized as natural breaches.

Artificial breaches are provided to cater a situation where flood endangers the safety of hydraulic structure or bridge or nearby city. Therefore, various breaching sections provided near major hydraulic structures are operated. Table 7-3 shows the list of existing breaching sections on different hydraulic structures. Part A shows the breaching sections on barrages and headworks. Part B shows the breaching sections on road bridges.

7.2.1.6 Diversion / Escape Channels

In Punjab all barrages/headworks and some bridges on rivers have breaching sections as given in Table 7-3, except Taunsa barrage because canals are off-taking from both sides and road, railway, gas/oil pipe line are crossing the river. Any breach, accidental or deliberate, on either side will result in colossal damage to the private and public property. The site of breaching section is always mentioned in the flood fighting plans of Taunsa barrage at RD 1 to 2 of Link bund and RD 1 to 2 of shank of Spur 2-A, but practically it was never operated. The breaching section is now being proposed at RD 9 to 10 at shank of Spur T-2. Since the water from this breaching section will touch bank of Kachhi and D. G. Khan canals thus a breaching section has to be provided at RD 22 to 24 of the canals. A causeway has to be constructed on Pacca road and water way has to be provided under main railway line. The bunds have to be constructed both upstream and downstream of Kachhi canal and railway line respectively. Gates with head regulator have to be constructed on Kachhi and D.G. Khan canals both upstream and downstream of RD 22 and RD 24.

Similarly, the current breaching section near Shahdara on Ravi River is no more operational due to heavy encroachments in the surrounding areas. The opening of two bays has been proposed by Pakistan Railway. Efforts may also be required through District Government Lahore to remove encroachments and relocate the encroachers. The scheme for opening of nine bays of Shahdara Railway Bridge titled "Enhancing Capacity of Shahdara Railway Bridge and Downstream Old G.T. Road Bridge" costing about Rs. 3,784 million was sent to Federal Government, which was deferred till model study.

Table 7-3: List of Existing Breaching Sections

PART A: BREACHING SECTIONS ON BARRAGES AND HEADWORKS

Sr. No.	River	Barrage / Headwork	Location RD of Breaching Section	Coordinates		Critical Gauge		Designed Capacity (lac cusecs)	Maximum Ever Recorded Flood			Year of Construction
				Latitude	Longitude	Point	Level (ft)		Gauge in R. L.	Discharge (cusec)	Date	
1	Ravi	Balloki Headwork	1st) RD: 48-49 of Madhudas Bund	31.30°	73.89°	RD: 24+100 of L.M.B	644.50	2.25	630.00	399,356	27-09-1988	1913
			2nd) RD: 11-12 of Right Marginal Bund	31.25°	73.86°							
2		Sidhnai Barrage	RD: 15-16 Right Marginal Bund	30.58°	72.20°	RD: 10+000 of L.M.B	478.00	1.75	477.60	325,000	02-10-1988	1974
3	Sutlej	Islam Headwork	1st) RD: 11-13 of Right Retired Bund	29.86°	72.56°	RD: 10+000 of L.R.B	458.00	3.00	452.20	492,581	11-11-1955	1927
			2nd) RD: 3-5 of Murphy Spur	29.84°	72.57°							
4		Suleimanki Headwork	RD: 18-19 of Right Marginal Bund	30.42°	73.83°	RD: 18+000 of RMB	575.00	3.25	571.80	598,872	08-10-1955	1927
5	Chenab	Marala Headwork	RD: 5 of Right Marginal Bund	32.69°	74.45°	RD: 12+000 of L.M.B	829.00	11.00	816.00	1,100,000	26-08-1957	1968
6		Khanki Headwork	RD. 3-4 of Right Marginal Bund	32.42°	73.96°	RD: 5+000 of L.M.B	742.00	8.00	739.00	1,085,000	27-08-1957	1974
7		Qadirabad Barrage	RD. 7-9 of Right Marginal Bund	32.34°	73.68°	RD: 15+000 of L.M.B	712.00	9.00	700.30	948,000	09-11-1992	1974
8		Trimmu Headwork	RD: 16-18 Right M.	31.17°	72.10°	RD: 15+000 of L.M.B	500.00	6.45	492.30	943,225	07-08-1959	1974

Sr. No.	River	Barrage / Headwork	Location RD of Breaching Section	Coordinates		Critical Gauge		Designed Capacity (lac cusecs)	Maximum Ever Recorded Flood			Year of Construction
				Latitude	Longitude	Point	Level (ft)		Gauge in R. L.	Discharge (cusec)	Date	
			Bund									
9		Panjnad Headwork	RD: 28-30 of Right Marginal Bund	29.41°	71.01°	RD: 15+000 of L.M.B	350.00	7.00	340.30	802,516	17-08-1973	1976
10	Jhelum	Rasul Barrage	RD: 2+500 to 3+000 of Right Closure Bund	32.69°	73.51°	RD: 12+000 of L.M.B	727.40	8.50	721.30	950,000	10-09-1992	1981
11	Indus	Ghazi Barotha Barrage	Right Guide Bank 3,500 Long	34.02°	72.39°	Right Guide Bank	1120.46	6.60	-	-	-	1976
12		Jinnah Headwork	RD: 6+700 to 8+700 of Right Marginal Bund	32.93°	71.50°	RD: 5+000 of L.M.B	701.00	9.50	-	1,036,453 includes 100,000 from breach	30-07-2010	1982

PART B: BREACHING SECTIONS ON ROAD BRIDGES					
Bridges	Breaching Sites	Critical Gauge Point Location	Designed Capacity (Lac cusecs)	Coordinates	
				Latitude	Longitude
RIVER CHENAB					
Alexandra Bridge	Dip between Alexandra & Wazirabad Railway Road Mile 821/03	-	8.70	32°29'28.09"N	74° 5'51.13"E
Old G.T Road Chiniot Bridge	R.D: 2500 of Chiniot Flood Bund	5000 of Chiniot Bund (600)Rising	7.00	31°44'46.72"N	72°58'31.60"E
Rivaz Bridge	Mile 44-45 of Jhand Chund Railway Line.	RL 526 at RD 1500 of Thatta Mahala Bund	7.00	31°24'25.42"N	72°17'25.65"E
Shershah Bridge	LEFT SIDE Shershah Flood Bund, Railway Track and Muzaffargarh Multan Metaled Road	At 3-4 KM Railway Track, 2 breaches of 500 ft each in the Bund Railway Track and the Highway	-	30° 4'29.50"N	71°18'13.99"E
	RIGHT SIDE 1.Doaba Flood Bund (Chenab Right Bank) 2.Railway Bund. 3. Highway Flood Bund. 4. Rohari Flood Bund.	RD: 12-13. KM 9-10 of Railway Bund. Opp: KM 9-10 of Railway Flood Bund. RD: 8000-9000, RD: 14001) & RD: 20000.	-	30° 4'49.40"N	71°16'22.75"E
Muhammad Wala Bridge	Akbar Flood Bund at RD 11+000	417.5 ft.	-	30° 17'30.18"N	71°22'38.70"E
RIVER RAVI					
Shahdara Bridge	RD 56-64 of Shahdara Disty Bund	RL. 698 at Shahdara Disty. Bund	2.50	31°41'27.84"N	74°21'9.67"E

Source: Irrigation & Power Department Government of the Punjab

At present, the capacity of Railway Bridge and old G.T. Road Bridge on River Ravi are 7,080 m^3/s (250,000 ft^3/s). Whereas the 100 year return period flood is estimated around 12,740 m^3/s (450,000 ft^3/s). The Saggian and Motorway bridges have capacities of 450,000 cusecs whereas new Ravi Bridge has capacity 9,203 m^3/s (325,000 ft^3/s). Not only bays will have to be added to Railway, old and new Ravi bridges, a sizeable strip of Shahdara Town will have to be relocated to provide adequate waterway for 100 year flood.

Rehabilitation and up-gradation of Trimmu barrage is, being taken-up by Head, PMO for Punjab Barrages, Rehabilitation and Modernization Projects, Lahore under Punjab Irrigated Agriculture Investment Program (PIAIP) under the supervision of PIAIP Consultants on the basis of 100 years return period flood, wherein it has been proposed to enhance the capacity of Barrage from 18,260 m^3/sec to 24,774 m^3/sec (645,000 ft^3/sec to 875,000 ft^3/sec) by adding additional bays on right side of the barrage. If the Barrage is Rehabilitated and Up-graded for 100 years return period flood, then there will be negligible need to operate the breaching section in future.

Indus River travels through Sindh province for a distance of about 590 km (355 mile) from Guddu barrage to the Arabian Sea. Indus River is an alluvial channel, highly braided, and has a slope of less than one-half foot per mile. Through natural accretion, the river has risen above the natural surface level (NSL). After year 1940, construction of bunds system on Indus River although has controlled inundation but has resulted in high peak flows as well as that evolved with the development of barrage controlled irrigation. Water escaping the bund system cannot return to the river, leaving virtually all of Sindh vulnerable to floods.

These high flood peaks have increased pressures on protective bunds on all the three barrages i.e. Guddu, Sukkur and Kotri in Sindh province. No flood relief arrangements such as fuse plug and breaching section is provided on these barrages. The safety of barrages thus comes under high risk during high flood.

A feasibility study report for identifying the routes to divert excessive flood water of Indus River was conducted by Government of Sindh[12]. In this study four possible paths for breaching sections were proposed and two of them were recommended. The recommendations in the mentioned study report are as follows;

1. Finalizing the proposed breaching section/escape route as soon as possible.

2. The breaching section and bypass route for Route-1 which originates about 13 km upstream of L.M.B of Guddu barrage offers a better option, as the location covers the entire Indus River reach between Guddu and Kotri barrages. This route is therefore recommended to be adopted in the mentioned study (Figure 7-2).

3. Breaching section for Route-2 emanates from Rohri North bund upstream of Sukkur barrage near Ali Wahan has also been considered to be adopted in the mentioned study (Figure 7-3). The flood escape Route-2 starts about 8 km upstream of Sukkur barrage near village Ali Wahan. Escape flows from this breach point will flow through Nara canal.

[12] Identifying the routes to divert excessive flood water of Indus River, February 2013, Government of Sindh.

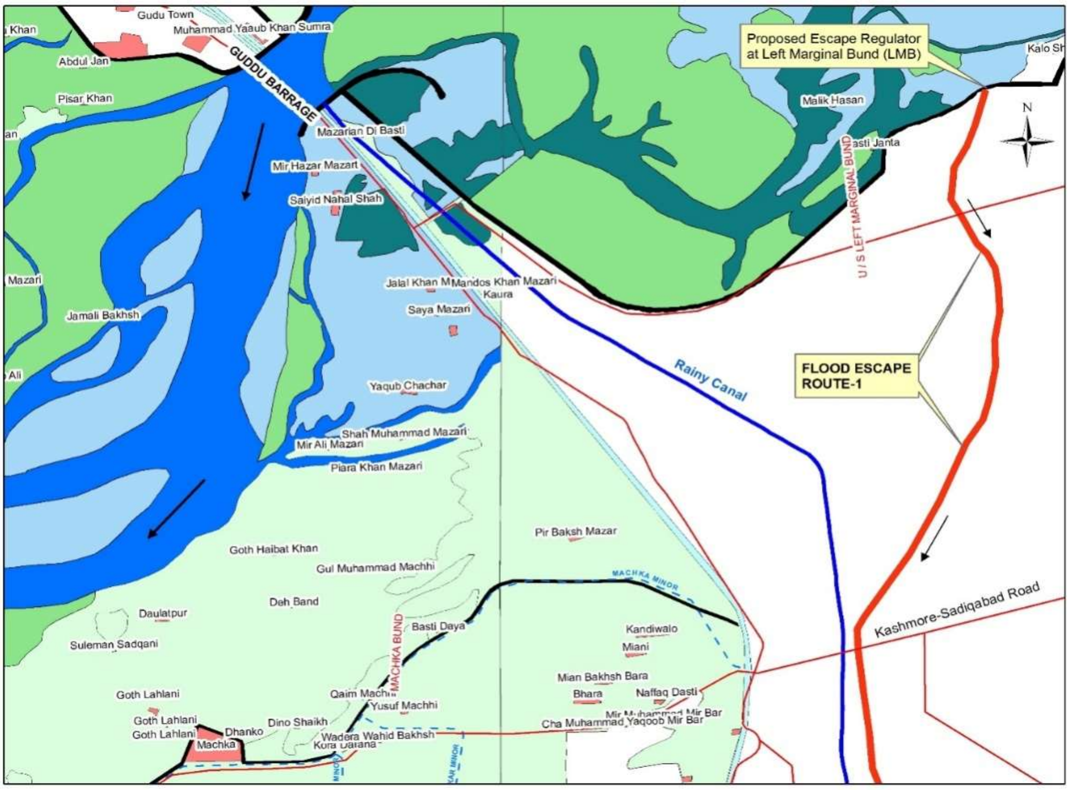


Figure 7-2: Escape Route-1 for Guddu Barrage

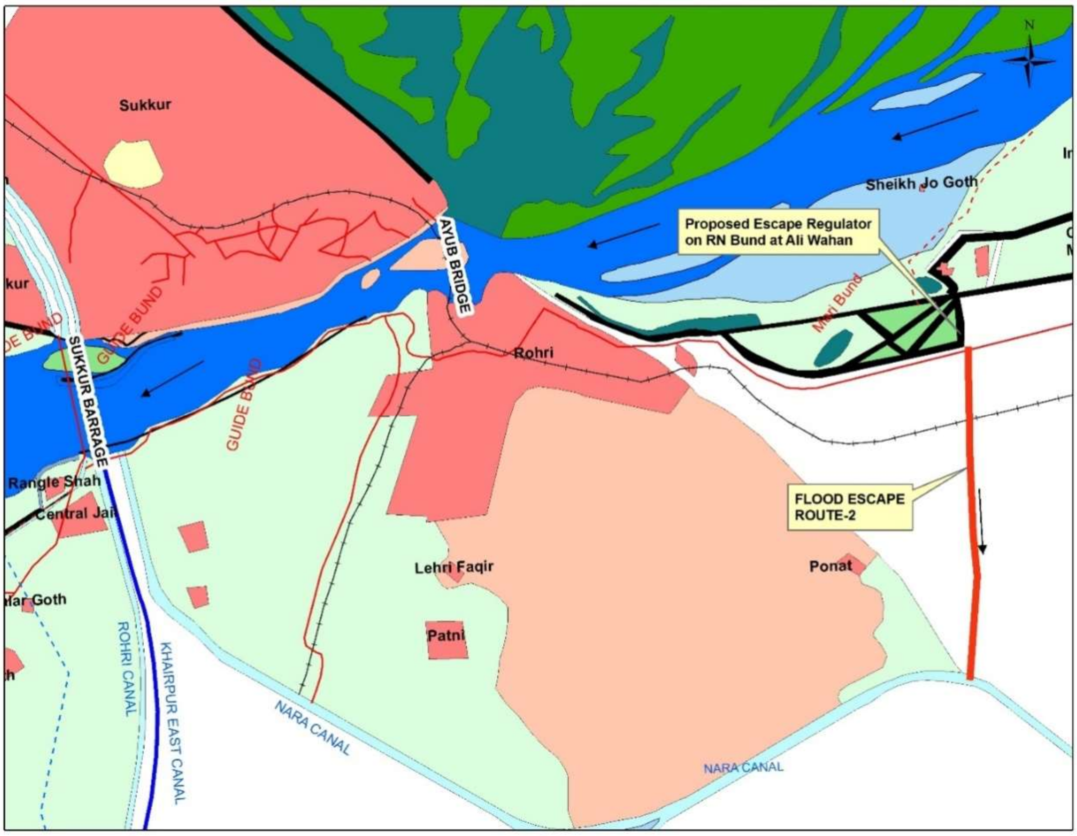


Figure 7-3: Escape Route-2 for Sukkur Barrage

Review of study indicates that the options are required to be further analysed particularly with respect to:

i) The cost of resettlement of population and relocation of major infrastructure enroute the escape channel and at the disposal location
ii) Confirmation of performance of intake structure (head regulator of proposed diversion channel) to draw the proposed flood magnitude
iii) Confirmation of conveyance capacity through numerical and physical model tests

To confirm the above observations on the Flood Escape Route study, a provision of study has been made in NFPP-IV which will include detailed topographic survey, numerical and physical modelling and evaluation and modification of existing infrastructure likely to be affected.

A study on two pilot locations (Jinnah barrage & Taunsa barrage) has been conducted under current project with 1D/2D modeling approach to ascertain breach effectiveness under 2010 flood and estimate flow depths and flow paths downstream of existing breaching sections at these two locations. Locations proposed by Irrigation department in flood fighting plans of both barrages have been evaluated. Details are provided in Floodplain Mapping and Zoning Task-C Report.

In view of findings of 1D/2D modeling exercise, it is highly recommended to conduct a comprehensive study of all existing breaching sections to ascertain their effectiveness and possible flow paths, flow depths, flood inundation extents and velocities of breach flood flows.

An important aspect during real-time management of flood is the decision of breach in times when flood levels of river exceeds certain limiting criteria to provide safety to infrastructure and settlements. Flowpaths downstream a breach location is somehow known to the flood managing departments at designated breaching locations. Whereas there is limited information and knowledge available with flood managing departments at unplanned breach locations. Recent flood events of 2010 and 2014 have highlighted management of breach flows downstream of an unplanned breach location. Decision to breach an embankment at unplanned location requires detailed knowledge of topography and possible flow paths.

With the use of latest technology and GIS based assessment of topography along the areas close to flood embankments, natural flowpaths can be demarked at vulnerable locations. An example of GIS based assessment of flowpaths on left bank of Panjand barrage as shown in Figure 7-4 below indicates that flows on left bank of Panjnad barrage (if breached naturally on left bank) would not return back to the river and would inundate the cities of Uch Sharif, Taranda Muhammad Panah, Liaquatpur, Allahabad and Khanpur.

7.2.1.7 Channel Improvements

Urban drainage systems are consolidated systems including drainage channels, networks, and pump stations within drainage basins. Channels in urban drainage system cater for larger volume of flood flows. Drastic population growth and insufficient O&M activities may cause early clogging of drainage channels and result to the malfunctioning of the drainage network. The major problems identified for inefficient delivery of drainage system in urban drainage are;

i) Encroachments and obstructions along natural drains
ii) Overtopping at number of places due to inadequate capacity
iii) Submergence of drains at outfall points
iv) Limited capacity of the entire drainage network to cope with heavy storms
v) Roads, canals, built up areas and drains have caused compartmentalization of the area
vi) Inadequate capacity of culverts/bridges at crossing points of drains

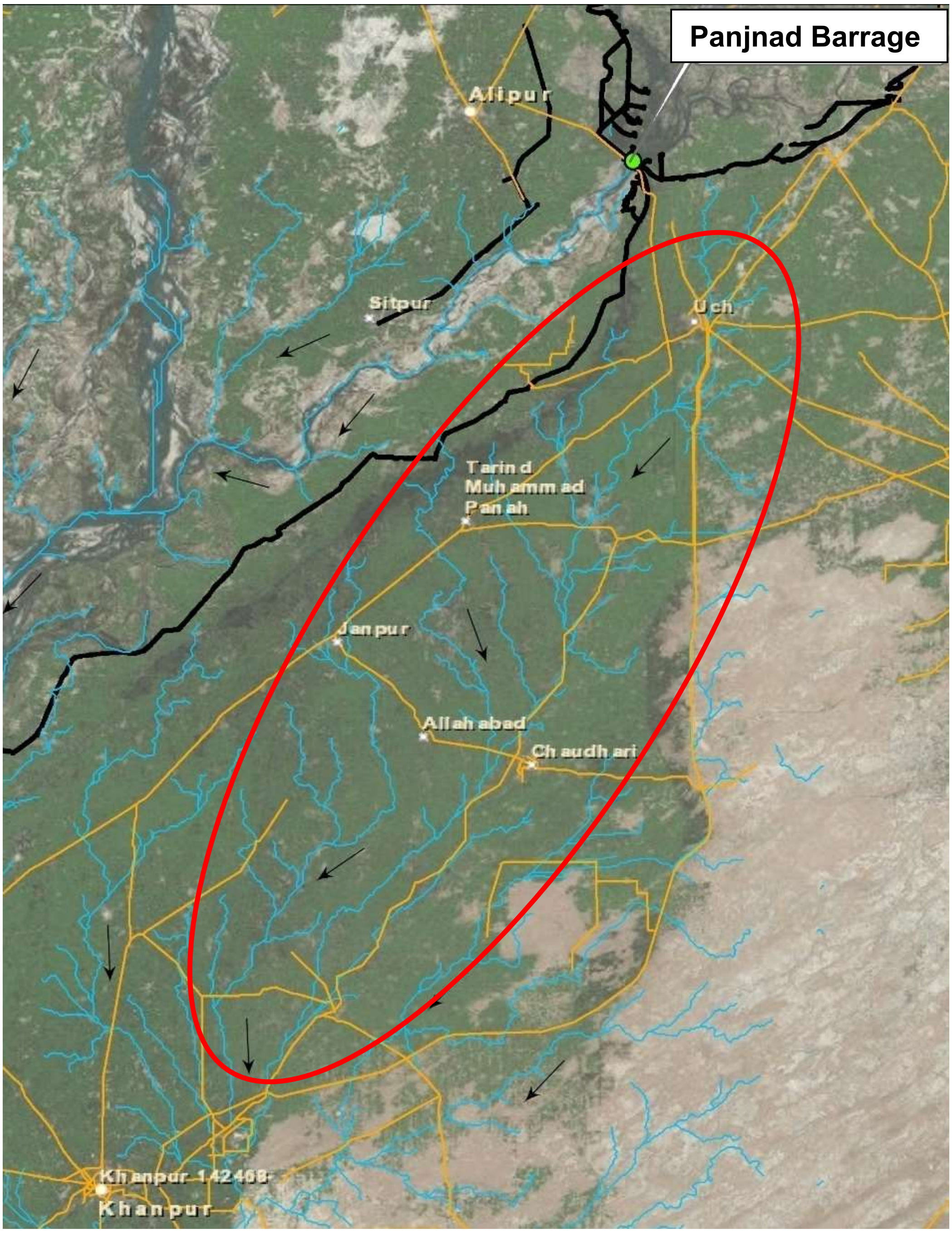


Figure 7-4: GIS Based Assessment of Flowpaths on Left Embankment of Panjand Barrage

Storm water drainage issue persists all across Pakistan in urban clusters which need proper planning and cost allocations for O&M by respective city governments. Major cities which need urgent attention towards rehabilitation and improvements in existing storm water drainage systems in view of population increase and climate change perspective have been identified under NFPP-IV studies as follows;

- **Punjab:** Lahore, Rawalpindi, Multan, Faisalabad, Sialkot, Dera Ghazi Khan and Muzaffargarh;
- **Sindh:** Karachi, Hyderabad, Sukkur, Thatta, Jacobabad, Kashmor and Shikarpur;
- **Khyber Pakhtunkhwa**: Peshawar, Mardan and Dera Ismail Khan; and
- **Balochistan:** Quetta, Sibi and Dera Allah Yar Khan.

A typical example of drainage channels in urban areas is shown in Figure 7-5.

Figure 7-5: Drainage Channels in Urban Areas

Similarly, the adequate conveyance capacity within the river result in smooth propagation of flood wave. Likewise encroachments along urban drains, main rivers are also facing this problem due to unplanned expansion of settlements and population growth along river banks resulting in bottle necks along flood flows. Under NFPP-IV studies, bottlenecks along main rivers have been identified as follows;

i) Bottleneck below Guddu barrage due to Kacha Kharif Bund
ii) Flood proofing of Qadirpur gas field
iii) River encroachment due to Pir jo goth below Sukkur barrage

7.2.2 Non-Structural Measures

7.2.2.1 Watershed Management

Major damaging floods in Pakistan were originated from catchments of major rivers. Catchment management to reduce flood magnitudes and volume has an influential impact on flood management. A detailed discussion on importance of watershed management, deforestation in Pakistan, existing laws on deforestation and recommendations to meet future challenges is provided in Section 5.2 of this report.

7.2.2.2 Floodplain Regulations

This particular aspect has been neglected in past. A large amount of culturable lands exists along floodplains of major rivers across Pakistan. Existing information on floodplains and its usage is essential in formulating policy and implementing regulations to handle floods. Information on floodplain maps and flood risk maps is provided in Floodplain Mapping and Zoning Report.

Under this project a comprehensive effort has been made to formulate draft river Act to control existing and future landuse through floodplain regulations. The details are also provided in “Floodplain Mapping and Zoning Report”.

7.2.2.3 Flood Forecasting and Warning

An effective and timely flood forecast and warning is a basic need to handle emergencies and to prevent flood disasters ahead of time. Better, longer and accurate the forecast the better would be the reaction of community/stakeholders.

Flood Forecasting Division (FFD) of Pakistan Meteorological Department issues precipitation and flood forecasts based on examining weather charts, satellite mapped precipitation, statistical flood forecasting tool. FFC got developed a phenomenon based Flood Early Warning System for FFD of PMD to have more reliable forecasts in the Indus system of rivers. The existing FEWS has been updated in the current study by including Kabul river from Warsak to Nowshera and the whole Swat river basin i.e. till confluence with Kabul

With the above update, FEWS covers upper watersheds of Swat, Jhelum, Chenab, Ravi &Sutlej (JCRS) and the hill torrents, and provides simulated flood hydrographs at the rim stations by using the forecasted or real-time rainfall.

Beside above, the river reaches of Indus and its tributaries below rim stations along with Kabul below Warsak are also covered in the FEWS to get the forecasted flood hydrograph at various barrages and bridges across the Indus and its tributaries (JCRS).

Flood forecasts at rim stations can be made by using:

(i) Forecasted rainfall (best choice but with low reliability)
lead time = time duration between issuance of forecast and occurrence of event + lag time

(ii) Real-time or near real-time rainfall estimates (good choice with relatively better reliability) lead time = lag time

Given the importance of forecasted rainfall to get a reasonable reaction time at the rim stations e.g. Marala on Chenab, Mangla on Jhelum, the current level of knowledge to generate at least 24 hours Quantitative Precipitation Forecast (QPF) with (at least) 3 hours time distribution, requires improvement. Similarly real-time or near real-time rainfall estimation also requires improvements by strengthening of existing rain measuring and river gauging network.

Incurrent NFPP-IV, specific cost provision (see Section 9) has been made to undertake a study to improve the QPF. This study would include, inter alia,

a) For improving forecasted rainfall;

   i) Confirm utility of satellite data for rainfall estimation and forecasting
   ii) Optimum use of satellite data for rainfall estimation and forecasting
   iii) Survey of available weather models and their utility for the Indus catchments
   iv) Verify the validity of analyses and forecasts of the selected models

b) For improving real or near real-time rainfall estimation;

   i) Analysis of existing Radars data from Sialkot, Mangla and Lahore to determine storm motion and orographic effects
   ii) Determination of the meteorological situations and types of rain events which give rise to systematic overestimates or underestimates of rainfall by Radar
   iii) Study of Radar observed storm characteristics and of influence of orography under different meteorological situations
   iv) Determination of the relationship between river levels and radar rain estimates for the hill torrents and their catchments
   v) Study of spatial and temporal variability of rainfall to determine the ability of gauge measurements to represent aerial rainfall over a range of time periods and areas

c) For improving FEWS-Pakistan model;

   i) Include catchment area of Indus river upstream of Tarbela dam
   ii) Update rivers geometry for low flood forecast
   iii) Remove bottle necks of FEWS model keeping in view reservations of PMD
   iv) Train professionals of PMD

The data environment and modeling techniques for flood forecasting have been improved with passage of time, still various steps are needed to improve and extend flood forecasting system. History of existing flood warning system, improvements/additions made during current studies and recommendations for future upgradation of models is provided in Floodplain Mapping and Zoning Report.

7.2.2.4 Strengthening of Rain and River Gauging Network

A dense hydro-meteorological network is strength of a country to observe and disseminate data for early warning and flood forecasting. Existing density of gauging stations needs a tactical planning to maintain and upgrade the networks as per World Meteorological Organization (WMO) standards and minimum requirements.

Requirements to install new gauging stations has been ascertained under current studies by following World Meteorological Organisation (WMO) guidelines[13] with respect to WMO's pre-defined physiographic classification. Table 7-4 indicates area in square kilometer for a single gauge for precipitation, evaporation, stream flow, sediment monitoring and water quality with respect to physiographic classification of terrain. For example, in mountains one non-recording precipitation gauge is required in an area of 25 km^2, and one stream flow gauge is required for an area of 1,000 km^2.

Table 7-4: WMO Guideline for Gauge Density (km^2/gauge)

Physiological Unit	Precipitation		Evaporation	Stream Flow	Sediments	Water Quality
	Non-Recording	Recording				
Coastal Plains	900	9,000	50,000	2,750	18,300	55,000
Mountains	25	2,500	50,000	1,000	6,700	20,000
Interior Plains	575	5,750	5,000	1,875	12,500	37,500
Hilly/ Undulating	575	5,750	50,000	1,875	12,500	47,500
Polar/ Arid	10,000	100,000	100,00	20,000	200,000	200,000

Watershed areas under various physiographic units have been estimated using GIS. Existing locations of stream flow and precipitation gauges have been used to estimate gauge density. The computed density is then compared with WMO's recommended density to estimate number of new gauges in each watershed. A sample analysis of Gomal river basin to ascertain stream gauge requirement is shown in Figure 7-6. Maps showing details of required gauging stations are provided in Annex-7. Following major and minor watersheds (in alphabetical order) across Pakistan have been analysed;

1. Chenab river basin
2. Chitral river basin
3. Gilgit river basin
4. Gomal river basin
5. Haro river basin
6. Hunza river basin
7. Indus river basin
8. Jhelum river basin
9. Kabul river basin
10. Kanshi river basin
11. Kunhar river basin
12. Neelum river basin
13. Panjkora river basin
14. Poonch river basin
15. Ravi river basin
16. Shigar river basin
17. Shyok river basin
18. Soan river basin
19. Sutlej river basin
20. Swat river basin

[13]WMO No. 168, Sixth Edition, 2008

Quantitative precipitation measurement over the catchments of the Indus tributaries and prediction of rainfall through accurate storm tracking is the gateway to effective flood forecasting and improved reservoir management under flood conditions. Use of Radars in near real time observations is essential. PMD has seven Radars installed with different specifications at various places: Islamabad, Lahore, Sialkot, Mangla, Karachi, D.I. Khan and R.Y. Khan. Due to developments in flood forecasting models, radar grid data has become an important aspect for their reliability. Therefore, it's essential to up- grade Radars on priority basis. PMD has proposed QPM Radars at Gawadar (Balochistan), Cherat & Chitral (KP), D. G. Khan (Punjab) and Gilgit (GB Region), where no Radar coverage is available. Under current studies four new locations to install new radars at Quetta (Balochistan), Nawabshah/ Thatta (Sindh), Hangu (FATA) and Bannu (KP) and their costs have also been included in the next ten years plan. Besides, costs allocations for strengthening the 27 Nos. Observational gauges, up-gradation of existing Radars and staff training of PMD has been included in NFPP-IV. Radar ranges of existing and 9 proposed weather Radars are provided in Figure 7-7.

In addition to above, we have proposed following Automatic Weather Stations (AWS) for strengthening of PMD in Balochistan Province:

- Hub	- Bolan	- Loralai	- Nal
- Awaran	- Hoshob	- Kapper	- Chagi
- Dureji	- Nag	- Pashin	- Makola

(Source: PMD)

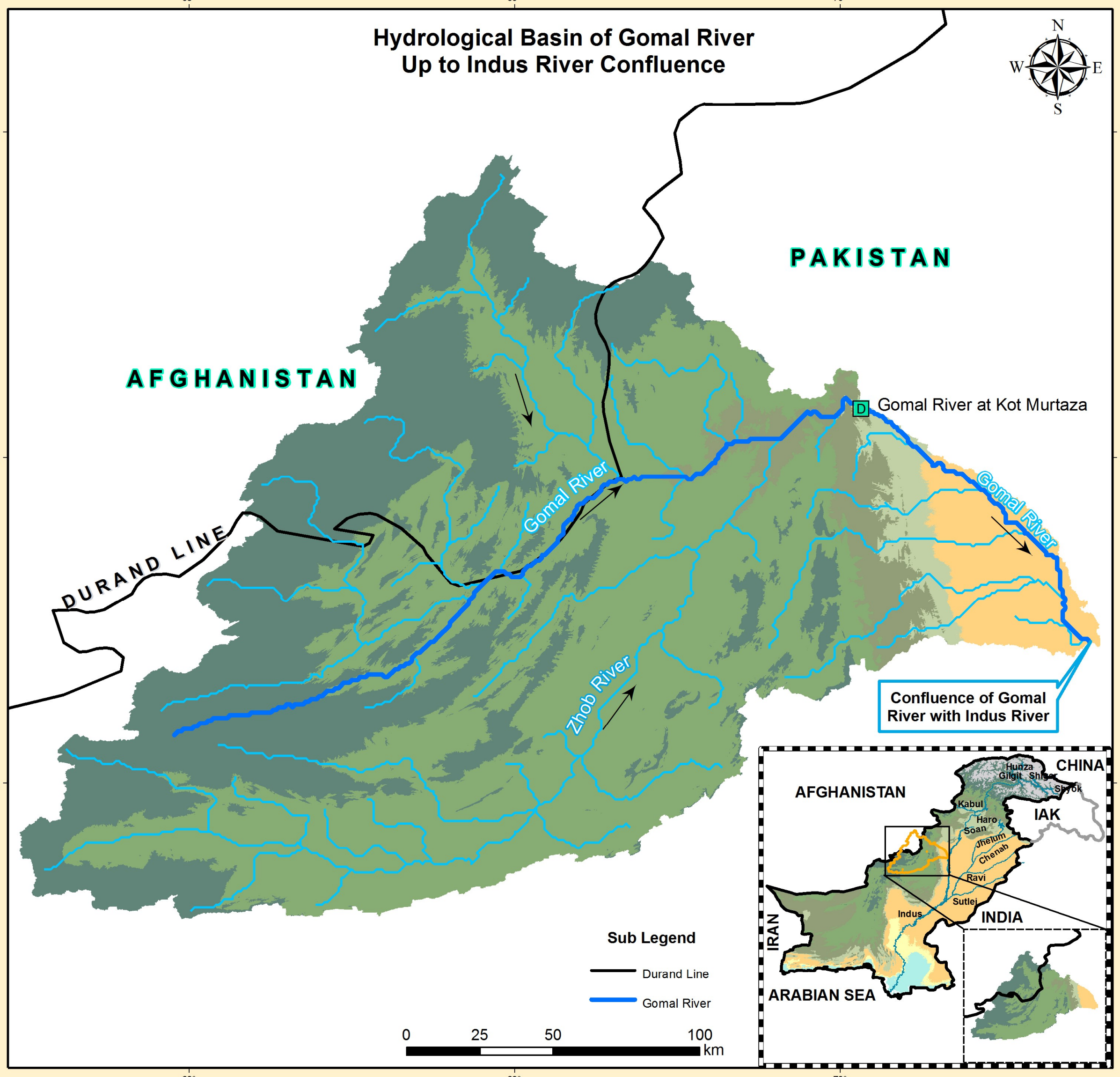
Similarly, a cost provision (see Section 9.5.12) has been estimated for strengthening of WAPDA's gauging network and capacity building of the relevant staff including;

i. Flood Telemetry network,
ii. SWH river gauging network
iii. Snow gauging network
iv. HF Radio network

Accurate flood forecasts and warnings would be useless if dissemination could not be assured to those who require them. Existing operational communication facilities with PMD and information sharing with FFC has been discussed comprehensively in a report on "Automation of Flood Situation Monitoring and Reporting".

7.2.2.5 Information and Education of Stakeholders

The whole society is affected by the adverse effects of floods. At the community level, the effect is in the shape of economic loss and at the personal level, the effect can be in the shape of property loss or even life endangerment. The recent recurrent floods in Pakistan call for a community and individual level participation in flood response. Community outreach at the union council level is needed to raise awareness and basic knowledge, to understand local vulnerabilities and capacities to prepare disaster management maps, to establish community disaster management committee, and to enhance preparedness and emergency response capacities. Community participation is also important in the implementation phase of river Act.



Elevation Band (m)	Physiographic Unit	Area (km²)		No. of Stations	Unit Area Per Station	Gauge Type	Required Additional Gauges [2]
		Afghanistan	Pakistan				
0-25	Coastal Plains	N-A	N-A	N-A	N-A	N-A	N-A
26-50	Interior Plains	N-A	N-A	N-A	N-A	N-A	N-A
51-250	Low Lands	N-A	2,055	0		Stream Flow	0
251-500	Up Lands	N-A	909	1	909	Stream Flow	0
501-1000	Hilly Areas	N-A	1,909	0		Stream Flow	1
1001-2000	Low Range Mountains	3,221	17,844	0		Stream Flow	18
2001-4000	Medium Range Mountains	5,405	8,866	0		Stream Flow	9
Above 4000	High Range Mountains	N-A	N-A	N-A	N-A	N-A	N-A

WMO CRITERIA: **Recommended Minimum Density of Stations (Area in km² Per Station) [3]**

Physiological Unit	Precipitation		Evaporation	Stream Flow	Sediments	Water Quality
	Non-Recording	Recording				
Coastal Plains	900	9,000	50,000	2,750	18,300	55,000
Mountains	25	2,500	50,000	1,000	6,700	20,000
Interior Plains	575	5,750	5,000	1,875	12,500	37,500
Hilly/Undulating	575	5,750	50,000	1,875	12,500	47,500
Polar/Arid	10,000	100,000	100,000	20,000	200,000	200,000

Legend

- D SWHP Stream Flow Station
- Stream

Physiography [1]

Elevation (m asl)

- Coastal Plain (1 - 25)
- Interior Plain (26 - 50)
- Low Land (51 - 250)
- Up Land (251 - 500)
- Hilly Area (501 - 1,000)
- Low Range Mountain (1,001 - 2,000)
- Medium Range Mountain (2,001 - 4,000)
- High Range Mountain (4,001 - 9,000)

1. Barton et al, 2013
2. Installation of additional guages are further subjected to the expert judgment
3. WMO No. 168, Sixth Edition, 2008

DEVELOPMENT OF NATIONAL FLOOD PROTECTION PLAN-IV AND RELATED STUDIES TO ENHANCE CAPACITY OF FEDERAL FLOOD COMMISSION-FFC

EXISTING AND REQUIRED GAUGING STATIONS IN GOMAL RIVER BASIN FOR WAPDA-SWH NETWORK

National Engineering Services Pakistan
1 C Block N Model Town Extension Lahore

Prepared By	Supervised & Issued By	Printing Date
Adil / Bilal GIS. Analyst M&TBW Section WR Division NESPAK	Syed Mehar Ali Shah Principal Engineer/Head Modeling & Trans-Boundary Waters Section Water Resource Division NESPAK	01-04-2014

Figure 7-6: Analysis for New Gauges as per WMO Required Density in Gomal Basin

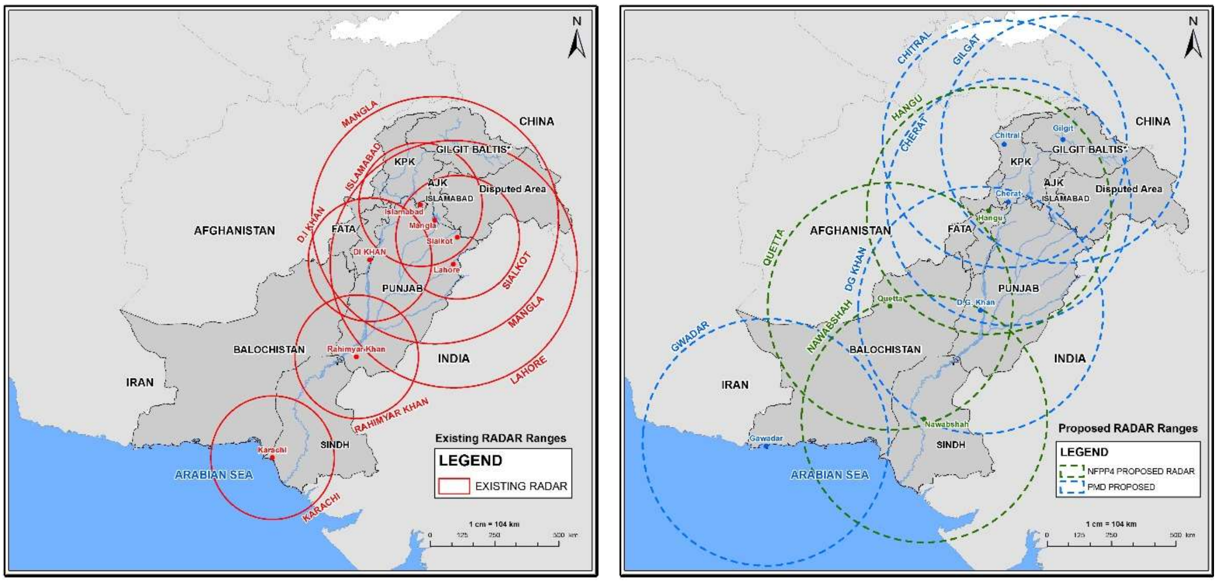


Figure 7-7:Ranges of Existing and Proposed Radars

7.2.2.6 Disaster Preparedness

All measures and policies taken before an event occurs that allow for prevention, mitigation, and readiness constitutes disaster preparedness. Preparedness includes designing warning systems, planning for evacuation, and reallocation, storing food and water, building temporary shelters, devising management strategies, and holding disaster drills and exercises.

NDMA, PDMAs and DDMAs are responsible for coordinating hazard risk reduction, preparedness, and responses to riverine floods, flash floods, cyclones etc. PDMAs carry out provincial coordination for flood preparedness which includes inputs from irrigation departments for flood prevention and mitigation and a host of measures involving numerous provincial departments and ministries for preparedness and response. Role of various organisations in handling floods are provided in Section 4.1.1 of this report.

7.2.2.7 Flood Insurance

An effective way to control and restrict floodplain activities and landuse is introduction to flood insurance of assets within floodplains. Currently, there is no mechanism or concept of flood insurance in Pakistan. Keeping in view haphazard population and infrastructure growth along floodplains there is a need to introduce flood insurance to compensate losses due to flood event. A higher annual premium may be imposed to infrastructure close to high risk areas to avoid ingress of encroachments in active floodplains. Revenue generated in this way can be used to provide compensations to flood losses and managing O&M requirements of flood protection structures. Other ways of financial resource management has been described in Section 5.8 of this report.

7.2.2.8 Unified Design Criteria for Flood Protection Structures

Flood protection works are designed and constructed in Pakistan as per non-uniform hydrologic, hydraulic, structural and geo-technical design parameters. This approach results in non-uniform factors of safety applied at each flood protection structure. An example of non-uniform safety factors for flood embankments is the varying freeboard magnitude above design high flood level (HFL) from 5 to 6 ft for Indus River and its major tributaries.

Under current studies, a comprehensive effort has been made to review and analyse existing design standards across country and recommend unified design standards for various types of flood protection structures (Embankments, spurs, flood protective walls, Gabion walls, etc.,) in view of latest design tools and construction techniques. An example of seepage analysis through an embankment using Seep/W-Geostudio which makes use of embankment material, dimensions and permeability parameters to estimate flow lines and equipotential lines is shown in Figure 7-8. Design standards developed under current studies are attached as Annex-3 of this report.

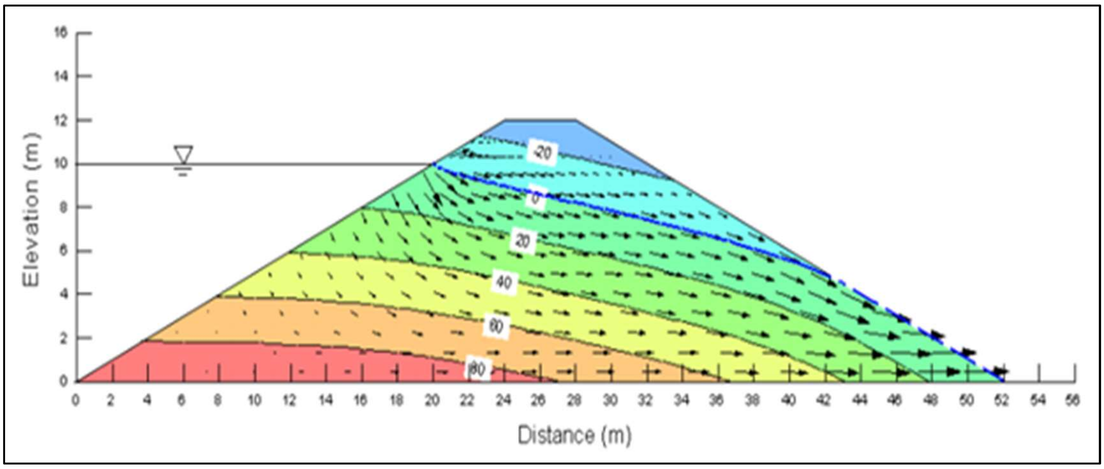


Figure 7-8: Piezometric Line and Pressure Head Contours in an Embankment using Seep/W-Geostudio (2007)

8. IDENTIFICATION, EVALUATION AND SELECTION OF FLOOD PROTECTION SCHEMES

8.1 COLLECTION OF PROPOSED PROJECTS/SCHEMES

Immediately after the start of the project, a request was transmitted to all stakeholders to provide proposed projects to be undertaken during the next ten years through WCAP. In addition to above, the efforts have been made to obtain the required information through meetings with concerned officials and field surveys. Detail on meetings with various departments and site visits is provided as Annex-2 of this report. A total number of 908 projects, estimated to cost of Rs.150,084 million were proposed by the Provincial and Federal Agencies under NFPP-IV as given in Table 8-1. All the proposed schemes by Provinces and FLAs in this Chapter are those which were collected before the approval process of CCI meeting. The approval process of CCI is described in detail as Chapter 9 below.

Table 8-1: Proposed Projects/Schemes and Associated Costs Collected under NFPP-IV Studies

Sr. No.	Departments / Federal Line Agencies	Number of Projects	Estimated Cost (Rs. Million 2014-2015 Price Level)
1.	Punjab Irrigation	81	42,588
2.	Sindh Irrigation	71	25,450
3.	Khyber Pakhtunkhwa Irrigation	83	32,432
4.	Balochistan Irrigation	525	41,024
5.	Gilgit-Baltistan Region	29	1,932
6.	FATA Irrigation & Hydle Power	72	3,098
7.	AJ&K Irrigation & Small Dams	47	3,561
	Total	**908**	**150,084**

Similarly, different Federal Departments and Organizations (PMD, WAPDA, NHA, Climate Change Division, NDMA and Pakistan Railways) have proposed/suggested certain non-structural measures/studies. The number of projects proposed/suggested by each department/organization is listed in Table 8-2.

Table 8-2: Summary of Non-Structural Projects

Sr. No.	Departments/Organizations	Number of Projects/Studies
1	Climate Change Division	4
2	PMD	6
3	WAPDA	6
4	NHA	10
5	NDMA	4
6	Pakistan Railways	9

A brief description of schemes/projects collected from various departments and federal organizations is given below.

8.1.1 Schemes Collected from Punjab Irrigation Department

A total of 81 schemes were provided for inclusion in the NFPP-IV for Punjab Province. Out of these, 46 schemes are for flood protection, 11 schemes are restoration type, 19 schemes are of spur construction and 5 schemes are of feasibility study with an estimated cost of Rs. 42,588 million.

8.1.2 Schemes Collected from Sindh Irrigation Department

A total of 71 schemes were provided for inclusion in the NFPP-IV for Sindh Province. These are high priority schemes suggested by PID of Sindh province. Out of this total, 47 schemes are for flood protection, 9 schemes are restoration type, one scheme of feasibility study and 14 schemes are of spur construction with total estimated cost of Rs. 25,450 million.

8.1.3 Schemes Collected from Khyber Pakhtunkhwa Irrigation Department

For NFPP-IV a total of 83 schemes were collected from North and South zone (various Irrigation circles) of PID, KP province. Seventy three (73) are flood protection schemes in this total along with 4 schemes for feasibility studies and 6 schemes for construction of new spurs is also suggested with an estimated cost of Rs. 32,432 million.

8.1.4 Schemes Collected from Balochistan Irrigation Department

For inclusion in this NFPP-IV, an investment of Rs. 41,024 million is suggested by Balochistan Irrigation Department with proposed 525 projects/schemes for Balochistan province with an estimated cost of Rs. 41,024 million. This investment will be made in categories of priority schemes, delay action dams, flood management schemes and feasibility studies. Four types of schemes were submitted to be included in NFPP-IV as given below:

- Priority List of Flood Protection Schemes (FPS) 293 Nos.
- Flood Management Irrigation Schemes (FMIS) 55 Nos.
- Delay Action/Storage Dams Schemes (DA/SD) 159 Nos.
- Schemes for Canal Irrigation System (CIS) 18 Nos.

8.1.5 Schemes Collected from Gilgit-Baltistan Region

A total of 29 flood protection schemes were collected during the course of project. Out of these, 26 schemes are for flood protection type and three of feasibility type with an estimated cost of Rs.1,932 million. The detail of schemes along with investment schedule is given in Annex-4.

8.1.6 Schemes Collected from FATA Irrigation & Hydel Power Department

A total of 72 flood protection schemes (FP=70 Nos. + Spurs=2) are suggested to be included for FATA in NFPP-IV. The detailed description of schemes and their investment plan is given in Annex-4. These schemes are estimated to cost Rs. 3,098 million.

8.1.7 Schemes Collected from AJ&K Irrigation & Small Dams Department

A total of 47 flood protection schemes are suggested to be included for AJ&K in NFPP-IV. List of collected schemes and their investment plan is given in Annex-4. These schemes are estimated to cost Rs. 3,561 million.

8.1.8 Schemes Collected from Pakistan Meteorological Department

Pakistan Meteorological Department is responsible to issue flood warnings. An accurate early warning of the flood increases the reaction time for evacuation of population and adopting precautions against Floods. PMD is planning to install five new QPM radars in future at various locations of the country, where no radar coverage is available. PMD has suggested 6 works/studies (5 proposed + 1 suggested) of system up gradation, installation of new radars, staff training component etc.

8.1.9 Schemes Collected from WAPDA

Water and Power Development Authority is a federal organization responsible for water resources and power development having vast telemetric and gauging network throughout Pakistan. The hydrologic studies are based on data gathered from gauging and telemetric stations. Their improvement will increase the analysis reliability and accuracy. This is important since all the hydraulic structures are designed based on hydrologic studies. WAPDA has suggested six (6) works/studies (5 proposed + 1 suggested) for their system up gradation and capacity building of the WAPDA Staff.

8.1.10 Schemes Collected from National Highway Authority

National Highway Authority is responsible at the federal level for the development and maintenance of road infrastructure in Pakistan. Their road network is stretched throughout Pakistan and is vulnerable to flood at many locations. Under this NFPP, different studies critical for NHA's network are given priority on the basis of their urgency. A total of ten (10) studies/projects are suggested by NHA for inclusion in this plan.

8.1.11 Schemes Collected from National Disaster Management Authority

The National Disaster Management Authority (NDMA), is an independent, autonomous, and constitutionally established federal institution with the mandate and responsible to deal with whole spectrum of disaster management and preparedness in the country. Under this NFPP-IV, 4 projects/works for relief operations and capacity building of NDMA are given priority on the basis of their urgency.

8.2 SELECTION CRITERIA AND ITS APPLICATION

More than 900 flood protection schemes were collected from PIDs/Federal Agencies to address flood protection requirements along major rivers, hill torrents and water control structures. This section explains the selection criteria for a flood protection scheme to be incorporated in estimation of total investment as a component of structural measures for flood management.

8.3 SELECTION CRITERIA FOR FLOOD PROTECTION SCHEMES

As stated earlier more than 900 flood protection schemes were collected from PID's to address flood protection requirements along major rivers, hill torrents and water control structures. This section explains the selection criteria for a flood protection scheme to be incorporated in estimation of total investment as a component of structural measures for flood management.

8.3.1 Objectives

The gist behind selecting a flood protection scheme is that the scheme should be technically sound to address the required flood protection without endangering upstream and downstream river reaches and economically viable to get maximum benefits of investment.

Since all of the suggested schemes by PIDs cannot be implemented due to lack of required technical and economic details from PIDs and financial constraints of funding authority, a combination of qualitative screening, quantitative technical and economic analysis, engineering judgment and experience has been applied to select a scheme.

Among various schemes collected from PIDs, majority of schemes are being proposed along major rivers. Initial assessment of schemes indicates that most of the schemes are basically restoration works required for existing flood protection schemes. Selection criteria for a conceptual scheme and detailed level scheme is given in following section.

8.3.2 Selection Criteria for Conceptual Schemes

A conceptual scheme is one for which sound technical details (location map, layout plan, cross sections, engineering details, etc.) and economic details (capital costs, O&M costs, benefits, etc.) are not provided by PID for the Consultants evaluation, its flood mitigation impact has been estimated through qualitative screening and engineering judgment by the Consultant after site verification, if possible. A scheme having high flood mitigation impact has been selected for feasibility studies in NFPP-IV. If a scheme cannot qualify for its high flood mitigation impact, it has been deferred/rejected. A flow chart of selection criteria for such types of schemes is given in Figure 8-1.

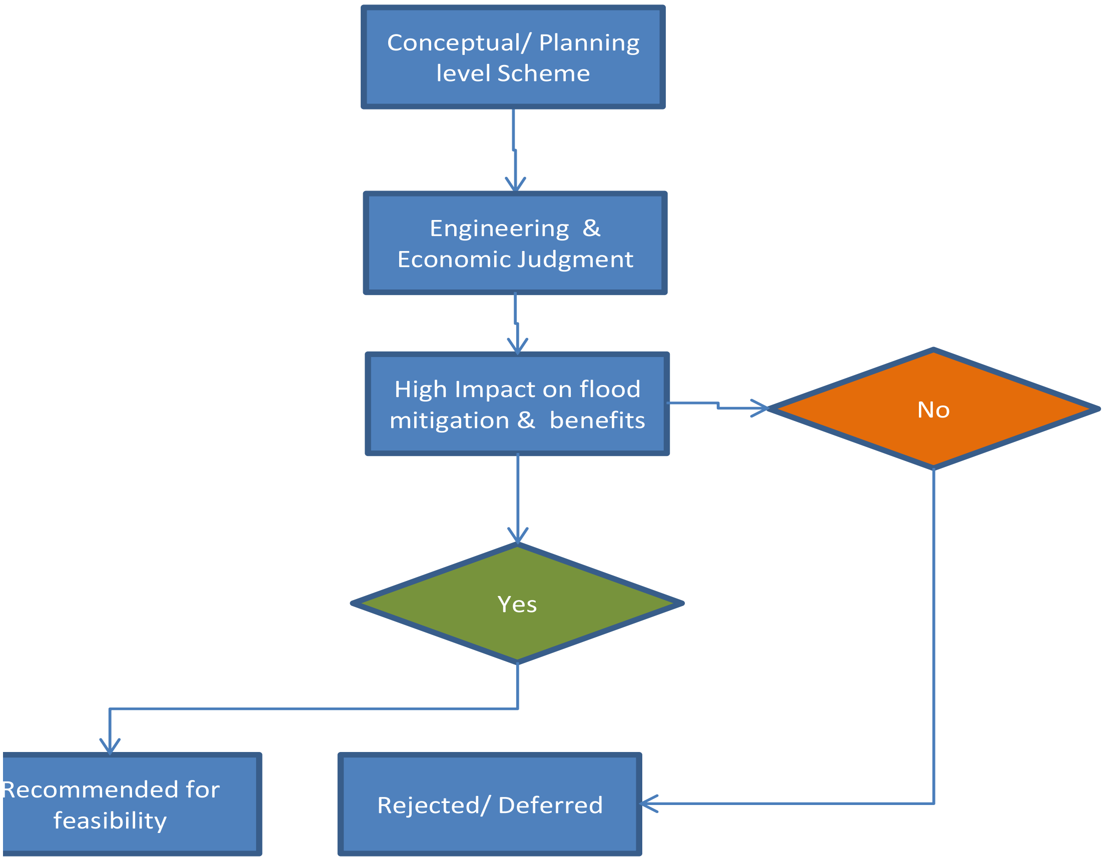


Figure 8-1: Selection Criteria for a Conceptual Scheme

8.3.3 Selection criteria for Detailed Level Schemes

Flood protection schemes collected from PIDs having sufficient/partial technical details (location map, layout plan, cross section, engineering details, etc.) and economic details (capital costs, O&M costs, benefits, etc.) have been scrutinized with a detailed selection algorithm given in Figure 8-2.

8.3.3.1 <u>Location Evaluation</u>

The location of the scheme has been identified and marked on the map to check its relative position with respect to the most recent floods (2010 to 2014) observed flood extents (available for upper Indus, Lower Indus and Jhelum only) or 50 year flood inundation extents (computed in FPSP-II along Indus River and its main tributaries and updated in current NFPP-IV studies).

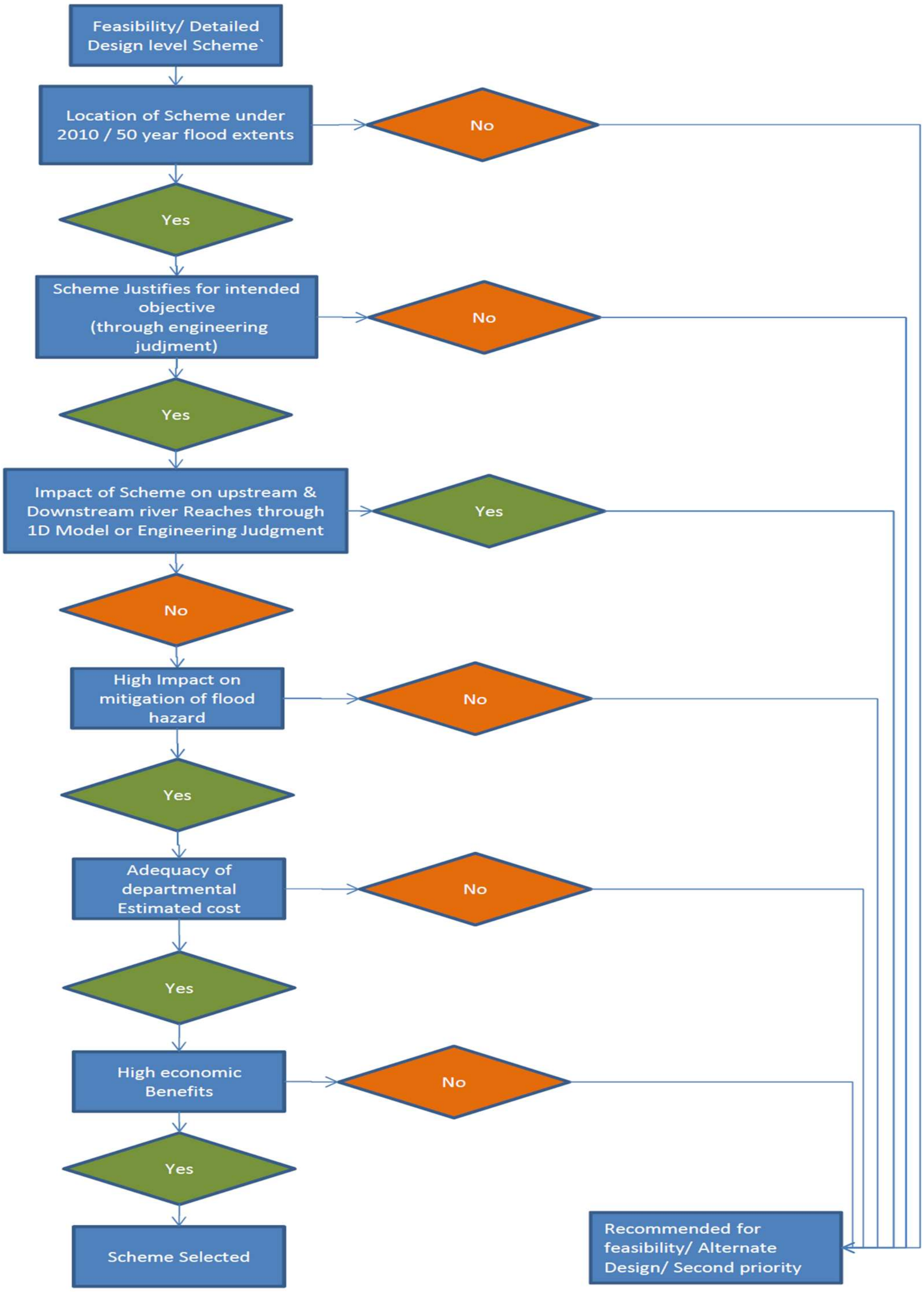


Figure 8-2: Selection Criteria for a Detailed Level Scheme

If the scheme is in direct impact of above mentioned flood extents, the scheme has been processed for further evaluation; else, the scheme would be tagged with a low priority.

8.3.3.2 Evaluation of Intended Purpose

The scheme filtered through above mentioned step has been evaluated through engineering judgment and experience for its intended purpose. A scheme that is being proposed for a purpose which can be achieved through implementing the scheme has been processed for further evaluation, else, the scheme has been rejected and added to a list of schemes for which feasibility to identify alternate design has been recommended.

8.3.3.3 Evaluation of Impact on Upstream and Downstream Reaches

Once the proposed flood protection scheme has been processed through above mentioned evaluation steps, the scheme has been further evaluated for its impact on upstream and downstream reaches. This particular task has been carried out through 1D hydrodynamic models (developed under FPSP-II). A scheme that qualifies for having negligible hydraulic impact on upstream and downstream river reach has been processed for further evaluation, else, the scheme would be rejected and added to a list of schemes for which feasibility to identify alternate design has been recommended.

8.3.3.4 Evaluation of Impact on Flood Mitigation

The scheme that qualifies above mentioned evaluations has been further analyzed for its immediate and long-term flood mitigation impact by quantifying number of people, areas, lands or facilities that are going to be protected through proposed scheme. The scheme with high flood mitigation impact has been selected for further processing; else, the scheme has been deferred and added to a list of low priority flood protection schemes.

8.3.3.5 Evaluation of Departmental Cost Estimates

After following above mentioned procedures, the cost of the scheme that has been provided by PIDs has been evaluated through unit costs of particular flood protection scheme that is being computed under NFPP-IV studies for typical designs. If the cost of the proposed scheme is comparable with Consultants estimate (with 10-15% difference) the scheme has been selected, else the scheme has been deferred and added to list of schemes whose feasibility study is required for reasonable cost estimates.

8.3.3.6 Evaluation of Economic Benefits

The last evaluation of scheme is its economic justification. The damage factors that have been developed under current studies (Refer report on *"Development of Inventory of Flood Protection Works and Benefit Monitoring and Evaluation"*) have been used to quantify the benefits that are expected through implementing the scheme. A scheme having benefit to cost ratio more than unity is selected for inclusion in list of schemes that would be implemented in next 10 years through NFPP-IV.

8.4 SELECTED PROJECTS/SCHEMES FOR NFPP-IV

After applying selection criteria mentioned in previous section, summary of schemes and projects that have been selected for NFPP-IV is given in Table 8-3.

Table 8-3: Summary of Selected Projects/Schemes for NFPP-IV Phase-I

Sr. No.	Departments / Federal Line Agencies	Number of Schemes	Estimated Cost (Rs. Million)
1	Punjab Irrigation Department	53	23,350
2	Sindh Irrigation Department	51	21,351
3	Khyber Pakhtunkhwa Irrigation Department	72	20,000
4	Balochistan Irrigation Department	259	17,700
5	Gilgit-Baltistan Region	29	1,932
6	FATA Irrigation & Hydel Power	72	3,098
7	AJ&K Irrigation & Small Dams	47	3,561
	Sub-Total	**583**	**90,992**
8	PMD (6 Nos. Projects/Studies)	-	4,505
9	WAPDA (6 Nos. Projects/Studies)	-	2,297
10	NHA (8 Nos. F. Studies)	-	-

Sr. No.	Departments / Federal Line Agencies	Number of Schemes	Estimated Cost (Rs. Million)
11	Climate Change Division (4 Nos. Studies)	-	30
12	NDMA (4 Nos. Projects/Works)	-	6,500
13	Pakistan Railways (Bridges+Bunds Improvements)	-	450
	Total		**104,774**

Details of investment schedule of projects/schemes proposed by PIDs and Federal Agencies/organizations are given in Annex-4. The recommended projects/schemes along Swat River, D.I Khan Area, Balochistan, GB, FATA and AJ&K are shown in Exhibit-8 to Exhibit-13 (included in CD), respectively. The summary of type of projects/schemes is given in Table 8-4 and the category-wise detail of plan is given in Table 8-5.

Table 8-4: Selected Types of Projects/Schemes Prior to CCI

Departments / Organizations	Type of Schemes	Number of Schemes/Projects
Punjab Irrigation Department		
1	Flood Protection Work	30
2	Construction of Spur	17
3	Feasibility Study	6
Sindh Irrigation Department		
1	Flood Protection Work	37
2	Restoration	10
3	Construction of Spur	4
Kyber Pakhtunkhwa Irrigation Department		
1	Flood Protection Work	62
2	Construction of Spur	6
3	Feasibility Study	4
Balochistan Irrigation Department		
1	Priority Schemes	213
2	Flood Management	42
3	Feasibility Study	4
Gilgit-Baltistan Region		
1	Flood Protection Work	26
2	Feasibility Study	3
AJ&K Irrigation and Small Dams		
1	Flood Protection Scheme	43
2	Feasibility Study	4
FATA Irrigation & Hydel Power		
1	Flood Protection Work	70
2	Construction of Spur	2
Pakistan Meteorological Department		
1	Strengthening, Installation, Up gradation of Equipments/Networks & FEWS	6
WAPDA		
1	Strengthening, Installation, Up gradation of Equipments/Networks (SWHP & Telemetric, etc.,)	6
National Highway Authority		
1	Feasibility Study	8
Climate Change Division		
1	Feasibility Study	4
National Disaster Management Authority		
1	**Projects/Works**	**4**
Pakistan Railways		
1	Model Studies for Nine Railways Bridges	9
2	Improvements in Number of Flood Protection Bunds all over the Country.	**--**

Table 8-5: Category-wise Investment Plan for NFPP-IV (Ten Years Plan)

Sr. No.	Proposed Interventions in Next Ten Years	Proposed Investments													
		Estimated Cost (Rs. in Million)	Federal Ministries/Agencies									Provincial Departments			
			Estimated Cost (Rs. in Million)									Estimated Cost (Rs. in Million)			
			FFC	NDMA	PMD	WAPDA	CCD	Pakistan Railways	Gilgit - Baltistan	FATA	AJ&K	Punjab	Sindh	KP	Balochistan
I	**Structural Measures**														
1.	Construction of Proposed Flood Protection Works.	90,992	1,820	-	-	-	-	-	1,893	3,036	3,490	22,883	20,924	19,600	17,346
2.	Flood Management Structures Across Hill Torrents and Flood Generating Nullahs.	26,371	527	-	-	-	-	-	1,661	3,144	1,387	6,674	2,222	3,949	6,807
3.	Feasibility & Detailed Design Studies of Barrages and Hydraulic Structures.	1,500	1,500	-	-	-	-	-	-	-	-	-	-	-	-
4.	Master Planning, Feasibility Studies, and Detailed Designing Studies.	3,751	3,751	-	-	-	-	-	-	-	-	-	-	-	-
5.	Physical Hydraulic Model Study for Major Railway Bridges and Improvements of Existing Flood Protection Facilities of Pakistan Railway.	450	20	-	-	-	-	430	-	-	-	-	-	-	-
6.	Physical Hydraulic Model Study for Selected Reaches of Major Rivers.	200	200	-	-	-	-	-	-	-	-	-	-	-	-
7.	Measures for GLOFs & Land Sliding in Hilly Areas.	1,000	-	-	-	-	-	-	350	100	200	100	50	100	100
8.	Remodeling & Proper Maintenance of Drainage Systemin Lower Indus.	9,763	-	-	-	-	-	-	-	-	-	-	9,763	-	-
9.	Coastal Flood Protection Works.	1,622	-	-	-	-	-	-	-	-	-	-	800	-	822
10.	Flood Mitigation, Channelization and Execution of the Lai Nullah Project (Only Flood Component).	16,000	-	-	-	-	-	-	-	-	-	16,000	-	-	-
11.	Studies for Proper Town Planning in Future and Improving the Existing Storm Drainage System of Urban Areas.	1,000	-	-	-	-	-	-	-	-	-	350	350	150	150
12.	Provision of Annual Funds under Provincial ADPs for Flood Fighting Activities during Flood Season and Procurement & Repair of Flood Fighting Equipment & Machinery under PIDs.	5,000	-	-	-	-	-	-	200	200	200	1,100	1,100	1,100	1,100
Sub-Total (I)		**157,649**	**7,818**	**0**	**0**	**0**	**0**	**430**	**4,104**	**6,480**	**5,277**	**47,107**	**35,159**	**24,949**	**26,325**

Sr. No.	Proposed Interventions in Next Ten Years	Proposed Investments													
		Estimated Cost (Rs. in Million)	Federal Ministries/Agencies Estimated Cost (Rs. in Million)									Provincial Departments Estimated Cost (Rs. in Million)			
			FFC	NDMA	PMD	WAPDA	CCD	Pakistan Railways	Gilgit - Baltistan	FATA	AJ&K	Punjab	Sindh	KP	Balochistan
II	**Non-structural Measures**														
1.	Up-gradation & Expansion in the Existing Flood Forecasting and Warning System of PMD.	4,505	-	-	4,505	-	-	-	-	-	-	-	-	-	-
2.	Up-gradation, Installation and Expansion in the Existing Gauging System of WAPDA.	2,297	-	-	-	2,297	-	-	-	-	-	-	-	-	-
3.	Study to be Conducted for Removal of Encroachments in major Rivers & Hill Torrents and Procurement of LiDAR's.	750	750	-	-	-	-	-	-	-	-	-	-	-	-
4.	Study and Implementation Cost for Development of Watershed Management in Upper Catchment Areas of Rivers & Hill Torrents.	4,500	-	-	-	-	-	-	800	500	800	400	400	800	800
5.	Disaster Management Activities by NDMA, Rescue and Relief.	6,500	-	6,500	-	-	-	-	-	-	-	-	-	-	-
6.	Study for Drought Management	50	50	-	-	-	-	-	-	-	-	-	-	-	-
7.	Feasibility/Technical Studies for Ramsar Sites.	30	-	-	-	-	30	-	-	-	-	-	-	-	-
8.	Capacity Building for All Institutions Dealing with Flood Management in the Country.	1,380	380	-	-	-	-	-	50	50	50	300	300	100	150
Sub-Total (II)		**20,012**	**1,180**	**6,500**	**4,505**	**2,297**	**30**	**0**	**850**	**550**	**850**	**700**	**700**	**900**	**950**
Total (I+II)		**177,661**	**8,998**	**6,500**	**4,505**	**2,297**	**30**	**430**	**4,954**	**7,030**	**6,127**	**47,807**	**35,859**	**25,849**	**27,275**

Notes:
1. Maximum efforts should be made to ensure availability of fund by federal/provincial governments on its own resources or through financial grants/aid.
2. External funding/loans may be sort out in case of failure of funds arrangement by Federal/Provincial Governments

9. FLOOD PROTECTION INVESTMENT PLAN

9.1 GENERAL

The consecutive five flood events i.e. from 2010 to 2014 have highlighted the need for immediate attention and a broader vision towards handling severity and variability of flood events. In recent years, vulnerability to urban flooding has increased. Due to this reason, implementation of structural flood protection measures as well as non-structural measures in the context of integrated, comprehensive and a unified flood management system is necessary during the next ten years' time. In this context, FFC plays a key role in planning, execution and monitoring of flood protection plan and physical works/schemes (structural/non-structural measures) countrywide.

After the completion of three previous NFPPs, FFC planned to prepare fourth NFPP for next ten years with the help of Provinces and FLAs. Thus, the major part of the study is to prepare comprehensive Investment Schedule for the flood protection and priorities projects/schemes proposed by the Provincials and FLAs to be implemented for the next ten (10) years.

Keeping in view socio economic importance of NFPP-IV and its linkage with other Ministries/Divisions, Provinces, FLAs/Organizations, Ministry of Water Resources submitted the initial investment Plan to Council of Common Interests (CCI) for its approval and important decisions on financing modalities.

Initially, the plan was prepared for a period of 10 years. However, during approval process in CCI meetings, Ministry of Water Resources proposed to phase out the plan for financing of NFPP-IV in two phases as; Phase-I: the original investment plan to be implemented in first five (5) years and Phase-II: after financial closure of first phase, the additional demand would be implemented in next 5 years. Both phases have been discussed side by side in conjunction with the original investment plan and the additional demand required by Provinces & FLAs/Organizations during consultation rounds.

9.2 APPROVAL PROCESS OF NFPP-IV BY THE COUNCIL OF COMMON INTERESTS

First Meeting of CCI on NFPP-IV Held on February 29, 2016

NFPP-IV was presented in the 28th meeting of Council of Common Interests (CCI) held on February 29, 2016, wherein following decision was taken;

> "The CCI decided that the Minister for the Climate Change and Minister for Water & Power in collaboration with all Provincial Chief Ministers shall workout a comprehensive National Flood Protection Plan and present the same in the next meeting of the CCI scheduled to be held on March 25, 2016".

In pursuance to the decision taken in 28th meeting of CCI, another follow up meeting was held on March 17, 2016 in Ministry of Water & Power, Islamabad, which was attended by Minister for Water & Power, Minister for Climate Change, Chief Minister Sindh, Additional Chief Secretary (Dev), Government of Balochistan, Secretary Irrigation Punjab, Secretary Irrigation Khyber Pakhtunkhwa and senior officials from Provincial and Federal Government.

Detailed presentation on NFPP-IV was made to the forum highlighting integrated flood management approach to be implemented in next ten years to handle flood issues across Pakistan. Province/area wise problems and solutions were presented along with estimated figures of short, medium and long-term investments. Province/area wise distribution of investments with financing resources was also discussed.

The forum agreed with proposed investments subject to following recommendations to be included in NFPP-IV;

- A Steering Committee will be established to oversee and monitor implementation of the Plan and provide policy guidelines;
- Third party verification will be carried out for all the works in order to ensure transparency in implementation;
- A study will be undertaken to determine suitable interventions for drought management; and
- Entire cost of the plan may be borne by the Federal Government-CCI to decide about the funding mechanism.

<u>Second Meeting of CCI on NFPP-IV Held on March 25, 2016</u>

With inclusion of above mentioned recommendations in NFPP-IV, the flood protection plan was presented again in 29th meeting of CCI held on March 25, 2016. The Honorable Chief Minister Sindh highlighted reservations on proposed construction of reservoirs downstream of Tarbela Dam. Whereas, Honorable Chief Minister, Khyber Pakhtunkhwa highlighted the need for another round of consultation with provinces to prioritize and finalize costs of flood protection schemes. Furthermore, it was discussed in detail and endorsed by all provinces that the financing for implementation phase of NFPP-IV shall be the responsibility of Federal Government (as per previous practice in implementation of NFPP-I, II and III).

Another aspect discussed in the same meeting was release of funds through Normal/ Emergent Flood Program for Sindh Province. It was highlighted that more than 30 schemes related to flood protection were still awaited for implementation.

In order to address the above mentioned reservations by the provinces, the Honorable Prime Minster of Pakistan decided that the Committee established in 28th meeting of CCI should continue consultative process for another month and include the suggestions of the Provincial Governments in the Plan after removing their concerns and keep CCI updated with the process. The revised NFPP-IV was circulated among all stakeholders on 26th April 2016.

To proceed with approval process of NFPP-IV, a meeting was held at Ministry of Water & Power, Islamabad on May 4, 2016 attended by Chief Minister Khyber Pakhtunkhwa, Chief Minister Balochistan, Minister for Climate Change, Irrigation Minister Punjab, Chief Secretary Balochistan and high Officials under chairmanship of Honorable Federal Minister for Water and Power to review suggestions of the provincial governments. During the meeting, it was decided that a team comprising of members from Ministry of Water and Power, Federal Flood Commission and NESPAK will visit provincial capitals to explore the possibilities of incorporating the schemes highlighted by the provinces as essential, in addition to those already included in the draft NFPP-IV. The team members who visited provincial capitals are as follows;

- Joint Secretary (Water), Ministry of Water & Power
- Chief Engineer (Floods), Federal Flood Commission
- Acting Team Leader, WCAP
- Team Leader, NFPP-IV, NESPAK
- Team Leader, Task-A of NFPP-IV, NESPAK

<u>Compliance of CCI Recommendations</u>

Above mentioned team members visited the concerned officials at Quetta, Peshawar, Karachi and Lahore on May 9 &10, May 25, May 31 and June 3, 2016, respectively. During these visits, additional flood protection (FP) schemes were proposed by all provinces to be included in NFPP-IV. The additional cost of schemes during visits to provinces and PMD &

NDMA was worked out as Rs. 154,585 million as shown in Table 9-1 (col.4), which is over and above the original estimated cost of the Plan i.e., Rs. 177,661 million as shown in Table 9-1(col 3) as detailed in Table 8-5. The proposed total cost of NFPP-IV with inclusion of additional requirements may become Rs. 332,246 million as shown in Table 9-1 (col.5).

Table 9-1: Original Proposed Cost of NFPP-IV vs Total Demand after CCI Meeting

(Cost in Million Rupees)

Sr. No.	Departments / FLAs	Structural & Non-Structural Measures		
		NFPP-IV Cost Prior To CCI Meeting	Additional Costs Required by Provinces	Desired Total Cost After CCI Meeting
1	2	3	4	5
1	Balochistan Irrigation Department	27,275	5,766	33,041
2	Khyber Pakhtunkhwa Irrigation Department	25,849	70,916	96,765
3	Sindh Irrigation Department	35,859	3,302	39,161
4	Punjab Irrigation Department	47,807	53,286	101,093
5	NDMA	6,500	11,820	18,320
	PMD	4,505	9,495	14,000
6	Federal Line Agencies (FLAs)	29,866	-	29,866
	TOTAL	**177,661**	**154,585**	**332,246**

Recommendation from Ministry of Water and Power

A meeting was held on February 10, 2017 at Ministry of Water and Power, Islamabad chaired by Minister of Water and Power to finalize various aspects of NFPP-IV in view of CCI recommendations. Following decisions were made in the said meeting;

1. *The original investment Plan of Rs. 177.661 billion may be submitted to CCI and considered as Phase-I of NFPP-IV to be implemented in first five (5) years.*
2. *After financial close of first phase of NFPP-IV (Rs. 177.661 billion), the additional demand of Rs. 154.585 billion would be taken up as Phase-II of NFPP-IV to be implemented in next 5 years after financing of these projects through Consultants and Technical teams of Provincial governments.*
3. *The issue of financing of NFPP-IV would be deliberated and decided by the CCI.*

In pursuance of above decisions, 10-years investment plan of NFPP-IV has been phased out in two periods, i.e., Phase-I will be implemented in first 5 years and Phase-II will be implemented in remaining 5 years. Accordingly, costs allocations among Federal Ministries/ Agencies and Provincial Departments elaborated in Table 8-5 have been modified. The revised allocations of costs in view of two phases plan implementation are provided as Table 9-7 with following modifications;

- Phase-I of NFPP-IV: 1st Five Years Plan Period = Rs. 177,661 million
- Phase-II of NFPP-IV: Next Five Years Plan Period = Rs. 154,585 million
- **Total Cost of NFPP-IV (Phase-I & Phase-II)** = **Rs. 332,246 million**

Similarly, yearly allocations of costs in view of two phases plan implementation of various structural and non-structural measures are provided in Table 9-8 by considering the following parameters;

- Investment amount has been distributed in two Phases, i.e., Phase-I and Phase-II.

- Distribution of Phase-II costs (for additional proposed flood protection works) have been proposed by Consultants as 30%, 25%, 20%, 15% and 10% for the years 6, 7, 8, 9 & 10, respectively.
- Distribution of additional costs for Flood Management of Hill Torrents Works in Phase-II has been carried out equally at 20% per year.

Decision of NFPP-IV by the Council of Common Interest

The CCI approved the proposed NFPP-IV in its meeting held on 2nd May, 2017[14] and decided that financing of the NFPP-IV would be made by the Federal and Provincial governments @ 50:50. The provinces will decide their respective share of contribution among themselves and report to the federal government.

9.3 PREVIOUS FINANCIAL PROVISIONS

Financial provisions are important factor for making the future Investment Schedule for flood protection measures. The projects or group of projects to be implemented were placed in high or medium or long term priority. Allocation of funds for previous plans periods and year wise (1978-1979 to 2013-2014) release of funds through which various flood projects/ works were completed through FFC are given in Table 9-2 and Table 9-3, respectively.

Table 9-2: Allocation of Funds

Sr. No.	Item	Three NFPPs and N/EFP (Cost in Million Rupees)				
		NFPP-I (1978-1987)	NFPP-II (1988-1997)	NFPP-III (1998- 2008)	N/EFP* (2009-2014)	N/EFP* (2014-15) (2016-17)
1.	Allocated Budget	1,894	802.500	4,985	4,681	2,409.907
2.	Funds Actually Available/ Spent	1,730	805.331	4,193	3,012	2,130.407
3.	Carryover to Next Plan Period	396	2,957	4,123	1,858	—
4.	Carryover Percentage to Actual Investment Plan	20 %	26 %	35 %	46 %	—

* N/EFP = Normal/Emergent Flood Programme (2009 to 2017).
Source: Federal Flood Commission, Islamabad.

Table 9-3: Summary of Budget Allocation and Releases under Normal/Emergent Flood Programme

(Cost in Million Rupees)

Financial Year	Allocation	Releases		Financial Year	Allocation	Releases
1978-79	111.18	115.34		1997-98	0.00	0.00
1979-80	147.80	145.62		1998-99	400.00	319.56
1980-81	200.00	199.31		1999-00	300.00	290.82
1981-82	300.00	219.31		2000-01	200.00	50.00
1982-83	266.60	252.37		2001-02	58.03	57.78
1983-84	229.00	166.24		2002-03	45.17	42.822
1984-85	130.00	129.99		2003-04	350.00	348.74
1985-86	175.29	172.96		2004-05	500.00	497.50

[14] Reference Case No. CCI. 6/1/2016 dated 29th February, 2016.

Financial Year	Allocation	Releases		Financial Year	Allocation	Releases
1986-87	178.70	178.64		2005-06	800.00	753.29
1987-88	150.00	149.96		2006-07	950.00	947.22
1988-89	89.68	89.67		2007-08	1,381.84	884.61
1989-90	74.44	74.44		2008-09	860.17	815.32
1990-91	85.00	85.00		2009-10	575.11	78.36
1991-92	50.00	50.00		2010-11	735.80	276.71
1992-93	50.00	50.00		2011-12	844.19	567.10
1993-94	39.99	39.99		2012-13	900.00	419.33
1994-95	313.39	313.39		2013-14	1,000.00	855.53
1995-96	100.00	100.00		2014-15	1,000.00	898.477
1996-97	0.00	2.84		2015-16	964.43	964.43

Source: Federal Flood Commission, Islamabad.

9.4 INVESTMENT SCHEDULE FOR NFPP-IV

9.4.1 Identification, Evaluation and Selection of Flood Protection Schemes

Firstly, a total number of 908 flood protection schemes projects, estimated to cost Rs. 150,084 million were proposed by the Provincials and FLAs under NFPP-IV as detail given in Chapter 8 above. 583 schemes/projects have been selected with an estimated cost of Rs. 90,992 million as given in Table 9-4. In addition, as discussed above that during the approval process of NFPP-IV in CCI, Provinces and PMD & NDMA are given additional cost worked out as Rs. 154,585 million as given in Table 9-4. Similarly, the type of selected schemes of Phase-I and Phase-II is given in Table 9-5.

Table 9-4: Summary of Selected Projects/Schemes for NFPP-IV

(Cost in Million Rupees)

Sr. No.	Departments / Federal Line Agencies	Phase-I (First 5 Years)		Phase-II (Next 5 Years)		Total Estimated Cost
		No. of Schemes	Estimated Cost	No. of Schemes	Estimated Cost	
1.	Punjab Irrigation	53	23,350	11	53,286	76,636
2.	Sindh Irrigation	51	21,351	9	3,302	24,653
3.	Khyber Pakhtunkhwa Irrigation	72	20,000	25	70,916	90,916
4.	Balochistan Irrigation	259	17,700	134	5,766	23,466
5.	Gilgit-Baltistan Region	29	1,932	-	-	1,932
6.	FATA Irrigation & Hydle Power	72	3,098	-	-	3,098
7.	AJ&K Irrigation & Small Dams	47	3,561	-	-	3,561
	Sub-Total	**583**	**90,992**	**179**	**133,270**	**224,262**
8.	PMD (6 Nos. Projects/Studies)	-	4,505	-	9,495	14,000
9.	WAPDA (6 Nos. Projects/ Studies)	-	2,297	-	-	2,297
10.	NHA (8 Nos. Feasibility Studies)	-	-	-	-	-
11.	Climate Change Division (4 Nos. Studies)	-	30	-	-	30
12.	NDMA (5 Nos. Projects/Works)	-	6,500	-	11,820	18,320
13.	Pakistan Railways (Bridges + Bunds Improvements)	-	450	-	-	450
	Total		**104,774**		**154,585**	**259,359**

Table 9-5: Selected Types of Projects/Schemes

Departments / Organizations	Type of Schemes	Types of Schemes/Projects		Total Number
		Phase-I	Phase-II	
Punjab Irrigation Department				
1	Flood Protection Work	30	9	39
2	Construction of Spur	17	-	17
3	Feasibility Study	6	-	6
4	Hill Torrent Study	-	2	2
Sindh Irrigation Department				
1	Flood Protection Work	37	3	40
2	Restoration	10	6	16
3	Construction of Spur	4	-	4
Khyber Pakhtunkhwa Irrigation Department				
1	Flood Protection Work	62	19	81
2	Construction of Spur	6	-	6
3	Feasibility Study	4	-	4
4	Revamping/Rehabilitation	-	6	6
5	Hill Torrent Study	-	-	-
Balochistan Irrigation Department				
1	Priority Schemes	213	49	262
2	Flood Management	42	85	127
3	Feasibility Study	4	-	4
Gilgit – Baltistan Region				
1	Flood Protection Work	26	--	26
2	Feasibility Study	3	--	3
AJ&K Irrigation and Small Dams				
1	Flood Protection Scheme	43	--	43
2	Feasibility Study	4	--	4
FATA Irrigation & Hydel Power				
1	Flood Protection Work	70	--	70
2	Construction of Spur	2	--	2
Pakistan Meteorological Department				
1	Strengthening, Installation, Up Gradation of Equipments / Networks & FEWS.	6	--	6
WAPDA				
1	Strengthening, Installation, Up Gradation of Equipments / Networks (SWHP & Telemetric, etc.).	6	--	6
National Highway Authority				
1	Feasibility Study	8	--	8
Climate Change Division				
1	Feasibility Study	4	--	4
National Disaster Management Authority				
1	Projects/Works	5	--	4
Pakistan Railways				
1	Model Studies for Nine Railways Bridges.	9	--	9
2	Improvements of Existing Flood Protection Works both sides of Railways Track and Bridges.	--	--	--

9.4.2 Prioritizing of Schemes and Phasing

Need for Prioritizing

Out of total 1,097 flood protection schemes/works as proposed by the departments of four provinces, FATA, AJ&K and Gilgit-Baltistan, 762 schemes have been selected and recommended for execution under Phase-I and Phase-II of NFPP-IV after passing through a scrutiny process for their selection based on technical and economic details. Since, plan is to be implemented in next 10 years (Phase-I & Phase-II) and it would not be possible to start executing all the schemes/projects included in the plan from 1st or 2nd year of its implementation because of numerous managerial and financial constraints, thus there is a need to set the execution priority for each of the schemes/works on the basis of their urgency/requirement and impact.

After setting-up the execution priority of works and expected beginning and completion of schemes/studies, the phasing of investment over next 10 years has been determined for implementation of NFPP-IV. The cost for each activity during each of 10 years has been summed up to determine financial requirements to be arranged for each of next 10 years.

Year-wise financial requirements for next ten (10) years would help federal and provincial governments and concerned departments/agencies to mobilize, in time, for arranging the necessary approval, appropriate funding and other pre-implementation works for the execution of proposed schemes/studies etc according to the implementation schedule proposed in NFPP-IV.

Fixation of Priority

There are certain flood protection projects/schemes/studies that need to be implemented on top priority basis in order to achieve the objective of country-wide flood management at the earliest possible time. Thus, an implementation plan based on best managerial judgment and engineering skill, assigning priority to each of selected schemes as top priority to achieve short term goals, high priority to achieve medium term goals, and medium priority to achieve long term goals, has been developed. These are briefly described as below.

a) Top Priority - Short Term Measures

The following types of schemes/projects have been assigned as Top Priority as short term measures:

i. Strengthening and re-modeling of existing flood protection works in the most vulnerable or problematic areas.
ii. Up-gradation/strengthening of river gauging network and flood early warning and forecasting system.
iii. Preparation of floodplain legislation (River Act).

b) High Priority – Medium Term Measures

The following types of schemes/projects have been assigned High Priority as medium term measures:

i. To revive the original capacity of barrages/bridges and enhance the existing system capacity of river reaches, hydraulic structures, embankment (top levels) to bear floods above their existing design magnitudes.
ii. Strengthening and re-modeling of existing flood protection works (not covered under Top Priority I) in all over the country.
iii. Design/construction of new works as per design standards with respect to hydrologic, hydraulic, structural, geotechnical investigations, etc.

iv. Watershed management/land use control in the uplands of all the concerned rivers.

c) Medium Priority – Long Term Measures

All the remaining works (not covered under Top priority and High priority) falling in the areas with lesser flood threat and low level of damages have been placed in Medium priority as long term measures.

9.4.3 Prioritizing of Schemes and Phasing

During course of preparation of NFPP-IV, 908 projects/schemes were proposed by the PIDs and FLAs out of which 583 projects/schemes have been selected with estimated cost of Rs. 90,992 million (Phase-I Table 9-4).

There are certain projects that are proposed by the Federal Line Agencies/Organizations without any cost estimates. Since these are the projects of high priority, thus are recommended for their feasibility studies as given in Table 9-6. In addition, there are some projects, proposed by PIDs and FLAs having very high estimated cost. These are also included in Table 9-6 for further studies. Necessary description on various investment categories are provided in the later sections of this report.

Table 9-6: Projects Recommended for Studies under NFPP-IV

Department/ F. L. Agencies	Sr. No.	Name of Projects or Problem Areas
Punjab Irrigation Department	1	Construction of flood bund on right side Indus River from D/S Taunsa Barrage to Ghazi Ghat Bridge Complex.
	2	Strengthening / Raising of Flood Bunds in D. G. Khan Irrigation Zone
	3	Improvements of Flood Bunds of Haveli Canal Circle in Multan Zone
	4	Construction of flood bund for village abadies of chak Balan, Kotla Dittan, Pandori, Bhaundana Jatlan & Matial along R/Side of Jhelum River.
	5	Constructing Flood Protection works D/S Qadirabad Baggage.
Sindh Irrigation Department	1	Hill Torrents Flood Mitigation for Jacobabad Kashmor Area
	2	Development of Retardation Basin for River Indus in Lakhi Range Near Manjhand
	3	Development of Routes to Divert Excessive Flood Water of River Indus
	4	Up-Gradation & Capacity Enhancement of Kotri Barrage
Khyber Pakhtunkhwa Irrigation Department	1	Flood Protection of Nowshera City and Cantt. Areas (Study Both Banks of Kabul River)
	2	Improvement of Rod Kohi (Hill Torrents) System in D.I. Khan Division and including Ramak – D.I. Khan Road Section of Indus Highway (PID & NHA)
	3	Feasibility Study (Survey and Model Study) of Indus River from Chasma Barrage to Ramak Boundary
	4	Feasibility Study of Kabul River from Peshawar to M1 Bridge and from M1 Bridge to Nowshera City
Balochistan Irrigation Department	1	Feasibility Study of an additional spillway of Mirani Dam
	2	Flood Management Scheme - Sagar Koh Panjgoor District (Feasibility Study)

Department/ F. L. Agencies	Sr. No.	Name of Projects or Problem Areas
	3	Study for Drought Management in Balochistan Province
	4	Study for Effluent Disposal of Nasirabad
	5	Flood protection structure in Kashmor on Eastern & South Eastern side of Kashmor
Gilgit-Baltistan Region	1	Land slide problem along Hunza River (L/S) - Miachare Nagar (Feasibility Study)
	2	Feasibility Study and Detailed Design for all Major Rivers and Nullahs, Ghizar District
	3	Construction of flood protective works in Astore District
Irrigation & Small Dams, AJ&K	1	Protection of Khari Sharif and adjoining areas along Jhelum River, Mirpur and Bhimber Districts
	2	Construction of Flood Protection Works along both banks of Mahl Nallah, District Bagh
	3	Flood Protection Works along Jhelum and Neelum Rivers in Muzaffarabad, Hattian and Neelum Districts (2 Nos Projects).
PMD	1	Up-Gradation of FEWS with inclusion of QPF Model and River Flow Model upstream Tarbela Dam
WAPDA	1	Improvements in Flood Telemetric and Snow Gauging Networks
	2	Feasibility Study - Chiniot Dam Project on Chenab River
National Highway Authority	1	Feasibility Study of Sukkur Barrage to Kotri Barrage Reach, Indus River (PID)
	2	Rojhan-Mithan Kot–DG Khan-Ramak Road Section - Hill Torrents Study (N-55)
	3	Hub - Gawadar Section of Makran Coastal Highway - Hill Torrent Study (N-10)
	4	District Qila Saifullah Road Section - Hill Torrent Study (N-55)
	5	Multan – Muzaffargarh Section (N-70) Including Major Bridges on Indus and Chenab Rivers in the Vicinity
	6	Improvement of Road Section from D.I. Khan Division to Peshawar (N-55) Including Kohat Hill Torrents (NHA & PID)
	7	Hub - Khuzdar Section of Highway N-25 Hill Torrent Study
	8	Balochistan NHA Roads in All Districts - Hill Torrent Study
Climate Change Division (WWF Pakistan)	1	Technical Feasibility Study – Taunsa Barrage Ramsar Site
	2	Technical Feasibility Study – Indus Dolphin Reserve Ramsar Site
	3	Technical Feasibility Study – Patisar Lake at Lal Suhanra National Park Ramsar Site
	4	Technical Feasibility Study – Chotiari Reservoir Ramsar Site
Federal Flood Commission	1	Studies for Updating Flood Limits of Barrages and other Important Structures on Major Rivers.

9.5 DESCRIPTION ON INVESTMENT CATEGORIES

9.5.1 Construction of Flood Protection Structures / Works along Rivers

Problem

Flood protection structures/works, bunds and studs were evolved with the development of major irrigation structures. Flood bunds are important river works constructed generally with earthwork to contain the river spills and protect the population situated on their country side. It has been reported that the major tributaries of Indus River are accreting at a rapid rate because of deforestation and lack of soil conservation measures, resulting in reduced flows for irrigation withdrawals. Due to accreting of rivers and reduction in flows, a meandering nature of the rivers has been developed over time. Due to failure in construction of major storages, there is a lack of flows throughout the year in most of rivers, which leads the Indus River tributaries towards deterioration. These tributaries having erodible litho-logical formations, continuously go on altering their flow path by extensive looping. These problems, not only affect the urban and rural settlements of the area, but also the agricultural, irrigation and communication systems along with other infrastructure.

There is a complex system of training works along Indus River system, which indicate that their construction has been based upon crises provoked planning without the study of their mutual interactions. As such, they create problems of restricting the waterway at one place and the bank erosion at the other. Due to un-consolidated alluvial formations, the process of extensive looping of the river starts and the extensive creaking and shifting of river course continues especially in the lower part of the river and the farmers of the area are facing serious economic disaster due to the erosion/sloughing of their land.

Recommended Measures for Flood Mitigation

The construction of 762 flood protection structures/works for checking spill and erosive action in various river reaches are proposed. For this purpose, an amount of Rs. 193,936 million is proposed in NFPP-IV. A summary of proposed flood protection works in various river reaches are provided in Table **9-9**. The detail of proposed flood protection works in the reaches along major rivers is presented here in the following sub-sections of this report.

Table 9-7: Revised Category-wise Investment Plan for NFPP-IV (Ten Years Plan)

Sr. No.	Proposed Interventions in Next Ten Years	Proposed Investments													
		Estimated Cost (Rs. in Million)	Federal Ministries/Agencies									Provincial Departments			
			Estimated Cost (Rs. in Million)									Estimated Cost (Rs. in Million)			
			FFC	NDMA	PMD	WAPDA	CCD	Pakistan Railways	Gilgit - Baltistan	FATA	AJ&K	Punjab	Sindh	KP	Balochistan
I	**Structural Measures**														
1.	Construction of Proposed Flood Protection Works.	193,936	1,820	-	-	-	-	-	1,893	3,036	3,490	48,843	24,226	87,516	23,112
2.	Flood Management Structures Across Hill Torrents and Flood Generating Nullahs.	56,697	527	-	-	-	-	-	1,661	3,144	1,387	34,000	2,222	6,949	6,807
3.	Feasibility & Detailed Design Studies of Barrages and Hydraulic Structures.	1,500	1,500	-	-	-	-	-	-	-	-	-	-	-	-
4.	Master Planning, Feasibility Studies, and Detailed Designing Studies.	3,751	3,751	-	-	-	-	-	-	-	-	-	-	-	-
5.	Physical Hydraulic Model Study for Major Railway Bridges and Improvements of Existing Flood Protection Facilities of Pakistan Railway.	450	20	-	-	-	-	430	-	-	-	-	-	-	-
6.	Physical Hydraulic Model Study for Selected Reaches of Major Rivers.	200	200	-	-	-	-	-	-	-	-	-	-	-	-
7.	Measures for GLOFs & Land Sliding in Hilly Areas.	1,000	-	-	-	-	-	-	350	100	200	100	-	150	100
8.	Remodeling & Proper Maintenance of Drainage System in Lower Indus.	9,763	-	-	-	-	-	-	-	-	-	-	9,763	-	-
9.	Coastal Flood Protection Works.	1,622	-	-	-	-	-	-	-	-	-	-	800	-	822
10.	Flood Mitigation, Channelization and Execution of the Lai Nullah Project (Only Flood Component).	16,000	-	-	-	-	-	-	-	-	-	16,000	-	-	-
11.	Studies for Proper Town Planning in Future and Improving the Existing Storm Drainage System of Urban Areas.	1,000	-	-	-	-	-	-	-	-	-	350	350	150	150
12.	Provision of Annual Funds under Provincial ADPs for Flood Fighting Activities during Flood Season and Procurement & Repair of Flood Fighting Equipment & Machinery under PIDs.	5,000	-	-	-	-	-	-	200	200	200	1,100	1,100	1,100	1,100
Sub-Total (I)		**290,919**	**7,818**	**-**	**-**	**-**	**-**	**430**	**4,104**	**6,480**	**5,277**	**100,393**	**38,461**	**95,865**	**32,091**

Sr. No.	Proposed Interventions in Next Ten Years	Estimated Cost (Rs. in Million)	Proposed Investments												
			Federal Ministries/Agencies									Provincial Departments			
			Estimated Cost (Rs. in Million)									Estimated Cost (Rs. in Million)			
			FFC	NDMA	PMD	WAPDA	CCD	Pakistan Railways	Gilgit - Baltistan	FATA	AJ&K	Punjab	Sindh	KP	Balochistan
II	**Non-structural Measures**														
1.	Up-gradation & Expansion in the Existing Flood Forecasting and Warning System of PMD.	14,000	-	-	14,000	-	-	-	-	-	-	-	-	-	-
2.	Up-gradation, Installation and Expansion in the Existing Gauging System of WAPDA.	2,297	-	-	-	2,297	-	-	-	-	-	-	-	-	-
3.	Study to be Conducted for Removal of Encroachments in major Rivers & Hill Torrents and Procurement of LiDAR's.	750	750	-	-	-	-	-	-	-	-	-	-	-	-
4.	Study and Implementation Cost for Development of Watershed Management in Upper Catchment Areas of Rivers & Hill Torrents.	4,500	-	-	-	-	-	-	800	500	800	400	400	800	800
5.	Disaster Management Activities by NDMA, Rescue and Relief.	18,320	-	18,320	-	-	-	-	-	-	-	-	-	-	-
6.	Study for Drought Management	50	50	-	-	-	-	-	-	-	-	-	-	-	-
7.	Feasibility/Technical Studies for Ramsar Sites.	30	-	-	-	-	30	-	-	-	-	-	-	-	-
8.	Capacity Building for All Institutions Dealing with Flood Management in the Country.	1,380	380	-	-	-	-	-	50	50	50	300	300	100	150
Sub-Total (II)		**41,327**	**1,180**	**18,320**	**14,000**	**2,297**	**30**	**-**	**850**	**550**	**850**	**700**	**700**	**900**	**950**
Total (I+II)		**332,246**	**8,998**	**18,320**	**14,000**	**2,297**	**30**	**430**	**4,954**	**7,030**	**6,127**	**101,093**	**39,161**	**96,765**	**33,041**

Table 9-8: Category-wise Phasing of Investment Plan for Ten Years (Phase-I & Phase-II)

Sr. No.	Description	Estimated Cost (Rs. Million)	Ten Years Plan Period (Rs in Million)									
			Year-1	Year-2	Year-3	Year-4	Year-5	Year-6	Year-7	Year-8	Year-9	Year-10
			PHASE-I					PHASE-II				
I	**Structural Measures**											
1.	Construction of Proposed Flood Protection Works.	193,936	18,695	23,254	25,301	14,943	8,799	30,883	25,736	20,589	15,442	10,294
2.	Flood Management Structures Across Hill Torrents and Flood Generating Nullahs.	56,697	5,275	9,230	6,065	3,692	2,110	6,065	6,065	6,065	6,065	6,065
3.	Feasibility & Detailed Design Studies of Barrages and Hydraulic Structures.	1,500	900	600	0	0	0	--	--	--	--	--
4.	Master Planning, Feasibility Studies, and Detailed Designing Studies.	3,751	1,751	2,000	0	0	0	--	--	--	--	--
5.	Physical Hydraulic Model Study for Major Railway Bridges and Improvements of Existing Flood Protection Facilities of Pakistan Railway.	450	60	225	165	0	0	--	--	--	--	--
6.	Physical Hydraulic Model Study for Selected Reaches of Major Rivers.	200	120	80	0	0	0	--	--	--	--	--
7.	Measures for GLOFs & Land Sliding in Hilly Areas.	1,000	150	300	330	140	80	--	--	--	--	--
8.	Remodeling & Proper Maintenance of Drainage System in Lower Indus.	9,763	4,796	4,655	312	0	0	--	--	--	--	--
9.	Coastal Flood Protection Works.	1,622	114	406	646	406	50	--	--	--	--	--
10.	Flood Mitigation, Channelization and Execution of the Lai Nullah Project (only Flood Component).	16,000	6,000	10,000	0	0	0	--	--	--	--	--
11.	Studies for Proper Town Planning in Future and Improving the Existing Storm Drainage System of Urban Areas.	1,000	100	250	300	200	150	--	--	--	--	--
12.	Provision of Annual Funds under Provincial ADPs for Flood Fighting Activities during Flood Season and Procurement & Repair of Flood Fighting Equipment & Machinery under PIDs.	5,000	500	500	2,250	1,000	750	--	--	--	--	--
	Sub-Total (I)	**290,919**	**38,460**	**51,500**	**35,368**	**20,382**	**11,939**	**36,948**	**31,801**	**26,654**	**21,507**	**16,360**

Sr. No.	Description	Estimated Cost (Rs. Million)	Ten Years Plan Period (Rs in Million)									
			Year-1	Year-2	Year-3	Year-4	Year-5	Year-6	Year-7	Year-8	Year-9	Year-10
			PHASE-I					PHASE-II				
II	**Non-Structural Measures**											
1.	Up-gradation & Expansion in the Existing Flood Forecasting and Warning System of PMD.	14,000	1,100	1,176	901	750	578	3,345	3,098	2,100	950	--
2.	Up-gradation, Installation and Expansion in the Existing Gauging System of WAPDA.	2,297	927	820	420	100	30	--	--	--	--	--
3.	Study to be Conducted for Removal of Encroachments in major Rivers & Hill Torrents and Procurement of LiDARs.	750	405	345	0	0	0	--	--	--	--	--
4.	Study and Implementation Cost for Development of Watershed Management in Upper Catchment Areas of Rivers & Hill Torrents.	4,500	400	1,250	1,950	750	150	--	--	--	--	--
5.	Disaster Management Activities by NDMA, Rescue and Relief.	18,320	1,500	1,700	1,500	1,000	800	2,820	2,600	2,218	2,100	2,081
6.	Study for Drought Management	50	50	0	0	0	0	--	--	--	--	--
7.	Feasibility/Technical Studies for Ramsar Sites.	30	15	15	0	0	0	--	--	--	--	--
8.	Capacity Building for All Institutions Dealing with Flood Management in the Country.	1,380	50	285	490	345	210	--	--	--	--	--
	Sub-Total (II)	**41,327**	**4,446**	**5,590**	**5,260**	**2,946**	**1,770**	**6,165**	**5,700**	**4,317**	**3,051**	**2,081**
	Total (I+II)	**332,246**	**42,906**	**57,090**	**40,628**	**23,329**	**13,709**	**43,113**	**37,501**	**30,971**	**24,558**	**18,441**
			PHASE-I Total Cost = Rs. 177,661 Million					**PHASE-II Total Cost = Rs.154,585 Million**				

Table 9-9: Summary of Proposed Flood Protection Works in Various River Reaches (Phase-I and Phase-II)

(Cost in Million Rupees)

A : PUNJAB IRRIGATION DEPARTMENT

Sr. No.	River	River Reach	No. of Schemes	Estimated Cost
1	Indus	Jinnah – Taunsa	12	6,980
		Taunsa – Guddu	12	5,582
2	Jhelum	Malakwal – Tarimmu	4	2,287
3	Chenab	Marala – Qadirabad	5	3,345
		Qadirabad – Tarimmu	8	1,810
		Trimmu – Panjnad	10	5,465
4	Ravi	Kot Nainan – Balloki (Deg Nullah)	8	11,166
		Balloki – Sidhnai	1	225
5	Sutlej	Ferozpur – Suleimanki/Islam	4	12,450
		Total	**64**	**49,310**
	Less Monitoring Cost @ 2% for FFC as in Annex-4 (-)		-	- 467
		Net Total	**64**	**48,843**

B : SINDH IRRIGATION DEPARTMENT

Sr. No.	River	River Reach	No. of Schemes	Estimated Cost
1	Indus	Guddu – Sukkur	11	5,371
		Sukkur – Kotri	43	17,208
		Kotri – Sea	6	2,074
		Total	**60**	**24,653**
	Less Monitoring Cost @ 2% for FFC as in Annex-4 (-)		**-**	- 427
		Net Total	**60**	**22,226**

C : KHYBER PAKHTUNKHWA IRRIGATION DEPARTMENT

Sr. No.	River/Basin	River Reach	No. of Schemes	Estimated Cost
1	Indus	Tarbela - Attock & Chashma – Ramak	10	4,966
2	River Basin	Kurram, Tochi and Gambila	15	1,410
3	Kabul Basin	Kabul Basin	21	34,851
4	Areas	Swat, Shangla, Dir and Chitral Basin	13	31,619
5	Areas	Hazara Area	8	1,300
6	Areas	Kohat Basin (Karak and Hangu Area)	5	1,010
7	Gomal Basin	D.I. Khan Hill Torrents Area	1	4,610
8	Areas	Swabi	15	4,100
9	Areas	Mardan and Malakand	9	4,050
		Total	**97**	**87,916**
	Less Monitoring Cost @ 2% for FFC as in Annex-4 (-)		-	- 400
		Net Total	**97**	**87,516**

D : BALOCHISTAN IRRIGATION DEPARTMENT

Sr. No.	Districts	No. of Schemes	Estimated Cost
1	Dera Bugti, Dhadar/Kachhi/Lahri, Gwadar	24	3,031
2	Hub/Lasbella, Khuzdar, Killa Saifullah, Killa Abdullah	79	3,096
3	Kohlu/Barkhan, Loralai, Mastung, Kalat	57	2,768
4	Nushki/Chagai, Quetta, Sibi/Harnai, Turbat/Kech	109	3,145
5	Uthal/Lasbella, Ziarat, Canal System, Khuzdar	52	8,184
6	Awaran, Kharan/Washuk, Panjgur	72	3,242
	Total	**393**	**23,466**
	Less Monitoring Cost @ 2% for FFC as in Annex-4 (-)	-	- 354
	Net Total	**393**	**23,112**

E : GILGIT-BALTISTAN REGION (PWD)			
Sr. No.	**Districts**	**No. of Schemes**	**Estimated Cost**
1	Gilgit, Hunza, Khizar, Diamer, Astore, Skardu and Ghanche	29	1,932
	Total	**29**	**1,932**
	Less Monitoring Cost @ 2% for FFC as in Annex-4 (-)	-	- 39
	Net Total	**29**	**1,893**
F : FEDERALLY ADMINISTERED TRIBAL AREAS (ID)			
Sr. No.	**Agencies**	**No. of Schemes**	**Estimated Cost**
1	Bajaur, Khyber, Kurram, Mohmand	32	1,971
2	Orakzai, North Waziristan, South Waziristan	25	714
3	FR Peshawar, FR Kohat, FR Bannu	7	229
4	FR Lakkai, FR Tank, FR D.I. Khan	8	184
	Total	**72**	**3,098**
	Less Monitoring Cost @ 2% for FFC as in Annex-4 (-)	-	- 62
	Net Total	**72**	**3,036**
G : AZAD JAMMU & KASHMIR (ISDO)			
Sr. No.	**Districts**	**No. of Schemes**	**Estimated Cost**
1	Bhimber, Mirpur, Kotli, Sundhnoti, Ponch	30	2,352
2	Haveli, Bagh, Muzaffargarh/Hattian, Neelum	17	1,209
	Total	**47**	**3,561**
	Less Monitoring Cost @ 2% for FFC as in Annex-4 (-)	-	- 71
	Net Total	**47**	**3,490**
	GRAND TOTAL (Including Monitoring Cost)	**762**	**193,936**

9.5.1.1 Proposed River Works

a. Indus River

The relatively silt free water below Chashma barrage usually meanders and has caused most severe erosion; damaging valuable crop lands, villages and infrastructures. Such meandering character may increase with release of water having comparatively less sediment load from Tarbela dam and Chashma barrage.

Jinnah/Chashma-Taunsa Reach

The Chashma-Taunsa reach has high flood damage potential, because of the following:

i) The river is braided and actively erodes its banks in some areas and deposits in other areas, the erosion is destroying rich farm lands, breaching flood bunds and destroying irrigation command areas by serving roads and irrigation distributaries. Land erosion is more dominant in upper Indus River. High banks experience under cutting by the low flows and unstable soil masses cave in and ultimately collapse, causing large tracts of useful land getting ultimately washed away.

ii) Construction of bridges at D.I.Khan-Darya Khan and Gazi Ghat in the mid 80’s has altered the river course locally for kilometers upstream and downstream.

iii) Construction of Taunsa barrage in 1958 and Chashma barrage in 1971 have resulted in changes in the river course for kilometers upstream and downstream, as well as aggradations of the channels upstream and degradation downstream.

Construction and up-gradation of existing/new flood protection works are required along upper Indus River under NFPP-IV for the Chashma-Taunsa reach. The protection works/schemes are given in Annex-4 and shown in Exhibit 1 (included in CD).

Taunsa-Guddu Reach

The flood problems of Taunsa-Guddu reach are similar to that of Chashma-Taunsa reach of upper Indus River. Apart from the problem posed by the river, there is acute problem of protection of irrigated areas, towns and villages from the hazards of the hill torrents falling into the upper Indus River. The above conditions warrant that this reach of the river be taken up as a high priority with respect to rehabilitation and up-gradation of flood protection works. New bunds and up-gradation of existing flood protection works is required along upper Indus River under NFPP-IV for the Taunsa-Guddu reach. The protection works/schemes are given in Annex-4 and shown in Exhibit 1 (included in CD).

b. Jhelum River

Flood problems of the Jhelum river can be broadly classified as inundation and erosion. Inundation prevails generally in the upper reaches, where relatively plain areas begin and are under the attack of high floods, while land erosion is more dominant in the lower part. Damage due to erosion is attributable to the meandering nature of low and medium flows.

Mangla-Malakwal Reach

Since the commissioning of Mangla dam in 1967 till 8th of September 1992, its main spillway had never passed a flood higher than 7,192 m^3/s (254,000 ft^3/s) except for a short duration test releases. A historical event occurred in 1992. On the 9th and 10th September 1992, the main spillway of the dam had to pass a peak flood about 25,490 m^3/sec (900,000 ft^3/sec) which exceeded the flood of record. The high out flows of 1992 affected the tailrace area of the spillway and brought about unprecedented floods in the downstream reaches of Jhelum River. The flood problems along the banks of Jhelum River are of varying nature and extent. In the past, flood control structures and river training works like spurs and bunds along the river have been designed and constructed as dictated by the local needs of short stretches. The river regime adjustments in response to such structures generally give rise to new flood problems in the vicinity. In the present scenario, on right side of Jhelum river d/s Mangla, raising of banks is proposed to protect Jhelum city. On left bank of Jhelum River raising of banks is proposed from Sarai Alamgir up to opposite of Pind Dadan Khan. The protection works/schemes are given in Annex-4 and shown in Exhibit 3 (included in CD).

Malakwal-Trimmu Reach

Flood problems of the Rasul-Trimmu reach are insignificant when compared to those of other major rivers and certain hill torrents. Jhelum River encounters problems that are complicated due to the high release capacity at Mangla dam. The onslaught of these unprecedented flows pose flood problems in the Rasul-Trimmu reach. Protection works are proposed against erosive action of Jhelum River from d/s bridge to u/s of Trimmu barrage including villages Hassan Pur Tiwana, Mouza Tetree, Kot-Mulday, etc. in districts Khushab and Jhange.

The protection works/schemes are given in Annex-4 and shown in Exhibit 3 (included in CD).

c. <u>Chenab River</u>

Due to no suitable sites for major storage reservoirs in Pakistan, the Chenab river will continue to flow as an uncontrolled river and there is no practical likelihood of any reduction in its flood peaks. Due to continuous deforestation in the hilly catchment outside Pakistan, even higher floods are expected in future. Chenab basin has been extensively developed for irrigation by constructing a network of irrigation channels, and industrial units have been set up at important cities located near the river. These population centers, canals, irrigated areas, and vital lines of communications have been protected by construction of bunds and river training works. Flood bunds generally do not receive the attention and care they actually deserve. The consequences are obvious and none too savory as these bunds mostly are unable to stand the sudden on-slaught of a rising exceptionally high flood and succumb to it, resulting in heavy and sometimes catastrophic damages to crops, properties and even human lives. The importance of flood bunds for safety of public and private properties, infrastructure, crops, livestock and even human beings warrants adequately solid designs prepared on the basis of state-of-the-art methods to evolve sustainably durable sections. Flood problems of the Chenab River are major. Flood inundation limits (on maps) of Chenab River for 5 and 50 year return period are prepared under Task-C of this project. These flood inundation maps of Chenab River are superimposed on the maps of existing flood protection works. These maps are presented in Task-C report.

Marala-Qadirabad Reach

Rehabilitation and up-gradation of existing flood protection works are required along river Chenab under NFPP-IV for the reach Marala barrage to Qadirabad barrage.

At upstream of Marala barrage erosion of left bank of Chenab River near the confluence point with Jammu Tawi needs immediate action. Pakistan Army post “Khandaq” exists on right bank of Chenab River near Line of Control (LoC). The flood protection works near the Khandaq post are damaged. Restoration of damages for protection of Military installation at Khandaq post near LoC on right bank of Manawar Tawi are proposed.

The Palkhu and Aik nullahs originates near the town of Saidpur in Bajwat area, the major left bank tributary of Chenab River. Aik and Palkhu nullahs passes through Sialkot and Wazirabad separately and then both Nullahs crosses the Grand Trunk Road at the northern edge of Wazirabad and then flows parallel to the Chenab river until it joins into the Chenab at Head Khanki. Channelization of Palkhu & Aiknullahs is proposed under the current project (FS & Construction).

The protection works/schemes are given in Annex-4 and shown in Exhibit 4 (included in CD).

Qadirabad-Trimmu Reach

In Qadirabad barrage to Trimmu barrage reach, Chiniot district is badly prone to flood damage. So a scheme of protective bund/spur on the eastern side of river Chenab in Chiniot district near Mouza Dhussry, Mouza Qazian, Thatha Mehmood, etc, is proposed. In addition, five more projects/works is also proposed in the plan.

Trimmu-Panjnad Reach

The works principally comprise raising and strengthening of original bunds of barrages, railway bridges and for protection of cities, towns and irrigated areas. Rangpur canal off takes from right side of Trimmu barrage. After off taking from Trimmu barrage it first runs towards Athara Hazari and then it flows almost parallel to Chaneb River for rest of its length. Flood protection works exist along several places between the Chenab River and Rangpur canal. Flood protection works are required at RD 292+500, RD 302+000 and between RDs 320-334 of Rangpur canal. So construction of J-head spurs on above mentioned RDs of Rangpur canal and also construction of new embankments from 18-Hazari to Rangpur town are proposed on the right bank of Chenab river.

These areas lie on the left bank of Chenab river below its confluence with Ravi river in a narrow belt to confluence point of Sutlej and Chenab rivers within a width varying from two to 16 km (10 mile) in a length of about 144 km (90 mile). Therefore, the floods in Chenab River, threaten extensive damage to life and property. The existing bunds come under severe action of flows every year. Taunsa Panjnad link canal outfalls in Chenab River on its right side downstream of Head Muhammad Wala Bridge. Construction of two new J-heads spurs also proposed d/s of Muzaffargarh district.

Downstream of Panjnad barrage, there is a canal staff colony with a flood protection bund. For strengthening of colony protection, a bund downstream of Panjnad barrage is also proposed in current flood protection plan.

The protection works/schemes are given in Annex-4 and shown in Exhibit 4 (included in CD).

d. Ravi River

Land erosion is more dominant in Ravi River. Damage due to erosion is attributable to the meandering nature of low and medium flows. The bends are almost continuous and the flows cause erosion of the river banks at the outer curves of the bends. High banks experience under cutting by the low flows and unstable soil masses cave in and collapse, causing large tracts of useful land getting ultimately washed away.

KotNainan-Balloki Reach

KotNainan – Balloki reach of Ravi river is one of the worst flood affected areas of the country where the phenomena of serious land erosion, deep embayment, land sloughing and inundation is markedly prominent. The Ravi being an incised river, and having erodible lithological formations, continuously goes on altering its flow path by extensive looping. These problems, not only affect the urban and rural settlements of the area, but also the agricultural, irrigation and communication systems along with other infrastructure.

BRBD Link Canal off takes from Upper Chenab Canal near Bambanwala canal rest house, 6km (4 mile) south west of Daska city. BRBD link was constructed during 1950-52 to transfer water from Chenab River to feed various irrigation systems. The alignment of BRBD canal had to be undertaken against the country slope due to certain constraints. As a result, this canal flows in high filling in its reach RD 215 to RD 283 where it crosses Ravi River through Ravi Syphon. The canal in its reach RD 205 to RD 283, flows parallel to Ravi river and is often affected by floods during monsoon season. It has been observed that, whenever river is in high flood, it spills over and flows along left bank of BRBD Link, causing erosion of canal bank. Due to importance of BRBD canal from Irrigation and defense point of view, different flood protection structures were constructed along its left bank. In the current flood protection plan and construction of several flood protection works is proposed, which include:

- Construction of Spur at RD45-46/L of Madhodas Bund.
- Channelization of Deg Nullah (FS & Construction).
- Protecting both sides of Deg Nullah Embankment D/S Chahore Bridge to Jaisty wala by providing stone pitching.
- Checking serious erosion of Bain Nullah to save different village of Narowal District.

Deg nullah is formed by the union of two small streams Devak and Basanter. Both these streams join near Pakistan border line near Lehri village in Narowal district and from here it's called Deg nullah. Therefrom, Deg continues in a south west direction for about 11 km (7 mile), where it bifurcates as Nikki Deg and Deg. The Deg crosses MR Link through a syphon near RD 220 and flows parallel to the Begumpur Distributary of MR Link and then along the Ratta minor of Begumpur Distributary. At RD 106 of BRBD Link the Deg passes underneath the canal through a syphon. The segment of Deg between MR Link and BRBD Link needs channelization, which is proposed under present protection plan.

The flow trend of Ravi river& Bain Nullah, opposite to Narowal district is along the right bank. Ravi River makes a sharp U-bend towards Narowal district. This rightward trend of Ravi River causes erosion of right bank. To check this river & nullah erosion, scheme proposed under the plan.

The protection works/schemes are given in Annex-4 and shown in Exhibit 5 (included in CD).

Balloki-Sidhani Reach

Balloki-Sidhnai reach constitutes the lower part of the Ravi River. Balloki-Sidhani reach has a complex system of training works, which indicates that their construction has been based upon crises provoked planning without the study of their mutual interactions. As such, they create problems of restricting the waterway at one place and the bank erosion at the other. Due to unconsolidated alluvial formations, the process of extensive looping of the river starts a couple of kilometers below Balloki barrage. The extensive creaking and shifting of river course continued especially in the lower part of the reach and the farmers of the area are facing serious economic disaster due to the erosion/sloughing of their land. Kalera Flood Bund parallel to the Ravi river, and is under influence of the meandering action of river, therefore, raising and strengthening on the Bund is proposed to protect the irrigation system.

The protection work is given in Annex-4 and shown in Exhibit 5 (included in CD).

e. <u>Sutlej River</u>

Flood problems of the Sutlej River are less as compared to those of other major rivers and certain hill torrents. Sutlej River HFL in the 1955 flood, which corresponds to a theoretical return period of over 500-year in accordance with the post dam analysis. Flood inundation limits of Sutlej River for 5 and 50 year return periods are prepared under Task-C of this project. These flood inundation maps of Sutlej River are superimposed on the maps of existing food protection works. These maps are presented in Task-C report.

Ferozepur –Suleimanki/Islam Reach

In the Ferozepur barrage to Suleimanki barrage reach, Jamlera flood protection bund which is RD 0-41+500 long and have 25 ft top width is proposed for raising.

PIAIP Consultants also prepared flood management plan for Suleimanki. The envisaged project components include:

- Flood bypass arrangement to manage 100-year return period flood, which includes a 305 m (998 ft) wide spill channel along country side of right guide bank, a gated spill weir along the alignment of Haveli-Lakha-Suleimanki road, a gated level crossing along left bank of Pakpattan canal and x-regulator across Pakpattan canal with provision of grooves for stop-logs.
- Provision of gates and hoisting system for spill weir and level crossing bays including motorization of gates.
- Provision of instrumentation (vibrating wire and stand pipe piezometers) for monitoring of uplift pressures for proposed structures (i.e. spill weir, level crossing and cross regulator for Pakpattan Canal).
- Raising and strengthening of right marginal bund with 6 ft. freeboard above 1988 flood levels and provision of wetting channel on the river side.
- Provision of new left marginal bund with wetting channel 100 ft from the river side toe of the existing Left Marginal Bund (LMB). Proposed bund to have 6 ft freeboard above 1988 flood levels.

The proposed measures would:

i) Raise safe flood management capacity at Suleimanki barrage from 332,000 cusec at present to 430,000 cusec (100-year flood) which would eliminate the need of operation of breaching section up to 100-year return period floods.

ii) Strengthen the right marginal bund and provide wetting channel which would act as pre-flood testing device to identify and repair weak zones in the bund to safeguard it against occurrence of unforced breaches.

iii) Provide new Left Marginal Bund with wetting channel for safety of the left bank off-taking Sadqia & Fordwah canals as the existing army bunkers in the old LMB have made it vulnerable to leakages which in the past developed into breaches due to weaker cleavage between brick/ concrete bunkers with the earthen bund. Provision of wetting channel as pre-flood testing device as per directive of FFC Islamabad would safeguard the bund against breaches.

Upstream approaches of channel leading towards spill weir would be stone pitched for guidance of flow. As this is a part of pond area and there would be chances of siltation and negative growth in the channel which have to be cleared periodically after every 5 years.

Ghulam Wah flood embankment is located upstream of Islam barrage. Remodeling / restoration of Ghulam Wah flood embankment from RD 3+240 - RD 45+689, along Sutlej river is proposed in the Suleimanki barrage to Islam barrage reach.

The protection works/schemes are given in Annex-4 and shown in Exhibit 6 (included in CD).

9.5.2 Flood Management Structures across Hill Torrents

Problem

Referring to Section 4.2.1.7 of this report on hill torrents locations in Pakistan there are thirteen (13) major hill torrent areas of Pakistan having considerable potential for conservation and development. The hill torrents bring in flashy floods of shorter durations and higher magnitudes. Because of steep gradients, flood flows move with high velocity, which result in the erosion of banks and bed of channels. Flood flows debouching on to the plain areas, are generally charged with high silt contents, which generally preclude their management by dams or reservoirs. As the flood flows traverse the flatter areas, they deposit their silt load as a result of reduction in velocity. The silting and scouring phenomena are largely responsible for frequent changes in flow regime and shifting of flow paths of hill torrents. Unpredictable and erratic nature of floods and high silt contents pose a serious challenge to ingenuity of flood planners for their economic management. The behaviour and development potential of a hill torrent depend upon a number of interacting factors like, hydrometeorology, catchment characteristics, physiographic features of piedmont area, existing water uses and agricultural potential of available land resources.

Solution

An orderly and integrated study of water resources of hill torrents and flood generating nullahs is required. Special attention should be given to determine the land and water resources which are considered as the key elements for development of irrigation system of hill torrent areas. Generally, all available area cannot be economically commanded or may not be fit for irrigation. Due to erratic and unpredictable nature of rainfall in most of the areas, available water resources do not match with crop water requirements. In some areas, land resources are a constraint while in others, water resources are short. In some areas, both the resources are limited or in abundance. All the four scenarios should be observed in various hill torrent areas. The principal objective of proposed study is to identify the opportunities of small storages/delay action dams, flood flows management structures/regulators for improvement of hill torrents irrigation system in Pakistan. The funds of Rs. 56,697 million are proposed in NFPP-IV for the next ten years for this purpose. A summary of estimated cost is given in Table 9-10 and detail descriptions of project/schemes are given in Annex-5.

Table 9-10: Cost Estimates for Hill Torrent Management across Provinces and Federal Line Agencies

Hill Torrents Areas	Number of Projects	Estimated Cost (Million Rupees)
Punjab	19	34,000
Sindh	17	2,222
Khyber Pakhtunkhwa	157	6,949
Balochistan	94	6,807
FATA	86	3,144
G-B Regions	20	1,661
AJ&K	40	1,387
Sub-Total	**433**	**56,170**
Monitoring of Hill Torrents Works under the Plan	-	527
Total	**433**	**56,697**

9.5.3 Feasibility and Detailed Design Studies of Barrages and Hydraulic Structures

Problem

Barrages/hydraulic structures have a pivotal role in providing sustained irrigation supplies to millions of acres of fertile lands in the country. Several barrages are suffering from aging, hydraulic, structural and sedimentation/retrogression problems. Some barrages and headworks are endangered by multiple serious problems, threatening their overall integrity/ stability.

Almost all of the barrages in Pakistan suffer from the problem of bela formation in front of main weir due to sediment deposition. Because of the bela formation the actual discharging capacity of barrage suffers which makes these structures unsafe against high floods. The bela formation has also altered the flow patterns. Some barrages are facing serious problems of retrogression. In monsoon season, when maximum rainfall occurs and snow melts from the glaciers, it causes the maximum flow in rivers, when these flows reach to exceptionally high level, embankments have to be breached to escape the excess water, resulting in damage to standing crops, loss of human and animal life, destruction of properties, dislocation of communication and unimaginable suffering of people which cannot be measured in terms of money.

With the passage of time the operation of breaching section of the barrage will not be possible because the environmental/social setup has changed from that of the time of construction of the barrages. Now, population density has been increased significantly the vicinity of barrages and the area previously meant for carrying the waters of breaching sections have been intercepted by establishing dwelling areas and ploughing the same land for agricultural purposes.

Solution

Under the circumstances, the other engineering options are required to be adopted to avoid the operation of breaching sections for the safety of the dwelling areas and agricultural lands. Therefore an amount of Rs. 1,500 million (Table 9-7) is proposed for studies and detailed design of the following barrages, syphons, hydraulic structures and bridges, as given in Table 9-11.

Table 9-11: Details of Structures to be Studied

Sr. No.	Name of Barrage/Syphon	Sr. No.	Name of Bridge
1	Islam Barrage	1	Old & New Jhelum Road and Railway Bridges
2	Marala Barrage	2	Khushab Bridge
3	Sidhnai Barrage	3	Alexandra & Bridges (Roads/Railway)
4	Rasul Barrage	4	Chiniot Bridge
5	Sukkur Barrage	5	Rivaz Road Bridge
6	Kotri Barrage	6	Muhammad Wala Bridge
7	Qadirabad Barrage	7	Old & New Shahdara Road and Railway Bridges
8	Taunsa Barrage	8	Lahore Bypass Bridge
9	Mailsi Syphon	9	Larkana-Khairpur Road Bridge
10	Ravi Syphon	10	Dadu-Moro Road Bridge

9.5.4 Coastal Flood Protection Works

Coastal Problem 1: flood Inundation

Referring to Section 2.2.3 of this report, coastal flooding occurs when normally dry, low-lying land is flooded by Sea water. Simply but a coastal flood is when the coast is flooded by a surge in the sea. The cause of such a surge is a severe storm. The storm wind pushes the water up and creates high waves. The sea water can inundate the land via several different ways as described below:

- Direct Inundation — where the Sea height exceeds the elevation of the land, often where waves have not built up a natural barrier such as a dune system.
- Overtopping of a Barrier — the barrier may be natural or human engineered and overtopping occurs due to swell conditions during storm or high tides often on open stretches of the coast. The height of the waves exceeds the height of the barrier and water flows over the top of the barrier to flood the land behind it. Overtopping can result in high velocity flows that can erode significant amounts of the land surface which can undermine defense structures.
- Breaching of a Barrier — again the barrier may be natural or human engineered, and breaching occurs on open coasts exposed to large waves. Breaching is where the barrier is broken down by waves allowing the sea water to extend inland.

Solution

As there is a history of huge disasters in coastal areas of Pakistan especially in Sindh and Balochistan provinces and there is a need for the protection of people and assets from coastal flooding, detail engineering studies for protection of populated coastal areas of Sindh and Balochistan are recommended which will focus on wave height, storm severity and inundation type & extents. Keeping in view the severity and frequency of coastal flooding extents, protection structure should be designed. An estimated cost of Rs. 1,622 million has been recommended for the costal flood studies and flood protection works.

Coastal Problem 2: Releases to Check Seawater Intrusion d/s Kotri

Clause 7 of the Water Accord states: “The need for certain minimum water flow to sea, below Kotri to check sea intrusion was recognized. Sindh held the view that the optimum level was 10 MAF, which was discussed at length. It was, therefore, decided that further studies would be undertaken to establish the minimal release needs for Kotri.”

The federal government launched three studies in October 2004. The first study was on water required below Kotri to check sea intrusion. The second was on water flow required blow Kotri to address Sindh’s environmental concerns and the third study was on environmental concerns of all four provinces.

These studies were entrusted to consultancy firms of international repute. A panel consisting of Dr Fernando J Gonzalez, the ex-regional director of World Bank, Dr Thinus Basson, a professor and consultant with various US universities, and Dr Bert Schultz, a Dutch national and world renowned consultant on irrigation and drainage, conducted these studies and finalised the recommendations. The panel recommended that 5,000 cusecs or 3.6 million acre feet (MAF) of water annually will be required to flow below the Kotri Barrage to stop seawater intrusion.

The recommendation would require an additional release from storages of 1.26 MAF to 2.20 MAF, depending on the weather, during the low flow months of September to middle of June.

Solution:

This would require additional storage capacity to prevent reduction in water availability for irrigation use. This means that unless additional storage capacity is made available, the required release below Kotri cannot be made. Thus, it seems necessary to build a new storage as it would not only resolve the problem of power shortage in the country but water availability during low flow season.

9.5.5 Measures for GLOFs & Land Sliding in Hilly Areas

Problem

A detail description on GLOF has been provided in Section 2.2.5 of this report. Landslides are mostly caused due to heavy rains on loose hilly soils and unpredictable glacial movements in the hilly areas of northern parts of Punjab, KP, FATA, Gilgit-Baltistan and Azad Jammu and Kashmir. Thousands of people have died so far besides damages to the property and infrastructure. Although, it is extremely difficult to prevent the landslide phenomenon, however in-significant protective measures have been taken so far to provide protection against damages due to landslides.

Solution

For the purpose to study and identify the vulnerable areas for GLOF and landslides and suggest preventive and protective measures, a lump sum amount of Rs. 1,000 million has been provided in NFPP-IV for the Governments of Punjab (Districts DG Khan, Murree, etc), Khyber Pakhtunkhwa (Districts Swat, Dir, Kohistan, etc), Balochistan (Bolan, Zhob, Muslim Bagh, Gawadar, Turbat, etc.) Gilgit-Baltistan areas (all Districts), FATA (all Agencies) and Azad Jammu and Kashmir (Districts Hattian, Kotli, etc.).

9.5.6 Remodeling and Proper Maintenance of Drainage System in Lower Indus

Problem

Sindh Province has a vast irrigation and drainage network and it is one of the primary beneficiaries of the Indus Basin Irrigation System (IBIS) of Pakistan. Due to an inadequate drainage network and the flat topography of the basin, nearly one-fifth of the canal command area is affected by water logging and salinity. To help address the problems of water logging and salinity, the Left Bank Outfall Drain (LBOD) was completed in 1997. LBOD collects drainage water from the three districts of the Sukkur barrage command called, Shaheed Benazirabad, Sanghar and Mirpurkhas, and drains to the Sea through Badin district through a tidal link drain. LBOD has performed well and the upper part of the LBOD area has benefited from the drainage.

However, there are several issues unresolved in Badin district and the coastal zone. Sindh Irrigation Department conducted a study to prepare the Regional Master Plan (RMP), which is an urgent need to reduce flood damage and loss of life by improving the disposal of drainage and flood water in the Indus River left bank area. The project study area includes all areas in Sindh province lying on the left bank of the Indus River, including the river delta, associated wetlands, and the coastal zone. It covers the irrigation areas served by the Indus River canals off-taking from the left bank of Guddu. The area experienced major flood damages during the floods in period 2010 - 2012. As expressed by the stakeholders in the area, there is a pressing need to rehabilitate the existing LBOD drainage infrastructure and to expand the drainage area from 4 districts to 15 districts by reviving the natural drainage system of dhoros, many of which are blocked and degraded, and building new surface storm water drains. In this way, many more people and a greatly expanded area will benefit from drainage services. As a result to the extensive stakeholder consultation process during phases I-IV of the study, 16 proposed projects were identified and pre - feasibility studies were conducted, that included the rationale, challenges, costs, implementation arrangements, economic and financial benefits, and environmental and social safeguard measures.

Solution

As a result of the detailed feasibility analyses, five investment projects were identified that met the criteria of sustainability, high economic return, and high likelihood of being implemented as designed. The five proposed projects spread in seven years, include i) rehabilitation of LBOD, ii) revival of natural waterways and storm drains, iii) mangrove plantation in coastal areas, iv) rehabilitation of Deh Akro II and Chotiari wetlands, and v) forest plantation using drainage water (pilot).

Therefore for the purpose of channelization, remodeling and proper maintenance of drainage system, an amount of Rs. 9,763 million is proposed in NFPP-IV for the project "Rehabilitation of LBOD Drainage Infrastructure" SIDA, Government of Sindh.

9.5.7 Master Planning, Feasibility Studies, Detailed Designing and Implementation, Including Physical Model Study of All Major Rivers and Railway Bridges

Problem

Pre-feasibility study generally serves as decision making tool weather the project is suitable for higher level of planning/feasibility studies or not. If a proposed project appears to have sufficient merits to justify the cost of investigations and analyses, it is recommended for feasibility/master planning studies for which a layout plan is outlined.

The decision for project investment is based upon the functional, economic and financial information derived from the feasibility/master planning studies. This essentially comprises identification of goals and the establishment of objectives, assessment of the problem and rational zoning of the project area, identification of alternatives plans and the corresponding data requirements. After the collection of data and field investigations, it entails data analyses and evaluation of alternatives, selection of the best planning strategy and adoption of the most suitable alternative plans; and finally the selection of most cost effective plan. This level of planning, thus, must provide information regarding technical soundness, economic justification, social and environmental impacts and the financial requirements of the project. Feasibility reports meeting these requirements provide a vehicle for arranging financial assistance from international financing agencies like World Bank, ADB, Islamic Bank, USAID etc.

In addition to above, flood problems in Indus River and its major tributaries differ from one area to another depending on physiographic and hydrologic condition. Comprehensive systems of flood protection embankments have been constructed to reduce the extent of flooding and minimize flood damages. However, recent flood events from 2010 to 2014 caused wide spread damages, although huge amount has been spent on flood sector projects during last four decades. These damages are due to encroachments in the flood plain areas, changes in the river morphology, river bed aggradations etc.

Solution

In NFPP-IV, various studies have been proposed for this purpose as follows;

- A total amount of Rs. 3,751 million has been allocated for Master Planning/Feasibility Studies/Detailed Design Studies for PIDs, FLAs, etc. as given in Table 9-7.
- A total amount of Rs. 200 million has been allocated for physical model study of selected major rivers reaches as follows;
  i) Indus River: Tarbela-Jinnah-Chashma-DI Khan-Taunsa-Ghazi Ghat Bridge-Guddu-Sukkur-Dadu Moro Bridge-Kotri-Sea,
  ii) Jhelum River: Mangla-Jhelum-Rasul-Khushab-Trimmu,
  iii) Chenab River: Qadirabad-Chiniot Bridge-Trimmu-Shershah Bridge-Panjnad,
  iv) Ravi River: Kot Naina-Balloki Barrage-Sidhnai Barrage,
  v) Sutlej River: Sehjra-Suleimanki Barrage-Panjnad Barrage,
  vi) Kabul River: Warsak-M-1 Bridge-Nowshera Road Bridge-upto Attock.
- An amount of Rs. 50 million has been allocated for physical model study of nine (9) Railways Bridges on the Indus River (Attock, Ayub & Kotri), Jhelum River (Jhelum), Chenab River (Wazirabad, Shershah & Rivaz) and Ravi River (Shahdara & Abdul Hakeem), respectively.
- An amount of Rs. 400 million has been allocated for improvements of existing railway structures which have been affected from floods such as Ugoki-Sambaryal section & Ugoki-SLK section, JCB-Sibi section & construction of new bridges, SSH-MZG Section and etc.

9.5.8 Flood Mitigation, Channelization and Execution of the Lai Nullah Project

The Lai Nullah Basin with a basin area of 235 km².The upper basin covering 161 km² (69%) falls in Islamabad city and the lower basin covering 74 km² (31%) falls in Rawalpindi city and its suburbs. The drain has a length of about 30 km and has six major tributaries, three originating at the foot hills of Islamabad in the higher altitude area and remaining three at the lower altitudes. The elevationoftheLaiNullahBasinrangesfrom420 m at the confluence of Soan river to almost 1,200 m at mountain top in the Margala range. Four major tributaries are Saidpur Kas, Tenawali Kas, Bedarawali Kas and Johd Kas finally flow into Lai nullah just upstream of Katarian Bridge. Lai nullah enters into Rawalpindi at Katarian bridge. The lowest ground level is particularly observed in the north-south direction along Lai nullah between Katarian bridge and Chaklala bridge, where flood inundation often occurs due to overflow of Lai Nullah. Floods in the Lai Nullah Basin occur during the monsoon season (July to September) when Pakistan receives rainfall from three types of weather systems, namely: (i) monsoon depressions from the Bay of Bengal, India (the most important system); (ii) westerly waves from the Mediterranean Sea; and (iii) seasonal lows from the Arabian Sea. High floods in Lai nullah have been menacing the twin cities since 1944. The nullah has an incised channel which overflows its banks during large floods, causing damage to human life and property. Previously the flood damages were not so extensive as they are today, this was due to the fact that the nullah had a wide open waterway, unobstructed by encroachments, and less populated areas along its banks and the banks of its tributaries. Under the pressure of rapidly expanding population, new abadies sprang up not only in low lying areas, but at places structures were built on the banks and berms of the nullah itself. The situation poses a permanent danger of unpredictable occurrence to Rawalpindi and Islamabad. It warrants that a permanent solution of the problem must be evolved as early as possible. Keeping in view the severity of matter, flood management/channelization for Lai Nullah is proposed in NFPP-IV, which has a cost of about Rs. 16,000 million on flood management component.

9.5.9 Study to be conducted for improving the Existing Strom Drainage System of Urban Areas (Major Cities)

Problem

Besides spills from the river, heavy monsoonal rainfall within the cities and towns causes urban flooding. The inundation period is extended when there is poor drainage system within the cities and towns.

Urban floods are a great disturbance for daily life in the city. During periods of urban flooding, streets can become swift moving rivers, while basements can become death traps as they fill with water. Urban floods are being experienced in Pakistan cities-especially during Monsoon seasons - cities having high population density like Karachi, Lahore, Faisalabad, Multan, Hyderabad, etc. with unplanned, clogged, encroached and undersize drainage systems.

The examples of urban flooding during recent years are the floods in year 2003 in Karachi. Thatta etc, year 2007 in KP, Sindh and coastal Balochistan, year 2010 in many cities and towns all over Pakistan, year 2011 in Sindh Province and year 2012 in Sindh (Districts Kashmore, Jacobabad & Shikarpur) and few cities in Balochistan.

The major problems for slow delivery of drainage system are;

i. In-efficient performance of natural drainage due to encroachments and obstructions.
ii. Overtopping at number of places due to in-adequate capacity
iii. Submergence of drains at out falls points
iv. Limited capacity of the entire drainage network to cope with heavy storms
v. Roads, canals, built up areas and drains have caused compartmentalization of the area
vi. Inadequate capacity of culverts/bridges at crossing points of drains.

Solution

Studies are required to identify the specific drainage problem for each of those cities and towns where it is more severe. Twenty (20) cities/towns have been identified which are included in NFPP-IV for the identification of specific drainage problems and suggest solution as follows;

i. Punjab: Lahore, Rawalpindi, Multan, Faisalabad, Sialkot, Dera Ghazi Khan and Muzaffargarh,
ii. Sindh: Karachi, Hyderabad, Sukkur, Thatta, Jacobabad, Kashmor and Shikarpur,
iii. Khyber Pakhtunkhwa: Peshawar, Mardan and Dera Ismail Khan, and
iv. Balochistan: Quetta, Sibi and Dera Allah Yar Khan

A lump sum amount of Rs. 1,000 million has been allocated in NFPP-IV for these studies.

9.5.10 Provision of Annual Funds under Provincial ADPs for Flood Fighting Activities during Flood Season and procurement & repair of Flood Fighting Equipment/ Machinery under PID

Problem

Irrigation Departments of all the provinces and federal agencies have been facing financial hardships for the execution of flood management projects. The concerned departments face lack of flood fighting equipment. It can be observed that the equipment used for flood fighting by concerned departments is old and needs improvements.

Solution

Provision of Rs. 5,000 millions, under Provincial ADP for procurement & repair of flood fighting equipment & machinery and for flood fighting activities during flood season (June-September each year for the next ten (10) years) is proposed under NFPP-IV.

9.5.11 Up-gradation & Expansion in the Existing Flood Forecasting & Warning System of Pakistan Meteorological Department

Problem 1

Pakistan Meteorological Department (PMD) is responsible to issue flood warnings. An accurate early warning of the flood increases the reaction time for evacuation of population and adopting precautions against Floods. PMD has proposed to install five new QPM radars at Gwadar (Balochistan), Cherat & Chitral (KP), D. G. Khan (Punjab) and Gilgit (GB areas), where no radar coverage is available. Consultants also proposed four new locations to install new radars at Quetta (Balochistan), Nawabshah/Thatta (Sindh), Hangu (FATA) and Bannu (KP) and their costs have also been included in the next ten years plan. PMD has seven radars installed with different specifications at various places: Islamabad, Lahore, Sialkot, Mangla, Karachi, D.I. Khan and R.Y. Khan. Most of these radars have been installed 15 to 20 years ago. Similarly, due to developments in flood forecasting models, radar grid data has become an important aspect for their reliability. Therefore, it’s essential to up- grade these seven radars on priority basis.

Furthermore, PMD wants to make more useful forecast and has suggested installing 27 telemetric rain gauge stations (12 stations in KP and 15 stations in Balochistan). In addition, PMD desires to develop four Flood Early Warning Centers at the following locations:

1. Flood Early Warning Center for Gilgit-Baltistan Areas at Gilgit.
2. Flood Early Warning Center for Kabul River in KP.
3. Flood Early Warning Center for D.G. Khan Hill Torrents.
4. Flood Early Warning Center at Quetta for Balochistan.

Similarly, PMD proposed 39 Nos. Radio Sounding Stations for acquiring upper air data, which is very important for forecasting purposes.

Solution

A cost allocation of Rs. 13,700 million has been made in NFPP-IV for installation of new Radars, up gradation of existing Radars, installation of new meteorological stations and establishment of flood early warning centers.

Problem 2

Investments on development and implementation of hydrological models through flood forecasting systems have been carried out in past. The performance of hydrological models depends on quality of temporal and spatial hydro-meteorological inputs. Timely and accurate inputs to hydrological models would result in quality forecast with a reasonable lead time. A major input to hydrological models is the forecasted rainfall over catchments above rim-stations (usually known as Quantitative Precipitation Forecast (QPF). This input is primarily a meteorological input which requires an expert knowledge of meteorological phenomena and updated real-time information on meteorological variables (wind directions, atmospheric pressures, relative humidity, temperatures, etc,).

With advancement in remote sensing technology, certain meteorological variables are now available for next 7 days in grid format through tools like Global Forecasting System (GFS). Use of GFS models requires certain calibration to enhance degree of confidence in predicting QPF.

Further, up-gradation of FEWS with respect to i) inclusion of catchment area upstream of Tarbela dam as hydrological and hydraulics models, ii) existing geometry of Indus river and its major tributaries and iii) addressing the constraints and reservations of PMD is required on immediate basis.

Solution

An amount of Rs. 300 million has been allocated for specific meteorological studies to estimate accurate and reliable QPF through optimized use of GFS models. The specified cost also includes up-gradation of FEWS and technical support and testing during real time operation.

9.5.12 Up-gradation, Installation and Expansion in the Existing System of Water and Power Development Authority

Problem

Water and Power Development Authority is a federal organization responsible for water resources and power development having vast telemetric and gauging network throughout Pakistan. The hydrologic studies are based on data gathered from gauging and telemetric stations. A dense hydro-meteorological network is strength of a country to observe and disseminate data for early warning and flood forecasting. Existing density of gauging stations needs a tactical planning to maintain and upgrade the networks as per World Meteorological Organization (WMO) standards and minimum requirements.

Solution

WAPDA has suggested following projects for improving their system in the NFPP-IV as given below:

1. Improving present and expansion of Flood Telemetric Network.
2. Expansion, strengthening and densification on snow gauging stations.
3. Improvement and strengthening of the existing SWH network.
4. Development of GMRC system.
5. Improvements on existing and additional HF Radios networks.
6. Feasibility Study – Chiniot Dam on Chenab River near Chiniot City.

An estimated cost of Rs. 2,297 million has been proposed in NFPP-IV.

9.5.13 Study to be conducted for Removal of Encroachments from High Risk Areas on Major Rivers

Problem

Encroachment implies “advancement beyond proper limits”. In case of river, encroachment is a term used to describe the advancement of structures, roads, railroads, improved paths, utilities, and other development, cultivation, the placement of fill, the removal of vegetation, or an alteration of topography. These encroachments cause impacts on natural processes, such as alteration of river course and river flood patterns, a decline in water quality, loss in habitat (both aquatic and terrestrial), disruption of equilibrium (or naturally stable) conditions, loss of flood attenuation, or reduction of ecological processes.

Constructed encroachments within river corridors and floodplains are vulnerable to flood damages. Placing structures in flood prone areas results in a loss of flood storage in flood plains. Moreover, protection of these encroachments often result in the use of river channelization practices, such as bank armoring, berming, dredging, floodwalls, and channel straightening to protect these investments. The removal of vegetation to improve views capes or access, and the removal of woody debris from rivers to facilitate human use can increase resource degradation and the property's susceptibility to flood damages, causing higher risks to public safety. Such practices result in greater channel instability, excessive erosion, and nutrient loading by concentrating flows and increasing stream velocities and power.

Encroachment increases impervious cover adjacent to rivers, thereby increasing the rate and volume of runoff, loading of sediment and other pollutants. The cumulative loss of wetlands that provide water quality protection to adjacent surface waters can result in ongoing reduction in water quality. The extent of encroachment, the cumulative effects of impervious cover, and the degree to which natural infiltration has been compromised can also contribute to the instability of the stream channel.

Encroachment in rivers usually is comprised of residential development and associated vegetation removal; it can also include roads, parks and beaches and urban areas. Recent development patterns on lakeshores have seen replacement of small "camps" with larger houses suitable for year-round use. This new development generally is accompanied by substantial lot clearing, lakeshore bank armoring (rip-rap), and increase in lawn coverage and impervious surface. Research has shown this development results in degraded shallow water habitat and increased phosphorus and sediment runoff.

Solution

To limit encroachments and future conflicts with river systems, and to achieve stream equilibrium conditions, development and effective implementation of meaningful river act is necessary, which will protect floodplains, river corridors, wetlands, lakes and shore lands. LiDAR[15] is a remote sensing technology that uses ultraviolet, visible or near infrared light to image objects. It can target a wide range of materials, including non-metallic objects, rocks, rain, chemical compounds, aerosols, clouds and even single molecules. A narrow laser-beam can map physical features with very high resolutions. For assessment of nature and patterns of existing encroachments in the complete river corridor an amount of Rs. 750 million is proposed in NFPP-IV which includes procurement of LiDARs.

9.5.14 Development of Watershed Management in the uplands of Major Rivers and Hill Torrents Areas

Problem

Referring to Section 5.2 of this report, watershed management is the study of the relevant characteristics of a watershed aimed at the sustainable distribution of its resources and the process of creating and implementing plans, programs, and projects to sustain and enhance watershed functions that affect the plant, animal and human communities within a watershed boundary. Features of a watershed that agencies seek to manage include water supply, water quality, drainage, storm water runoff, water rights, and the overall planning and utilization of watersheds. Land owners, land use agencies, storm water management

[15]Acronyms of Laser Illuminated Detection and Ranging.

experts, environmental specialists, water use surveyors and communities all play an integral part in watershed management.

In other words watershed management is the application of science for manipulating or modifying the hydrological cycle of a locality in the best interest of mankind. All previous discussion ultimately leads to adoption of suitable measures at proper time at required sites. There are three major land uses in a watershed namely land under forest/range vegetation, land under farm crops and land under streams, rivers, ponds and lakes. The entire list of watershed management operations therefore can be conveniently put into following three (3) groups:

1. Operation related to protecting and promoting existing native vegetation and establishing and maintaining permanent vegetation cover in forest, range and wild lands.
2. Operation related to successful farm crop production in farm lands i.e. modifying farm operations.
3. Operation related to stream training and stream bank consolidation.

Solution

Seven watershed regions can be identified in Pakistan[16]. In these regions following areas are proposed for development of watershed management under NFPP-IV:

	Region	**Proposed Watershed area**
i.	The Northern Mountain Region	Swat Basin
ii.	The uplands of Northern Punjab	Hazara, Haro & Soan Rivers
iii.	Western Mountain Region	Gomal, Zhob, Kaha and Various Hill Torrents
iv.	The South-Western Balochistan Plateau	Nari Basin
v.	The Coastal Zone	Hub Basin
vi.	The Indus plains	Gaj Nai Basin
vii.	Gilgit-Baltistan Area	Chilas

To achieve the above mentioned objectives/operations for development of watershed management, the first step is the identification of appropriate area for watershed management and selection of suitable watershed management measures for that area. For identification of suitable areas from the above mentioned selected areas and studying the feasible watershed management practices an amount of Rs. 4,500 million is proposed in NFPP-IV.

9.5.15 Wetland Sites Recommended by RAMSAR Advisory Mission

Problem

As a response to the devastating floods that took place in August 2010, WWF-Pakistan in collaboration with Climate Change Division (CCD) and with the financial support from One UN Joint Programme on Environment (JPE) arranged and facilitated a RAMSAR Advisory Mission (RAM) to Pakistan. A RAM team was established, composed of specialists in different aspects of wetland wise use and conservation, the management and restoration of wetlands and the use of floodplain wetlands for mitigating the severe impacts from floods. The team members were Imran Ullah Khan (IUCN-Pakistan), Chen Zhang (Chinese

[16] Watershed Management in Pakistan by Dr. Masood A. A. Quraishi

Academy of Sciences, China), Xinqiao Zhang (WWF-China Programme Office) and Lew Young (Secretariat, RAMSAR Convention on Wetlands).

The main purpose of this Mission was:

a) To devise a workable and cost effective strategy for wise-use of the floods;
b) To make recommendations for alteration in the prevailing flood control strategy so as to obtain maximum benefit from flood water for the forests, wildlife, sustainable agriculture, ground water recharge, flushing of polluted wetland/lakes. The strategy is anticipated to be based on successful approaches adopted for reducing the threats of floods and that have been used for the Yangtze River Basin, and other river basins around the world.
c) Identification of high priority wetlands/RAMSAR Sites for restoration by using the floods as a tool for restoration

From the field visits by the RAM team, a number of sites were identified where floodplain restoration and management projects could be conducted on a pilot basis. These were the ponds at the Lal Suhanra National Park and the Indus Dolphin Reserve Ramsar Site. Although it was not possible to visit the Taunsa Barrage Ramsar Site during the RAM, it is another potential pilot site because the management of the ponds at the site have been given over to the Punjab Forest, Wildlife and Fisheries Department, and WWF Pakistan have initiated a community conservation project at the site. WWF Pakistan has also helped to draft management plans for both the Taunsa Barrage and the Indus Dolphin Reserve Ramsar Sites.

In addition, a number of other sites in Sindh Province were recommended to the RAM team during the de-briefing meeting in Lahore on 5th November 2012. These were the Chotiari Reservoir, Hadero Lake, Keenjhar Lake, Halejie Lake and Manchar Lake.

The mission identified four (4) potential wetland sites, recommended to be investigated on priority basis.

i. Taunsa Barrage Ramsar Site
ii. Indus Dolphin Reserve Ramsar Site
iii. Patisar lake at Lal Suhanra National Park
iv. Chotiari Reservoir

<u>Solution</u>

In order to investigate further, it is required to investigate the above mentioned four (4) potential wetland sites for diverting and using effectively the flood water to these wetland areas for development of forestry, Wildlife and other purposes for the benefit of stakeholders and locals and study the flood mitigation impact thereafter and initial environmental impacts, as per “Scope of Services’ given in Annex-6. An amount of Rs. 30 million is proposed in NFPP-IV for above mentioned studies.

9.5.16 Disaster Management Activities by NDMA, Rescue and Relief

<u>Problem</u>

National Disaster Management Authority, is the lead agency at the Federal level to deal with whole spectrum of Disaster Management Activities. It is the executive arm of the National Disaster Management Commission (NDMC), which has been established under the Chairmanship of the Prime Minister, as the apex policy making body in the field of Disaster. In the event of a disaster all stakeholders, including Government Ministries/ Departments/ Organizations, Armed Forces, INGOs, NGOs, UN Agencies work through and from part of the NDMA to conduct one window operation. NDMA serve as the lead agency for international cooperation in disaster risk management and ensure that the NGOs performance matches with accepted international standards. This will particularly include; information sharing, early warning, surveillance, joint training, and common standards and protocols required for regional and international cooperation. NDMA also coordinate emergency response of federal government in the event of a national level disaster through the National Emergency Operations Centre (NEOC).

Before flood, NDMA maps all flood hazards in the country with risk analysis on a regular basis and develop guidelines and standards for national and provincial stakeholders regarding their role in disaster risk management by ensuring establishment of DM Authorities and Emergency Operations Centres at provincial, district and municipal levels in hazard-prone areas. Along with risk analysis, NDMA provides technical assistance to federal ministries, departments and provincial DM authorities for disaster risk management initiatives and organize training and awareness raising activities for capacity development of stakeholders, particularly in hazard-prone areas.

In flood situation, NDMA aims to develop sustainable operational capacity and professional competence to undertake its humanitarian operations at its full capacity by acting as Secretariat of the NDMC to facilitate implementation of DRM strategies.

Solution

For enhancing the capacity of Government Agencies responsible for disaster management, development of capacity of stakeholders in post-disaster recovery, rescue and relief operation by Army and preparation of disaster management plans at various levels Rs. 18,320 million as shown in Annex-4 are proposed in the current NFPP-IV.

9.5.17 Capacity Building and Staff Training of Institutions

Problem

The recent major floods have exposed all aspects of flood management in Pakistan. From flood protection bunds to decision making at the departmental level, investigations show flaws and weaknesses. Non-structural measures are an integral part of flood management policy. We cannot reduce the probability of flood completely, but what we can do through proper planning and policy to avert the catastrophic effects of floods, in doing so a proper flood management plan plays an important part. The essence of a best plan is effective coordination between concerned departments right down to the community level. For minimizing the losses due to flood, the awareness of people residing in the flood prone areas, the coordination among the flood management related organizations at Federal, Provincial, District/Local Government level play a vital role in minimizing the losses due to flood.

Solution

Capacity building is a conceptual approach to development that focuses on understanding the obstacles that inhibit people, governments, international organizations and non-governmental organizations from realizing their development goals while enhancing the abilities that will allow them to achieve measurable and sustainable results. Capacity building is an ongoing process through which individuals, groups, organizations and societies enhance their ability to identify and meet development challenges. In developing nations the organizations should interpret community capacity building and focus on it rather than promoting one-way development. One of the most fundamental ideas associated with capacity building is the idea of building the capacities of government organizations in developing countries so they are able to handle the problems. Developing an organization's capacity whether at the local, regional or national level will allow for better performance that can lead to sustainable development. Fundraising, training centers, exposure visit, office and documentation support, on the job training, learning centers and consultants are all some forms of capacity building. The capacity building and training of staff of flood management related organizations at Federal, Provincial, District/Local Government level is necessary in the light of most modern/current practices being adopted all over the world. To achieve this, an amount of Rs 1,380 million is proposed in NFPP-IV for capacity building/staff training of institutions dealing with flood management in country. The sectors/departments proposed for the capacity building in NFPP-IV are Provincial Irrigation Departments (Punjab, Sind, KP, Balochistan), Federal Agencies (GB Region, FATA, AJ&K), Federal Organizations (FFC, WAPDA, PMD, PCIW) is included. In addition to this improvement and strengthening of Hydraulic Research Stations at Hyderabad & Gujranwala (Nandipur) and training for computer staffs (Provincial Irrigation Balochistan) and awareness campaign/workshops at different cities in the various locations of country for educating the people residing in flood prone areas are also included. The breakup of proposed amount is given in Table 9-12.

Table 9-12: Capacity Building under Proposed NFPP-IV (Ten Year)

Sr. No.	Institution Name	Estimated Cost (in Million Rupees)
A - Provincial Irrigation Departments		
1	Punjab (Rs.150 million) and Strengthening of Hydraulic Research Stations at Gujranwala (Rs. 150 million).	300
2	Sindh (Rs.150 million) and Strengthening of Hydraulic Research Stations at Hyderabad (Rs. 150 million).	300
3	Khyber Pakhtunkhwa	100
4	Balochistan (Rs. 100 million) and Training for Computer Staffs (Rs. 50 million).	150
B - Federal Agencies / Organizations		
1	Gilgit-Baltistan Region	50
2	FATA	50
3	AJ&K	50
4	FFC (Rs.100 million)	380
	WAPDA (Rs.100 million)	
	PMD (Rs.100 million)	
	PCIW (Rs.50 million)	
	Flood Related Workshops at Various Cities of Pakistan Gilgit-Baltistan Area (Rs. 30 million)	
	Total	**1,380**

9.5.18 Drought Management with Floods

<u>Problem</u>

Sindh province is facing drought conditions frequently from last two decades due to various climatologically reasons. Particularly, Tharparkar area is severely affected by prolonged droughts resulting in deaths of infants and miseries. In order to minimize impacts of prolonged droughts, floods can be efficiently used by diverting excess flows to the areas of drought.

<u>Solution</u>

Drought mitigation through floods requires a comprehensive study based on possibilities of new flow paths/ capacity enhancement and extension of existing canals reaching Tharparkar. An amount of Rs. 50 million has been proposed for studies on drought mitigation through floods in Sindh. The proposed study will provide recommendations based on techno-economical evaluations.

9.6 STEERING COMMITTEE FOR NFPP-IV

The implementation of NFPP-IV has been approved by the CCI in the meeting held on 2nd May, 2017 and decided that Financing of the NFPP-IV would be made by the Federal and Provincial Governments @ 50:50. In the meeting, it was also decided that the scale and magnitude of proposed investments in flood sector require comprehensive monitoring of activities related to funding arrangements, distribution of funds and plan implementation as per priorities.

To ensure transparency and efficient utilization of funds, third party verification is proposed. It will provide important feedback on performance of plan implementation by evaluating activities through certain benchmarks and monitoring indicators and will ensure objectives of integrated flood management through structural and non-structural interventions.

It is worth mentioning that the decision is taken in the meeting held on 13 March, 2012 in PM House under the chairmanship of Prime Minister of Pakistan that Federal Flood Commission to prepare and submit for approval a proposal for its strengthening/re-structuring.

9.6.1 Formation of Plan Implementation Unit of FFC

The Steering Committee of Water Sector Capacity Building & Advisory Sector project (WCAP) in its meeting held on 22nd June 2017, decided that the expected savings as a result of re-scoping of some activities will be utilized for newly proposed activities including "Establishment of Plan Implementation Unit" for coordination and monitoring the implementation of NFPP-IV (Ten-year Plan).The existing manpower of office of Chief Engineering Adviser/Chairman Federal Flood Commission, would not be able to coordinate/monitor the implementation of NFPP-IV having investment plan worth Rs. 332.246 billion. Therefore, the Plan Implementation Unit (PIU) has been proposed to be established in FFC for over-all management, coordination and monitoring the implementation of various interventions as per provision made in the approved NFPP-IV.

The detail description of Steering Committee, Plan Implementation Unit and the Capacity Building of FFC is given in Task-B Report (Section-5) as per Clause-V of the ToRs of Task-B.

10. ECONOMIC APPRAISAL OF PROPOSED FLOOD PROTECTION SCHEMES

Economic analysis of proposed flood protection works/schemes located in seven agencies of Pakistan (Four provinces, Gilgit-Baltistan, FATA & AJ&K) was carried out for determining economic viability, selecting level of protection and setting priorities for investment under NFPP-IV.

The objective of the proposed plan is to reduce the damages and human suffering by providing proper flood protection facilities against different rivers/hill torrents. In addition, the project would contribute towards social development of inhabitants of Project area in the long run. Furthermore, a public investment on the proposed works is to increase economic welfare of the people of the Project area.

10.1 EVALUATION CRITERIA

Economic justification of the project has been examined by the application of the efficiency criterion of public investments using the “Discounted Cash Flow” economic measures like Benefit Cost Ratio, Net Present Worth and Economic Internal Rate of Return are computed as a measure of the possibility of investment on the physical works proposed on the project.

10.2 ANALYTICAL PROCEDURE

The analysis of the costs and benefits of all the proposed flood protection schemes included in 10-year investment plan under NFPP-IV were undertaken with 2017 price level. For economic analysis of the project all costs incurred on the project and the benefit from the project are expressed in prices reflecting the real value of the economy. Financial costs and benefits have therefore, been converted to economic prices to remove the distortions due to monitory and fiscal policies. The major traded goods are valued at border prices and the local costs adjusted by appropriate conversion factors (CFs). An economic project life of 25 years is assumed using 2017 international price data for traded goods, adjusted taxes, duties, transport and handling.

Table 10-1: Farm-gate Commodity Prices

(Cost in Rupees)

Item	Unit	KP	Punjab	Balochistan	Sindh	GB	FATA	AJ&K
Cotton	Ton	-	74,727	74,648	74,415	-	-	-
Rice	Ton	31,150	45,491	21,859	28,179	20,485	31,150	20,896
Maize	Ton	13,750	14,677	14,866	15,427	12,842	13,750	13,447
Wheat	Ton	30,279	29,352	29,162	28,602	31,187	30,279	30,581
Pulses	Ton	-	73,600	88,320	84,640	-	-	-
Oilseed	Ton	27,104	26,872	26,825	26,685	27,331	27,104	27,180
Vegetables	Ton	22,080	16,370	29,440	27,600	22,080	22,080	22,080
Fodder	Ton	2,480	1,930	2,580	2,210	2,480	2,480	2,480
Sugarcane	Ton	3,596	3,506	3,488	3,433	3,685	3,596	3,626
Orchards	Ton	27,600	29,440	36,800	29,900	23,000	27,600	25,760
Nitrogen	Kg	83.47	81.27	80.83	79.50	85.62	83.47	84.19
Phosphorus	Kg	82.06	80.72	80.45	79.64	83.37	82.06	82.50
Potash	Kg	75.61	73.59	73.18	71.96	77.59	75.61	76.27

Prices of non-traded goods and services are based on existing local market prices adjusted by standard conversion factor of 0.91. Farm labour is shadow prices at the rate of Rs.

262.50 per day reflecting the weighted opportunity cost of labour in slack periods. A discount of 25% on the market wage rate to unskilled labour for period of slake demand is considered. The derived farm-gate commodities prices for the flood protection projects for the seven provinces/ agencies are summarized in Table 10-1.

10.3 PROJECT BENEFITS

In the economic evaluation of any proposal for flood control, it is important to estimate the economic benefits from the protection provided by the proposed works. In principle benefits are measured by the amount of flood loses to be averted and reduced because of the project works. In physical terms flood benefits/damages are direct or indirect. Direct damages are sustained as a result of contact with flood water and may be caused by soaking, erosion wash-out or sediment deposition. Direct and indirect primary benefits under pre project and post condition have been calculated by developing flood damaging factors and flood prone areas to be inundated, eroded and reclaimed for proposed schemes in different agencies of Pakistan.

10.3.1 Flood Damage Factors

Flood damage is a parameter that represents direct loses per unit area from river spill/river erosion and reclamation of eroded land and is expressed in rupee per hectare flooded. Direct damages principally comprise damage to crop, private housing, infrastructure and other facilities, which are sustained as a result of contact with flood water. Indirect damages are caused by flooding but not by contact with flood water like loss of irrigation facilities in the downstream reaches due to suspension of irrigation supplies.

- Flood damage to standing crops during inundation against design flood have been estimated by considering the depth, duration and time of flooding, flood susceptibility of each crop, the farm cost and farm-gate prices. The estimated monthly economic value of potential yield loss is based on expected economic farm-gate gross revenue minus on-farm cost that would have been incurred post-dated to the flood event. The total value of monthly crop losses per hectare of Culturable Command Area (CCA) are estimated by considering the effects on each of the crops relative to the month of flooding and cropping pattern which are combined with monthly probability of flood occurrence to obtain crop losses per hectare of flooded area.

- Crop factor due to river erosion is based on analytical procedure that considers the cropping pattern, yield level, farm cost, farm-gate prices and cropping intensity. Gross margin per hectare is estimated to derive net potential of flood losses for Kharif and Rabi crops. These losses are combined with cropping pattern of respective problem area to get crop losses per hectare due to river erosion. Crop factor for reclaimed land is calculated by considering cropping and production level as exists in the adjacent area that may be achieved within next 10 index years after the completion of project works.

- Estimates of non-crop direct damages due to inundation/erosion are derived from the concentration of housing, road and railway infrastructure with in the area protected by the project on unit area basis. Flood damage factors for houses and infrastructure are estimated by considering the composition, density and unit cost of replacement in each area.

- Other direct inundation/erosion factors covering damages to irrigation network, water supply, electrical distribution systems, telecommunication, etc. are estimated assuming a ratio of crop/housing/road and rail damages to total direct damages 1:1.2.

- Indirect damages of inundation/erosion which result from the disruption of economic and physical linkage on or adjacent to the flood plain are estimated at 10 percent of the total direct damages.

Flood damage factors estimated for all agencies of Pakistan (Four Provinces, Gilgit-Baltistan, FATA and AJ&K) are summarized in Table 10-2 for inundation and erosion of area.

Table 10-2: Flood Damage Factors by Provinces/Agencies in Project Area

(Rupees per Hectare)

Sr. No.	Name of Province/Agency	Crops	Private Housing	Infrastructure	O. Direct Damages	Indirect Damages	Composite Factor
Inundation Factors							
1	Khyber Pakhtunkhwa	9,522	23,717	3,002	7,248	4,349	47,838
2	Punjab	31,149	57,343	6,355	18,969	11,382	125,198
3	Balochistan	65,684	21,639	4,759	18,416	11,050	121,548
4	Sindh	38,278	26,480	8,545	14,661	8,796	96,760
Weighted Average Pakistan		**37,361**	**33,368**	**5,853**	**15,317**	**9,190**	**101,089**
Erosion Factors							
1	Gilgit-Baltistan Region	41,509	30,140	13,991	15,036	9,022	109,698
2	Azad Jammu & Kashmir	24,352	51,205	22,845	19,680	11,808	129,891
3	FATA	20,101	11,096	4,569	7,153	4,292	47,211
4	Khyber Pakhtunkhwa	15,870	23,717	3,002	8,518	5,111	56,217
5	Punjab	56,754	83,532	12,709	30,599	18,360	201,955
6	Balochistan	82,588	34,611	9,517	25,343	15,206	167,265
7	Sindh	47,790	82,220	17,089	29,420	17,652	194,171
Weighted Average (Pakistan)		**31,343**	**37,965**	**11,231**	**15,870**	**9,522**	**105,931**

10.3.2 Benefitted Areas

The benefited areas of proposed flood protection schemes located in all the seven agencies of Pakistan have been taken for calculating the benefits on account of protection/avoidance from inundation, erosion and reclamation of eroded land as given in Table 10-3.

Table 10-3: Benefited Areas by Provinces/Agencies

(Area in Hectare)

Sr. No.	Name of Province/Agency	Protection from Inundation	Protection from Erosion	Reclaimed Area	Total Area Benefited
1	Gilgit-Baltistan Region	-	8,822	1,917	10,739
2	Azad Jammu & Kashmir	-	9,930	2,376	12,307
3	FATA	-	44,527	17,505	62,032
4	Khyber Pakhtunkhwa	273,670	558,941	78,665	911,276
5	Punjab	736,313	191,337	60,423	988,074
6	Balochistan	50,394	48,565	15,725	114,685
7	Sindh	1,439,173	-	-	1,439,173
8	**Pakistan**	**2,479,555**	**779,250**	**154,176**	**3,538,285**

10.3.3 Summary of Benefits

The actual maximum potential benefits on account of avoidance of land erosion and restoration of crop production on reclaimed land are estimated as Rs. 82,547 million and Rs. 6,017 million in the seven agencies respectively under post project condition. Whereas annuitized benefits on account of protection from inundation are estimated as Rs. 16,223 million. It is assumed that maximum prevention of land erosion and full development on reclaimed land will be achieved in 10th year of development. Therefore, the benefits are interpolated in first 10 years of development. The benefit due to contribution of inundation are assumed to increase at an annual average rate of three percent due to expected real increase in crop prices, continued growth rate trends in crop yields, increases the value and intensity of infrastructure protected, and continued growth in population, housing and infrastructure development in project areas up to 10 year beyond which it will remain constant. The summary of project benefits for seven provinces/agencies is given in Table 10-4.

Table 10-4: Project Benefits

(Cost in Million Rupees)

Sr. No.	Province/ FLA	Avoidance of Inundation	Prevention of Erosion	Reclamation of Area	Total
1	GB	0	968	65	1,033
2	AJ&K	0	1,290	58	1,348
3	FATA	0	2,102	245	2,348
4	KP	847	31,422	1,306	33,576
5	Punjab	5,966	38,641	3,429	48,037
6	Balochistan	396	8,123	913	9,433
7	Sindh	9,013	0	0	9,013
8	**Pakistan**	**16,223**	**82,547**	**6,017**	**104,787**

10.4 PROJECT COST

The costs of schemes considered in NFPP-IV aggregated to Rs. 332,243 million at 2017 price level with 10 years implementation period.

The financial costs are converted to economic costs after excluding transfer payments and adjusting by appropriate conversion factors. The estimated economic costs are rupees 245,297 million as given in Table 10-5. The economic value of annual incremental operation and maintenance is calculated as rupees 4,906 million annually.

Table 10-5: Project Economic Cost of Investment Plan

(Cost in Million Rupees)

Sr. No.	Provinces/ Agencies	Estimated Cost	Ten Years Investment Plan									
			Year-1	Year-2	Year-3	Year-4	Year-5	Year-6	Year-7	Year-8	Year-9	Year-10
1	GB Region	3,656.8	717.6	1,023.3	853.5	595.8	466.6	-	-	-	-	-
2	AJ&K	4,523.5	1,103.7	1,470.6	981.2	544.8	423.0	-	-	-	-	-
3	FATA	5,189.5	1,027.7	1,354.0	1,213.8	916.2	677.7	-	-	-	-	-
4	KP	71,440.8	5,058.8	5,725.5	4,549.4	2,525.7	1,224.1	15,485.8	12,979.3	10,469.8	7,964.8	5,457.5
5	Punjab	74,636.2	9,096.6	12,855.3	7,196.9	4,056.2	2,091.6	9,784.7	8,826.4	7,867.3	6,909.7	5,951.4
6	Balochistan	24,393.4	4,155.8	6,395.1	4,673.4	2,966.4	1,944.6	1,277.2	1064.6	851.2	638.6	425.9
7	Sindh	28,912.6	6,370.1	8,580.5	6,677.2	3,138.5	1,708.4	7,31.7	609.8	487.3	365.5	243.6
8	**Pakistan**	**245,297**	**31,677.4**	**42,149.5**	**9,985.5**	**29,995.5**	**16,064.0**	**31,831.2**	**27,687.8**	**22,864.7**	**18,130.9**	**13,615.1**

Note: Overall cost include all seven provinces/agencies and FFC, NDMA, CCD and Pakistan Railway.

11. CONCLUSIONS AND RECOMMENDATIONS

11.1 NON-STRUCTURAL MEASURES

11.1.1 Watershed Management

i. Establish Watershed Management Departments/Agencies with the relevant provincial Governments like Gilgit-Baltistan, Azad Jammu and Kashmir and Balochistan and strengthen department in KP through necessary legislation.

ii. Re-forestation, soil conservation and improvement in land use in the watersheds should be promoted.

iii. Formulate watershed management policy and carry out necessary legislation at national level as well as provincial level and implement forcefully.

iv. Ensure effective enforcement of the existing laws and regulations on forests use and management and involvement of the communities in the policy making process from the very outset enables the government to address and arrest sharp forest decline by creating a feeling of sense of ownership and empowerment among communities.

11.1.2 Global Warming and Climate Change

i. Take measures to control the release of carbon dioxide by vehicles, factories etc., through strict implementation of laws and imposing penalties to prevent the excessive smoke producing vehicles to be on road especially diesel consuming vehicles like buses, truck etc.

ii. Raise the standard of population living below the line of poverty by proving them electricity and Sui gas so that to avoid burning of wood for cooking of their meals and heating of their livings to fight against cold weather.

iii. Prevent excessive grazing and deforestation and cutting of trees.

11.1.3 Revision of SOPs for Operation of Major Reservoirs

i. Existing reservoir operational rules (SOPs) for Mangla and Tarbela needs to be further reviewed particularly for Tarbela in the light of 2010 and 2014 floods to ensure efficient control of floods in order to provide maximum relief to downstream areas.

11.1.4 Environmental Management

i. Environmental problems vary from area to area within the country and even within city as well, thus there is need to investigate them locally.

ii. Deforestation should be discouraged not only in the uplands of rivers but all over in the country.

iii. Rules and laws are required to be formulated and implemented at Government level to improve the environmental resilience.

iv. Awareness and trainings to community to strengthen resilience and education curriculum at university levels should have some space for environmental related issues related to disasters in general and floods in particular.

v. Institutional framework for environmental issues in country is the need of time, government organizations/institutions at local level should be equipped to deal with environmental degradation caused by adverse impacts of floods, for the purpose Ministry of Climate change and Pakistan Meteorological department should play role for awareness of the environmental degradation to the communities and there is a need to involve all the stakeholders (PIDs, NDMA, PDMA, DCO'S) for better planning and execution of plans made for environmental resilience.

11.1.5 Financial Resource Management

i. There is need for designing a strategy to ensure the proper utilization of funds, this helps to evade situations in which the funds remain idle or lack of profitable utilization of funds in hand, while availing of funds, it is important to understand the involved cost and risk factors and any sort of wastage of funds needs to be avoided.

ii. There is need to strengthen the existing accountability laws and ensure implementation forcefully without any of interference, political or otherwise.

iii. Explore all possible means of gathering the financial resources required for flood management and flood relief, some of the possible sources other than federal grants and donations from local and international donors for the financial sustainability of flood management include; Cess on irrigated land in general at the rate of Rs. 1500 per acre should be levied (part of it can be used for flood protection works), Cess on areas / land benefitting from development schemes, Cess on big cities under protection may be a part of utility bills, Cess on commercial activity in the river areas, property tax collected from the flood protected commercial establishments, proceeds of sand excavation leases, proceeds of sale / auction of timber collected from river, licensing / registration fees of commercial activities on river bank areas, licensing / registration fees of navigational activities of rivers, contribution by Provincial and Local Governments; and contributions by high income groups in vulnerable areas.

11.1.6 Flood Forecasting and Warning Systems

i. Flood Early Warning System (FEWS-Pakistan) needs to be up-graded on immediate basis for inclusion of catchment area upstream of Tarbela dam, updating of existing river and floodplain geometry, study on Radar calibrations, enhancement in reliability of Quantitative Precipitation Forecast through meteorological studies and training of PMD professionals. Reliable and accurate QPF estimate can enhance lead times for forecast of flash floods.

ii. Expansion and up-gradation of existing gauging network, radars network and telemetry network under PMD and WAPDA is required on priority basis.

11.1.7 Floodplain Policies and Legislation

i. ‘River Act’ for the rivers floodplains has been formulated during current NFPP-IV studies keeping relevant stakeholders on board and there is strong need to carry out necessary legislation at provincial as well as well federal level. Provinces may modify it according to their requirements, from river to river.

ii. There is strong need to implement the ‘River Act’ in its real sense and spirit for removing encroachments, permanent settlements and undue developments in the floodplains so that flood damages can be reduced.

11.1.8 Floodplain Mapping and Zoning other than Indus River and its Tributaries

i. There is strong need to investigate the requirement of Floodplain Mapping and Zoning in the areas other than Indus River and its tributaries. These areas may include floodplains of rivers and major streams/Nullahs in Punjab, Khyber Pakhtunkhwa and Balochistan. For this purpose, provincial governments should carry out necessary investigations and studies at their own resources.

11.1.9 Community Awareness and Preparedness

i. Governmental role in enhancing awareness and preparedness in community to fight against floods should be significant.

ii. PIDs, NDMA, PDMA, DDMA and district management etc., should play active role through workshops, electronic and print media to create awareness in flood prone communities for preparing them to fight against floods and its after affects, awareness about encroachments and un-planned developments in floodplain areas resulting huge damages to their lives and property,

iii. Keeping in view the flood situation, flood events, social problems and government limited resources, there is need to improve the present traditional attitudes of community and concrete steps should be taken to legislate for restriction of permanent settlements in floodplains and enhance the awareness and preparedness to cope the emergency situation.

11.1.10 Institutional Capacity Building

Capacity building and training of FFC, PIDs, NDMA, PDMAs, PMD, WAPDA, NHA and Pakistan Army formations dealing with floods is recommended on priority basis.

11.2 STRUCTURAL MEASURES

11.2.1 Flood Protection Works

i. Minor repairing, strengthening and up-gradation of existing flood protection works of minor scale need to be carried out on immediate basis through federal/ provincial (NFPP-IV) resources to protect the population and infrastructure against flood threat.

ii. Major repairing and large scale restoration of existing flood protection works needs to be carried out by federal financing that will be assessed accordingly after heavy floods for which assessment is provided in the cost provisions.

iii. The need for new flood protection works have been identified along with cost provision and federal agencies/government should arrange funding for their design and construction as per implementation schedule of NFPP-IV. Due to changes in river morphology after major floods in future, need of some new flood protection schemes may emerge, for which provision as “un-allocated” has been made in NFPP-IV against program of works, separately for each provisions.

11.2.2 Rehabilitation and Capacity Enhancement of Barrages/Bridges

i. Rehabilitation and capacity enhancement of barrages and bridges needs special attention for their immediate execution. Necessary provisions for their studies and implementation have been made in the current NFPP-IV.

11.2.3 Dams and Storages

i. Major reservoirs need to be investigated and constructed on priority basis to preserve the flood water to substantiate irrigation flows and controlled releases to check seawater intrusion. Construction and operation of reservoirs is under WAPDA jurisdictions and need Federal government's attention for necessary approvals, settlement of political and technical issues with the provinces and arrangement of funds.

ii. Analysis indicate that small dams have substantial potential in mitigating flood peaks from their respective catchments. It is recommended to consider various small dams in KPK, AJ&K, Punjab and Balochistan for cumulative impact on flood mitigation. The list of small dams is given in Task-A report. The pre-feasibility/feasibility studies on these dams may be taken-up by the provinces at their own resources.

11.2.4 Breaching Sections at Barrages/Bridges and Flood Escape Channels

i. It is highly recommended to conduct a comprehensive study of all existing breaching sections to ascertain their effectiveness and possible flow paths, flow depths, velocities and inundation extents of breach flood flows.

ii. Feasibility study for identification of route of flood escape channel, conducted by Government of Sindh, should be further investigated for finalization of route and with respect to i) the cost of resettlement of population and relocation of major infrastructure to route the escape channel and at the disposal location, ii) confirmation of performance of intake structure (head regulator of proposed diversion channel) to draw the proposed flood magnitude, and iii) confirmation of conveyance capacity through numerical and physical model tests.

iii. Adequate conveyance capacity within the river and urban channels needs to be restored by removing bottle necks and encroachments.