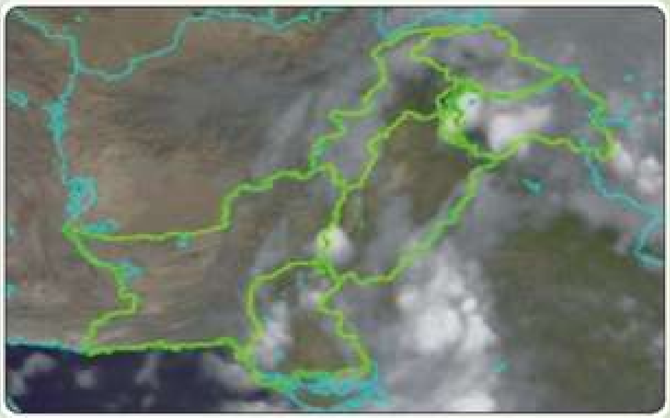
N D M P

NATIONAL DISASTER MANAGEMENT PLAN

Volume - II

National Multi-Hazard Early Warning System Plan



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PREFACE

The National Disaster Management Plan (NDMP) is a milestone in the history of the Disaster Management System (DRM) in Pakistan. The rapid change in global climate has given rise to many disasters that pose a severe threat to the human life, property and infrastructure. Disasters like floods, earthquakes, tsunamis, droughts, sediment disasters, avalanches, GLOFs, and cyclones with storm surges are some prominent manifestations of climate change phenomenon. Pakistan, which is ranked in the top ten countries that are the most vulnerable to climate change effects, started planning to safeguard and secure the life, land and property of its people in particular the poor, the vulnerable and the marginalized. However, recurring disasters since 2005 have provided the required stimuli for accelerating the efforts towards capacity building of the responsible agencies, which include federal, provincial, district governments, community organizations, NGOs and individuals.

Prior to 2005, the West Pakistan National Calamities Act of 1958 was the available legal remedy that regulated the maintenance and restoration of order in areas affected by calamities and relief against such calamities. An Emergency Relief Cell within the Cabinet Division has been serving since 1971 as an institutional disaster relief support at the national level. Similar institutional arrangements existed at the provincial level in the form of relief commissioners. However, that regime provided a reactive approach towards emergency response only.

The United Nations International Strategy for Disaster Reduction (UNISDR) introduced the paradigm shift from a reactive to a proactive approach in the form of the Hyogo Framework of Action (2005-2015) signed by 168 countries including Pakistan. To fulfill the global obligations as well as to cope with the challenges emerged in the aftermath of the October 2005 earthquake, the Government of Pakistan promulgated the National Disaster Management Ordinance in 2007 to introduce a comprehensive National Disaster Management System in the country. The Ordinance became the Act called the National Disaster Management Act in December 2010. The Act establishes three tiers for the disaster management system: i.e., national, provincial and district levels.

Under the Act, the National Disaster Management Commission (NDMC) was established at the national level, and has the responsibility for laying down policies and guidelines for disaster risk management and approval of the National Plan. The National Disaster Management Authority (NDMA) was subsequently established in 2007 in line with the Act, and serves as the implementing, coordinating and monitoring body for disaster risk management at the national level. Along with the Ordinance (now Act), the National Disaster Risk Management Framework (NDRMF) was prepared by the NDMA in March 2007. The NDRMF served as an overall guideline for disaster risk management at national, provincial and district levels. In March 2010, the NDMA formulated the National Disaster Response Plan (NDRP) identifying specific roles and responsibilities of the relevant stakeholders in emergency response including Standard Operation Procedures (SOPs).

Concurrently, NDMA, in collaboration with national and international partners, had been in the process of strengthening the DRM system in the country. In order to support this new approach in Pakistan, the Japan International Cooperation Agency (JICA) dispatched a series of missions from the year 2008 to 2009 based on the request from the Government of Pakistan. It studied the whole legal and administrative system of DRM in Pakistan and held meetings with all stakeholders to identify the needs and requirements to enhance the capacity of the national DRM system. Based on thorough bilateral consultations, a project document on formulation of a National Disaster Management Plan (NDMP) for Pakistan was conceived for implementation through Japanese Grant-in-Aid. A PC-II was prepared accordingly and was approved by the Planning Commission in the meeting of Central Development Working Party held on 19-11-2009. For implementation through Grant-in-Aid, the scope of work for the project was discussed, agreed and signed between the Government of Pakistan and JICA on 11-12-2009 and the project Inception Report was prepared in April 2010. The Plan, aimed at enhancing the capacity of the country to prepare for and respond to disasters by defining the measures to be considered necessary for disaster management and risk reduction in line with the provision of the National Disaster Management Act (Chapter II, Section 10), was finalized in June 2012.

The overall NDMP is a comprehensive plan, having a total investment cost of USD 1040.9 million (PKR 92.02 Bn with 1 USD = PKR 88.4), consisting of the "Main Plan" document along with three supporting volumes besides the Executive Summary, which identifies macro level hazards and risk assessment, development of the multi hazard early warning system to reduce the vulnerability to disasters by enhancing and strengthening the early warning capacity, identification of the roles and responsibilities of the stakeholders, including federal, provincial and district governments, community organizations, NGOs, businesses, and individuals who are involved in the disaster management. The Community Based Disaster Risk Management (CBDRM) approach, in view of its universal reorganization and importance in DRM planning, has been given due place in the Plan. Based on pilot activities tested in different hazard contexts and social settings, best practices and guidelines have been documented in the Plan to serve as models for future CBDRM activities in Pakistan. The Plan also provides strategic direction for systematic human resource development in the field of disaster management and the operational plan for the National Institute of Disaster Management (NIDM).

The components of NDMP published in one main document with three supporting volumes, besides the Executive Summary, are entitled:

• National Disaster Management Plan	Main Plan
• Human Resource Development Plan on Disaster Management	Vol. I
• Multi-Hazard Early Warning System Plan	Vol. II
• Instructors' Guidelines on Community Based Disaster Risk Management	Vol. III

Multi-Hazard Early Warning System Plan (Volume II)

The Plan consists of two parts. Part I is an introduction and Part II consists of the contents of the Plan

PART I INTRODUCTION

1. Background

Pakistan is vulnerable to natural disasters from a range of hazards including floods (river/flash /coastal floods and other floods due to storm and cyclone with storm surge), cyclones, droughts, earthquakes, glacial lake outburst floods (GLOFs), landslides, avalanches and tsunamis, together with appurtenant secondary disasters, e.g., river erosion, waterborne diseases and epidemics after natural disasters, pest attacks, oil spills, forest fires, etc.

The need to establish multi-hazard early warning systems (EWSs) that decrease personal and economic damages by informing the populous of disasters in advance has become a serious consideration in recent years. Until now, however, technical efforts in multi-hazard EWS have often resulted in systems that are not fully functional because of multiple reasons e.g inadequate human and technical capacities, insufficient cooperation among the agencies concerned, ignorance about the significance of EWS on the part of communities, and lack of experience-based know-how with no record of the historical or cultural background in areas of disaster prevention. For the reduction of vulnerabilities and risks to natural disasters, a multi-hazard EWS is proposed as the fundamental measure against floods, GLOFs and sediment disasters, including landslide, cyclone with storm surge, drought and tsunami.

2. Vision/Goals of Multi-Hazard Early Warning System Plan

The vision of the Multi-Hazard EWS Plan is to reduce the vulnerability to natural disasters by enhancing and strengthening the early warning capacity against multiple hazards due to natural disasters so that the overall vision of formulation of the Disaster Management Plan would be achieved. The Multi-Hazard EWS Plan shall support and lead each activity smoothly for early warning at the national level; whereas, the establishment of a Multi Hazard EWS is a condition precedent to the operation of mitigation systems against possible damage arising from the occurrence of natural calamities.

3. Composition of the Multi-Hazard Early Warning System Plan

The structure of multi-hazard early warning system plan consists of salient items as shown in Table 1.

Table 1 Salient Items of Multi Hazard EWS Plan

Salient Item	Section
Introduction	1.1 Introduction
	1.2 Hazards Targeted in the Proposed Multi-Hazard Early Warning System Plan
Goal of the Multi-hazard Early Warning System Plan	2.1 Vision and Goals of Multi-Hazard Early Warning System Plan
	2.2 Implementation Policy
Existing Conditions	3.1 Current Meteorological Observations and Common Policy of Alerts
	3.2 Current Seismic Observations
	3.3 Review on Current SOPs and Dissemination System
	3.4 Current Information and Communication System Situation
	3.5 Current Education System Situation regarding EWS in Pakistan
	3.6 Summary of Hazard and Risk Assessment
Planning Issue, Challenges, and Conceivable Projects	4.1 Introduction
	4.2 Planning MHEWS
Planning Framework	5.1 Introduction
	5.2 Programs and Projects Proposed in the Multi-Hazard EWS Plan
	5.3 Prioritized Multi-Hazard EWS
	5.4 Proposed Implementation Scheme
Scope of Feasibility Study	6.1 Introduction
	6.2 General Scope of Feasibility Study
	6.3 ToR of the Feasibility Study on Multi-Hazard EWS in Pakistan

PART II CONTENTS OF THE PLAN

1. Implementation Policy

Target Year

The target year for the establishment of the Multi-Hazard EWS Plan is set for 2022 (10 year implementation) with the framework subject to review every five years.

Basic Implementation Framework

The implementation of the Multi-Hazard EWS Plan has been categorized into the short to medium term, long term and other recognized super long term projects. The short to medium term projects shall consist of rehabilitation and new installation and/or establishment of new equipment, facilities and systems including social programs (CBDRM) urgently required within 2-3 years as the priority projects. The long-term projects shall also consist of strengthening and improvement or new establishment of equipment and facilities including the systems required within 6-7 years as priority projects with feasibility study to be executed. In addition, the plan framework, including super long-term projects, shall cover the overall Multi Hazard EWS projects or components proposed in this plan as shown in Table 5 below.

Table 2 Target Year of Multi-Hazard EWS

Plan	Year
Framework (Whole Plan)	2022
Short to Medium Term Projects/Studies	2015
Long Term Projects/Studies	2018
Interim Evaluation of Plan	2016

2. Planning Framework

1) Strategy

The strategies to be adopted for the Plan over the next ten years are given in Table 3 below.

Table 3 Strategies for Multi-Hazard EWS

No.	Strategy
Strategy 1	Strengthen weather forecasting & early warning systems
Strategy 2	Prepare hazard maps at local scale in targeted locations
Strategy 3	Strengthen early warning dissemination systems
Strategy 4	Develop capacity of early warning & evacuation systems

2) Relevant and Responsible Agencies

The activities for the Multi-Hazard Early Warning System should be executed with the involvement of a number of stakeholders so that effective operations resulting in numerous benefits are expected in the cycle of the whole system. In this regard, the agencies given in Table 4 below shall be involved.

Table 4 Relevant and Responsible Agencies

Category	Relevant and Responsible Agencies
Central Government	NDMA, FFC, PMD, WAPDA, GSP, PCIW, Army, NIO, IRSA, SUPARCO, ERRA, Planning Commission, MWP
Provincial Government	F/G/S/PDMAs, PIDs, Civil Defence, Rescue 1122 (Fire Brigades), Police, Department of Information / C&W/ Health and Social Welfare
District Government	DDMAs (DCs/DCOs, Revenue Offices, etc.), Police, C&W, Civil Defence, TMAs, CDGs, Tehsils, UCs
Others	NGOs, INGOs, Mosques, Schools, Media, PRCS

3) Basic Communication Routes

The warnings and alerts shall all be disseminated to related agencies and vulnerable districts (DDMAs) likely to be affected by the expected disasters. As basic policy, PMD and agencies observing essential data regarding disasters shall directly issue the warning(s) to DDMAs and other related agencies

DDMAs to which the warnings are issued by PMD should disseminate the information on magnitudes and significance of anticipated hazards based on the District Disaster Management Plans (DDMPs) and contingency plan(s) for expected disaster(s) without any delay.

Media, particularly electronic media (TV and radio stations), should play an important role as disseminating agencies in the EWS. Media shall send warning messages in a ticker or news flash in accordance with the request from PMD and/or NDMA/ F/G/S/PDMAs /DDMAs.

4) Basic Communication Mode

The communication mode for all types of EWSs should be multiplexed to secure reliable communication and information between early warning agencies (PMD) and end users (communities and vulnerable persons).

The available modes should be adopted as much as possible. The main mode(s) for each EWS to be used are Phone/Fax, Siren, Media (Radio/TV), SMS, Internet by Virtual Private Network (VPN) and Public Address Systems by CDMA, DDMAs, Civil Defence, Police, Fire Brigade etc.

Basically, current warning communication criteria should be sustained to avoid any confusion or complicated situations because current criteria have no fatal errors for sending warnings against targeted disasters from the engineering and social points of views. However, the criteria of the warning communication shall be reviewed annually by the PMD and the revision of warning criteria shall be concurred with by NDMA/ F/G/S/PDMAs when the revisions are required based on the propriety evaluation and verification to be conducted by the PMD.

5) Policy on Outline of System Formulation

Observed data related to the forecast approach can be transmitted by appropriate communication systems in terms of reliability, economic efficiency and maintenance aspects. The General Packet Radio Service (GPRS) with Internet, SMS, Meteor Burst Communication, H.F. Radio Wave and satellite V-Sat shall be adopted for the data transmission from meteorological observation equipment. The Plan proposes not only mere improvement with its extension of capacity, but also shifting of warning contents from qualitative to quantitative forecasts.

6) Cooperation and Coordination in Other Related Activities

The Multi-Hazard EWS would not be appropriately operated alone and its effectiveness would be reduced if the acceptance and orientation of the EWS are not recognized by target communities. The suitable operation of the EWS could be achieved in collaboration with other related activities on a routine basis.

In addition to innovation and enhancement of the Multi-Hazard EWS based on review of the current EWS, it is essential to undertake the following activities for more efficient operation of the system:

- Preparation of Hazard Maps
- Enhancement of DRM Education and Public Awareness (Enlightenment) regarding EWS
- Capacity Development of the Staff of Early Warning Agency(ies)

3. Programs and Projects Proposed in the Plan

The proposed programs and projects to be implemented under the plan are given in the Table 5 below.

Table 5 List of the Projects and Programs

Priority-1 (Short to Medium Term Projects/Studies)	**Related Strategy No.**
1-1 Establishment of Specialized Medium Range Forecasting Centre, including Appurtenant Facilities	1, 3
1-2 Establishment of (Additional) Upper-Air Observation Systems	1
1-3 Replacement of Existing Radar Stations Phase-I - Islamabad Radar Station - Karachi/Badin/Thatta Radar Station	1
1-4 Strengthening of Flood Forecasting by Satellite Info. and Hazard Maps of Indus River	1
1-5 Establishment of Communication System between PMD and NDMA	3
1-6 Development of the EWS National Plan, Guidelines and SOPs for HEPR	3
1-7 Establishment of New Meteorological Radar Stations Phase-1 (for Cherat)	1
Priority-2 (Long Term Projects/Studies with F/S)	**Related Strategy No.**
2-1 Tsunami Simulation and Hazard Maps	2
2-2 Expansion of AWS Network including Communication System	1
2-3 Establishment of New Meteorological Radar Stations Phase-II (Pasni/Gwadar) with Finalization of Cyclone EWS SOP	1, 3
2-4 Establishment of Regional Flood Forecasting Warning Centres	1
2-5 Expansion of Rainfall and Water Level Observation Network	1
2-6 Establishment of Local Flash Flood Forecast and Warning System (LFFFC) w/ Hazard Map Phase-I	1, 2
2-7 EWS for GLOF and Snowmelt Flash Flood w/ Hazard Maps	1, 2
2-8 Research Activities for Snow/Glacier/Glacial Lakes	1, 4
2-9 Preparation of Landslide Hazard Maps	1, 2
2-10 Establishment of Communication System among DMAs (NDMA- F/G/S/PDMAs -DDMA)	3
2-11 Establishment of Weather Forecast Guidance System	1, 4
Priority-3 (Super Long Term Projects/Studies with F/S)	**Related Strategy No.**
3-1 Establishment of New Meteorological Radar Stations Phase-III (for Chitral and Quetta)	1
3-2 Additional Installation of AWS for the Observation of Basic Meteorological Data	1
3-3 Establishment of Local Flash Flood Forecast and Warning System (LFFFC) w/ Hazard Map Phase-II	1, 2
Priority-4 (Super Long Term Projects/Studies with F/S)	**Related Strategy No.**
4-1 Replacement of Existing Radar Stations Phase-II (D. I. Khan and Rahim Yar Khan Radars)	1
4-2 Establishment of New Meteorological Radar Stations Phase-IV (for D. G. Khan and Sukkar)	1
Priority-5 (Super Long Term Projects/Studies with F/S)	**Related Strategy No.**
5-1 Establishment of Tide Monitoring Network	1
5-2 Establishment of Seismic Intensity Reporting System	1
5-3 Establishment of Landslide EWS	1
5-4 Establishment of Avalanche EWS	1
Recurring Activities	**Related Strategy No.**
R-1 Education Program for Meteo-Hydrology for PMD Staff	4
R-2 Enhancement of Community Enlightenment regarding EWS with training and drills	4

4. Implementation Cost

Priority wise estimated cost for implementation of projects is given in Table 6. Table 7 (a) indicates overall cost of NDMP while Table 7 (b) gives cost of MHEWS (Vol-II).

Table 6 Assumed Cost of Projects/Programs

Priority Projects	Estimated Cost (million PKR)
Priority-1	3,226
Priority-2	5,535
Priority-3, 4 and 5	7,330
Recurring Activities	570
Total	16,661

(US $ 188.5) 1USD=88.4PKR

Table 7 (a) Priority Actions/Programs for the Next Ten Years (2012-2022)

Strategy	app. Cost (million USD)	Time Frame									
		Phase 1				Phase 2			Phase 3		
		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
4.1 Intervention-1: Establish the Institutional and Legal System for Disaster Management											
1. Establish and function disaster management organizations at national, provincial and district levels.	2.0	■	■								
2. Formulate disaster management operation plans for relevant organizations.	0.2	■	■								
3. Implement periodic meetings among the disaster management organizations to monitor the situations.	0.1	■	■								
4. Implement drills and training of disaster management activities in the organizations to improve their capacities.	-	■	■								
4.2 Intervention-2: Prepare Disaster Management Plans at Various Levels											
1.Formulate and update disaster management plans at national, provincial, district and community or TMA levels.	1.0	■	■	■	■	■	■	■	■	■	■
2.Develop hazard specific contingency plans.	1.0			■	■	■	■				
3.Develop sectoral disaster risk management operation in federal ministries, departments and authorities.	1.0	■	■	■							
4.3 Intervention-3: Establish national hazard and vulnerability assessment											
1.Conduct detailed multi–hazard vulnerability and risk analysis/assessments at national level	14.0		■	■	■		■				■
2.Conduct detailed multi–hazard vulnerability and risk analysis/assessments at local level	5.0	■	■			■	■			■	■
3.Conduct research and studies on impact of climate change on glaciers and ice cap	5.0	■	■								
4.4 Intervention-4: Establish multi-hazard early warning and evacuation systems											
1.Strengthen forecasting and early warning systems	168.5	■	■	■	■	■	■	■	■	■	■
2.Prepare hazard maps at local scale in targeted locations	5.7	■	■	■	■	■	■				
3.Strengthen early warning dissemination systems	3.1			■	■	■					
4.Develop capacity of early warning and evacuation systems	11.2	■	■	■	■	■	■	■	■	■	■
4.5 Intervention-5: Promotion of training, education and awareness in relation to disaster management											
1. Develop NIDM (National Institute of Disaster Management) to promote human resource development in the field of disaster management.	20.7	■	■	■	■	■	■	■	■	■	■
2. Enhance the capacity of government agencies in charge of disaster management.	12.9	■	■	■	■	■	■	■	■	■	■
3. Promote mainstreaming DRR through capacity enhancement of governmental officers.	2.6			■	■	■	■	■	■	■	■
4. Develop the capacity of communities to cope with disasters.	26.2	■	■	■	■	■	■	■	■	■	■
5. Raise people's awareness of disaster management.	1.9	■	■	■	■	■	■	■	■	■	■
4.6 Intervention-6: Strengthen awareness program on disaster risk reduction at local level											
1. Enhance knowledge on disasters management in the general public	1.0	■	■	■	■	■	■	■	■	■	■
2. Establish safe evacuation places in the case of disaster situation	10.0			■	■	■	■	■	■	■	■
3. Implementi and disseminate CBDRM activities	1.0	■									
4. Disseminate self help and mutual help efforts in disaster management	1.0	■	■	■	■	■	■	■	■	■	■
5. Establish disaster mitigation measures incorporated with existing development program	1.0	■	■	■	■	■	■	■	■	■	■
4.7 Intervention7: Infrastructure development for disaster risk reduction											
1. develop schools, hospitals and other important public facilities with safe against disasters	100.0	■	■	■	■	■	■	■	■	■	■
2. Protect imprtant coastal facilities against disasters taking into account climate change	21.0	■	■	■	■	■					
3. Enforce the building code in construction of buildings	10.0	■	■	■	■	■	■	■	■	■	■
4. Implement appropriate structural measures in flood prone areas taking into account comprehensive and integrated flood management plans	565.6	■	■	■	■	■	■	■	■	■	■
5. Enhance disaster risk management capacity in urban areas	11.0		■	■	■	■	■	■			
4.8 Intervention-8: Mainstreaming disaster risk reduction into development											
1. Establish disaster risk reduction policies in National Development Plan and National Poverty Reduction Strategy	-	■									
2. Set up sectoral guidelines on mainstreaming disaster risk reduction	1.0	■									
3. Establish criteria to assess development projects from a risk reduction perspective	0.2		■	■	■						
4. Improve technical capacity of federal and provincial governments to integrate risk reduction into development plans and programs	-		■	■							
4.9 Intervention-9: Establish national emergency response system											
1.Establish and strengthen warehouse or stockpiling system for storing food, medicine, relief supplies and rescue equipments.at strategic locations	10.0	■	■	■	■						
2.Enhance emergency response capacities, such as emergency operation centers, Civil Defence and urban search and rescue teams in major cities.	10.0			■	■	■	■	■	■	■	■
3.Establish a robust communication system and efficient transport and logistics mechanism to be used during emergency situations.	6.0		■	■	■	■	■				
4.Develop and implement emergency response plans in relevant ministries and departments at federal, provincial and district levels	5.0			■	■	■	■	■			
5.Establish an National Disaster Management Fund to enable the federal government to organize emergency response effectively.	-										
4.10 Intervention-10: Capacity Development for Post Disaster Recovery											
1. Prepare guidelines for post disaster recovery programs and activities	1.0	■									
2. Develop capacity of stakeholders in post disaster recovery	3.0		■	■	■	■	■	■	■	■	■
3. Develop system and methodology for recovery needs assessment	1.0		■								
Total Cost (million USD)	**1,040.90**										
Total Cost (billion PKR)	**92.02**										

1USD=88.4PKR

Table 7. (b) Priority Actions/Programs/Cost of MHEWS for the Next Ten Years (2012-2022)

Strategy	app. Cost (million USD)	Time Frame									
		Phase 1				Phase 2			Phase 3		
		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
4.4 Intervention-4: Establish multi-hazard early warning and evacuation systems											
1.Strengthen forecasting and early warning systems	168.5										
2.Prepare hazard maps at local scale in targeted locations	5.7										
3.Strengthen early warning dissemination systems	3.1										
4.Develop capacity of early warning and evacuation systems	11.2										
Total Cost (million USD)	**188.50**										
Total Cost (billion PKR)	**16.66**										

1USD=88.4PKR

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LIST OF ABBREVIATION

AAS	Agro-Meteorological Advisory Service
ADB	Asian Development Bank
ADPC	Asian Disaster Preparedness Centre
ADSL	Asymmetric Digital Subscriber Line
AJ & K	Azad Jammu and Kashmir
AWO	Automatic Weather Observation
AWS	Automatic Weather Stations
BS	Basic Salary
CB	Cell Broadcast
CBDRM	Community-Based Disaster Risk Management
CBEWS	Community-Based Early Worming System
CD	Capacity Development
CDG	City District Government
CDWP	Central Development Working Party
CRED	Center for Research on the Epidemiology of Disasters
C&W	Communication & Works
C/P	Counter part
DC	Deputy Commissioner
DCO	District Coordination Officer
D/D	Detail design
DDMA	District Disaster Management Authority
DDMRP	District Disaster Risk Management Plans
DDMU	District Disaster Management Unit*
DEOC	Disaster Emergency Operation Centre
DEWS	Disease Early Warning System
DF/R	Draft Final Report
DG	Director General
D.G. Khan	Dera Ghazi Khan
D.I. Khan	Dera Ismail Khan
DIS	Disaster Information System
DM	Disaster Management
DMA	Disaster Management Authority
DRM	Disaster Risk Management
DRMP	Disaster Risk Management Plan
DTC	Diarrhea Treatment Centre
DTH	Direct-to-Home
DWD	National Meteorological Service of Germany
EM-DAT	The OFDA/CRED International Disaster Database
EOC	Emergency Operations Centre
ERC	Emergency Relief Cell
ERRA	Earthquake Reconstruction and Rehabilitation Authority
ETo	Reference Crop Evapotranspiration
EW	Early Warning
EWS	Early Warning System
F/G/S/PDMAs	FATA/Gilgit-Baltistan/State/Provincial Disaster Management Authorities
F/G/S/PEOCs	FATA/Gilgit-Baltistan/State/Provincial Emergency Operation Centres
FAB	Frequency Allocation Board
FATA	Federally Administrated Tribal Areas
FEWS	Flood Early Warning System
FFC	Federal Flood Commission
FFD	Flood Forecasting Division
FFEWS	Flood Forecasting And Early Warning System
FFWMCC	Flood Forecasting and Warning Master Control Centre
FFWS	Flood Forecasting Warning System
FPSP	Flood Protection Sector Projects
F/R	Final Report
F/S	Feasibility study
FT	Fault-Tolerant
FWFC	Flood Warning Forecasting Centre
GB	Gilgit Baltistan
GBDMA	Gilgit Baltistan Disaster Management Authority
GBDRMP	Gilgit Baltistan Disaster Risk Management Plan
GBR	Bundesanstalt für Geowissenschaften und Rohstoffe
GCISC	Global Change Impact Studies Centre
GFZ	Geo Forcheng Zentrum
GIS	Geographic Information System
GHQ	General Head Quarter
GLOF	Glacial Lake Outburst Flood
GMDSS	Global Maritime Distress Safety System
GME	Global weather forecast model (German Term)
GPS	Global Positioning System
GPRS	General Packet Radio Service
GPV	Grid Point Value
GSHAP	Global Seismic Hazard Assessment Program
GSM	Global System for Mobile Communications
GSP	Geological Survey of Pakistan
GTS	Global Telecommunication System
GTZ	German Society for Technical Cooperation (Deutsche Gesellschaft fur Technische Zusammenarbeit)
GUITAR	the Name of Tsunami Simulation Software by Germany
HEMIS	Health Emergency Management Information System
HEPR	Health Emergency Preparedness and Response
H. F.	High Frequency
HRD	Human Resource development for Disaster Management
HRDP	Human Resource Development Plans
HRM	High Resolution Model
H.R.P.T	High Resolution Digital Telemetry

* In case of KP, 'DDMA' may be read as 'DDMU'.

ICIMOD	International Centre for Integrated Mountain Development
IC/R	Inception Report
ICT	Islamabad Capital Territory
IDI	Infrastructure Development Institute
IFAS	Integrated Flood AnalysisSystem
IMG	Institute of Meteorology and Geophysics
INGOs	International Non-governmental Organizations
ICPT	International Centre for Theoretical Physics (Italy)
IPC	Inter-Provincial Coordination
IRSA	Indus River System Authority
ISDN	Integrated Services Digital Network
ITCZ	Intertropical Convergence Zone
IT/R	Interim Report
ITU	International Telecommunication Union
JICA	Japan International Cooperation Agency
JMA	Japan Meteorological Agency
KP	Khyber Pakhtunkhwa
KPT	Karachi Port Trust
LAN	Local Area Network
LFFFC	Local Flash Flood Forecasting Centres
LFFFWC	Local Flash Flood Forecasting Warning Centre
MSA	Maritime Security Agency
MB	Mega Bite
MBC	Meteor Burst Communication
MHEWS	Multi-Hazard Early Warning System
MoIT	Ministry of Information Technology
MOS	Model Output Statistics
Mw	Moment Magnitude
NASA	the National Aeronautics and Space Administration
NDMA	National Disaster Management Authority
NDMC	National Disaster Management Commission
NDMC	National Drought Monitoring Centre
NDMP	National Disaster Management Plan
NEOC	National Emergency Operations Centre
NFPPs	National Flood Protection Plans
NGDC	National Geophysical Data Centre
NGOs	Non-governmental Organizations
NHA	National Highway Authority
NHER	National Health Emergency Preparedness and Response
NIDM	National Institute of Disaster Management
NIO	National Institute of Oceanography
NMCC	National Meteological Communication Centre
NOAA	National Oceanic and Atmospheric Administration
NSMC	National Seismic Monitoring Centre
NSM & TEWS	National Seismic Monitoring and Tsunami Early Warning Centre
NTWC	National Tsunami Warning Centre
NWFC	National Weather Forecast Centre
NWFP	North West Frontier Province
NWP	Numerical Weather Prediction
OFDA	Office of U.S. Foreign Disaster Assistance
O&M	Observation and Monitoring
O&M	Operation and Maintenance
PAKSAT	a series of names of Satellite by Pakistan
PBC	Pakistan Broadcasting Corporation
PC	Planning Commission
PCIW	Pakistan Commissioner for Indus Waters
PCRWR	Pakistan Council of Research in Water Resources
PDMA	Provincial Disaster Management Authority
PDRMP	Provincial Disaster Risk Management Plan
PEMRA	Pakistan Electronic Media Regulation Authority
PEOC	Provincial Emergency Operations Centre
PEPAC	Pakistan Environmental Planning and Architectural Consultants Limited
PID	Provincial Irrigation and Power Department
PIPD	Provincial Irrigation and Power Department
PKR	Pakistani Rupee
PMD	Pakistan Meteorological Department
PP	Point-to-Point
PPI	Plan Position Indicator
PRECIS	Name of Regional Climate Model by UK Met-Office
PRCS	Pakistan Red Crescent Society
PTA	Pakistan Telecommunication Authority
PTCL	Pakistan Telecommunication Company Limited
PTML	Pakistan Telecommunications Mobile Limited
PTWC	Pacific Tsunami Warning Center
QPM	Quantitative Precipitation Measurement
R&D	Research and Development
RAMC	Regional Agrometorological Centre
RDA	Rawalpindi Development Authority
RDFF	Routine Daily Flood Forecast
RDMC	Regional Drought Monitoring Centre
RFFWC	Regional Flood Forecasting and Warning Centres
RMCs	Regional Meteorological Centre
RMM	Regional Mesoscale Model
RSMC	Regional Seimic Monotoring Centre
SDMC	State Disaster Management Commission
SDMRP	State Disaster Management Response Plan
SLMP	Sustainable Land Management Project
SMRFC	Specialized Medium Range Forecasting Centre
SMS	Short Message Service
SODAR	Sonic Detection and Ranging
SOP	Standard Operating Procedure
SOPs	Standard Operating Procedures
SUPARCO	Space and Upper Atmospheric Research Commission
SPI	Standard Precipitation Index
SMRFC	Specialized Medium Range Forecasting Centre

TCMC	Tropical Cyclone Monitoring Centre
TCWC	Tropical Cyclone Warning Centre
TELOP	Television Opaque Projector
TEWC	Tsunami Early Warning System
TMA	Tehsil Municipal Administration
UN	United Nations
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
UTC	Universal Time, Coordinated
USAID	United States Agency for International Development
VHF	Very High Frequency
VSAT	Very small Aperture Terminal
V.P.N.	Virtual Private Network
WAPDA	Water and Power Development Authority
WASA	Water and Sanitation Agency
WB	World Bank
WFO	World Food Program (UN)
WFR	Weather Research & Forecasting
WHO	World Health Organization
WLL	Wireless Local Loop
WMO	World Meteorological Organization
WPR	Wind Profiler
WRF	Weather Research and Forecast (Name of Numerical Calculation Model)

LIST OF BASIC TERMS

Acceptable risk
The level of loss a society or community considers it can live with and for which it does not need to invest in mitigation

Biological hazard
Biological vectors, micro-organisms, toxins and bioactive substances, which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation.

Capacity
The combination of all the strengths and resources available within a community, society or organization that can reduce the level of risk, or the effects of a disaster.

Capacity may include physical, institutional, social or economic means as well as skilled personnel or collective attributes such as leadership and management. Capacity may also be described as capability.

Capacity building
Efforts aimed to develop human skills or societal infrastructure within a community or organization needed to reduce the level of risk. In extended understanding, capacity building also includes development of institutional, financial, political and other resources, at different levels of the society.

Climate change
The climate of a place or region is changed if over an extended period (typically decades or longer) there is a statistically significant change in measurements of either the mean temperature or variability of the climate for that region.

Coping capacity
The means by which people or organizations use available resources and abilities to face a disaster. In general, this involves managing resources, both in normal times as well as during crises or adverse conditions.

Disaster
A serious disruption of the functioning of a community or society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources. It results from the combination of hazards, conditions of vulnerability and insufficient capacity to reduce the potential negative consequences of risk.

Disaster risk management (DRM)
The comprehensive approach to reduce the adverse impacts of a disaster. DRM encompasses all actions taken before, during, and after the disasters. It includes activities on mitigation, preparedness, emergency response, recovery, rehabilitation, and reconstruction.

Disaster risk reduction/disaster reduction
The measures aimed to minimize vulnerabilities and disaster risks throughout a society, to avoid (prevention) or to limit (mitigation and preparedness) the adverse impacts of hazards, within the broad context of sustainable development.

Early warning
The provision of timely and effective information, through identified institutions, to communities and individuals so that they could take action to reduce their risks and prepare for effective response.

Emergency management
The management and deployment of resources for dealing with all aspects of emergencies, in particularly preparedness, response and rehabilitation

Forecast
Estimate of the occurrence of a future event (UNESCO, WMO). The is term is used with different meanings in different disciplines.

Geological hazard
Natural earth processes that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. For example earthquakes, tsunamis, volcanic activity and emissions, landslides, rockslides, rock falls or avalanches, surface collapses, expansive soils and debris or mud flows.

Hazard
Potentially damaging physical event or phenomenon that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation.

Hazards can include natural (geological, hydro meteorological and biological) or induced by human processes (environmental degradation and technological hazards). Hazards can be single, sequential or combined in their origin and effects. Each hazard is characterized by its location, intensity, frequency and probability.

Hazard analysis
Identification, studies and monitoring of any hazard to determine its potential, origin, characteristics and behavior.

Land-Use planning
Branch of physical and socio-economic planning that determines the means and assesses the values or limitations of various options in which land is to be utilized, with the corresponding effects on different segments of the population or interests of a community taken into account in resulting decisions. Land-use planning can help to mitigate disasters and reduce risks by discouraging high-density settlements and construction of key installations in hazard-prone areas, control of population density and expansion Mitigation Structural and non-structural measures undertaken to limit the adverse impact of natural hazards, environmental degradation and technological hazards.

Natural hazards
Natural processes or phenomena occurring on the earth that may constitute a damaging event. Natural hazards can be classified by origin namely: geological, hydro meteorological or biological. Hazardous events can vary in magnitude or intensity, frequency, duration, area of extent, speed of onset, spatial dispersion and temporal spacing.

Preparedness
Activities and measures taken in advance to ensure effective response to the impact of hazards, including the issuance of timely and effective early warnings and the temporary evacuation of people and property from threatened locations.

Prevention
Activities to ensure complete avoidance of the adverse impact of hazards.

Public awareness
The processes of informing the general population, increasing levels of consciousness about risks and how people can reduce their exposure to hazards. This is particularly important for public officials in fulfilling their responsibilities to save lives and property in the event of a disaster.

Recovery
Decisions and actions taken after a disaster with a view to restoring or improving the pre-disaster living conditions of the stricken community, while encouraging and facilitating necessary adjustments to reduce disaster risk.

Relief / response
The provision of assistance during or immediately after a disaster to meet the life preservation and basic subsistence needs of those people affected. It can be of an immediate, short-term, or protracted duration.

Resilience / resilient
The capacity of a community, society or organization potentially exposed to hazards to adapt, by resisting or changing in order to maintain an acceptable level of functioning. Resilience can be increased by learning from past disasters for better future protection and to improve risk reduction measures.

Retrofitting (or upgrading)
Reinforcement of existing buildings and structures to become more resistant and resilient to the forces of natural hazards.

Risk
The chances of losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between hazards and vulnerable social conditions. Risk is expressed as Risk = Hazards x Vulnerability. Some experts also include the concept of exposure to refer to the physical aspects of vulnerability.

Risk assessment/analysis
A methodology to determine the nature and extent of risk by analyzing potential hazards and evaluating existing vulnerability that could pose a potential threat to people, property, livelihoods and the environment.

Structural/non-structural measures
Structural measures refer to any physical construction to reduce or avoid possible impacts of hazards, which include engineering measures and construction of hazard-resistant and protective structures and infrastructure.

Non-structural measures refer to policies, awareness, knowledge development, public commitment, and methods and operating practices, including participatory mechanisms and the provision of information, which can reduce risk and related impacts.

Sustainable development
Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: the concept of "needs", in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and the future needs. (Brundtland Commission, 1987).

Technological hazards
Danger originating from technological or industrial accidents, infrastructure failures or certain human activities, which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Some examples: industrial pollution, nuclear activities and radioactivity, toxic wastes, dam failures; transport, explosions, fires, spills.

Vulnerability
The conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community or society to the impact of hazards.

Wildland fire
Any fire occurring in vegetation areas regardless of ignition sources, damages or benefits.

CHAPTER 1 INTRODUCTION

1.1 Introduction

Pakistan is vulnerable to natural disasters from a range of hazards including floods (river floods, flash floods, coastal floods and other floods due to storm and cyclone with storm surge), cyclones, droughts, earthquakes, glacial lake outburst floods (GLOFs), landslides, avalanches and tsunamis, together with appurtenant secondary disasters such as river erosion, waterborne diseases and epidemics after natural disasters and pest attacks.

There are two types of measures for mitigating the damage from natural disasters, namely: structural and non-structural measures. For example, flood discharge regulation with the construction of dams and prevention of overflow of excess floods with the construction of flood protection bunds are categorized as structural measures, while methods to minimize the damage and human suffering with the implementation of advanced evacuation activities and, in particular, the regulation of land use in flood prone areas, etc., are some examples of non-structural measures.

Structural measures are usually cost-intensive and take a longer period to implement. Non-structural measures, on the other hand, are relatively less expensive and the effects, that is, in the aspect of reduction of human casualties, can be realized sooner. However, significant activities such as the promulgation of appropriate laws, enhancement of people's awareness and eventually the people's daily life practices are required to sustain the effects of non-structural measures.

The most dramatic example of human suffering and damage from disaster was the recent tremendous flood that struck whole areas in Pakistan in 2010. That flood accounted for an estimated 2,000 deaths. In a continuing series of disasters, flash floods hit in Sindh and Balochistan Provinces with more than 500 deaths due to monsoon rains and the outbreak of dengue fever occurred in Punjab Province and was recognized as an epidemic in 2011. In Pakistan, the effects of such damage by all kinds of natural disasters create a vicious cycle in that they cause economic damage that sets back efforts to eradicate poverty which in turn worsens poverty and make life more difficult for the remaining families.

The need to create Multi-Hazard Early Warning Systems (EWSs) that decrease personal and economical damages by informing disasters in advance as a means of eradicating this vicious cycle has become a serious consideration in recent years. Until now, however, technical efforts in multi-hazard EWS have often resulted in systems that are not fully functional because of appropriate systems of human and equipment capacities, insufficient cooperation among the agencies concerned, ignorance of the significance of EWS on the part of communities, and lack of experience-based know-how with no record on the historical or cultural background in areas of disaster prevention.

As to the EWS for flood hazards, there are regional differences in rainfall and runoff characteristics due to geographical locations. The condition is different among drainage basins such as the drainage basins of the Indus River, the major tributaries like Jhelm, Chenab, Ravi, Sutlej and Kabul, the small tributaries in mountain regions in the Indus River System, and the small independent river systems in Balochistan. The Indus River and the major tributaries are equipped with EWSs, but such inaccurate EWSs should be improved. Furthermore, there is no warning system against flash floods for nullahs (medium or small rivers) affecting human and social lives except for the Lai Nullah at Islamabad and Rawalpindi.

Regarding earthquakes and tsunamis due to the geological movement of the submarine crust, though it is still difficult to timely predict their occurrence, vulnerabilities and risks could be reduced through optimum preparedness and emergency response plans. To reduce seismic disasters, optimum preparedness like the promotion of earthquake-proof houses, buildings and public facilities will be effective, and proper emergency response plans and drills will reduce vulnerabilities. Together with the establishment of a tsunami EWS, optimum emergency response plans and drills shall further reduce vulnerabilities and risks.

This report contains the current status of early warning systems in Pakistan and the proposed goals.

1.2 Hazards Targeted in the Proposed Multi-Hazard Early Warning System Plan

For the reduction of vulnerabilities and risks to natural disasters, a Multi-Hazard Early Warning System (EWS) is proposed as the fundamental measure against floods, GLOFs and sediment disasters, including landslides, cyclones with storm surges, droughts and tsunamis, avalanches, earthquakes and health emergencies. However, for GLOFs and landslides, basic studies are proposed, because the available basic information is insufficient to make a definite assessment at present.

1.3 Definition of Disaster-Related Terms

In the current disaster management activities and achievements, such as the Disaster Management Framework (2007), the Standard Operating Procedures (SOP) of 2008, the NDMA Response Plan of 2010 prepared by the National Disaster Management Authority (NDMA), and during meetings, vague and non-technical words have been used in the discussions on EWS. In this report, some of these words or terms are defined from the aspect of Multi-Hazard Warning Systems as shown in Table 1.3.1 and Table 1.3.2.

Table 1.3.1 Clarification of Vague Terms in the Project

Term	Meaning in General	Definition in the Project
(Indus) River Flood	Flood is a phenomenon of inundation by water coming from a river, drainage or other water bodies, such as lakes or seas due to overflowing from ordinary boundary between land and water or water surging.	In the Project, flood refers to "River Flood" resulting in the rising of water level of major rivers, namely; Indus, Jhelum, Chenab, Ravi, Sutlej and Kabul.
Flash Flood	One of flood phenomena. A flash flood is a rapid flooding (mostly less than 6 hours) of geomorphic low-lying areas due to downpour or heavy rains caused by low depression, climate front line (thunderstorm) or cyclone.	Floods due to water overflowing the *nullah* or drainage lines caused by heavy rain and inundation by rapid flow from hill torrents in property areas are considered as "Flash Floods". City floods due to water overflowing from *nullah* or drainage channels are also included in a kind of "Flash Flood". Floods around Peshawar and the suburbs at the end of July 2010 are considered as "Flash Floods" since most of the floodwaters originated from Swat River.
Hill Torrent (Flood)	Hill torrent floods are basically a rapid flooding of geomorphic steep surface areas at alluvial cones or floodplain areas caused by overflowing water from channels due to rapid velocity and any amount of flow quantity.	
City Flood, Urban Flood	Flood and inundation phenomena occurred in the city or built-up areas.	
River	A river is a natural waterway, usually freshwater, flowing toward lower level of water surface such as an ocean, a lake, a sea, or another river. Therefore, *nullahs* are a kind of river in general.	In the Project, "River(s)" refer(s) to six flows/channels, namely: Indus, Jhelum, Chenab, Ravi, Sutlej and Kabul rivers as the major rivers in Pakistan.
Nullah (Nallah)	A Pakistani term. Rivers excluding huge rivers in the Indus River System.	Except for the six rivers mentioned above, the flows, channels and bodies of stream water are referred to as *"Nullah"*.
Slope Failure	In this phenomenon, a slope abruptly collapses when the soil that has already been weakened by moisture in the ground loses its self-cohesiveness under the influence of rain or an earthquake. Due to sudden collapse, many people fail to escape if it occurs near a residential area, thus leading to a higher rate of fatalities.	In the Project, phenomena of slope failure are referred to as a part of a landslide. Therefore, slope failure and landslides are treated and integrated in "Landslide".
Landslide	This is a phenomenon in which part of or all of the soil on a slope moves downward slowly under the influence of groundwater and gravity. Since a large amount of soil mass usually moves, serious damage can occur. If a slide has been started, it is extremely difficult to stop it.	
Debris Flow	This is a phenomenon in which soil and rock on the hillside or in the riverbed are carried downward at a dash under the influence of continuous rain or torrential rain. Although the flow velocity differs by the scale of debris flow, it sometimes reaches 20-40 km/hr, thereby destroying houses and farmland in an instant.	"Debris Flow" refers to the meaning in general described in the left column. Therefore, flows containing solid wastes do not mean debris flow in the Project. In addition, Debris Flow is dealt with as a Flash Flood phenomenon.

Source: JICA Expert Team

Table 1.3.2 Objective Disasters for the Formulation of Multi-Hazard Early Warning System Plan

Term	Objective Contents
Flood or (Indus River Flood)	"River Flood" includes flooding along the INDUS, JHELUM, CHENAB, RAVI, SUTLEJ and KABUL Rivers. A certain early warning system against "River Flood" has already been established under FFD-PMD Lahore.
Flash Flood	"Flash Flood" includes not only hill torrent floods, but also city floods. Compared to River Flood, the flooding period is shorter but its flows have comparatively rapid velocities. In Pakistan, only the Lai Nullah Basin Early Warning System in Capital Areas and Rawalpindi has been prepared against "flash flood" under NWFC-PMD Islamabad. "Flash Flood" results from short-time extreme rainfall phenomena within a narrow range.
Landslide	Strictly speaking from geological engineering aspects, "slope failure" and "landslide" have differences in the mechanism of collapse. In this project, these phenomena are treated as "Landslide" since the methodology of public awareness and public evacuation regarding EWS uses mostly the same approach. Besides, "landslide" results from not only saturated water in slopes but also earthquakes. For the early warning system, "landslide" by saturated water due to heavy rainfall may be considered.
Cyclone	A cyclone is a low/depression area of closed, circular fluid motion rotating in the same direction as the Earth beyond certain intensification. While tropical cyclones can produce extremely powerful winds and torrential rain, they are also able to produce high waves and damaging storm surge.
Storm Surge	A Storm Surge is phenomena of sea level rise associated with a low-pressure weather system, typically a tropical cyclone. Therefore, an early warning plan for "storm surge" should be incorporated with that of "cyclone".
Tsunami	A tsunami can cause a considerable number of fatalities, inflict major damage, and cause significant economic loss to large sections of coastlines. Hence, it is considered as one of the multi-hazard disasters for formulation of EWS.
Drought	A drought is an extended period of weeks, months or years when a region/province notes a deficiency in its water supply. Generally, this occurs when a region receives consistently below average precipitation. In addition, extreme climate conditions might occur in the future due to global warning. It can have a substantial impact on the ecosystem and agriculture of the affected region.
GLOF	"GLOF" refers to a Glacial Lake Outburst Flood that occurs when water in a glacier lake suddenly discharges due to a breach of a moraine dam (glacier lake). The results can be catastrophic to the downstream riparian area. (Richardson and Reynolds 2000) The Gilgit Baltistan (GB) has suffered from threats of "GLOF" and the threat has increased due to the impacts of climate changes. Hence, it is considered as one of the multi-hazard disasters for formulation of EWS.
Avalanche	An avalanche is defined as the sudden falling of snow from the side of a mountain. Northern parts of Pakistan have been affected by avalanches. According to the disaster records, the tragedies due to the avalanches accounts for a certain percentage of total disasters. In this connection, avalanche has been considered as one of the multi-hazard disasters for formulation of EWS.
Earthquake	Earthquake is defined as shaking and vibration at the surface of the earth resulting from underground movement along a fault plane of from volcanic activity or due to movement of plate boundaries of the Earth. The scale of earthquakes is measured by moment magnitude and the shaking intensity at each location is usually reported by Mercalli intensity scale.

Source: JICA Expert Team

CHAPTER 2 GOAL OF THE MULTI-HAZARD EARLY WARNING SYSTEM PLAN

2.1 Formulation of the Multi-Hazard Early Warning System Plan

As described in Chapter 1, the establishment of an appropriate Multi-Hazard Early Warning System (EWS) has to be supported by well-coordinated actions among all stakeholders, resulting in the reduction of human suffering and property damage from all future natural disasters and the encouragement of capacity building for implementing a multi-hazard EWS at the earliest possible time in Pakistan. Therefore, the vision of the Multi-Hazard EWS Plan is to reduce the vulnerabilities and risks to natural disasters, by strengthening the early warning capabilities against natural disasters such as floods (river floods and flash floods), tsunamis, cyclones with storm surges, landslides and droughts, and by strengthening the institutional mechanisms to achieve the overall goal of the Disaster Management Plan. To achieve this vision, the basic implementation policies shall also be considered and set up as described below.

2.1.1 Vision of Multi-Hazard Early Warning System Plan

Table 2.1.1 Vision of the Multi-Hazard EWS Plan

Target	Vision
Whole EWS	To reduce vulnerability to natural disasters and risks by enhancing and strengthening the early warning capacity against multiple hazards due to natural disasters

As stated above, the objective of the Multi-Hazard EWS Plan is to reduce the vulnerability to natural disasters by enhancing and strengthening the early warning capacity against multiple hazards due to natural disasters so that the overall goal of formulation of the Disaster Management Plan would be achieved. The Multi-Hazard EWS Plan shall support and lead each activity smoothly for early warning at the national level; whereas, the establishment of a Multi-Hazard EWS is a condition precedent to the operation of mitigation systems against possible damage arising from the occurrence of natural calamities, by suitable disaster risk management of mitigation/prevention measures, preparedness, emergency responses and coordination among the agencies related to the multi-hazard EWS in Pakistan.

2.1.2 Goal of Multi-Hazard Early Warning System Plan

The goal of establishment and operation of EWS shall be as follows:

Table 2.1.2 Goal of Establishment and Operation of EWS-1

Target	Goal
Earthquake and Tsunami	Optimum preparedness, emergency responses, and rapid earthquake damage assessment; timely warning for evacuation from tsunami.

The goal of each EWS is to establish the optimum preparedness and emergency response plans. Earthquake observation is to provide data on magnitude, epicentre location as well as the expected affected area to support rapid and effective emergency response activities. Since communication lines may be disrupted when a major earthquake occurs, it is necessary to have a redundant, reliable communication method. Observed strong motion records can be used for engineering purposes as well, such as seismic risk analysis and building code improvement.

The goal of the EWS for tsunami is to provide coastal residents timely warning for evacuation before an expected tsunami occurs. Given that lead time for evacuation from tsunami is very limited, early warning against tsunami should be issued within a very short time. Since a tsunami is generally associated with a major earthquake, communication lines are expected to be disrupted. Therefore, it is necessary to use a redundant, reliable communication method aiming as follows:

Table 2.1.3 Goal of Establishment and Operation of EWS-2

Target	Goal
Flood, Landslide, Cyclone with Storm Surge	Early release of more accurate information; setup of redundant and multiple communication dissemination system for alerts and evacuation orders.

The EWS for flood, landslide, and cyclones with storm surge also aims at providing the people to be affected by a particular disaster with earlier and more accurate information, such as the intensity of cyclone/rainfall and available water level related to rivers and *nullahs*, together with other related information prior to the occurrence of disastrous phenomena. Including the tsunami EWS, there should be as much lead time as possible for evacuation from disasters. In this connection, the establishment of multiple communication and dissemination mechanisms shall also be essential to secure the information system in early warning activities. For these objectives, engineering and social techniques should fully be considered and adopted in the system.

2.2 Implementation Policy

1) Target Year (Time Frame)

Each project proposed in the Multi-Hazard EWS Plan will be completed through feasibility study (F/S), detailed engineering and implementation. However, the manners and methods proposed for the EWS will constantly advance by means of technological innovation. On the other hand, the Multi-Hazard EWS Plan shall be compiled together with the Disaster Risk Management Plan in Pakistan as the umbrella plans.

In this connection, the target year of the Multi-Hazard EWS Plan is set for 2022 (10 years implementation) with the framework subject to review every five years. The implementation of the Multi-Hazard EWS Plan is to be categorized into the short to medium-term, long-term and other recognized super long-term projects. The short to medium-term projects shall consist of rehabilitation and new installation and/or establishment of new equipment, facilities and system including social programs (CBDRM) urgently required within 2-3 years as the priority projects of which the implementation can be pursued immediately without any F/S or an approved existing F/S. The long-term projects shall also consist of strengthening and improvement or new establishment of equipment and facilities including the system required within 6-7 years as priority projects with F/S to be executed. In addition, the framework plan including super long-term projects shall cover the overall Multi-Hazard EWS projects or components proposed in this plan.

Table 2.2.1 Target Year of Multi-Hazard EWS

Plan	Target Year
Framework (Whole Plan)	2022
Short to Medium-term Projects/Studies	2015
Long-term Projects/Studies	2018
Interim Evaluation of Plan	2016

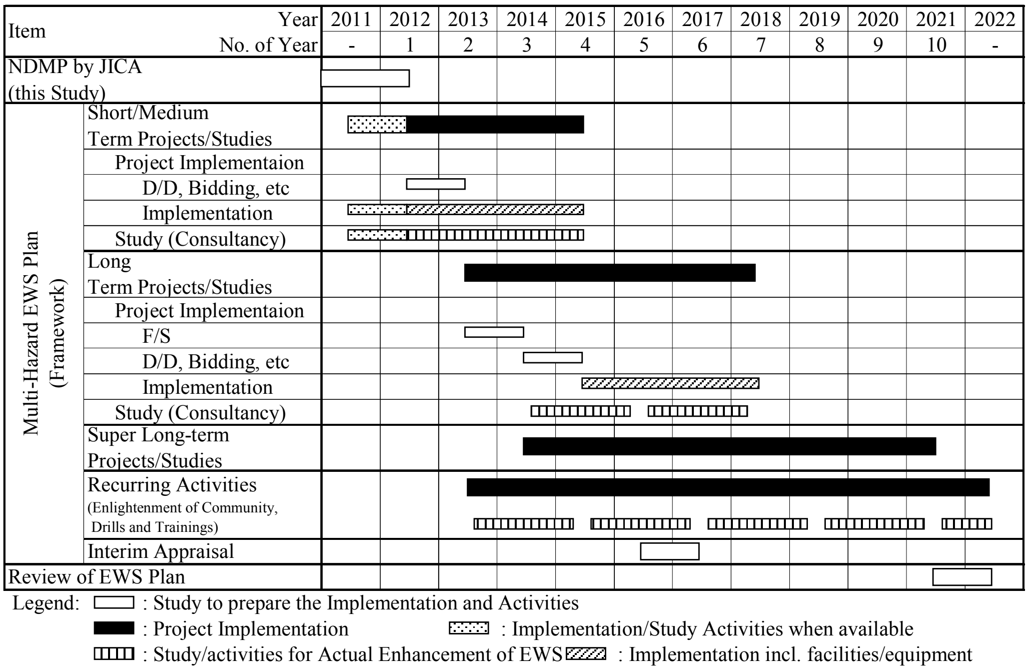


Figure 2.2.1 Multi-Hazard EWS Plan Framework

2) Strategies of the Selection of Proposed EWS

In the Multi-Hazard EWS Plan, the following projects and programs are proposed to achieve the goal(s):

a. Strategy-1: Strengthen forecasting and early warning systems

To achieve the goal, the following two (2) types of projects/programs to strengthen forecasting and early warning systems are considered

i) Projects and Programs for Sustainment of the Current System for High Hazard and Risk

One of the most significant projects is to replace, retrofit or rehabilitate the existing facilities and equipment for the sustainment of the current EWS for High Hazard and Risk. The capacity of the existing system would drastically detract if some early warning systems bog down due to deterioration and aging problems. In this connection, the EWS plan for rehabilitation and replacement works of existing systems shall be proposed as one of the prioritized projects taking into consideration the improvement and innovation of the system with engineering aspects.

ii) Projects and Programs for the Establishment of New EWS for High Hazard and Risk

Based on the Hazard and Risk Assessment for the national level, higher hazard/risk areas for each type of disaster have been identified and realized. One of the main purposes for establishing a new EWS is to mitigate the loss and damage due to disasters. In this regard, projects/programs shall be selected based on the risk and hazard assessment analysis results in this project.

b. Strategy-2: Prepare hazard maps at local scale in targeted locations

Small-scaled hazard maps should be prepared for highly vulnerable areas. Even if the alerts or evacuation orders are correctly disseminated, activities in EWS will not be effective if the target communities do not understand the hazards and risks of the disaster or do not know safe places where they should evacuate. In this connection, responsible agencies should prepare the hazard maps for each type of disaster together with the EWS. The hazard maps prepared will also serve as the base for the formulation of local government's own disaster management plans with improved early warning systems.

c. Strategy-3: Strengthen early warning dissemination systems

The integrated early warning system is composed of proper steps, such as observation, forecasting process, dissemination of warning, judgment of direction, and communication with end users. In this connection, the communication system is one of the essential steps in terms of promptness and swiftness of dissemination of warning. The most important thing is to deliver the warnings/emergencies to all stakeholders simultaneously without hierarchy in a multilayered system.

d. Strategy-4: Develop capacity of early warning and evacuation systems

Even though the latest high technology EWS is recommended, the application of such an EWS is limited due to budgetary and implementation schedule concerns. A community-based early warning system (CBEWS) is not as highly effective compared to the EWS that is structuralized by facilities and equipment, but initial and operational costs for sustainability are quite low and economical. Furthermore, the CBEWS can substitute for the mechanical warning system as a multiple dissemination system. In Pakistan, a number of CBDRM programs by several agencies, such as UNDP, USAID, GTZ, ADPC, NGOs and other cooperative agencies, as well as JICA under this project, have been activated. These activities, which have positive results, are strongly recommended and applied for the Multi-Hazard EWS.

In addition, the new EWS utilizing facilities and equipments entails capacity development activities of users (early warning agencies). Capacity development activities of related agencies are one of indispensable programs in the EWS Plan.

2.3 Approach to the Goal of Multi-Hazard EWS Plan

To achieve the objective (goal) of the establishment of Multi-Hazard Early Warning System Plan, the contents shown in the table below are hereafter described in this and related reports.

Table 2.3.1 Approach to the Establishment of Multi-Hazard EWS Plan

Approach	Explanation
Definition of Terms Related to Disasters	Unification of technical terms for easier understanding of the Plan is necessary. (See Chapter 1)
Composition and Framework of the Projects	Strategy for EWS Plan including Short, Medium and Long Term Project is set up. (See previous section in Chapter 2)
Clarification of Existing Condition	Identification of current EWS is confirmed. (See Chapter 3)
Clarification of Issues on Current EWS	Planning issues of EWS are discussed. (See Chapter 4)
Conceived Strategy and Idea for the Improvement of EWS in Pakistan	Based on the implementation policies and issues, Facilities, Equipment, Systems and Studies to be needed for strengthening and enhancement of Multi-Hazard EWS are discussed and conceivable projects and Programs are proposed. (See Chapter 4, Section 5.1 and 5.2 in Chapter 5)
Proposal of Projects/Components of EWS	
Clarification of Priority Projects/ Components	Conceivable projects are prioritized and schedules are proposed based on the policies. (See Section 5.3 and 5.4 in Chapter 5)
Proposal of Implementation Schedule	
Hazard and Risk Assessment	It is necessary to evaluate the conceived project in accordance with Hazard and Risk Assessment Results. (See Chapter 4 in Main Report)
Human Capacity Development	It is indispensable to evaluate the human resources and current human capacity to plan multi-hazard EWS. Based on the current human resources and capacities, a Human Capacity Development Plan shall also be proposed in line with Proposed Facilities and Equipment for Multi-Hazard EWS. (See each section for the current capacity in Chapter 3 and See Chapters 4 and 5 for the Human Capacity Development Plan)

Source: JICA Expert Team

CHAPTER 3 EXISTING CONDITIONS

3.1 Current Meteorological Observation and Common Policy of Alerts

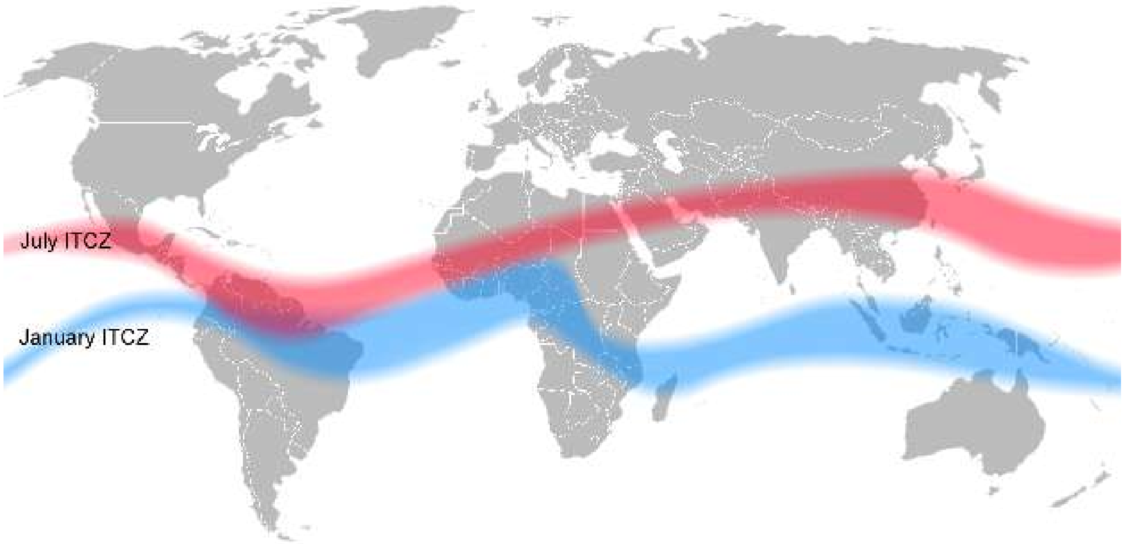
3.1.1 Common Relationship between Meteorological Phenomena and Required Equipment with Alerting System in Pakistan

The current meteorological observation and prediction systems in Pakistan have been developed based on the common policy for development of observation and forecasting systems due to the relationship between meteorological phenomena causing the disasters and equipment/facilities required for the early prediction and alerting system against such disasters. These common and basic policies for the development of observation and forecasting systems due to each meteorological phenomenon are as described below.

1) Intertropical Convergence Zone (ITCZ)

The Intertropical Convergence Zone (ITCZ) is an area of global scaled meteorological phenomenon surrounding the low latitude areas, which is generated by the confluence of the trade wind in the northern hemisphere and the trade wind in the southern hemisphere. As shown in the figure below, the ITCZ moves back and forth across the equator following the sun's zenith point. In the summer season in the northern hemisphere, the ITCZ moves close to Pakistan due to the influence of the Tibetan plateau (the average altitude is about 4,500m) heated by the sunshine and causes the annual rainy seasons. On the other hand, dry seasons come as the ITCZ departs from Pakistan (in winter seasons in northern hemisphere).

In this regard, it is significant to identify the location and strength of the ITCZ for the weather and climate forecasts over short, middle and long terms. The enhancement of meteorological forecast supporting systems such as the Wind Profiler and Satellite Imagery Data are useful to detect the ITCZ for accurate weather and climate forecasts.



Source: Wikipedia (http://en.wikipedia.org/wiki/File:ITCZ_january-july.png (accessed in February 2012)

Figure 3.1.1 Seasonal Variation of the ITCZ

2) Monsoon Trough and Monsoon Depression

Daily cloud zones during summer season in Pakistan are caused by the Monsoon Trough due to the ITCZ. In summer, southeast winds generated around the Sub-Himalayan areas blow from the Indian Ocean toward the Depression in the Southern area of the Indian continent. At this time, another west wind from the Arabian Peninsula and the northwest wind from the internal region converge with the aforementioned southeast winds. These phenomena form a complicated monsoon trough.

In Pakistan, located at latitudes of approximately 20 degrees north or more, the increasing Coriolis force with latitude makes the formation of depressions within the monsoon trough. These depressions are called "Monsoon Depression(s)." From July to August, river and flash floods frequently occur throughout the country. Most of these floods are caused due to the heavy rainfall by these phenomena, namely: Monsoon Trough and Monsoon Depression.

In this connection, it is essential to identify the location and strength of the Monsoon Trough and the Monsoon Depression(s), as well as the rain area(s) with strength and intensity for the weather and climate forecast over short, middle and long terms. To observe these meteorological phenomena, the data derived by the wind profiler system, meteorological radar system, satellite imagery and automated weather observation system are indispensable. Likewise, the enhancement and strengthening of the meteorological forecast supporting system and the numerical weather prediction system (Regional Mesoscale Model: RMM) are also indispensable.

3) Cyclone with Storm Surge

The generation of cyclones around Pakistan is closely related to the ITCZ. In the Pakistani rainy season when the ITCZ is located on the Indian Subcontinent, the number of cyclones is less because the occurrence and the development of tropical cyclones need systematic wind convergence like the ITCZ. On the other hand, the cyclone-generated seasons are the time when the ITCZ is situated on the Indian Ocean. The wind profiler systems are useful for easy and exact dectection of the movement of ITCZ and the occurrence of tropical cyclone with the variation of wind direction.

To grasp the generation of cyclones, the improvement of observation of meteorological data as well as the forecasting system is necessary. For this purpose, the enhancement of the wind profiler system, meteorological radar system, satellite imagery data collection system, automated weather observation system, meteorological forecast supporting system and numerical weather prediction system are required.

4) Heavy Rainfall due to Low/Depression and Cold Front other than Monsoon Season

In Pakistan, heavy rains have occasionally fallen in the winter season outside the monsoon season due to low/depressions and/or cold fronts derived from the influx of northwestern cold air. These phenomena should be observed and forecast by the equipment/facilities together with the improvement of forecasting systems as mentioned in Item 2) above for Monsoon Trough/Monsoon Depression and Cyclone.

5) Thunderstorm, Wind Gust and Hail due to Descent of Cold Air

The descent of cold air from the northern area generates thunderstorms causing flash floods and wind gusts (twisters/downbursts) with damage to infrastructure, crops and transportation, and generates cumulonimbus-causing hail with damage to agricultural products. To mitigate the damage it is necessary to predict these phenomena quickly and early through the enhancement of observation with the Meteorological Doppler Radar System, Satellite Imagery Data Collection System, Automated Weather Observation System and Wind Profiler System, as well as improvement of the Meteorological Forecast Supporting System and the Numerical Weather Prediction System (Regional Mesosclae Model: RMM).

6) Snow Avalanche and Snowmelt Flood

In the northern region of Pakistan (GB and part of KP), disasters by avalanche and snowmelt floods occur due to the large accumulation of snow. For the forecast of these phenomena, the Satellite Imagery Data Collection System and the Automated Weather Observation System together with the Meteorological Supporting System and the Numerical Weather Prediction System (RMM) are required.

7) Low Temperature

In the winter season in Pakistan, low temperatures have affected the growth and development of agricultural crops. To forecast this phenomenon, the enhancement of observation systems and improvement of the forecasting systems as mentioned in Item 6), Avalanche and Snowmelt Flood, are required.

8) Drought and Heat Wave

Drought is one of the most worrisome disasters in Pakistan due to its scale, the span of damage and the range of affected people (most of them belong to the socially vulnerable). Heat waves also affect human health and agricultural products in certain summer seasons in Pakistan. In this connection, the aforementioned enhancement of observation systems and improvement of forecasting systems are required for the mitigation of damage.

9) Summary of Required Systems for Mitigation of Damage due to Meteorological Phenomena

As described in Items 1) to 8) above, the commonly required systems to mitigate the damage by early warning dissemination are as summarized in the table below.

Table 3.1.1 Summary of Required EWS and Meteorological Phenomena

Meteorological Phenomena	Meteorological Observation System/ Equipment Required	Meteorological Forecasting System Required	Warning and/or Alert to be Issued
ITCZ	• Upper Air Observation • Satellite HRPT Data Information System	• Meteorological Forecast Supporting System	✓ Short, Middle and Long Term Weather Forecast
Monsoon Trough and Monsoon Depression with Heavy Rain	• Upper Air Observation • Satellite HRPT Data Information System • Meteorological Radar • AWS	• Meteorological Forecast Supporting System • Numerical Weather Prediction (Regional Forecast Mode)	✓ Short, Middle and Long Term Weather Forecast ✓ Heavy Rain and Flood A. ✓ Heavy Rain Forecast and Alert
Cyclone with Storm Surge			✓ Cyclone Strong Wind A. ✓ Storm Surge A. ✓ Cyclone Heavy Rain A. ✓ Cyclone Track Prediction ✓ Cyclone Alert
Heavy Rainfall due to Low/Depression and Cold Front			✓ Heavy Rain and Flood A. ✓ Heavy Rain Forecast and Alert
Thunder and Wind Gust	• Thunder Watching System • Upper Air Observation • Meteorological Doppler Radar • Satellite HRPT Data Information System • AWS	• Meteorological Forecast Supporting System • Numerical Weather Prediction(Regional Mesoscale Model: RMM)	✓ Thunderstorm Alert ✓ Strong Wind Alert ✓ Twister Alert ✓ Storm Wind Alert
Hail	• Upper Air Observation • Satellite HRPT Data Information System • AWS		✓ Thunderstorm Alert ✓ Hail Alert
Avalanche and Snowmelt Flood	• Satellite HRPT Data Information System • AWS		✓ Avalanche Alert ✓ Snowmelt Alert
Low Temperature			✓ Low Temperature Alert
Drought and Heat Wave	• Upper Air Observation • Satellite HRPT Data Information System • Meteorological Radar • AWS	• Meteorological Forecast Supporting System • Numerical Weather Prediction (Regional Mesoscale Model: RMM)	✓ Drought Alert ✓ Heat Wave Alert

Note: AWS: Automated Weather Observation System; A: Alert
Source: JICA Expert Team

3.1.2 Meteorological Radars

1) Location and Observation Range

Radar observations of rain in the whole area of Pakistan excluding parts of Balochistan, Sindh, Khyber Pakhtunkhwa (KP), Gilgit Baltistan (GB) and Federally Administrated Tribal Areas (FATA) have been carried out by the Pakistan Meteorological Department (PMD) utilizing the seven (7) meteorological radar stations located in Islamabad, Karachi, Dera Ismail Khan and Rahimyar Khan established under Japan Grand Aid, and Lahore, Mangla and Sialkot established under an ADB Loan package. The coverage area of the meteorological radar network in Pakistan is shown in Figure 3.1.3 and enumerated in Table 3.1.2. In particular, the Lahore, Mangla and Sialkot radar systems have been operated not only for observation of rainfall intensity but also for flood monitoring of major rivers in the Indus Basin utilizing accumulated rainfall software, and wind direction and speed observation with Doppler technology.

Radar Antenna
(Islamabad Meteorological Radar Station)

Plan Position Indicator (PPI)
(Islamabad Meteorological Radar Station)

Radar Transmitter
(Islamabad Meteorological Radar Station)

Signal Processing Indicator (left)
Radar Control Indicator (right)
(Karachi Meteorological Radar Station)

Radar Antenna
(Lahore Meteorological Radar Station)

Radar Transmitter
(Lahore Meteorological Radar Station)

Figure 3.1.2 Existing Meteorological Radar Systems

Table 3.1.2 List of Meteorological Observation Radar Stations

No	Year of Establishment	Station Name	Longitude	Longitude	Altitude (m)	Type of Radar	Data Management		
							Managing Office	Established Project	Current Status*1
1	1991	Islamabad	33°44'N	73°30'E	522	C-Band	Islamabad	Japan's Grant Aid	O
2	1991	Karachi	24°55'N	67°05'E	41	C-Band	Karachi	Japan's Grant Aid	O
3	1999	Dera Ismail Khan	31°49'N	70°56'E	171	C-Band	FFD_Lahore	Japan's Grant Aid	O
4	1999	Rahimyar Khan	28°26'N	70°19'E	70	C-Band	FFD_Lahore	Japan's Grant Aid	O
5	2006	Sialkot	32°31'N	74°32'E	255	C-Band	FFD_Lahore	ADB	O
6	2007	Mangla	33°04'N	73°38'E	283	Doppler S-Band	FFD_Lahore	ADB	O
7	2008	Lahore	31°33'N	74°20'E	214	Doppler S-Band	FFD_Lahore	ADB	O

Note: *1 : O: Operated correctly by PMD as of 2011
Source: PMD

2) Meteorological Radar Observation and Operation

In Japan, the meteorological radars are normally operated around-the-clock. However, in order to save on consumables such as magnetron and cost of electricity, most of the radar stations in

Pakistan are operated in response to weather conditions. PMD continuously operates the radar stations in the monsoon season, and inconstantly operates them in accordance with requests from PMD's meteorologists in the dry season. Regarding the management policy for meteorological radar stations, the Islamabad and Karachi radar stations are managed by the PMD Head Office in Islamabad and the Camp Office in Karachi respectively. Other radar stations such as Dera Ismail Khan (D. I. Khan), Rahimyar Khan, Lahore, Mangla and Sialkot are managed by the Flood Forecasting Division (FFD) of PMD in Lahore. The Islamabad and Karachi radar stations have already been in operation for more than 20 years, whereas the D. I. Khan and Rahimyar Khan radar stations they have been in use for more than 12 years.

Original Source: PMD and Arranged by JICA Study Team

Figure 3.1.3 Existing Meteorological Radar System Network

These aging radar systems frequently cause problems for PMD. In particular, there is a possibility that the Islamabad and Karachi radar systems will just stop functioning on some future day due to such aging issues. In view thereof, the Japan International Cooperation Agency (JICA) dispatched a Follow-up Study Team for the study of current conditions of the radar equipment, issues on the existing equipment and repair methods for the systems in Islamabad, Karachi and Rahimyar Khan radar stations as well as provision of appropriate operation and maintenance works of the Meteorological Radar System. Based on this Follow-up Study, the execution of procurement of spare parts and dispatch of the radar engineers for replacement of old parts with the new spare parts and provision of the maintenance training to the PMD engineers are under review by JICA. However, since D. I. Khan is located in an at-risk area as designated by the Japanese Government, all the equipment installed in D. I. Khan is exempt from the scope of the Follow-up Study. It is expected that the Islamabad and Karachi radar systems could operate for five years or more after procurement of spare parts and dispatch of radar engineers for the repair work.

Table 3.1.3 Operation Time of Existing Meteorological Radar Stations in the Past

Station	Operational Life (No. of Yrs.)	Total Operation Hours (*1)	Mean Daily Operation Hours
Islamabad	20	75,757	Approx. 10.9
Karachi	20	56,535	Approx. 8.2
D.I. Khan	12	8,594	Approx. 2.2
Rahimyar Khan	12	8,384	Approx. 2.0
Lahore	4	6,416	Approx. 8.8
Mangla	5	1,267	Approx. 1.2

Note : *1 : Surveyed by JICA Expert Team
Source: PMD (As of 2011 for Operation Life and as of July 2010 for Operation hours)

3) Data Communication System

The four (4) meteorological radar stations located in Islamabad, Karachi, D. I. Khan and Rahimyar Khan with Radar Data Transmission System, Radar Image Display System, Radio Communication System and Radar Composite Image Transmission System were established under Japan's Grant Aid, and the Meteorological Radar Observation Network connecting these four radar stations was established through the dedicated lines of the Pakistan Telecommunication Company Limited (PTCL). However, the 2 GHz band, which is the frequency band of the original Radio Communication System, is no longer in operation for the mobile telecommunications in accordance with the recommendations of the International Telecommunication Union (ITU), and digital communications (Internet) are accelerating in Pakistan for data receiving/transmitting. The cost of the Internet is much cheaper than the recurrent cost of the PTCL's dedicated lines. Due to these reasons, as of 2010, all related PMD offices and centres only share all the radar image pictures uploaded on PMD's website by each radar station through the Internet. The meteorological radar data for Mangla and Sialkot radar stations had been transmitted to FFD in Lahore through Satellite Communication System (VSAT). However, due to the high running cost of VSAT, the radar image pictures are transmitted through e-mail, and are then uploaded by FFD on PMD's website in addition to the previously described four radars.

4) Staff's Ability for the Operation and Maintenance of Existing Meteorological Radars

As described above, PMD has operated seven (7) meteorological radar stations with the following trained staff at each radar site.

Table 3.1.4 Technical Staff Assignments (Over BS-13) at Each Meteorological Radar Station

Assignment	Typical Staff Arrangement at Each Meteorological Radar Station
Electronic Engr.	1
Asst Programmer	1
Asst Meteorologist	0~1
Asst Electronic Engr.	1~2
Asst Mechanical Engr.	0~1
Prof. Assistant	2~3
Others (Sub-Engineer)	3~5
Total	8~14

Source: PMD (As of November 2011)

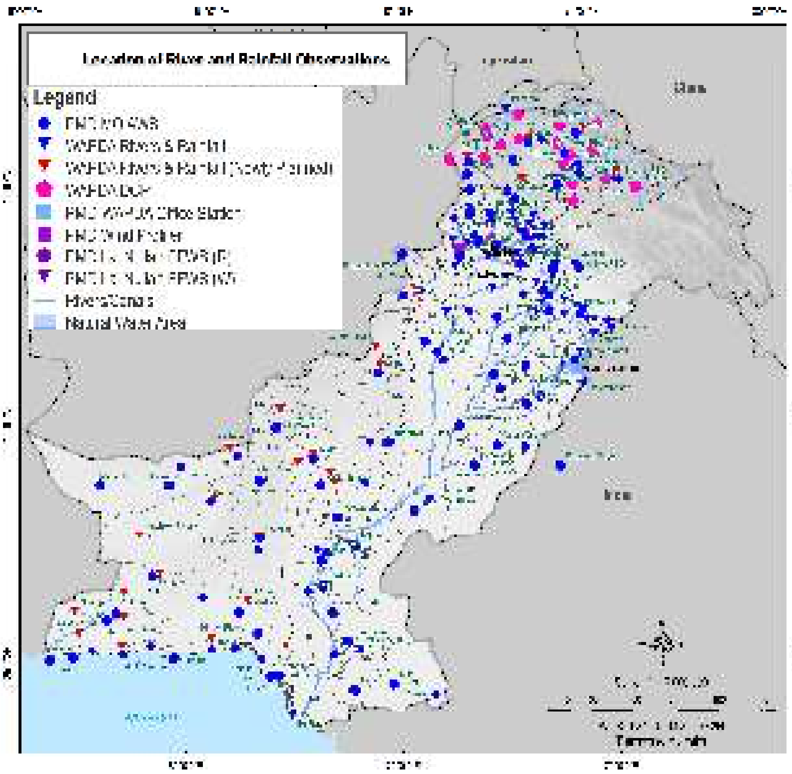
Basically, the operation and maintenance activities have been conducted correctly with appropriate skills and techniques of the staff shown in the table above except for issues due to the aging issues of radar facilities. The start and termination of the operations for each radar system are directed by the focal meteorologists or higher technical officers of the National Weather Forecasting Centre (NWFC) in Islamabad or the Flood Forecasting Division (FFD) in Lahore in accordance with the Standard Operating Procedures (SOPs).

3.1.3 Current Meteorological Weather Stations (W-Dir, W-S, B-P, Precipitation, Upper Air, etc.)

1) Locations of Ground Meteorological Observation Point

As of 2010, there were 86 meteorological observation stations in the whole of Pakistan as shown in Figure 3.1.4 and enumerated in Appendix 3.1.1. The National Drought Monitoring Centre (NDMC) and the Tropical Cyclone Warning Centre (TCWC) manage 48 automatic weather stations (AWS/AWO) out of the 86 stations. NDMC has planned to install approximately 30 new AWS/AWOs for weather observation within two years.

On the other hand, TCWC is considering the installation of buoys for the meteorological observation to detect high tides due to cyclones and tsunamis. However, the installation and maintenance of this high tide monitoring system is very expensive. Therefore, the installation of this system is not recommended (refer to Subsections 3.2.2 and 4.2.1).



Source: PMD

Figure 3.1.4 Location of Existing AWS/AWO for Meteorological Observation

		
Meteorological Observation Field at the Islamabad PMD Head Office	AWS/AWO Equipment at the Islamabad PMD Head Office	AWS/AWO at the Meteorological Observatory (Karachi International Airport)

Figure 3.1.5 Existing AWS/AWO for Meteorological Observation

2) Observation

At all the meteorological observatories, meteorological observation is implemented and recorded manually every three hours as routine work. The observations have been carried out in compliance with the observation manuals on methods of observation, recording and reporting. The observation instruments have been well maintained in spite of their decrepit condition. Upper air observation with pilot balloons has also been conducted as needed. There is an estimated 30 sets of Korean-made equipment for the AWS/AWOs that will be installed in the future.

3) Data Transmission System

The meteorological observation data generated by AWS/AWOs have been transmitted from each meteorological observatory to the PMD Head Office through the Internet, VSAT or GPRS communication system. The meteorological observation data collected manually at 35 of the 86 stations has been transmitted hourly through several communication methods such as analogue radio, land phone, cellular phone, SMS, Internet or VSAT, and the data at the remaining stations (51 stations) have been transmitted every 3 hours. All the meteorological observation data have been uploaded on the PMD website and disclosed to the public. In the near future, the transmission method will be transferred from VSAT to GPRS gradually. It is necessary to formulate transmission system unification since the non-uniformity of the system has caused the loss of data and delay of data transmission.

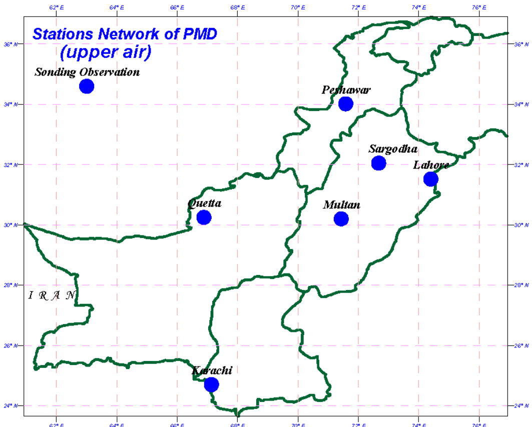
4) Upper-Air Observation

There are six (6) sounding observation locations out of the eight (8) upper-air observation stations in Pakistan, as shown in Figure 3.1.6. Due to the non-availability of spare parts, only one station (Karachi) is partially operational at present.

Radiosonde observation is taken once daily at 0000 UTC at the Karachi station. PMD has recently procured one (1) Model PA 5.0 SODAR (Sonic Detection and Ranging (also known as one type of wind profilers), which measures the scattering of sound waves by atmospheric turbulence) that can scan the atmosphere up to 5 km.

The system at the PMD Meteorological Complex in Karachi has been operational since May 2010. It is difficult to make the other upper-air observation stations functional due to the high cost of consumables, although WMO recommends radiosonde observations twice a day (at 0000 UTC and 1200 UTC). There is no upper-air observation station in the northern mountainous area.[1]

[1] These statements were taken from the report of the WMO FACT-FINDING AND NEEDS-ASSESSMENT MISSION (4-8 November 2010).



Source: Surface, Climate and Upper-Air Observation System
in Pakistan (submitted by MUHAMMAD TOUSEEF ALAM
Pakistan Meteorological Department) for JMA/WMO Workshop
on Quality Management in Surface, Climate and Upper-air Observations in RA II (Asia)

Figure 3.1.6 Upper-Air Observation Networks in Pakistan

Upper-air observation is one of the most significant meteorological observation activities to detect heavy rain causing meteorological disasters and the starting of rains. In this connection, corrective actions for proper observation are highly required.

5) Staff Ability for the Operation and Maintenance of Existing Ground Observation System

As described above, the PMD operates eighty-six (86) meteorological ground observation points at the following offices.

Table 3.1.5 Administrative Offices of PMD for O&M of Each Ground Meteorological Observation Point

Administrative Office/Centre	Ground Meteorological Observation			Upper Air Observation (*1)	
	AWS	Manual/Others	Subtotal	Radiosonde	WPR
NDMC (Islamabad)	20 (GPRS) + 15*3	-	35	-	
TCWC (Karachi)	10 (GPRS)	-	10	-	
FFD (Lahore)	-	-	-		
RMC (Karachi)	-	41	41	1	1
RMC (Lahore)	-			3 (*2)	
RMC (Peshawar)	-			1	
RMC (Quetta)	-			1	
Total	45	41	86	6	1

Note : *1: No operation as of 2011 due to budget restriction
*2: Located at Lahore, Sargodha and Multan
*3: No Automatic Communication

Source: PMD

For operation and maintenance of AWSs, the data are transmitted automatically and the staff (mechanics and observers) of each office responsible for their maintenance have checked and repaired them when the facilities are not working. High-level techniques and skills for the operation and maintenance activities for ground observation systems are not required. In this connection, the PMD has managed them well and has sufficient skills for operation and maintenance (O&M) activities because they are perpetually operated through most of the year. The PMD also has suitable skills for operation and maintenance of the upper-air observation although the observations are not being operated adequately due to budget restrictions resulting from purchase of the radiosonde.

3.1.4 Current Rainfall and Rainfall Observation Station

1) Rainfall Observation Station

a. Locations of Rainfall Observation Station

The Pakistan's Water and Power Development Authority (WAPDA) monitors the hourly rainfall observation systems for flood forecasting and flood warning in the Indus River Basin and also for the flood management of the Tarbela, Mangla and Chashma reservoirs at 45 stations in total, namely; 15 locations in the Indus River Basin (including 2 stations in Kabul River), 15 locations in the Jhelum River Basin, 8 in the Chenab River Basin, 6 in Ravi and 1 in the Sutlej River Basins (see Figure 3.1.4 and Appendix 3.1.2). Data from these stations are also transmitted to FFD of PMD in real-time.

In addition, PMD has 500 manual rainfall gauging stations, as tabulated in Appendix 3.1.3. The Lai Nullah Flood Forecasting System being managed by the Flood Forecasting and Warning Master Control Centre for Lai Nullah (FFWMCC) of PMD at Islamabad has real-time rainfall gauging stations at 6 locations (see Figure 3.1.7). PMD has also drafted a plan to additionally install real-time rainfall gauging stations with the function of river flow observation at approximately 30 stations in small to medium river basins.

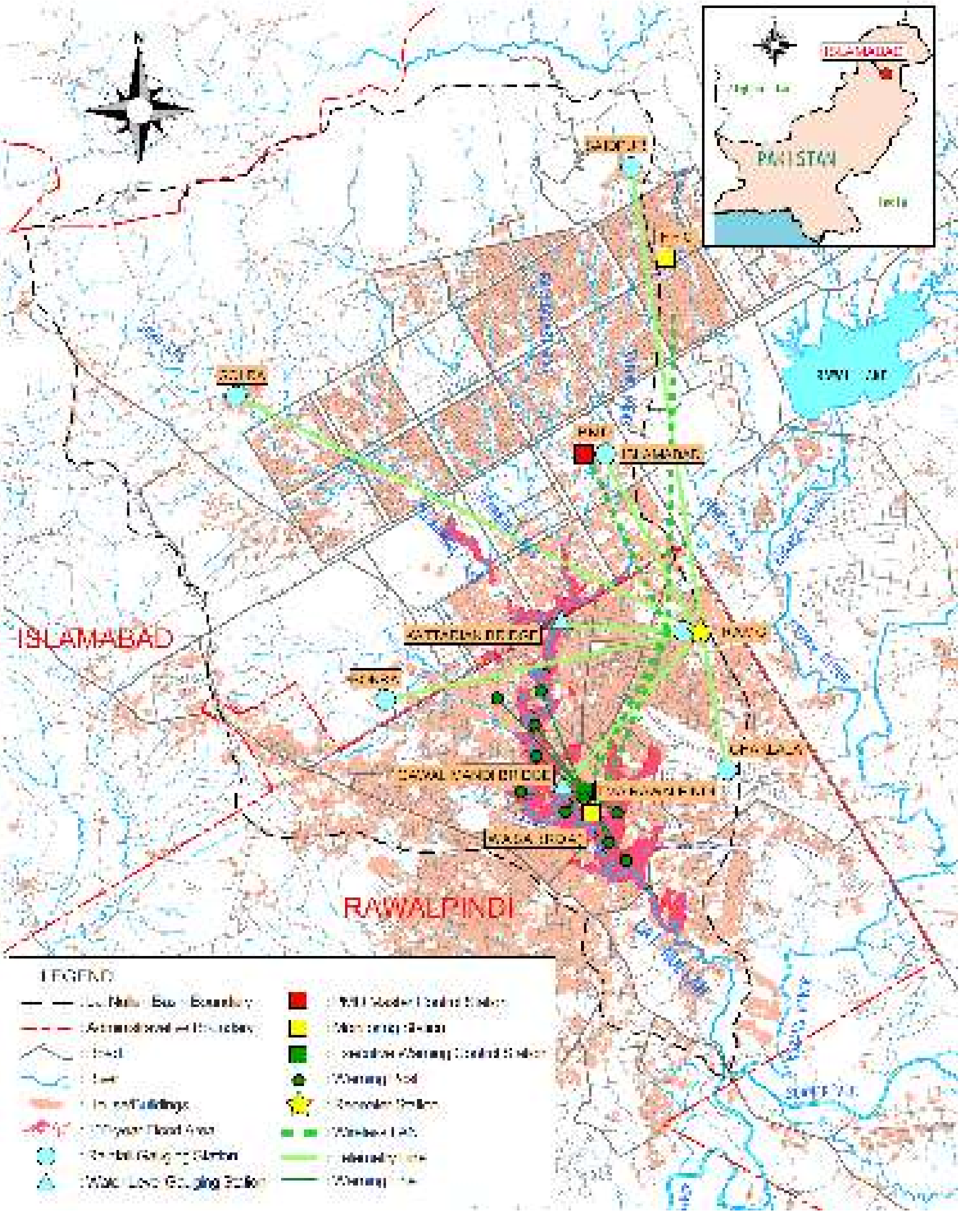


Figure 3.1.7 Lai Nullah FFEWS Network

	
Automatic Rainfall Observation Equipment	Rainfall Gauge, Solar Panel with Antenna
(At Ravi Syphone Observation Station) (As of June 2010)	

Figure 3.1.8 Typical Existing Facilities of Rainfall Observation by WAPDA

b. Observation

The rainfall observation system managed by WAPDA at 45 stations was installed from 1993 to 2006 and it is well maintained. Of the 45 stations, 3 stations were submerged and damaged by the 2010 Pakistan Flood and malfunctioned, although all the stations operated until 31 July 2010. For the PMD 500 automatic rainfall gauging stations, staff members of PMD called "Assistant Commissioners" and "Deputy Commissioners" have manually recorded and managed daily rainfall data at these stations.

c. Data Transmission System

At rainfall observation stations managed by WAPDA, hourly rainfall data are observed and transmitted to WAPDA and FFD of PMD through the Meteor Burst Communication System (MBC). The MBC system has become unstable and errors have resulted in missing data. On the other hand, the daily rainfall data at PMD's 500 automatic rainfall-gauging stations are summarized monthly and sent to PMD, either by hand delivery or mail. Regarding the Lai Nullah Flood Forecasting System, data of six (6) rainfall-gauging stations are transmitted to FFWMCC at PMD Islamabad Head Office through a dedicated radio system in real time.

2) River Water Level Observation

a. Location of Water Level Observation Stations

For the Indus River Basin Flood Forecasting and Warning System, the real-time data of the 45 stations are managed by WAPDA. Hourly water level observation is performed at 35 stations, namely: 11 stations in the Indus River (including 2stations in the Kabul River), 12 stations in the Jhelum River, 6 stations in the Chenab River, 5 stations in the Ravi and 1 station in the Sutlej River. In the Lai Nullah Flood Forecasting System established under a Japan Grant Aid Project, two (2) real-time river water level stations are operated (see Figure 3.1.9).

As mentioned above, the installation of approximately 30 stations for rainfall observation in small to medium river basins is planned. It is expected that these future stations will also record water level observations of the designated small to medium river basins (see Appendix 3.1.2).

	
Automatic Water Level Observation Equipment	River Water Level Gauge
(at Ravi Syphon Observation Station)	

As of June 2010

Figure 3.1.9 Typical Existing Facilities of River Water Level Observation by WAPDA

Provincial irrigation departments also monitor river water discharge at focal locations, such as locations of barrages, weirs and siphons for their O&M activities. This river flow information is also sent to FFD of PMD as one of the essential reference data to predict floods and issue warnings and advisories.

b. Observation

The hourly water level observation system managed by WAPDA has been established together with the rainfall observation system. As described in the condition of current observation systems, three (3) rainfall stations out of 45 were submerged and damaged by the 2010 Pakistan Flood and malfunctioned, although all the stations had been operating until 31 July 2010. Among the three stations, two have water level observation functions and, therefore, the operations have malfunctioned since 1 August 2010.

c. Data Transmission System

At the water level observation stations managed by WAPDA, hourly water levels are observed and transmitted to WAPDA and FFD of PMD through the MBC system, together with rainfall observation data. Regarding the Lai Nullah Flood Forecasting System, data from two gauging stations are transmitted to FFWMCC at the PMD Islamabad Head Office through a dedicated radio system in real-time.

3) Staff Ability for the Operation and Maintenance of Existing Meteorological Radars

Rainfall and river water observations of WAPDA and PMD to be utilized for warnings and advisories regarding early warning activities have been correctly conducted by their staff. These activities for the operation and maintenance are not complicated. As a result, most of the data derived from each station has been obtained subject to the designated observation periods since the commencement of their observation activities. As for PMD, mechanics, observers and electricians in all levels (senior ~ junior) have been involved in such O&M activities.

3.1.5 Meteorological Data Obtained from International Research Network

1) Satellite Imagery Data

a. Satellite Data from National Oceanic and Atmospheric Administration (NOAA)

The NOAA Satellite Data Receiving System has been operated by the R&D Division of PMD, but PMD has not received any high resolution (1 km mesh) meteorological satellite images broadcasted by the NOAA satellite because PMD's Satellite Data Receiving System from NOAA Polar Orbit Satellites has not functioned well since October 2009. At present, PMD obtains only low-resolution NOAA satellite images through the Internet and uploads them to the PMD website, but they are not used for forecasting. In order to detect detailed cloud conditions accurately for forecasting, high resolution images are extremely essential as reference data; therefore, prompt rehabilitation of the NOAA meteorological satellite image receiving system is necessary.

b. Data from Chinese Synchronous Meteorological Satellite "Feng Yun 2"

PMD has received high-resolution meteorological satellite images from the Chinese Synchronous Meteorological Satellite Feng Yun 2 through the Feng Yun 2 Satellite Data Receiving System operated by the National Drought Monitoring Centre (NDMC) of PMD. The operation of the satellite data receiving system is troubled sometimes. The received high-resolution images are uploaded to the PMD website.

Receiving Antenna of Satellite Imagery
by Feng Yun 2 at the PMD Head Office in Islamabad

Figure 3.1.10 Typical Existing Meteorological Satellite Data Receiving System

2) Meteorological Data from Abroad through Global Telecommunication System (GTS)

The PMD has been receiving meteorological data observed at foreign countries and organizations from the Global Telecommunication System (GTS) through the GTS Communication Switch operated by the National Meteorological Communication Centre (NMCC) of PMD. PMD's GTS has been connected to New Delhi by a 64 kbps dedicated line. In addition to this, PMD has kept the availability of GTS connections to Tehran, Iran and Tashkent, Uzbekistan as spare. At present, the GTS Communication Switch is operated fairly well. However, the system shall be considered with a backup system because these units are located in Karachi far from PMD Headquarter at Islamabad.

3) Staff Ability for the Operation and Maintenance of Meteorological Data Acquisition from Satellite and GTS

The satellite and GTS operations have been administrated by other international agencies, such as NASA or WMO. These data can be obtained through communication equipment and systems such as the Internet, dedicated line or V-Sat communication. Basically, high-level techniques are not required for the data acquisitions unless the communication system between sources and PMD malfunctions.

Administrative offices for these systems are as follows:

Table 3.1.6 Administrative Offices of PMD for O&M of Meteorological Data Acquisition from Satellite and GTS

Administrative Office/Centre	Satellite Image Data	GTS Data
NWFC (Islamabad)	Responsible	-
RMC (Karachi)	-	Responsible

Source: PMD

3.1.6 Current Weather Forecasting and Warning/Alert System

This Multi-Hazard EWS Plan has been prepared to mitigate damage caused by designated targeted disasters as described in Chapters 1 and 2. The targeted disasters are mainly for meteorological or related disasters, such as river/flash floods, landslides, cyclones with storm surges, droughts, GLOFs and avalanches.

Early warnings for these meteorological disasters can be properly released in line with weather forecasting information provided by PMD as a main fundamental factor in accordance with each appropriate Standard Operating Procedure (SOP) (refer to section 3.3). Hence, accurate weather predictions are imperative for the early warnings against meteorological disasters.

PMD is a unique agency responsible for the dissemination of weather forecasting in Pakistan. The current process and issues regarding weather forecasting conducted by PMD are as follows:

1) General

a. General Classification of Weather Forecasts

In general, weather information can be classified into four (4) categories, namely: very short-term forecasts, short-term forecasts, medium-term forecasts and long-term forecasts. The relationship between each forecast and the early warning system are as follows:

i) Very Short-Term Forecast

Very short-term forecasts are to predict and report weather information for several hours (1~6 hours) applying to flash flood and landslide warnings in localized areas.

Currently, PMD is not issuing such specific very short-term forecasts except for the Lai Nullah Basin for Islamabad and Rawalpindi Cities because these forecasts can be obtained by dense rainfall distribution data and water levels in real time. Some areas affected by flash floods and/or landslides are located near high mountains where the existing isolated rainfall radar network cannot determine the actual rainfall.

In this connection, real-time rainfall and water level gauging stations as well as observations by rainfall radar (fixed (C/S-band) and/or movable (X-band) radar and

WPR shall be installed in high-risk areas with the establishment of the designated EWS and capacity development of staff of PMD to learn the rainfall forecast techniques.

ii) Short-Term Forecast

Short-term forecasts refer to 1 (over 6 hours) ~3day forecasts to predict river flooding in the middle reaches of major rivers including comparatively long run-off floods of medium to small scaled nullahs.

The Indus flood warning system has been established and is functioning well with broadly installed hourly rainfall and water level gauging stations, Islamabad, Mangla, Sialkot and Lahore radar systems with empirical and calculated flood run-off models for which improvement is required (see Subsection 3.3.2).

The improved Indus River flood warning system shall include the establishment of warning systems in the upper reaches of the Indus, Jhelum and Kabul Rivers and some other tributaries that pose a danger to human lives. For this purpose, enhancement of the existing rainfall radar network, augmentation of rainfall and water level observations with the improvement of flood models as well as the improvement of NWP are needed.

iii) Medium-Term Forecast

Medium-term forecasts contribute to predict Indus River Basin floods and the possibility of flash floods at certain vulnerable areas and confirm continuous droughts.

At present, PMD has given advisories for the possibility of such droughts by employing statistical and empirical techniques.

Hence, it is necessary to produce more accurate medium-term forecasts to augment the NWP capacity and ability because the result of the existing NWP by PMD is calculated up to 78 hours based on a 11km x 11km mesh of hydrostatic mechanics models in a narrow area. This target area should be expanded and the forecasting term should also be extended to obtain results for 1 week or more with higher-performance equipment.

iv) Long-Term Forecast

Long-term forecasts cover long periods (more than 2 weeks up to seasonal conditions) weather and climates to predict the seasonal weather tendencies for the preparation of countermeasures against disasters, water use, etc.

PMD currently reports the outlook for the weather and climate of Pakistan based on the international network and climate model calculations independently.

In the future, PMD should enhance and strengthen the connection to the Global Telecommunication System of the WMO network and the climate model utilizing adequate equipment.

b. Process of Weather Information Produced by PMD

The general flow/process of weather information from obtaining observation data to issuance of weather information and early warning for meteorological disasters are shown in the following figure:

Observation

Surface Meteorological Observation Points: 86points including 48 AWS
Rainfall (45points) and River Water Level (35points) observation stations with Data from Lai Nullah FF&WS
Satellite HRPT Data
Upper Air Observation Data
Meteorological Radar Observation Data (Islamabad, Karachi, RYKhan, D.I.Khan with Mangla, Sialkot, Lahore)
Data from GTS

Processing/Forecast

Production of Meteorological Charts (Surface and Upper Air) in PMD own Conduct of Numerical Calculation Study by PMD Own based on GME (GFZ) RHRM Results provided by NOMAD3 Obtaining Charts and Numerical Calculation Results from India with Study in PMD Own Obtaining GFS with Study in PMD Own	Confirmation of GMOP Data Confirmation of Rainfall & Water Level Confirmation of Radar Data Calculation of Hydraulic Model for Indus Review & Confirmation of Charts Reconfirmation of Radar Data Updating Latest Satellite HRPT Image	Lai Nullah Basin • Confirmation of Rainfall Intensity and Accumulation • Confirmation of Water Level • Comparing raw data and warning standard

Discussion by Principal Meteorologists / Statistical and Empirical Approach

Issuance / Dissemination

Type	Situation/ Type of Forecast	Criteria	Remarks	Issuing Office/Centre
Weather Info.		Pakistan Weather Outlook National Weather Forecast Pakistan Cities' Forecast Weekly Weather Forecast	With Daily Chart 24 hrs	NWFC (each RMC)
River Flood	Qualitative Forecast	Blue Alert Yellow Alert Red Alert	Due to the location of depressions	FFD
	Quantitative Forecast	Low/Medium/High/Very High/Exceptionally High	By Routine Daily Flood Forecast (RDFF)	FFD
	Other Early Warnings	Significant Flood Forecast Areal Flood Inundation Flood Forecast	With Names of Designated Locations/Villages likely affected	FFD
	Miscellaneous Flood Forecast/Information	Weather Information Flood Information for Media Special Press Briefings	With warning for other disasters, such as landslides, flash floods	FFD NWFC
Flash Flood	Lai Nullah Basin	Pre-Alert Alert Evacuation	Due to Water Level and Precipitation Volume in the Basin	FFWMCC for Lai Nullah
	Other Areas (General Information)	Warning Messages with General Weather Info.	At certain designated locations likely affected by landslides	FFD NWFC
Cyclone	Warning	Watch/Alert/Warning	With Storm Surge warning	TCWC
Drought	Advisory	Only Climate Situation	Fortnightly	NDMC
Landslide, GLOF, Avalanche	By Miscellaneous Flood Forecast/Information for floods	No Criteria (Warning Messages with General Weather Info.)	Only advisory for disasters with name of regions likely occurred and affected	NWFC FFD

Issuance/Warning Measures: Website (http://www.pakmet.com.pk/), Fax/Telephone, SMS (limited contacts)

Note: See Section 3.3 for details

Figure 3.1.11 Flowchart of Meteorological Information Issuance System

2) Accuracy and Capacity of Current Numerical Weather Prediction in Pakistan[2]

a. Outline of Numerical Modeling

Numerical modeling is the process of obtaining an objective forecast of the future state of the atmosphere by solving a set of equations that describe the evolution of variables (temperature, wind speed, humidity, air pressure, etc.) that define the state of the atmosphere.

The process begins with analysing the current state of the atmosphere by taking a previous short-range forecast and using observations to amend this forecast so that the best guess of the current true state of the atmosphere is obtained. All numerical models of the atmosphere are based upon a set of governing equations. Numerical models differ in the approximations and assumptions made in the application of these equations, how they are solved and also in the representation of physical processes.

b. Regional Climate Model in Pakistan

Climate models are increasingly used for downscaling climate scenarios, seasonal climate predictions, land use climate impact and ocean-atmospheric interaction studies all over the world. A climate model consists of complex computer programs. These programs look at several mathematical equations that govern the atmospheric processes at once. They take into account conservation of mass, energy, and momentum in a grid box system (the world is divided in to several grid boxes). The model focuses on each grid box and the transfer of energy between grid boxes. The aim is to reproduce as faithfully as possible the real climate system.

PMD is using the PRECIS regional climate modeling system developed by Hadley Centre of Meteorological Service, United Kingdom and RegCM3 (Regional Climate Model version 3) of ICTP, Trieste, Italy, for developing climate scenarios, climate predictions, land use / land cover climate impact and for climate and climate change related research. The models are functional and installed in Pentium4 Servers at Research & Development (R&D) Division of PMD, Islamabad.

c. Numerical Weather Prediction Systems in Pakistan

The simulation of atmospheric processes on a computer with the aim of taking their latest state to derive a prognosis of the future development is called numerical weather prediction. Nowadays most of the weather forecasts are compiled on this basis in Pakistan and the rest of the world.

PMD is using the Mesoscale Model (HRM-11km) for numerical weather forecasting at present. The HRM was developed by DWD (National Meteorological Service of Germany). The models have been installed at Research & Development Division of PMD. The data (such as GPV data) of the Global Model (GME) and also of DWD, which are received through a dedicated Internet

[2] Quoted from http://www.pakmet.com.pk/rnd/rndweb/Modeling.htm

line (3 MB/s Fiber Optic Internet connectivity), shall be used as initial conditions in HRM for the numerical weather prediction. The use of this high-resolution model will further improve the weather forecasts issued by PMD and also enhance the accuracy of weather predictions.

The current statuses of ability of numerical calculation by PMD are as follows:

Table 3.1.7 Current Status of Ability of Numerical Calculation by PMD

Item	Current (Existing)
Calculation Capacity	Ordinary: 1-2 days Max. : up to 72 hours (3days)
Mesh	11 kms x 11kms
Processing Time	Several Hours (4-5 hours) for each forecast (precipitation, temperatures, rainfall contour)
Accuracy of Forecast utilizing Numerical Analysis	<u>Weather Forecast:</u> Approx 80% for rainfall (24 hours) Approx 70% for rainfall (48 hours) Less than 60% for rainfall (72 hours) Cyclone Tracking Forecast:

Source: PMD

3) Staff Ability for Weather Forecasts

Staff related to weather forecasting activities belong to the National Weather Forecasting Centre (NWFC) at Islamabad for general and comprehensive weather forecasts, the National Drought Monitoring Centre (NDMC) at Islamabad for drought advisories, the Flood Forecasting Division (FFD) at Lahore for Indus major river floods, the Tropical Cyclone Warning Centre (TCWC) at Karachi for cyclone warnings and the Research & Development (R&D) Division at Islamabad for numerical weather forecasting calculations.

The summary of staff assignments of each office/center are shown below:

Table 3.1.8 Summary of Staff Assignment of Each Office in PMD Related to Weather Forecasting (Over BS-15)

No.	Name of Posts	BPS	No. of Post(s) (*[1])					
			NWFC	NDMC	FFD	TCWC	NSMC TWC	R&D
1	Director General	21						
2	Chief Meteorologist	20		1	1		1	1
3	Director / Principal Meteorologist	19	1	1	1	1	1	3
4	Principal Engineer	19					1	
5	Chief Admin. Officer	19						
6	Dy. Director / Senior Meteorologist	18	3	1	1	2	2	4
7	Senior Elect. Eng. / Dy. Dir. (Eng)	18	1					
8	Deputy Chief Admin. Officer	18						
9	Senior Programmer	18						
10	Meteorologist/Seismologist	17	6	2	3	5	3	3
11	Librarian	17						
12	Electronic Engineer	17	1	1	1	1	2	
13	Admin Officer	17				1		
14	Accounts Officer	17						
15	Private Secretary	17						
16	Security Officer	17						
17	Programmer	17		1	1	1		
18	Workshop Engineer	17						
19	Assistant Programmer	16		1	2	2		
20	Assistant Meteorologist	16	3	1			3	
21	Assistant Electronic Engineer	16						
22	Assistant Mechanical Engineer	16						
23	Superintendent/Assist. Officer	16					1	
	Others (Data Entry*[2], Sub-Engineer*[3], Observer*[4], Stenographer*[5], Prof.Assistant*[6], Met.Assistant*[7], Technical Assistant*[8])	-	2*[3] 2*[5] 3 *[6] 5 *[7]	4*[3] 3*[2] 2*[4]	5 *[3]	2*[2] 3*[3] 5*[8]	10*[2] 3*[3] 1*[4]	3*[2]
Total			27	18	15	23	14	14

Note: *1: The numbers are sanction base.
Source: PMD

To identify the abilities of staff belonging to offices/centres mentioned above, interview surveys were conducted throughout the Project Implementation.

As a result, the impairment of forecast ability due to lack of personnel capacities has not been confirmed in terms of existing mechanical and software capacities but the consecutive improvement and development of human resources capacity will be strengthened in line with renewal and update of the hardware and software regarding forecasting abilities.

3.2 Current Seismic Observations

3.2.1 Seismograph

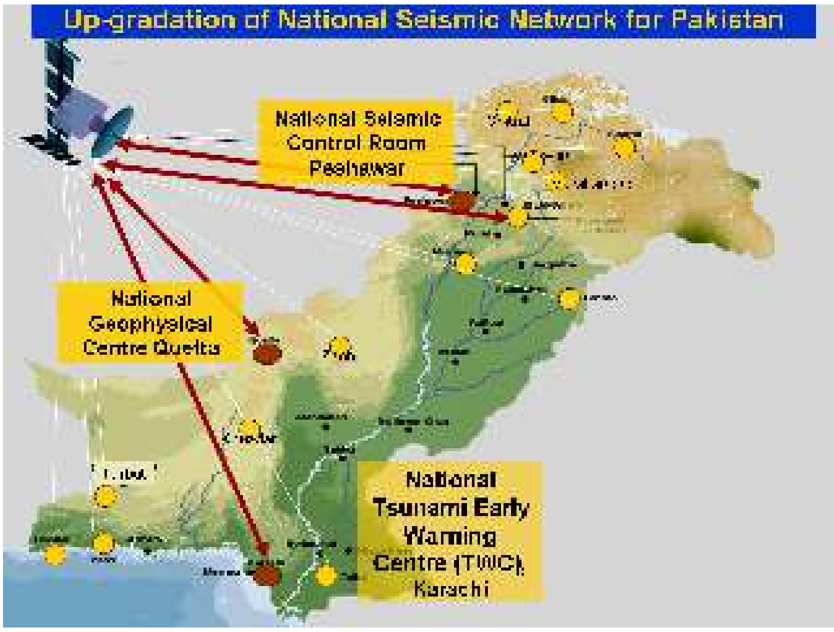
1) Location of Seismograph Stations

As of August 2010, the National Seismic Monitoring Centre (NSMC) at Karachi of PMD manages 21 seismograph monitoring stations in the whole of Pakistan. NSMC plans to install new stations at 13 designated locations. Hence, NSMC can monitor earthquake activities from 34 stations in total in Pakistan as of the end of 2010, as listed in Table 3.2.1. Therefore, PMD will have 21 accelerographs, 13 short period seismographs, and 20 broadband seismographs. It is noted that communication methods and destinations of data transmission differ by station. Besides PMD, WAPDA also operates a seismic network, mostly on dams. Figure 3.2.1 shows the upgrading plan of the national seismic network by PMD, and Table 3.2.2 gives a summary of the total number of seismic stations by instrument type.

Table 3.2.1 Seismic Observation Stations Operated by PMD

No	Station Name	District	Latitude	Longitude	Altitude (m)	Observation Elements			Data Transmission		
						Accelero-graph	Short Period	Broad-band	Destination	Frequency	Method
1	Islamabad	Islamabad	33.70 N	73.10 E	507	□	○	□	Islamabad,Karachi	Real-time	Internet/ (VSAT)
2	Peshawar	Peshawar	34.02 N	71.56 E	392	○	○		Islamabad,Karachi	Real-time	Internet
3	Kakul	Abbottabad	34.18 N	73.24 E	1,229		○		Islamabad,Karachi	Real-time	Internet
4	Hyderabad	Hyderabad	25.38 N	68.36 E	30		○		Islamabad,Karachi	Real-time	Internet
5	Korangi (KHI)	Karachi	24.83 N	67.12 E	22		□		(Islamabad,Karachi)	(Real-time)	(Internet)
6	Balakot	Mansehra	34.53 N	73.33 E	995	○		○	Islamabad,Karachi	Real-time	VSAT
7	Chitral	Chitral	35.88 N	71.28 E	1,498	○		○	Islamabad,Karachi	Real-time	VSAT
8	Muzafarabad	Muzafarabad	34.36 N	73.49 E	1,169	○		○	Islamabad,Karachi	Real-time	VSAT
9	Zhob	Znob	31.21 N	69.28 E	1,405	○		○	Islamabad,Karachi	Real-time	VSAT
10	Quetta	Quetta	30.05 N	66.58 E	1,719	○		○	Islamabad,Karachi	Real-time	VSAT
11	Bahawalnagar	Bahawalnagar	29.95 N	73.25 E	161	○		○	Islamabad,Karachi	Real-time	VSAT
12	Khuzadar	Khuzadar	27.28 N	66.60 E	1,248	○		○	Islamabad,Karachi	Real-time	VSAT
13	Turbat	Kech	25.98 N	63.02 E	141	○		○	Islamabad,Karachi	Real-time	VSAT
14	Umerkot	Umerkot	25.33 N	69.72 E	33	○		○	Islamabad,Karachi	Real-time	VSAT
15	Karachi	Karachi	24.92 N	67.13 E	38	○		○	Islamabad,Karachi	Real-time	VSAT
16	Uthal	Lasbera	25.80 N	66.61 E	27		□		(Islamabad,Karachi)	(Real-time)	(Internet)
17	DHA Karachi	Karachi	24.79 N	67.06 E			□		(Islamabad,Karachi)	(Real-time)	(Internet)
18	Mithi	Tharparkar	24.73 N	69.79 E	30		○		Karachi	Monthly	Handover
19	Chhor	Umerkot	25.51 N	69.78 E	6		○		Karachi	Monthly	Handover
20	Rohri	Sukkur	22.68 N	68.90 E	66		○		Karachi	Monthly	Handover
21	Larkana	Larkana	22.56 N	68.21 E	53		○		Karachi	Monthly	Handover
22	Larkana Moen Jo Daro	Larkana	27.32 N	68.14 E	53		○		Karachi	Monthly	Handover
23	Badin	Badin	24.66 N	68.84 E	9		○		Karachi	Monthly	Handover
24	Gilgit	Gilgit	35.90 N	74.30 E	1,600	□		□	(Islamabad,Karachi)	(Real-time)	(VSAT)
25	Chilas	Diamir	35.40 N	74.10 E	1,250	□		□	(Islamabad,Karachi)	(Real-time)	(VSAT)
26	Skardu	Skardu	35.30 N	75.60 E	2,317	□		□	(Islamabad,Karachi)	(Real-time)	(VSAT)
27	Tarbela	Haripur	34.10 N	72.80 E	372	□		□	(Islamabad,Karachi)	(Real-time)	(VSAT)
28	Cherat	Nowshera	33.80 N	71.90 E	892	□		□	(Islamabad,Karachi)	(Real-time)	(VSAT)
29	Kattas	Chakwal	32.70 N	72.60 E	679	□		□	(Islamabad,Karachi)	(Real-time)	(VSAT)
30	Fort Munro	D. G. Khan	29.90 N	70.00 E	442	□		□	(Islamabad,Karachi)	(Real-time)	(VSAT)
31	Nok Kundi	Chagai	28.80 N	62.70 E	649	□		□	(Islamabad,Karachi)	(Real-time)	(VSAT)
32	Nagar Parker	Tharparkar	24.40 N	70.80 E	69	□		□	(Islamabad,Karachi)	(Real-time)	(VSAT)

Note: *1:○:Present □: Planned
Source: PMD



Source: PMD

Figure 3.2.1 National Seismic Network of Pakistan

Table 3.2.2 Number of Existing and Planned Seismic Stations

Condition	Accelerograph	Short Period	Broadband
Existing	11	10	10
Planned	10	3	10
Total	21	13	20

Source: PMD

As for the worldwide seismic monitoring system, NSMC can obtain near-real-time seismic activity data at 150 stations worldwide, such as those in Indonesia, Australia and Israel, through the German company Geo Forcheng Zentrum (GFZ). However, the most significant data to identify the epicentre with a high degree of accuracy for the tsunami warning in nearby countries such as India, Iran, Oman and China cannot be monitored in real-time through the GFZ network.

PMD has envisaged a plan to install an Ocean Bottom Seismograph and a Tsunami Sensor GPS Buoy. At the same time, it recognized that the installation cost for these systems is quite expensive and the maintenance activities will be burdensome. Taking all of these into consideration, it has been determined that there is no urgent need for these instruments at the moment.

	
Seismic Observation Display System	Strong-Motion Seismic Recorder
(at Karachi Observation Station)	

Figure 3.2.2 Typical Existing Facilities of Seismograph Station operated by WAPDA

2) Observation

There are currently several types of seismographs installed at the 21 stations in Pakistan, such as acceleration seismograph equipment at 11 stations, short-period seismograph at 11 stations and broadband seismographs at 10 stations, as shown in Table 3.2.1. However, three (3) of the 21 stations have been inoperative due to power system failure since 26 July 2010. As a result, seismic activities have not been recorded. This problem has not been solved up to the present even though PMD can do the repair or replacement immediately.

Of the 13 new seismograph stations that have to be set within 2010, 10 stations will be equipped with broadband seismographs made in China.

3) Current Analysis Method

The epicentre and magnitude can be analyzed by the SEISCOMP3 provided from GFZ based on the monitored seismic data within 3 to 5 minutes after an actual earthquake and automatically disseminated to prescribed officers of related government staff through SMS. In addition, these data of epicentre and magnitude are automatically sent to the tsunami simulation software named "GUITAR", and the possibility of a tsunami is estimated. It takes approximately 5 minutes for the system to obtain simulation results. Subsequently, the results are also disseminated to prescribed officers immediately through SMS in case a tsunami will occur.

4) Data Transmission System

The monitored data at 14 out of the 21 stations have been collected in real-time through the Internet lines or VSAT communication systems by NSMC. In such communication systems, the VSAT line can be utilized for not only seismograph data but also other data transmissions. So far, the VSAT system has been utilized by PAKSAT, a communication satellite acquired by Pakistan of which the proper operation was terminated. Therefore, the satellite utilized by the VSAT system has made the shift to IntelSat by the U.S. and the shift was completed by August 2010.

5) Staff Ability for the Seismic Observation System

As described above, the PMD has operated twenty (20) seismic observation points by the following offices.

Table 3.2.3 Administrative Offices of PMD for O&M of Seismograph Observation Point

Administrative Office/Centre	Existing Seismograph
NSMC (Karachi)	-
RSMC (Islamabad)	20
RSMC (Quetta)	-
RSMC (Peshawar)	-
Total	20

Source: PMD

As for the operations and maintenance of seismographs, most of the places where the seismographs are installed are managed by permanent resident staff at each location. Their classes are mainly categorized into "Senior Observer (BS-7)". The senior observers are well trained for the observation activities and maintenance and small repair activities. The data are transmitted automatically and the staff of each management office responsible for their maintenance have checked and repaired them when the facilities are not working. It is not required to obtain high level techniques and skills for the operation and maintenance activities for the seismograph observation systems. In this connection, the PMD has managed them well and sufficient skills for operation and maintenance (O&M) activities are good because they are perpetually operated through most of the year.

3.2.2 Tide Gauge Stations for Tsunami

The tide gauge station at Karachi has been operated by Karachi Port Trust during the last three years with support from UNESCO. Data is transmitted every minute via satellite to the Pacific Tsunami Warning Center in Hawaii. Data is also published on the Web every 15 minutes. Currently, PMD receives tide gauge data only via the Internet. UNESCO added three (3) tide gauge stations along the coast in 2010, as shown in Table 3.2.4.

As well as other meteorological observation activities, observations and maintenance of tide gauges are not extremely complicated activities. Therefore, there is no issue regarding the staff abilities for the O&M activities for observation of tide gauges. The new tsunami EWS was established in 2010 in association with UNESCO and the system has not had any trouble since the establishment.

Table 3.2.4 Tide Gauge Stations in Pakistan Coast

Station	Status	Beneficial Population
Karachi	Operated for 3 years	18,000,000 in 2007
Keti Bandar	Installed in 2010	N/A
Ormara	Installed in 2010	40,000 in 2005
Gwadar	Installed in 2010	53,080 in 2006

Source: Karachi Port Trust

3.3 Review on Current SOPs and Dissemination System for EWS

PMD is developing the Standard Operation Procedures (SOPs) for several target hazards such as earthquake, tsunami, Indus River Basin floods, flash floods (Lai Nullah Basin), cyclones and droughts.

3.3.1 Tsunami Warning SOP

1) National Seismic Monitoring and Tsunami Early Warning Centre in Karachi (NTWC)

The tsunami warning SOP was developed by the National Seismic Monitoring and Tsunami Early Warning Centre, PMD (NSM & TEWS, alias National Tsunami Warning Centre, NTWC), with the assistance of UNESCO in 2010. The document consists of two parts, namely; Part I for the Arabian Sea (Makaran Subduction Zone) and Part II for the rest of the Indian Ocean (Sumatra and surroundings).

2) Standard for Information

Three parameters (earthquake location, depth, and magnitude) are used to evaluate the tsunami potential of an earthquake. Table 3.3.1 shows the magnitude range and tsunami potential described in the SOP. Bulletins 1 to 4 shown in Table 3.3.2 will be disseminated to response authorities and media using SMS, facsimile, satellite phone, PMD's website, and e-mail. Figure 3.3.1 shows the flowchart of tsunami warning SOP.

Table 3.3.1 Magnitude and Tsunami Potential

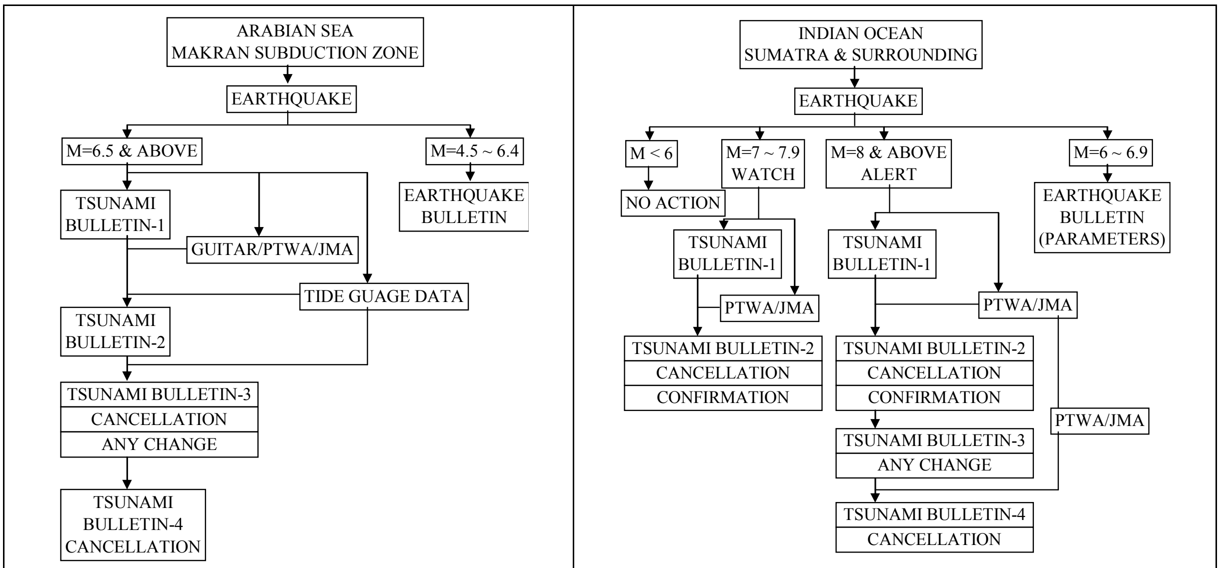
<table>
<tr><th>Location</th><th>Magnitude</th><th>Tsunami potential</th><th>Action</th></tr>
<tr><td rowspan="6">Under the Arabian Sea</td><td>Less than 4.5</td><td rowspan="3">Small possibility of local destructive tsunami</td><td>No Action</td></tr>
<tr><td>4.5 to 6.4</td><td>Earthquake bulletins</td></tr>
<tr><td>6.5 to 7.0</td><td rowspan="4">Tsunami bulletins</td></tr>
<tr><td>7.1 to 7.5</td><td>Local destructive tsunami</td></tr>
<tr><td>7.6 to 7.9</td><td>Regional widespread destructive tsunami</td></tr>
<tr><td>8.0 and above</td><td>Widespread destructive tsunami</td></tr>
<tr><td rowspan="4">Indian Ocean, Sumatra and Surrounding Areas</td><td>Less than 6.0</td><td rowspan="3">Small possibility of local/regional tsunami</td><td>No Action</td></tr>
<tr><td>6.0 to 6.9</td><td>Earthquake bulletins</td></tr>
<tr><td>7.0 to 7.9</td><td rowspan="2">Tsunami bulletins</td></tr>
<tr><td>8.0 and above</td><td>Widespread tsunami</td></tr>
</table>

Source: Tsunami Warning SOP, PMD

Table 3.3.2 Contents of Tsunami Bulletin

Bulletin No.	Contents	Target
1	Earthquake parameters, tsunami **evaluation based on historical earthquake and tsunami data**	Arabian Sea
2	Earthquake parameters, **evaluation regarding potential and destructive effects** of tsunami, **estimated arrival times/wave heights** based on simulation and information from PTWC and JMA, tide gauge data	
3	Earthquake parameters, tide gauge data, **Cancellation** in case of no tsunami generation or **Any Change of Information**	
4	Earthquake parameters, evaluation regarding **Cancellation** in case tsunami generation is confirmed.	
1	Tsunami **Watch** and Earthquake parameters, tsunami evaluation based on historical earthquake and tsunami data	In case < M8 Indian Ocean (Sumatra and surroundings)
2	**Confirmation** (Possibility/Observation of Tsunami Activity)	
	Cancellation (Observation of Tsunami Activity)	
1	**Tsunami Alert** and Earthquake parameters and tsunami	In case > M8 Indian Ocean (Sumatra and surroundings)
2	Tsunami **estimated arrival times/wave heights** based on simulation and information from PTWC and JMA, tide gauge data with Earthquake parameters	
3	Earthquake parameters, tide gauge data, **Cancellation** in case of no tsunami generation or **Any Change of Information**	
4	Earthquake parameters, evaluation regarding **Cancellation** in case tsunami generation is confirmed.	

Source: Tsunami warning SOP, PMD



For Arabian Sea	For Indian Ocean (Sumatra and Surroundings)

Source: PMD

Figure 3.3.1 Flowchart of Tsunami Warning SOP

3) Devices and Contacts for Information

Multiple communication channels have been established for the dissemination of bulletins. Two SMS terminals for mobile phone dissemination and three FAX terminals (two automated and one manual) have been reserved for this purpose. Routine tests and exercises are carried out to test the Standard Operating Procedure.

NSM & TEWC conducts regular tests to check the operational status of the data acquisition system, communication system and dissemination system. Exercises are also carried out repeatedly to test the SOP. For this purpose dummy messages are sent with the header "TEST", to ensure that the message is not misunderstood.

Devices and contacts for all the information (bulletins) defined in the SOP have also been fixed in the SOP. The confirmed devices for information and the contact lists are as shown in the following table.

Table 3.3.3 Devices and Contacts for Information in the Current Tsunami EWS

Magnitude of Earthquake	Arabian Sea			Indian Ocean		
	Type of Information	Response Authority *1	Media	Type of Information	Response Authority *1	Media
4.5 ~ 5.9	Earthquake B	SMS/Fax	SMS/Fax	No Action		
6.0 ~ 6.4				Earthquake B	SMS	No Info.
6.5 ~ 6.9	All Tsunami Bulletins	SMS/Fax	SMS/Fax			
7.0 ~ 7.9				Tsunami B-1	SMS/Fax	No Info.
				Tsunami B-2		Fax
> 8.0				All Bulletins	SMS/Fax	SMS/Fax

Note *1: Response Authorities include: National Disaster Management Authority (NDMA); Provincial Disaster Management Authorities (PDMA-Balochistan & Sindh); District Coordination Officer(s) (DCO) (DDMA: Gwadar, Lasbella, Karachi, Thatta and Badin); Pakistan Army and Pakistan Navy; Karachi Port Trust (KPT) and Maritime Security Agency (MSA).

Source: PMD

3.3.2 Indus River Flood and General Flash Flood Warning SOP

1) Forecasting and Warning System

FFD is responsible for the flood forecasting service in the whole of Pakistan and for the early warning system in the Indus River Basin covering the Indus River downstream of Tarbela Dam, in collaboration with WAPDA and the Provincial Irrigation Department. The types and kinds of flood forecasting released by FFD are given in Table 3.3.4 to Table 3.3.7.

There are three kinds of flood forecast, namely; (i) Qualitative flood forecast; (ii) Quantitative flood forecast; and (iii) Early warning. The methods of forecasting and warning are summarized below.

a. Qualitative Flood Forecast

Qualitative flood forecasts are meant to provide advance information about an approaching weather system that may cause a significant flood wave in the Indus river system. Three qualitative flood forecast alerts called Blue, Yellow and Red are issued to alert the concerned government agencies based on the location and situation of monsoon low/depression or tropical cyclone. The three colour alerts are as follows:

Blue Alert: Issued in case of the possibility of flood within 24 to 72 hours, depending upon the future movement of the monsoon low/depression at Rajhastan.

Yellow Alert: Issued in case the occurrence of flood becomes imminent, the monsoon low/depression turning towards the catchment.

Red Alert: Issued in case the low/depression arrives and starts to directly affect the catchment area with heavy flood-producing rains.

b. Quantitative Forecast

Based on actual precipitation amount and measurement of flow discharge, the following forecasting and early warning messages are issued by FFD in accordance with the flood situation. The flood forecast has seven parts issued in two bulletins (Bulletin A and Bulletin B).

Table 3.3.4 Quantitative Forecast and Warning by FFD

Title	Major Contents	Timing
Routine Daily Flood Forecast (RDFF) (for Basic Information)	Observed Indus River discharge, meteorological charts, data of meteorological radars	Once a day (before mid-day)
(for Flood Forecast)	***<u>Bulletin-A</u>*** (1) General situation of river flows; (2) Meteorological features; (3) Weather forecast expected next 24 hrs; (4) Amount of rainfall during the past 24 hrs in the country; (5) General weather outlook for next 48 hrs. ***<u>Bulletin-B (when necessary)</u>*** (6) Weather/rain forecast in the upper and lower catchment areas of all the five rivers; (7) Quantitative forecast of river flows at 22 sites including rim stations.	

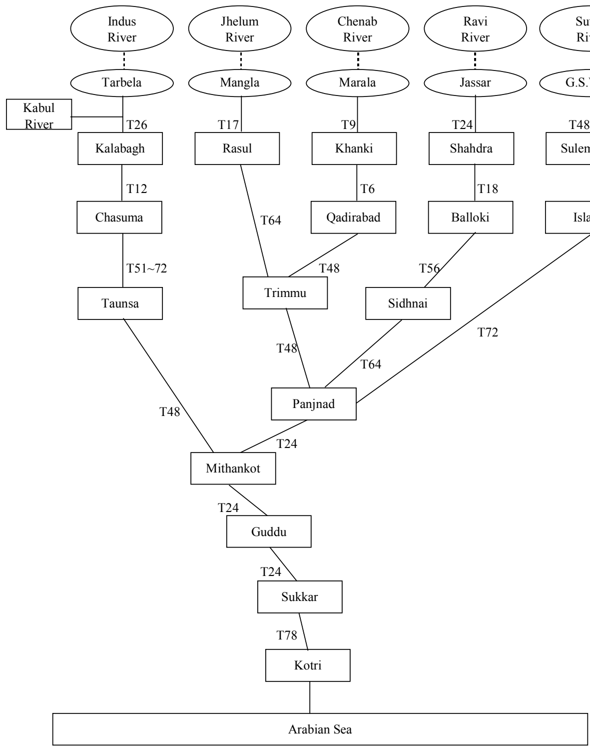
Source: PMD

In terms of intensity of flow discharge indicated in RDFF as explained above, Pakistan floods are classified into five (5) levels as shown in the table below.

Table 3.3.5 Classification of Floods Issued by FFD

S. No.	Classification	Description
1	Low Flood	A flood situation when the river is flowing within deep channel(s) but is about to spread over river islands/*belas*.
2	Medium Flood	When the river flow is partly inundating river islands/*belas* but below half of its highest flood level.
3	High Flood	When the water level of the river is almost fully submerging islands/*belas* and continues to rise up to high banks/bunds but without encroaching on the freeboard.
4	Very High Flood	When the water level of the river flows is between high banks/bunds with encroachment on the freeboard.
5	Exceptionally High Flood	When there is imminent danger of overtopping/breaching or a breach has actually occurred or high bank areas become inundated.

The discharges in each flood classification of the Indus Basin River System are shown in Appendix 3.2.1, and the travel times between each focal point in the river system for forecasting are as shown in Appendix 3.2.2 and Figure 3.3.2 below.



Source: PMD

Figure 3.3.2 Travel Time of Flow in Rivers in Normal Condition

c. Early Warning

Under the effect of an approaching weather system, the flood situation undergoes rapid fluctuations. This quite often necessitates the issuance of a special flood forecast pertaining to a specific site. This is in fact the most important forecast issued by FFD. Most commonly it is issued in respect of the rim station but can also be issued for any other site downstream. The common contents of "Early Warning" issued by FFD are as shown in the table below.

Table 3.3.6 Early Warning Issued by FFD

Title of Forecast	Major Contents	Timing
Significant Flood Forecast	Name of river and location; flooding time, period and discharge quantity	Ad-hoc
Areal Flood Inundation Flood Forecast	Name of villages likely to be inundated when flood exceeds the exceptionally high flood level and spill-over is expected to occur, causing inundation of the area along the river channel.	

Source: PMD

d. Miscellaneous Flood Forecast/Information

Aside from the standard flood forecasting described above, the following information has been issued when necessary.

Table 3.3.7 Miscellaneous Flood Forecast/Information Issued by FFD

Title of Forecast	Major Contents	Timing
Weather Information by FFD	For non-technical persons: (1) Prevailing meteorological situation (2) Rainfall recorded during the last 24 hrs (3) The weather and the flood forecast in descriptive form	Ad-hoc in monsoon season
Flood Information for Media	Generally conducted in the evening at about 6:00 p.m. only on occasions when flood situation is serious enough to call for such briefings to filter out unauthorized and incorrect flood information from reaching the public.	
Special Press Briefings by Minister of Water and Power/ Chairman of FFC or Chairman of NDMA	A brief mention of the prevailing weather system Mention of a few heavy rainfall amounts and any reported damage A brief on present and future flood situation Advice to the flood prone population Question/answer session Concluding remarks	Chief Meteorologist of FFD may advise the Minister of W&P/ Chairman of FFC or NDMA to conduct special press briefings for the public in the context of flood mitigation.

Source: PMD

The kinds of flood forecasting and early warning are tabulated in Appendix 3.2.3 collectively.

2) Dissemination System

All of forecasting information related to the Indus River Flood as shown above have been issued to response authorities, such as NDMA, F/G/S/PDMAs, related DDMA and media using SMS, facsimile, PMD's website, and e-mail. In particular, FFD has recently commenced simultaneous warning delivery service by SMS to related government officials. Currently the number of subscribers is about 200.

3.3.3 Cyclone Warning SOP

As one of its mandatory responsibilities, PMD prepares and issues tropical cyclone warnings in Pakistan. The cyclone warnings are issued by the Marine Meteorology and Tropical Cyclone Warning Centre (TCWC) of PMD located in Karachi City.

1) Alert and Warning System

The types and kinds of observation, alert and warning issued by TCWC are as summarized below.

a. Tropical Cyclone Watch

The "Tropical Cyclone Watch" is issued when a tropical cyclone gets formed or enters the Arabian Sea north of Lat. 10^{o}N. This is issued irrespective of the cyclone's threat to affect Pakistan's coastal areas. Its purpose is to keep the concerned authorities aware.

b. Tropical Cyclone Alert

The "Tropical Cyclone Alert" is issued when there is likelihood that a tropical cyclone will affect Pakistan's coastal areas.

c. Tropical Cyclone Warning

The "Tropical Cyclone Warning" is issued when there is a very strong likelihood that a tropical cyclone will affect Pakistan's coast. These warnings are issued every three or six hours and/or whenever necessary and imperative.

Table 3.3.8 Tropical Cyclone Warnings by TCWC

Item	Description
Contents	a. The tropical cyclone (TC) location b. Intensity c. Maximum sustained winds d. Projected movement e. Expected landfall
Types of Warnings	(i) Warning bulletins for ships on the high seas (ii) Warning bulletins for ships plying the coastal waters (iii) Port warnings (iv) Fisheries warnings (v) Warnings for government officials and functionaries (NDMA and F/G/S/PDMAs) (vi) Warnings for recipients who are registered with PMD (vii) Warnings for aviation (vii) Warnings for the general public through electronic and print media (viii) NGOs and Civic Community bodies

Source: PMD

2) Dissemination of Tropical Cyclone Warnings

The modes of telecommunication used for the dissemination of tropical cyclone warnings in Pakistan are:

Coastal Radio (ASK) covering the Arabian Sea north of 20oN, Gulf of Oman and the Persian Gulf
Telephones
Electronic and print media
Radio Pakistan
Pakistan television
Telex/Telefax;
Website: www.pakmet.com.pk
E-mail

The mode of telecommunication differs for different types of messages. When one type of communication channel fails, the alternate channel is used.

3.3.4 Flood Forecasting and Warning System for Lai Nullah Basin (Lai Nullah FFWS Project)

The Lai Nullah Basin has a catchment area of 234.8 km^2, extending to the twin cities of Islamabad and Rawalpindi. On 23 July 2001, an unprecedented rainfall occurred over Islamabad-Rawalpindi resulting in 620 mm of rain in a span of about 10 hours. The flood caused the worst damage in the basin, including death of 74 people and the complete or partial destruction of about 3,000 houses.

In this connection, PMD has established a flash flood early warning system for Lai Nullah Basin (Lai Nullah FFWS Project) under a Japan Grant Aid Project. This Lai Nullah FFWS Project includes the installation of the following facilities and equipment:

- Master Control Centre: 1 with System
- Other Control Centres: 3 with System
- Relay Station: 1
- Rainfall G Station: 4 for System
- Rainfall G Station: 2 for System + Building
- Water L G Station: 2 for System + Building
- Warning Post: 1 (Siren) + 9 (Siren + Building)
- Patrol Car: 3 units

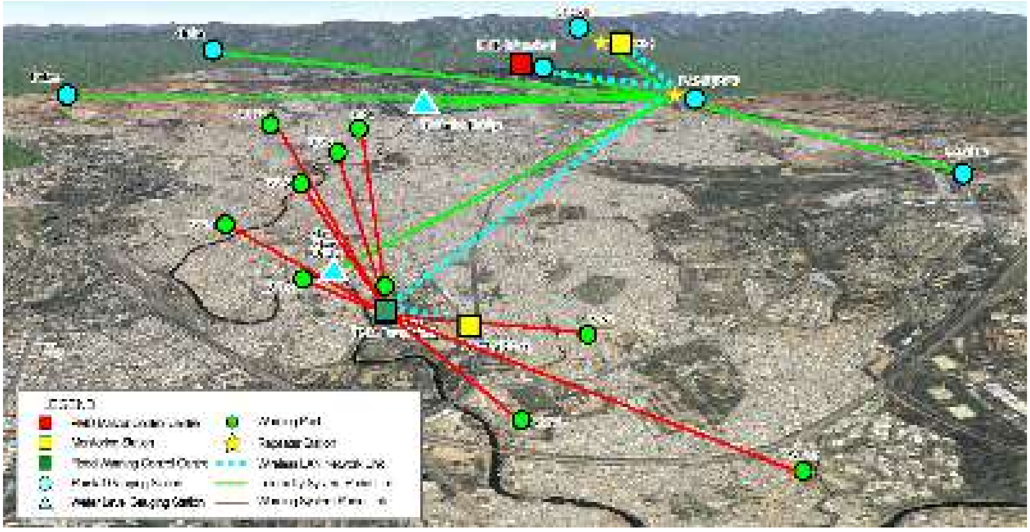
The Lai Nullah FFWS Project has involved not only PMD but also other related agencies to appropriately operate the FFWS. The District Government of Rawalpindi has prepared the "Flood Relief Plan" for smooth operation and recognition of the system every year. According to the plan, flood warning posts are maintained by TMA. In addition, the list of locations, functions and maintenance offices for the FFWS system is shown in the following table and data transmission system is illustrated in Figure 3.3.3.

Table 3.3.9 System Summary of Lai Nullah FFWS

Station	Function	Organization in Charge
1. Master Control Station		
1.1 PMD, Islamabad	• Flood forecasting; data collection • Data processing • Dissemination of flood information to related agencies (Data transmission subsystem	PMD
2. Rainfall Gauging Station		
2.1 PMD, Islamabad 2.2 Saidpur 2.3 Gorla 2.4 Bokla 2.5 RAMC 2.6 Cgajlala	Automatic rainfall data observation (Telemetry subsystem)	PMD
3. Water Level Gauging Station		
3.1 Kattarian Bridge 3.2 Gawal Mandi Bridge	Automatic water level data observation (Telemetry subsystem)	PMD
4. Repeater Station		
4.1 RAMC Telemetry Repeater	• Repeater function for telemetry	PMD
4.2 RAMC Wireless LAN Repeater	• Repeater function for wireless LAN	
5. Monitoring Station		
5.1 FFC	Flood information monitoring (Data transmission subsystem)	FFC
5.2 WASA of RDA	Flood information monitoring (Data transmission subsystem)	WASA
6. Executive Warning Station		
6.1 TMA Rawalpindi: -- Warning Control & Supervision -- Flood Information Monitoring	Control and supervision of warning system	CDG/TMA
	Flood information monitoring (Data transmission subsystem)	
7. Flood Warning Post		
7.1 WP-1: TMA Rawalpindi 7.2 WP-2: Christian Colony 7.3 WP-3: Water Treatment Facility adjacent to MC 7.4 WP-4: Ratta Amral Bridge 7.5 WP-5: Gunj Mandi Bridge 7.6 WP-6: Pir Wadhai Bridge 7.7 WP-7: Fire Station Pir Wadhai 7.8 Sector IV-B, Khayaban Park 7.9 WP-9: Gawal Mandi Children's Park 7.10 WP-10: Gpvernment Middle School, Dhoke	Flood evacuation warning by motor siren and loudspeaker	TMA

* Two (2) units of 4WD vehicles are required for emergency and operation/maintenance.

Source: JICA Expert Team



Source: PMD

Figure 3.3.3 Flash Flood EWS for Lai Nullah

In addition, the Lai Nullah FFWS Project had prepared hazard maps to strengthen and enhance the system effectiveness. These maps have been distributed to residents and the people who are living along the Lai Nullah Channel are encouraged to understand the warning system and to identify the areas to be inundated by flash flood.

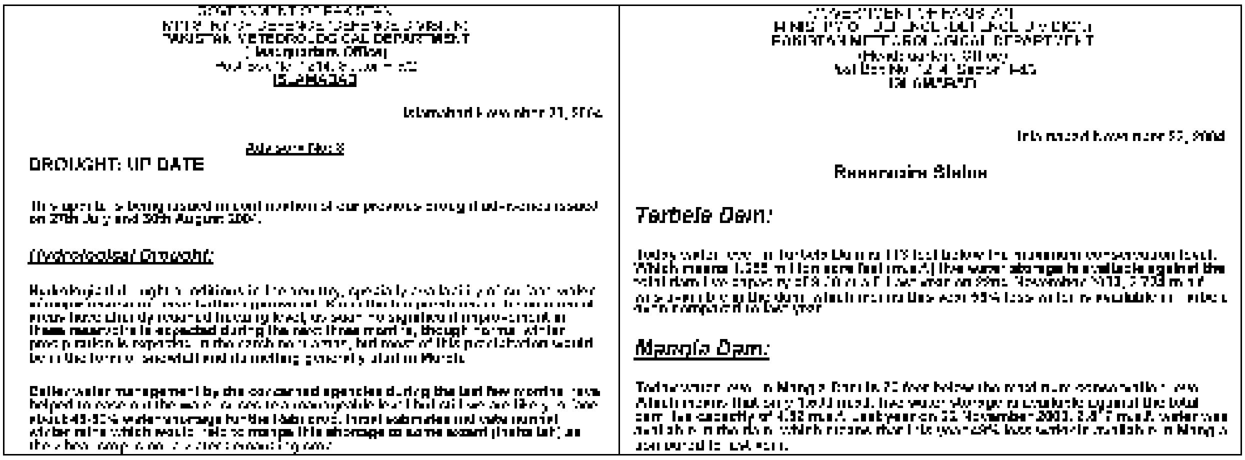
3.3.5 Drought Advisory

PMD took an initiative to establish the National Drought/Environment Monitoring and Early Warning Centre (NDMC-PMD) after the worst drought in Pakistan during 1999-2001 under the project for NDMC-PMD by local funds. The main objective of the Center and the project is to monitor the drought situation in the country and issue timely advisories. Its national centre is in Islamabad while four regional drought monitoring centers (RDMC-PMD) are in Lahore, Karachi, Peshawar and Quetta. These four RDMC-PMDs are responsible for data collection and analysis in their respective regions.

NDMC-PMD will prepare and release drought advisories using the aforementioned collected and analyzed data, particularly SPI calculated from point rainfall data, water availability in reservoirs, soil moisture data where available, ETO data, river and stream flow data, and field reports.

Based on the analysis, advisories are issued. These advisories and information are disseminated through the NDMC-PMD official website www.ndmc.gov.pk and other electronic and print media. NDMC-PMD issues fortnightly drought bulletins.

As a case example, a drought advisory from the past is shown below.


DROUGHT: UP DATE

Hydrological Drought:

Reservoirs Status

Tarbela Dam:

Mangla Dam:

Source: NDMC-PMD

Figure 3.3.4 Drought Advisory Example

3.3.6 Summary of Early Warning Systems

As described above, most of the early warning messages against water-related hazards are issued by PMD. The coverage for the warning and alert issuances against each disaster are as summarized in the table below.

Table 3.3.10 Summary of Roles and Functions of PMD in Multi-Hazard EWS

Disaster	Forecasting Agency	Remarks
(Indus River Basin) Flood	FFD-PMD*1 (PID/PIPD)	Issued in accordance with SOP*2 prepared for Indus, Jhelum, Chenab, Ravi, Sutlej and Kabul.
Flash Flood	FFD-PMD NWFC-PMD*3	Issued in accordance with SOP prepared for Bein, Aik, Basantar, Deg, Palkhu by FFD. Issued in accordance with Flood Relief Plan Lai Nullah by FFWMC-NWFC*3 * Except for *nullahs* mentioned above, PMD issues General Flash Flood Warning together with weather information from NWFC.
Landslide	None (PMD)	EWS has not been prepared, but NDMA, GSP and ERRA have partly prepared hazard maps for vulnerable areas. PMD also issues general advisories on landslides due to rain.
Cyclone	TCWC-PMD*4 NWFC-PMD	Issued by SOP (Draft)
Storm Surge	TCWC-PMD	Storm Surge Disaster shall be forecast in Cyclone EWS.
Tsunami	NSMC-PMD*5	Issued by SOP
Drought	NDMC-PMD*6	Forecasting System has been established. (As fortnightly advisory base)

Note:*1: FFD:Flood Forecasting Division of PMD at Lahore
*2: SOP: Standard Operating Procedure
*3: NWFC: National Weather Forecasting Centre at Islamabad
FFW&MC: Flood Forecasting, Warning & Monitoring Centre of PMD for General Flash Flood at Islamabad
FFWMC: Flood Forecasting & Warning Master Control Centre for Lai Nullah at Islamabad
*4: TCWC: Tropical Cyclone Warning Centre of PMD at Karachi
*5: NSMC: National Seismic Monitoring Centre of PMD at Karachi
*6: NDMC: National Drought Monitoring Centre at Islamabad

Source: JICA Study Team in association with PMD; Presentation Materials by Mr. Azmat Hayat Khan, Director of NDMC-PMD for National Drought Monitoring Centre; Concept Proposal Paper on Networking National Institutions and End Users through Electronic Media for Drought Monitoring Centre; SOP by FFD-PMD

3.3.7 Small Scaled Hazard Maps prepared by Related Agencies

Related agencies have already prepared some small-scaled hazard maps (district based and/or city based) against targeted disasters at vulnerable locations, as shown in the table below.

Table 3.3.11 Small-Scaled Hazard Maps prepared by Related Agencies

Targeted Disaster/ Name of Map	Targeted Area	Agency	Remarks
EARTHQUAKE			
Seismic Zoning Map	Mansehra, Muzaffarabad, Islamabad, Abottabad, Haripur, Batagram, Kohistan (District-based)	ERRA	500-year return period and 2500-year return period (2 sheets)
Seismic Hazard Microzonation Map	Balakot Town,Muzaffarabad City	ERRA	(2 sheets)
Earthquake Affected Area General Fault Map	Mansehra, Muzaffarabad, Islamabad, Abottabad, Haripur, Batagram, Kohistan, Shangla, Swat (Districts)	ERRA	1:50,000 Base
Union Council Wise Earthquake Damaged Houses Map	Mansehra, Muzaffarabad, Islamabad, Abottabad, Haripur, Batagram, Kohistan, Shangla, Swat (Districts)	ERRA	1:50,000 Base
Union Council Wise Earthquake Damaged Houses Map	Abottabad District	ERRA	1:10,000 Base
No. of Houses Destroyed/ Retrofitable By Tehsil No. of Houses By Tehsil Status of Partner Organizations Rural Housing Reconstruction	Mansehra (Ogai), Muzaffarabad, Batagram (Allai), Abottabad, Haripur, Batagram, Kohistan (Districts)	ERRA	District Base
Seismic Hazard Assessment Map	Muzaffarabad and Mansehra	NDMA	1:50,000 Base
Seismic Zoning	Karachi	Karachi Building Control Authority	For seismic design of buildings
TSUNAMI			
Tsunami Simulation Map	Gwadar	PMD	Under UNESCO Project
FLOOD			
Flood Plain & Flood Risk Map	Indus (31 sheets lower than Tarbela Dam), Jhelum (6 sheets), Chenab (13 sheets), Ravi (8sheets), Sutlej (8sheets)	FFC	1:50,000 Base Not Published
Flood Hazard Map for Lai Nullah	Rawalpindi (1-Whole Area and 8-Micro Maps)	PMD	Utilizing Aero Photo
LANDSLIDE, SEDIMENT DISASTERS, AVALANCHE			
Preliminary Susceptibility Hazard Map	Mansehra & Muzaffarabad (Districts)	ERRA	For Debris Flow and Snow Avalanche
Preliminary Location Map	Mansehra & Muzaffarabad (Districts)	ERRA	For Possible Valley Blockage
Preliminary Slope Instability Map	Balakot Town	ERRA	For Landslides
Land Use Guidance Map for Earthquake Vulnerability	The Municipalities of Murree, Chitral, Quetta, Mansehra and Muzaffarabad	NDMA	In collaboration with UNDP (One-UN)
Landslide Hazard Map along Karakoram Highway	Muzaffarabad	GSP	1:50,000 Base

Source: JICA Expert Team

As listed above, the preparation of hazard maps for all vulnerable areas in Pakistan has just started and related agencies should continue the preparation in accordance with their mandatory responsibility regarding disaster risk reduction. The policies of preparation of hazard maps are as described in Subsection 5.1.2 in detail.

3.3.8 Current Dissemination System of Early Warning

1) Releasing Agencies of Early Warning

As explained in Subsection 3.3.6, most of the warnings and other information have been released by PMD. For the Indus River floods, some hydrological data such as real-time observation flow discharge passing at designated locations (barrages and their administrating facilities) have also been issued directly from PID to avoid the loss of time.

2) Recipients of Early Warning Forecast by PMD and PID

The end recipients of warnings that PMD and PID have provided are district government agencies (DDMA). PMD is also responsible for keeping other related national and provincial governments well informed such as the Chairman of NDMA, who is atop the list, the Chairman of FFC, and all other concerned officials as well as print and electronic media.

In each SOP, the dissemination list for forecasting issuances has already been prepared. The main and general dissemination recipients for forecasting issuances are tabulated below.

Table 3.3.12 Dissemination List in Multi-Hazard EWS by PMD

Main Recipients	
Chairman, NDMA Islamabad (NEOC)	D.G. Mets. Islamabad (Internal)
Secretary, Ministry of Defence, Rawalpindi	Director of RMC in Related Province (Internal)
Secretary of Water & Power Islamabad.	F/G/S/PDMAs, Chief Ministers
Chairman, FFC Islamabad	Print and Electronic Media
D. G. Engineers, Engineering Directorate, GHQ Rawalpindi	All others concerned, such as DCs/DCOs of districts likely affected, F/G/S/PDMAs

Source: JICA Expert Team

3) Mode of Dissemination and Communication from Early Warning Agencies to Concerned Government Offices

The mode of communication between PMD and recipients are usually three communication tools/systems as well as the dissemination/transmission of forecasting issuances over the Internet.

Table 3.3.13 Dissemination Tools in Multi-Hazard EWS by PMD

Basic Tools for Communication	Details
Landline	Facsimile and Phone
Cellular Phone	Phone and SMS
Internet	On web: www.pakmet.com.pk

Source: JICA Expert Team

Among these three tools, PMD has mainly utilized the facsimile machine to disseminate information, because a warning forecast in writing can secure the certainty of dissemination. However, this method of dissemination sometimes produces errors in transmission, and some districts do not have facilities to receive the warning properly. It also takes much time to send warning messages one by one. On the other hand, dissemination system utilizing phones is the simplest mode for dissemination. However, this mode has also problems that messages often cannot be conveyed correctly by verbal conversation. Internet communication will be expanded hereafter. However, there are still some concerns about communication reliability managed by private Internet providers and district capacity to maintain the Internet communication system round-the-clock.

4) Mode of Dissemination and Communication from F/G/S/PDMAs to other Related Agencies and Citizens

Current provincial disaster risk management plans including the system and procedure for Multi-Hazard Early Warning System prepared by NDMA and F/G/S/PDMAs have delineated roles and information method of EW to the public as shown in the table below.

Table 3.3.14 Current Status of Dissemination System of F/G/S/PDMAs

Specified Document	Phase of EW	Main Communication and Information Tool	Responsible Person for Public Information re: EWS
PDRMP (Punjab)	Alert; Activation; Stand Out	• Telecommunication Network between offices • To the public via electronic media within as much as 36 hours of an event as Bulletins and Advisories	DG of PDMA
PDRMP (Sindh)	In accordance with established EWS for each disasters	By fastest means of communication by E-mail/Telephone/FAX to the concerned disaster responding agency through PEOC	DG of PDMA
PDRMP (Balochistan)	Alert; Activation	Authenticated warnings will be communicated by the fastest means by E-mail/Telephone/Fax to the concerned agencies. Appropriate media channels will be used to distribute the warning to public and concerned authorities for appropriate standby preparedness.	DG of PDMA
SDRMP (AJ&K)	In accordance with the alerts/warnings by EW Agencies	• The AJ&K DMA shall disseminate warning for public alert through appropriate channels like TV/Radio. • Police department can also be extremely helpful in disseminating warnings. The armed forces can be of assistance in areas around their bases. • Computer and facsimile machines fixed in EOC. • ADSL or broadband internet connections in EOC • Mobile Phones provided to all staff as backup • Satellite Phone in cases where there was total breakdown of normal communications • Radio Equipment of Police and Army	Chairman of SDMA; DG of SDMA in case of absence or unavailability of the SDMA Chairman
DRMP (GB)	In accordance with the alerts/warnings by EW agencies	With national and international media to mobilize their support for dissemination of early warnings	DG of GBDMA
(KP) *[1]	(In accordance with the alerts/warnings by EW agencies)	Disaster Risk Management Plans of KP and FATA are in process. However, warnings shall be disseminated by multiple tools to secure communication including E mail/ Telephone/ FAX/ SMS/HF-Radio/VHF-Radio/ Radio Broadcasting, etc.	(DG of PDMA)
(FATA) *[1]			(DG of FDMA)

Source: JICA Expert Team

As shown in the table above, information from provincial governments to the public regarding early warning for disasters has relied on electronic media, such as TV and radio.

5) Communication between District and Communities

Disaster risk management plans prepared by each district government (DDMRP) show the basic policy on the communication tools for early warning in emergency cases as shown in the table below.

Table 3.3.15 Current Status of Dissemination System of DDMAs

Specified Document	Phase of EW	Main Communication and Information Tool	Responsible person for Public Information re:EWS
DDRMP (Badin)	In accordance with established EWS for each disasters	The warning will be communicated to the concerned authorities and general public through reliable and appropriate media channels.	Chairman/Secretary of DDMA
DDRMP (Kech)	To be established	The local media could play an important role in early and timely information dissemination linking communities with warning agencies	-
DDRMP (Thatta)	To be established	DEOC will arrange the media briefings and interviews with key personnel and media channels for proper dissemination of the information concerning disaster situation in order to reduce the losses.	-

Source: JICA Expert Team

On the other hand, current communication systems between district governments and communities are distinct for every type of disaster and the location of districts. The following are basic dissemination systems stipulated in the existing flood contingency plans or operating manuals.

Table 3.3.16 Dissemination Mode by Each District (Sample Checklist) in Contingency Plan

District	Target Disaster	Designated Mode	Remarks
Province: Khyber Pakhtunkhwa (KP)			
Charsadda	Flood	Not mentioned in the Plan in detail (by land phone and direct conversation)	Flood Monsoon Plan2010
Mansehra	Kala Dhaka	Utilization of wireless communication posts with support from mosques and other institutions (formal and informal base) Aggressive flood monitoring system by communities Support by army base	Monsoon Contingency Plan 2009
	Atabad Landslide Outburst	Village based evacuation committees consisting of 7-10 members will immediately be mobilized to issue evacuation order by Public-Address.	
Province: Punjab			
Bahawalpur	River Flood (Sutlej)	Advance warning before 48 hours prior to the actual flood shall be conveyed Land phone among related offices Loudspeakers of mosques located in areas likely affected by floods	Current DRMP
Bakkar	River Flood (Indus)	After the information of flood discharge from Chashma Barrage Cellular phone between related officers Loudspeakers of mosques, verbal communication by police & revenue staff, and other mobile teams	Flood Contingency Plan
Rawalpindi	Flash Flood of Lai Nullah	Siren, word-of-mouth (public-address) dissemination by all related department staff of district/*tehsil* government	Flood Relief Plan 2010 See Figure 3.3.5
Chiniot	Chenab River Flood	The revenue field staff and TMA sector leaders go around in each town and village, and disseminate by loudspeakers/ megaphones	Flood Relief Plan
D.G Khan	River Flood (Indus) and Flash Flood	Land Phone, Wireless Radio, Cellular Phone	Flood Fighting Plan 2010
Gujrat	River Flood (Chenab and Jhelum)	Mainly wireless radio sets among officers in charge	Flood Fighting & Relief Plan 2010
Balochistan			
Kech	Nullah/Rainfall	Not mentioned in detail (by land phone)	Contingency Plan

Source: JICA Expert Team

As shown above, the usual mode of communication for EWS is the landline telephone or the cellular/mobile phone.

6) Other Current Dissemination Systems

As explained above, electronic media, TV and radio broadcast stations/companies have played the important role of transmitter given a commission to convey the issuances and warning to the public in the pre-disaster period.

PMD has already agreed to release breaking caption news to four TV stations including the national TV station. Moreover, PMD has also constructed a fully-equipped studio for TV broadcast in its own building. Hereafter, it is going to be much easier to broadcast programs about disaster forecasting so that the public can recognize potential disasters and be prepared.

In addition, the warning message system by SMS is growing more popular year-by-year. PMD has already installed an Automatic SMS Volley System at designated centres and divisions.

On the other hand, the communication system between NDMA, F/G/S/PDMAs and DDMAs is mainly a telephonic communication system. Presently NDMA is considering the implementation of a communication program as a pilot project for the installation of VPN-Network System to enhance the capacity of F/G/S/PDMAs /DDMAs.

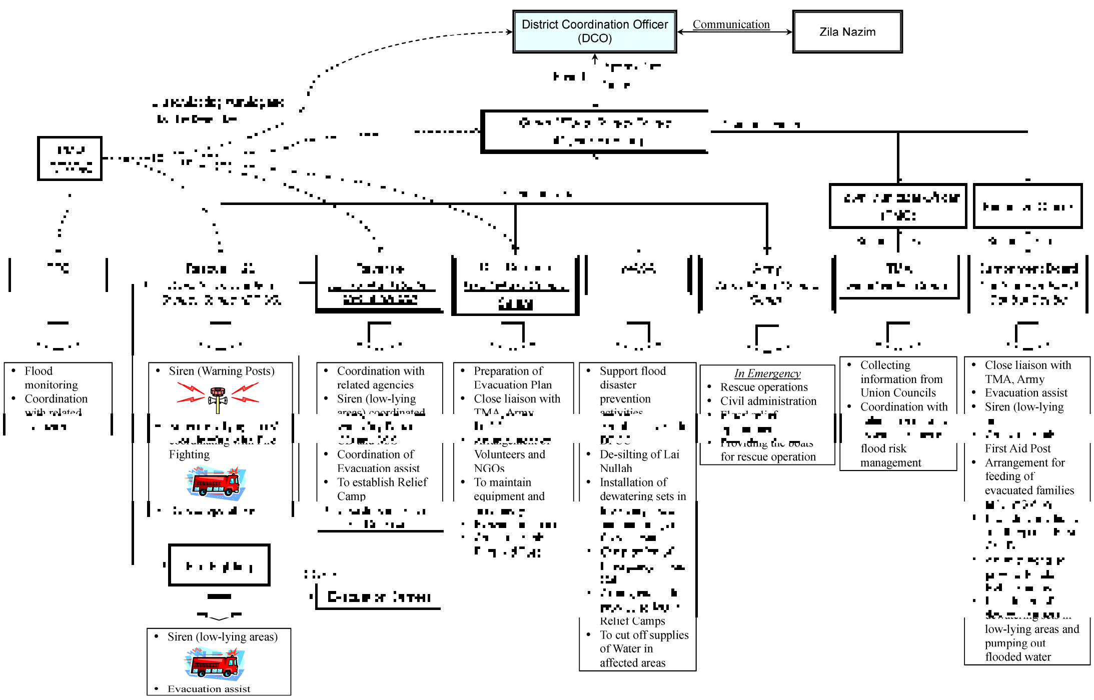
7) Summary of Dissemination System

The current dissemination system of EWS is as summarized in the table below.

Table 3.3.17 Dissemination Mode of Current EWS

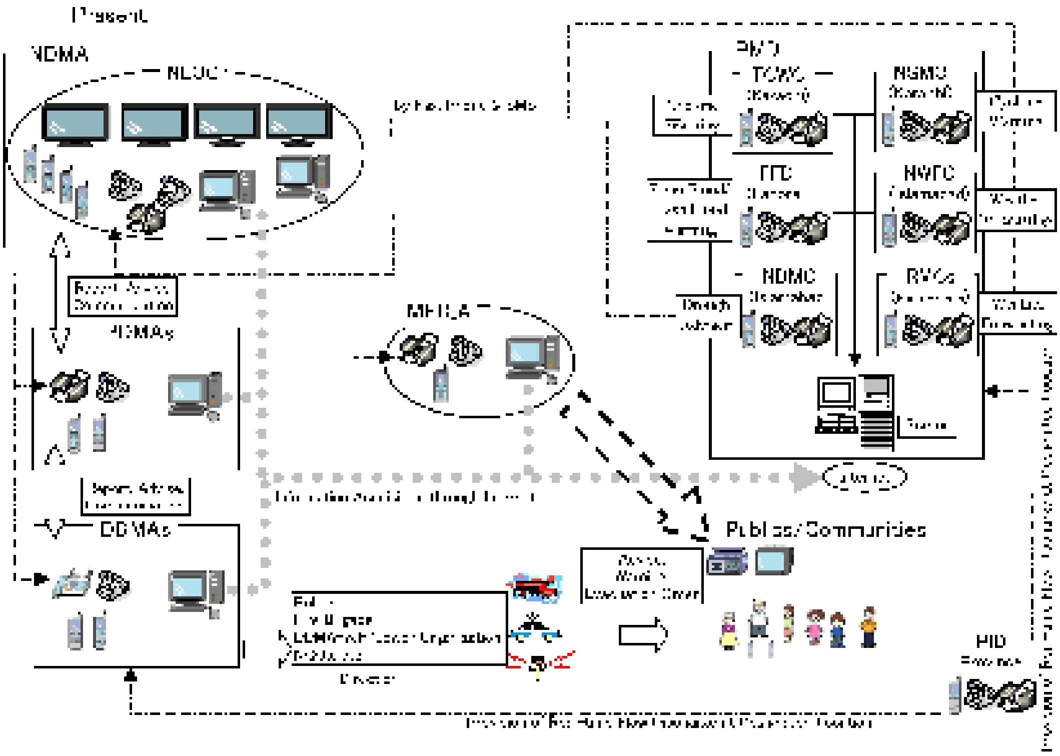
Item	Description	Remarks
Releasing Agencies	Mainly by PMD	with PID for Flood
End Recipients of EW Forecast by PMD	District Government Agencies (DDMAs)	Except for TV News
Mode of Communication from PMD to NDMA/ F/G/S/PDMAs /DDMAs	Floods, Cyclone and Other Meteorological Information: Landline, Cellular Phone, Internet	Mainly Facsimile
	Tsunami: Landline, Cellular Phone, Internet and SMS Volley System	Mainly SMS
Communication between District and Residents	River Flood, Cyclone and Other Meteorological Information: Basically phone and verbal dissemination, electrical media	Some districts have applied wireless radio communication and loud speaker of mosques
	Tsunami: phone and verbal dissemination, electronic media	
	Flash Flood: Siren, verbal dissemination	Only Lai Nullah

Source: JICA Expert Team



Source: NDMC-PMD

Figure 3.3.5 Command Structure and Activities on Flood Risk Management in Rawalpindi Districts



Source: JICA Study Team

Figure 3.3.6 Present Early Warning Dissemination Flow Chart

3.4 Current Situation of Information and Communication System Situation in Pakistan

As described in Section 3.3, most of the communication modes utilized in current EWSs are land phones with fax machines. Subsequently, the communication by cellular phone with SMS (Short Message System) has been utilized in some warning systems (Tsunami and Indus Flood Warning Systems). In this section, the current situation of the communication systems, such as telecom, broadcast and radio waves, in Pakistan has been confirmed and the direction of the development of the communication systems to be basically utilized in the future has also been affirmed.

All current situations described below are based on information from the World Information and Communication Condition prepared by the Ministry of Internal Affairs and Communication, Japan[3] except for the direction of utilization for EWS.

3.4.1 Basic Policy and Legal System regarding Information and Communication System in Pakistan

1) Legal and Management Systems

The area, business and management of information and communication in Pakistan conform to the following legal and management systems:

[3] http://g-ict.soumu.go.jp/

Table 3.4.1 Legal Systems of Information and Communication in Pakistan

Name of Adherence Rule	Year of Establishment	Related Area
Pakistan Broadcasting Corporation Act	1973	Broadcast
Pakistan Telecommunication Act	Enacted in 1996 Amended in 2006	Telecom, Broadcast and Radiowave
Pakistan Electronic Media Regulatory Ordinance	Enacted in 2002 Amended in 2007	Broadcast
Pakistan Electronic Media Regulatory Rules	2002	Broadcast
PEMRA Cable Television Operation Rules	2002	Broadcast (Cable TV)

Source: JICA Expert Team

Table 3.4.2 Regulatory Agencies for Information and Communication Activities in Pakistan

Business Area	Regulatory Agencies	Representative Business Firms
Telecom	Ministry of Information Technology (MoIT) Pakistan Telecommunication Authority (PTA) Frequency Allocation Board (FAB)	<u>Land Phone</u> Pakistan Telecommunication Company Ltd. (PTCL) <u>Communication System for Govt. to Govt.</u> National Telecommunications Corporation (NTC) <u>Mobile Phone</u> Mobilink, PTML, Warid, Telenor, CMPak, Instaphone
Broadcast	Ministry of Information and Broadcasting Pakistan Electronic Media Regulation Authority (PEMRA)	<u>Radio</u> Pakistan Broadcasting Corporation (PBC) About 120 local FM Stations for Commercial Use <u>TV (Terrestrial)</u> Pakistan TV (PTV) ATV <u>Satellite TV</u> PTV <u>Cable TV</u> About 1,750 Businesses
Radiowave	MoIT PTA FAB	<u>Frequency Allotment</u> Refer to : http://www.fab.gov.pk/documents/Pakistan%20Table%20of%20Frequency%20Allocations.pdf

Source : JICA Expert Team

2) Current Condition of Information and Communication in Pakistan

a. Telecom

i) Land Phones

Due to the growth of use of mobile phones and Wireless Local Loop (WLL) communication, the number of subscribers to land phone line has declined with the peak in year 2005. Out of the total number of subscribers, the PTCL alone accounts for approximately 96%. Most of the land phone subscribers are living in the urbanized major cities.

Table 3.4.3 Penetration of Utilization of Land Phone Line in Pakistan (2004-2009)

Description	Year					
	2004	2005	2006	2007	2008	2009
Number of Lines (thousand)	4,502	5,228	5,240	4,806	4,416	3,523
Penetration of Land Phone (%)	2.9%	3.3%	3.3%	2.9%	2.5%	-

Source: International Telecommunication Union (http://www.itu.int/ITU-D/ict/)

ii) Mobile Phones

Since the commencement of the mobile phone service, six carriers have gone into the business of mobile phone service. As of September in 2009, the number of mobile phone subscribers was approximately 95,910 thousand for a penetration of 58.6%.

Table 3.4.4 Penetration of Utilization of Mobile Phone Service in Pakistan (2004-2009)

Description	Year					
	2004	2005	2006	2007	2008	2009
Number of Subscribers (thousand)	5,023	12,771	34,507	62,961	88,020	95,910
Penetration of Land Phone (%)	3.2%	8.1%	22.0%	36.4%	49.7%	58.6%

Source: International Telecommunication Union (http://www.itu.int/ITU-D/ict/)

iii) Satellite Communication

PTCL and several private businesses have provided banking facilities, mass media and airline companies with data communication service utilizing 65 V-Sat Stations. In addition, the federal government has commenced operating a Communication Satellite (Paksat 1) with transponders (30 C-Band and 4 Ku-Band) for its own use.

iv) Internet

According to PTA, the number of broadband Internet subscribers was 267,180 as of December 2008. These subscribers are almost all in urbanized cities.

Table 3.4.5 Penetration of Utilization of Internet Service in Pakistan (2004-2009)

Description	Year					
	2004	2005	2006	2007	2008	2009
Number of Subscribers (thousand)	2,000	2,100	2,400	3,500	3,700	3,700
Penetration of Land Phone (%)	1.3%	1.3%	1.5%	2.1%	2.2%	2.2%

Source : International Telecommunication Union (http://www.itu.int/ITU-D/ict/)

b. Broadcast Service

i) Radio

Pakistan Broadcasting Corporation (PBC) under government management has executed the SW, AM and FM radio broadcasting services. Approximately 120 private FM radio stations authorized by PEMRA have broadcast for commercial purposes.

ii) Terrestrial TV

There are two terrestrial TV networks, namely PTV as a unique public station and ATV with a commercial purpose. PTV Home is broadcast on a national network by PTV and covers 87% of the total population of Pakistan.

iii) Satellite TV

DTH (Direct-to-Home) broadcast has not been provided in Pakistan although PEMRA has already delivered a licence for DTH service utilizing satellites to two companies. PTV with local providers has rebroadcast the programs of terrestrial TV through satellite.

iv) Cable TV

As of 2008, the number of authorized cable TV companies reached about 1,750. These provide the programs mainly in urbanized cities.

c. Radio waves

The Frequency Allocation Board (FAB) exclusively administrates the allocation and distribution of the frequency of radio waves to government agencies, public/private telecom service providers, radio/television broadcast companies and private/public radio transmission operators and the Pakistan Telecommunication Authority (PTA) delivers the licences to each user based on the application for the utilization of a given radio wave.

3.4.2 Direction of Utilization for EWS

As explained in previous clauses in this subsection, the infrastructure for information and communication systems in Pakistan has grown since the 1990's. In particular, the number of mobile phone subscribers has rapidly increased based on the development of network infrastructure. Therefore, the utilization of mobile phones and the network for the communication system of EWS shall be taken into account, such as SMS, GSM/GPRS, etc.

On the other hand, the terrestrial TV network and AM/FM radio network shall also be considered since the coverage areas for these broadcast networks are almost the whole of Pakistan. In particular, radio networks shall be fully considered for the communication mode of EWS for the following reasons:

- TV programming is the same across Pakistan, but localized programs can be considered in radio broadcasts. In Pakistan, there are many mother tongues depending on topographical and racial conditions. In this regard, it is ideal that messages for EWS be released in each tongue in case of emergencies.

- The risk of disaster increases in proportion to the poverty ratio. Taking this fact into consideration, it is deemed that the effectiveness of delivery of early warning by radio broadcasts is higher than the effectiveness of TV.
- PMD has already agreed with PTV for emergency programming (TELOP) for early warnings.

3.5 Current Education System Situation regarding EWS in Pakistan

3.5.1 Institute of Meteorology and Geophysics (IMG)

PMD offers professional training courses in various branches of meteorology, geophysics and applied sciences at the Institute of Meteorology and Geophysics (IMG), Karachi. The Institute established in 1960, provides training to the serving personnel of Pakistan Meteorological Department and also offers training facilities to persons belonging to other departments. Trainees from meteorological services of other countries are also accepted. The courses are of various levels and are designed for the new-comer to meteorology as well as for those who have acquired sufficient experience in the field and require higher training. The syllabi of courses provided at the Institute have been prepared mainly according to the pattern recommended in the World Meteorological Organization (WMO) technical publication. The courses aim is to provide both theoretical and practical background to a student and to equip him fully for the job, he is to take up after completion of his training.

The curriculums of IMG, which is situated at the Met. Complex, University Road, Karachi, are shown below:

- Model Met Observatory,
- Rawinsonde and Pilot Baloon Observatory
- Wind Finding and Weather Surveillance Radar
- Instruments Inspectorate and Meteorological Workshop
- Explanation of PMD Facilities and Equipment including;
  - Main Analysis Centre
  - National Meteorological Communication Centre
  - National Seismic Monitoring Center & Seismic Observatory
  - Tsunami Early Warning Centre
  - Tropical Cyclone Warning Centre
  - Climate Data Processing Centre

These directorates and units are very beneficial for the trainees for their practical, hands-on practice within one campus (Met Complex) and the trainees become familiar with their functions as well.

Adequate emphasis is laid on practical and professional aspects of the subject at the Institute and is supplemented by on-the-job training at one of the Meteorological Offices. The Institute has its own library with thousands of books and journals on meteorology and related disciplines. New books, journals and publications are added from time to time. The Institute's "Computer Lab" is equipped with latest computers and high-speed DSL Internet connections. The institute has its own modern projection hall, equipped with multimedia and overhead projectors and sound system.

The medium of instruction is English. Candidates from abroad desiring enrolment are to be sponsored by their respective governments. Candidates from other departments are to be nominated by appropriate authorities.

At the conclusion of the training, certificates are awarded to successful students. Evaluation reports on the completion of training are also sent to the sponsoring authority, on request.[4]

3.5.2 Training Course of SUPARCO

Apart from training its own employees, SUPARCO also imparts training in space related fields to scientists, engineers and officials belonging to other relevant agencies in the country as well as International Agencies of which it is a member. Various short training courses, seminars and workshops are arranged on regular basis for this purpose.

In addition to this, SUPARCO also assists various universities, colleges and other academic & professional institutions by facilitating visits to relevant SUPARCO establishments, laboratories and facilities to enhance knowledge through on-going scientific projects and research work.[5]

Courses

- Training Courses on Satellite Remote Sensing and GIS
- Training Courses on Space Weather
- Training Courses on Space Applications

3.6 Summary of Hazard and Risk Assessment

3.6.1 General

Pakistan is one of the countries most vulnerable to disaster in the world since it has more variety in terms of topography and meteorology by region. The earthquake of 08 October 2005 highlighted Pakistan's vulnerability to natural disasters. This was further evidenced by the recent tremendous tragedy of the Indus River Flood starting at the end of July 2010 and converging in the middle of September (named as the 2010 Pakistan Floods).

[4] Original Source: http://www.pakmet.com.pk/training/
[5] Original Source: http://www.suparco.gov.pk/pages/education-training.asp

In Chapter 4 of the main report of the JICA Project for the NDMP, hazard and risk assessment in Pakistan has been studied in detail for natural disasters such as earthquakes (with tsunami), floods, sediment disasters (landslide), cyclones with storm surges, droughts, GLOFs and avalanches. The essences of the hazard and risk assessment are as described in the following subsections.

3.6.2 Disaster Record

There is no domestically comprehensive historical record of disasters except for large-scale events. This data and lists by EM-DAT[6] could be useful only for the recognition of history and hazard of disasters. According to EM-DAT data, there were 151 disasters with 87,129 deaths and 59,749,936 of affected people over three decades (1981-2010). It is deemed that further damages due to unreckoned disasters could be estimated.

As shown below, Pakistan has been hampered by damage from a wide range of disasters in the past.

Table 3.6.1 Summary of Historical Disaster Records in Pakistan by EM-DAT, 1981-2010

Category	Type of Disaster	No. of Disasters (%)	Total Deaths (%)	Total Affected People (%)
		during 30 years (1981 - 2010)		
Meteorological Disaster	Flood	57 (38%)	8,966 (10%)	48,704,898 (82%)
	Storm (Cyclone and Depression)	17 (11%)	1,451 (2%)	2,195,741 (4%)
	Extreme Temperature	12 (8%)	1,211 (1%)	1,785 (0%)
	Drought	1 (1%)	143 (0%)	2,200,000 (4%)
	Avalanche	10 (7%)	425 (0%)	4,747 (0%)
	Landslide	9 (6%)	204 (0%)	29,923 (0%)
	Sub-Total	**106 (70%)**	**12,400 (14%)**	**53,137,094 (89%)**
Seismic Disaster	Earthquake	**20 (13%)**	**74,278 (85%)**	**6,594,674 (11%)**
Others	Epidemic Disaster	9 (6%)	246 (0%)	15,657 (0%)
	Industrial Disaster	15 (10%)	205 (0%)	2,511 (0%)
	Insect Infestation	1 (1%)	-	-
	Sub-Total	**25 (17%)**	**451 (1%)**	**18,168 (0%)**
Total		**151 (100%)**	**87,129 (100%)**	**59,749,936 (100%)**

Source: EM-DAT: The OFDA/CRED International Disaster Database – www.emdat.be – Université Catholique de Louvain –Brussels – Belgium

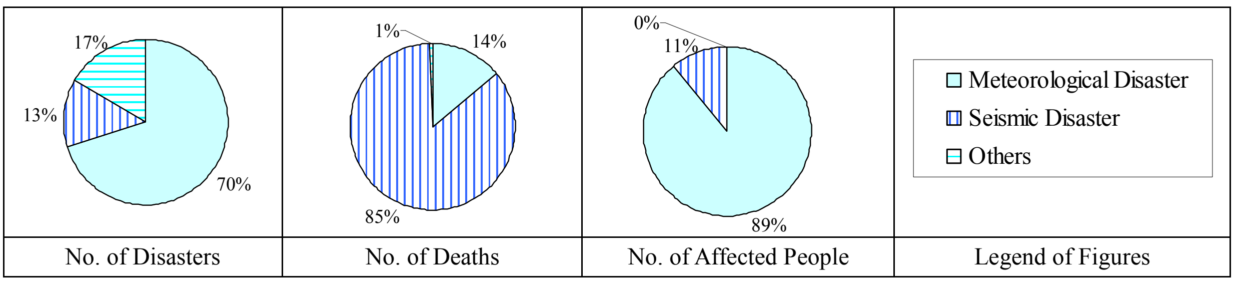


Figure 3.6.1 Ratio of Disaster Types based on Table 3.6.1 (1/2)

6 EM-DAT: The OFDA/CRED International Disaster Database – www.emdat.be – Université Catholique de Louvain – Brussels – Belgium.

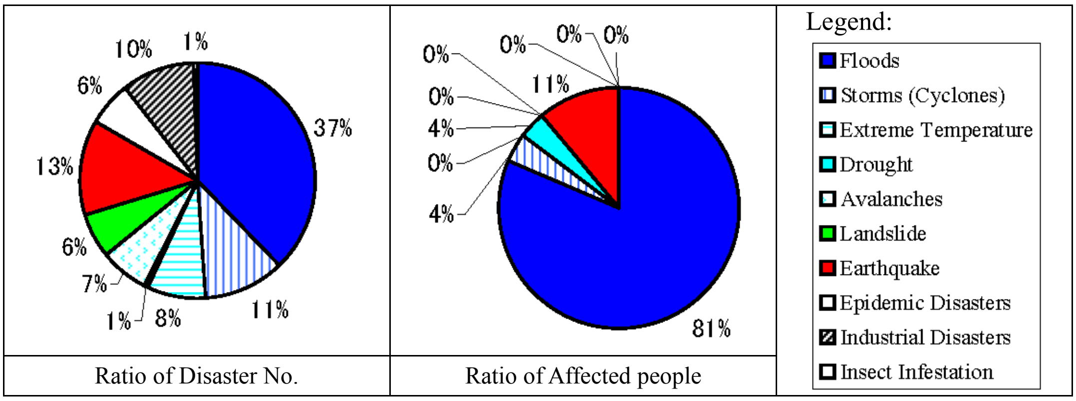


Figure 3.6.2 Ratio of Disaster Types based on Table 3.6.1 (2/2)

The data by the EM-DAT have not completely covered all disasters in Pakistan but the following facts can be highlighted:

- The most frequent type of disaster is meteorological disaster and this type of disaster has affected the largest number of people in Pakistan.
- In meteorological disasters, floods are the most common and significant since the number of disaster account for 37% and the ratio of people affected by floods dominates thetotal number of affected people.
- The seismic disaster (earthquake and tsunami) is the most considerable of all natural disasters from the viewpoint of number of deaths.
- The ratio of people suffering from other disasters excluding meteorological and seismic types, such as epidemic, industrial and insect infestation disasters, account for a low percentage.
- According to an interview survey, a certain percentage of the people that were reported to be suffering from earthquake seem to include victims of the tsunami in 1945 although the EM-DAT data has not distinguished this clearly.

Nowadays, continual tragedies caused by meteorological disasters, especially by floods, are still occurring and have continued in different places over the recent years. According to FFC Annual Reports, approximately 3,368 people died including 1,985 deaths during the tremendous 2010 Flood as tabulated below:

Table 3.6.2 Number of Deaths by Floods and related Disasters during 5 Years (2006-2010)

Year	Death Toll
2006	541
2007	586
2008	157
2009	99
2010	1,985

Source: FFC Annual Report (2009, 2010)

In addition to disasters due to floods and related disasters (landslides, cyclones, etc.), tsunamis are also considerable disasters due to their sudden catastrophic effects. In 1945, coastal areas in Pakistan incurred a huge tsunami disaster due to an ocean-trench earthquake that caused more than 4,000 human deaths. These records of disasters demonstrate that Pakistan is one of the most vulnerable countries to natural disasters in the world

Taking into account the nature of EWS that can alleviate personal suffering due to disasters, these facts suggest that the DMAs in all levels (NDMA/ F/G/S/PDMAs /DDMAs) should enhance and strengthen the capacities and abilities of their current EWSs for natural disasters.

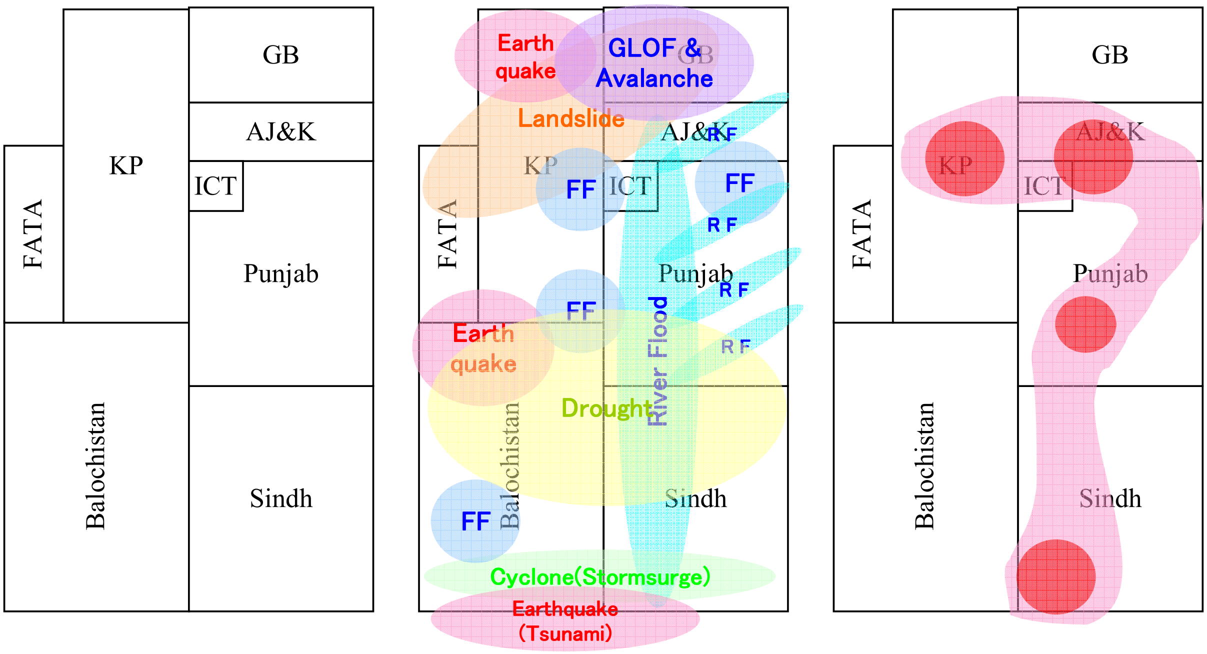
3.6.3 Features of Hazards and Risks of Each Disaster

Based on the data of damage by natural disasters including the data of EM-DAT and the limited written records of damage by district and provincial governments, as well as the actual experiences and common knowledge of disasters by related government officials, the risks of natural disasters in Pakistan have been identified.[7] The summaries of hazards and risks from the point of view of EWS are described below.

1) Locations of Hazards and Risks

According to the hazard and risk assessment by the JICA Project, hazards by natural disaster are distributed throughout the whole of Pakistan according to topographical, geological, climatologic and hydrological conditions. On the other hand, the risks of natural disasters in Pakistan dominantly shift into Punjab (including ICT) and Sindh including parts of KP and AJK since population, properties and productivities are concentrated in these areas. The results of hazard and risk distribution based on the JICA Project are as illustrated below.

[7] Refer to Chapter 4 of the main report of the JICA Project for NDMP (2011).



Pattern Diagram of Pakistan | Hazard Distribution | High Comprehensive Risk Area

Note: F.F: Flash Flood R.F.: River Flood
Source: JICA Expert Team

Figure 3.6.3 Distribution of Hazard and Risk Assessment by JICA Project

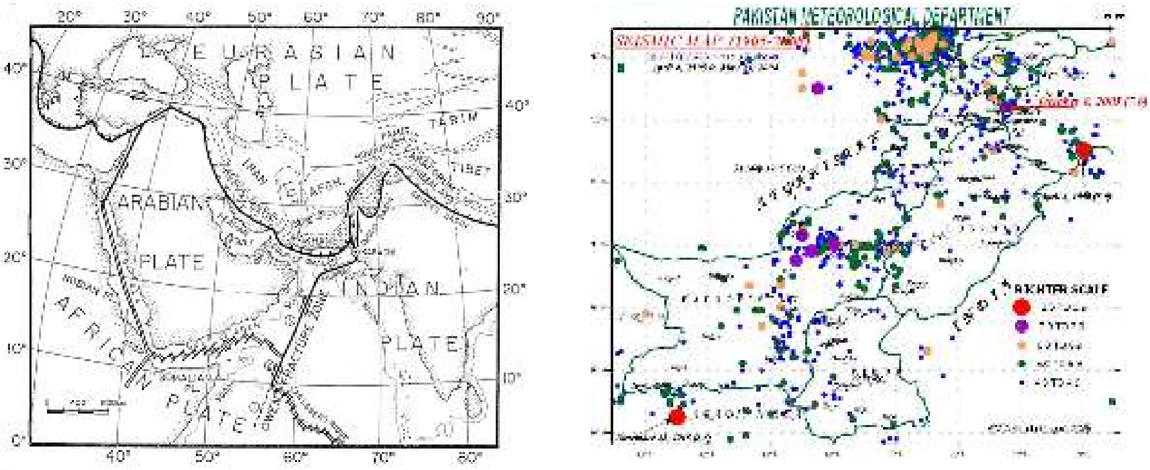
These results shall be considered to contrive suitable early warning system plans and prioritize the appropriate plan among the alternatives.

2) Seismic Disasters (Earthquakes and Tsunamis)

a. Earthquakes

Plate boundary between the Eurasian plate and the Indian plate runs through Pakistan's territory from southwest to northeast, and the Arabian plate subducts beneath the Eurasian plate in the southern part of Pakistan at the rate of 19 mm/year.

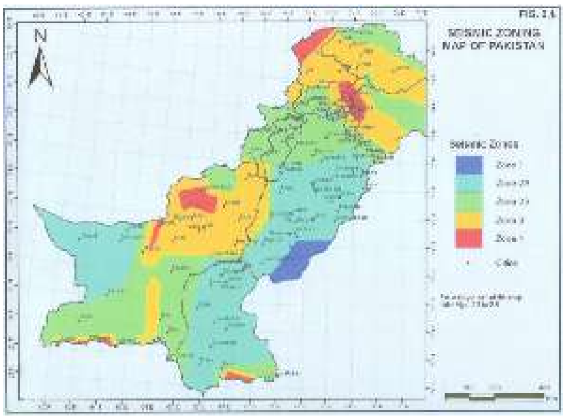
Due to its tectonic setting, seismic activity in Pakistan is high. For example, Figure 3.6.4 shows the epicentres of earthquakes with magnitude larger than 4, between 1905 and 2008, as compiled by PMD. It is notable that seismicity is especially high in the northern and western parts of the country.



Source: PMD

Figure 3.6.4 Tectonic Setting around Pakistan and Seismic Map of Pakistan

A seismic hazard map on a regional scale including Pakistan was developed by the Global Seismic Hazard Assessment Program (GSHAP) during 1992-1999. In Pakistan, the national seismic zoning map was developed during the process of elaborating the Building Code in 2007, by the Ministry of Housing and Works based on the results of GSHAP and researches after the 2005 Pakistan Earthquakes. In addition, the preparation of local-scaled seismic hazard maps in high hazard areas has already been commenced by related agencies, such as the NDMA, ERRA and GSP.

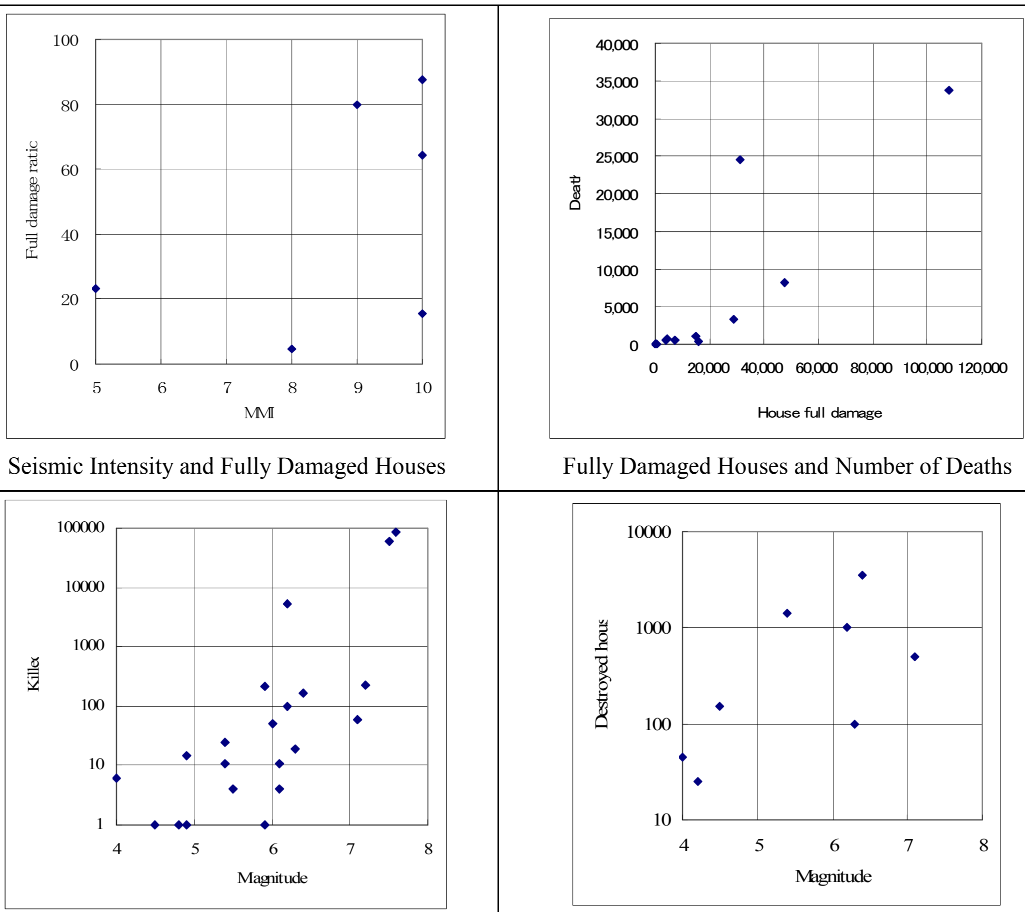


Source: Building Code of Pakistan

Figure 3.6.5 Seismic Zoning Map of Pakistan

In Pakistan, historical earthquake records show that earthquakes as small as magnitude 4 had caused victims. Earthquakes with magnitudes larger than 7, such as the 1935 Quetta earthquake and the 2005 Pakistan earthquake, had caused significant numbers of casualties. This fact can be attributed to the vulnerability of buildings to earthquake.

A detailed damage survey was conducted by ADB and World Bank after the 2005 Pakistan Earthquake. This damage survey has led the correlation between seismic intensity and full damage ratio of houses. In addition, the relationship between earthquake magnitude and the number of killed victims and the number of destroyed houses can be studied based on the data from the NGDC. These results are plotted in Figure 3.6.6.



Seismic Intensity and Fully Damaged Houses

Fully Damaged Houses and Number of Deaths

Earthquake Magnitude and Number of Casualties

Earthquake Magnitude and Destroyed Houses

Source 1: ADB-WB (2005), "Preliminary Damage and Needs Assessment – Pakistan 2005 Earthquake", prepared by Asian Development Bank and World Bank, Islamabad, Pakistan, November 12, 2005.
Source 2: NGDC and JICA Study Team

Figure 3.6.6 Relationship between Magnitude/Intensity and Damage by Earthquakes

Based on the situations with current seismic monitoring system mentioned above, the following can be found:

- The hazard by earthquake has already been identified. The National Hazard Map has been prepared as seismic zoning map and historical seismic record in the past has been preserved well.
- EWS for earthquake is still one of challenges at a global level. On the other hand, the quick response and rescue management system against earthquake can be established based on the

dense earthquake monitoring system. In this regard, the system based on 21 accelerographs in Pakistan is insufficient to realize the damage scale at each city/town/village.

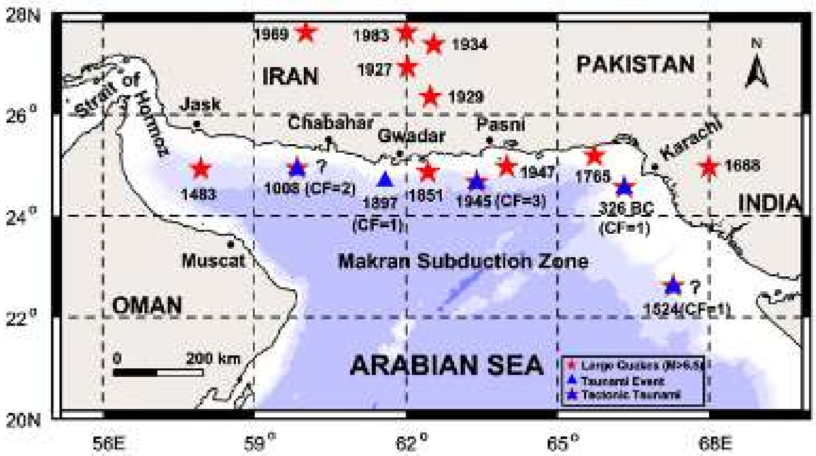
b. Tsunamis

Large earthquakes along the Arabian Coast inducing tsunami disaster had occurred historically along the Makran subduction zone due to the tectonic setting in the Arabian Sea where the Arabian plate subduct beneath the Eurasian plate, though not all of them had generated tsunami. Since the Makran subduction zone is located 70km from the Pakistan coast, it has been reported that the 1945 tsunami hit the coast in less than 20 minutes. On the other hand, distant tsunamis had not affected Pakistan so far. The 2004 Indian Ocean Tsunami did not reach Pakistan, sincePakistan is located behind the Indian subcontinent where the tsunami originated.

Table 3.6.3 Historical Tsunami in the Arabian Sea

Year	Long.	Lat.	Mw / M	Loss of Life	Run-up (m)
326 B.C.	67.30	24.00	Unknown	Unknown	-
1008	60.00	25.00	Unknown	1,000	-
1524	-	-	Unknown	Unknown	-
1883	-	-	Volcano	-	0.50 at Karachi
1897	62.30	25.00	Volcano	Unknown	-
1945	63.00	24.50	8.1 (8.3)	4,000	15.24 at Pasni, Ormara 1.37 at Karachi

Source: Mohammad Heidarzadeh et al., 2008
National Geophysical Data Centre (NGDC)

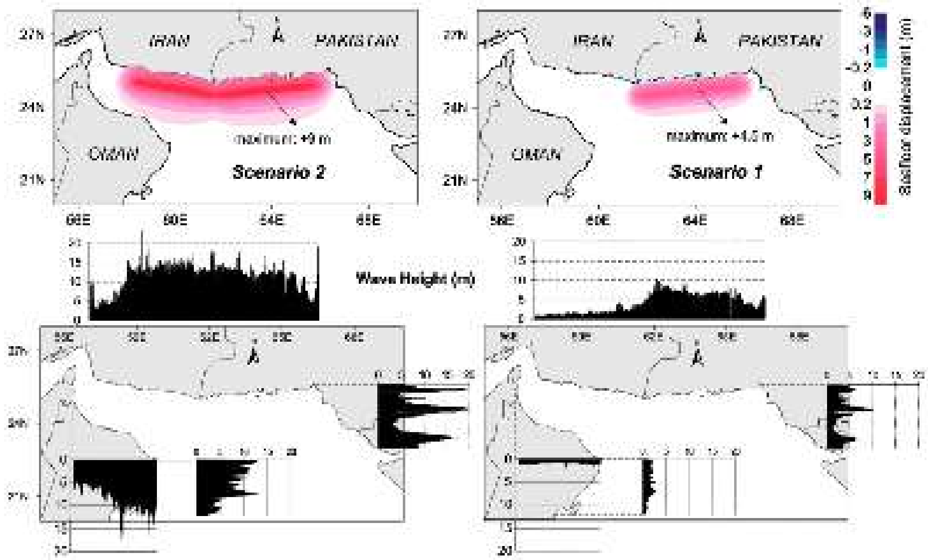


Source: Mohammad Heidarzadeh et al., 2008

Figure 3.6.7 Location of Epicentres of Major Earthquakes along the Arabian Coast

A numerical simulation of tsunami was conducted by PMD to develop an inundation map in Gwadar (PMD, 2010). The simulation assumes an earthquake with Mw 8.5 magnitude, located 120 km away from the coastline. The result shows that the first tsunami wave arrives at Gwadar in 22 minutes, and the maximum run up at Gwadar is approximately 3.7 m. The maximum possible time duration for tsunami existence is 2 hours and 30 minutes approximately. It also estimates that maximum flow depth could be 5 m, and maximum inundation distance at Gwadar could be up to 1.46 km. It is pointed out that high resolution bathymetry data with topography and calibration activities is essential to improve accuracy of simulation. This activity has been continued by PMD in association with the Norwegian Government.

Iranian researchers also conducted numerous studies regarding tsunamis in the Arabian Sea as well as numerical simulation considering the worst case scenario along the Makran Coast. The study for the worst scenario assumes an event with Mw 8.6 and Mw 9, as shown in Figure 3.6.8. Scenario 1 produces wave heights up to 10 m along Pakistan coasts, and Scenario 2 causes wave amplitudes of 12 - 15 m and horizontal penetration of 1 - 5 km in various coasts.



Source: Mohammad Heidarzadeh et al., 2009

Figure 3.6.8 Previous Tsunami Simulation Results

Based on the current situation of tsunami EWS and tsunami hazards, the followings have been identified:

- Tsunamis had hit and affected the people along coastal areas in Pakistan periodically. Huge tsunamis will hit the coastal zone again due to seismic activities in the Arabian Sea and Indian Ocean.
- Tsunami EWS due to the occurrence of earthquakes has been established since 2010 (see Subsection 3.3.1). This EWS should be sustained and updated with trainings and drills exercises as well as improvement of simulation analysis.
- Hazard and risk maps against tsunami disasters have not been prepared yet.

3) Meteorological Disasters

Hazards due to meteorological disasters have been found everywhere in Pakistan. River floods frequently occur along five (5) major rivers; namely, Indus, Jhelum, Chenab, Ravi and Sutlej and the downstream reach of the Kabul River. Flash floods are perennial problems of districts located at the foot of hilly and mountain areas. Landslides often occur with heavy accumulated rainfall in the mountain areas where the slope is more than 30 degrees, although these are composite disasters with geological and seismic issues.

Taking climate change into consideration, cyclones are expected to intensify due to global warming and hit the coastal areas of Pakistan with increased heights of storm surge due to an increase in the sea level. Climate change or global warming would induce the increase of a number of GLOFs in glacial areas and extreme drought phenomena in arid areas in Pakistan.

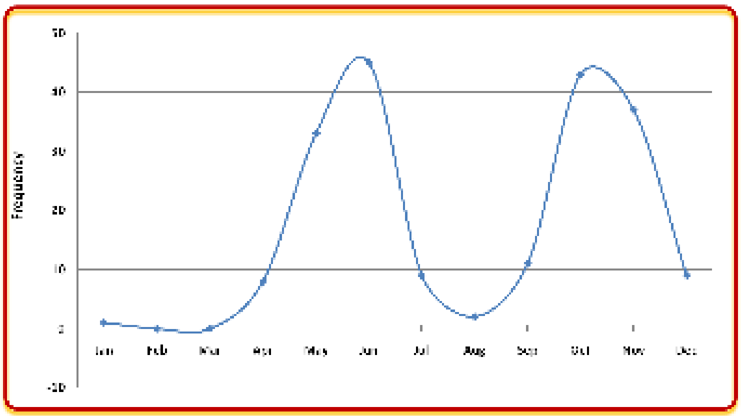
To alleviate these meteorological disasters, findings regarding EWS as well as the basic information of hazards and risks are described. The following are the hazards and risks of each meteorological disaster in Pakistan.

a. Cyclones

A cyclone is a low depression area of closed, circular fluid motion rotating in the same direction as the Earth's rotation. While cyclones can produce extremely powerful winds and torrential rains resulting in heavy river flow and flash floods with related disasters, they are also able to produce high waves and damaging storm surge resulting in coastal floods and high tide.

The temperature of seawater where the cyclone is formed would have to be at least 26 degrees centigrade, and a higher temperature is more favorable for the evolution of cyclones. This warm water sustains instability, convection for further intensification, and keeps the tropical cyclone alive. Warm water accelerates the evaporation process and high temperature helps to intensify the system further by causing the surface atmospheric pressure to fall. Unstable atmosphere is required to continue thunder activity to make the environment favorable for a cyclone event by increasing the vertical current which lifts warm moist air beyond the level of condensation. The cool upper atmosphere and surface warm air increase the vertical temperature gradient to make the atmosphere unstable. The horizontal temperature gradient performs an equally significant role. Convergence at the surface, which is responsible in lifting up the warm and moist air, is intensified by strong divergence at 300 hpa and above. The latent heat released during condensation makes the divergence strong to remove/disperse the air at the upper level. Consequently, the pressure at the surface falls further and intensifies the system. Strong divergence removes the air at the upper level, causing the pressure to fall at the surface, establishing higher surface pressure gradient which further intensifies the vertical current. As a result, the surface winds reach the level of cyclone.

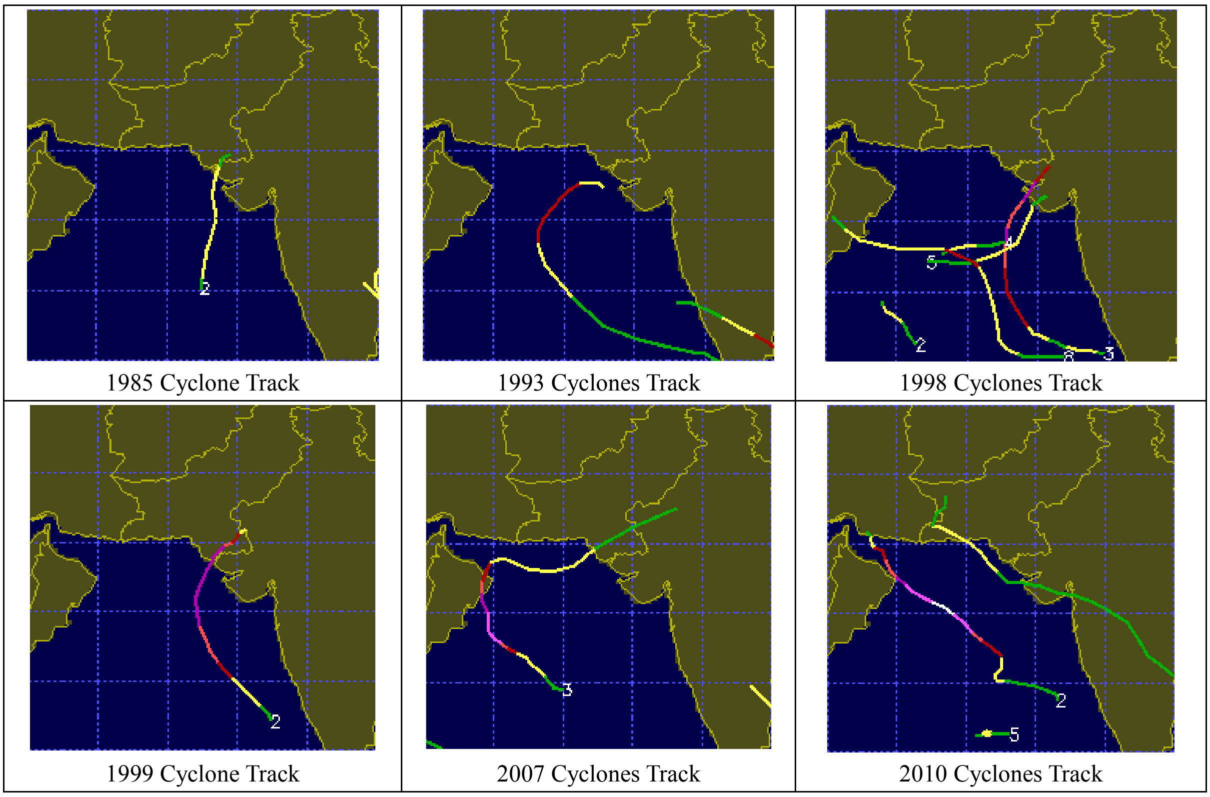
The frequency of cyclone evolution by the climate developing system, which has been explained immediately above and Subsection 3.1.1 in this chapter, has been influenced by the seasonal climate condition. As shown below, the season when the evolution of tropical cyclones occurs most frequently is between the monsoon and westerly wave seasons, that is, the months of June and October.



Source: TCWC-PMD, Karachi

Figure 3.6.9 Monthly Frequency of Tropical Cyclones and Depressions over the Arabian Sea (1891-2010)

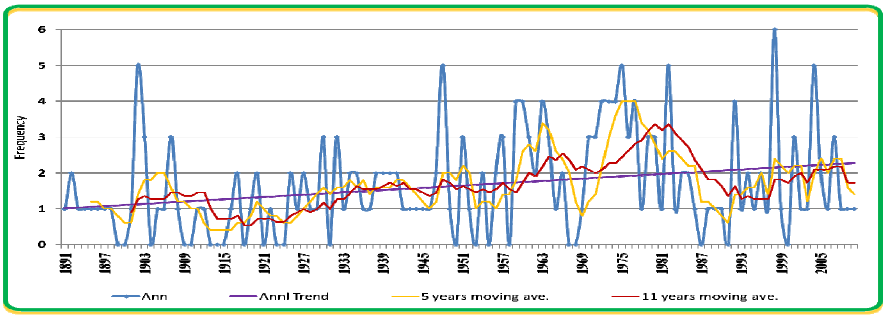
Based on the situation explained above, about 14 cyclones were recorded during the period 1971-2010 around Pakistan. The meteorological data about the cyclonic storms in the North Arabian Sea has been available for more than a century. During the last 100 years a number of cyclonic storms have struck Pakistan's coastal areas. The cyclone tracks that recently hit around Pakistan has been shown in Figure 3.6.10.



Source: http://weather.unisys.com

Figure 3.6.10 Cyclone Tracks that recently hit around Pakistan

Including the intensity of the depression, there were approximately 200 cyclones and depressions spawned during the period 1891-2010. Annual frequency of cyclones and depressions over the Arabian Sea has annually increased as shown in Figure 3.6.11 below.



Source: TCWC-PMD, Karachi

Figure 3.6.11 Annual Frequency of Tropical Cyclones and Depressions over the Arabian Sea (1891-2010)

Based on the situations mentioned above with current cyclone monitoring and EWS, the following can be found:

- Cyclones mainly hit coastal zones in Balochistan and Sindh. Eight (8) cyclones have affected Pakistan during the last 25 years (see Figure 3.6.10). However, the annual frequency of tropical cyclones in the Arabian Sea has increased due to Climate Change.
- Cyclone EWS has been established in PMD (see Subsection 3.3.3). However, issuances of warnings and alerts in advance of the brunt of cyclone have mostly relied on the indirect sources, such as weather charts, satellite image and foreign agencies' information. Current direct monitoring equipment, such as the Karachi Radar of which coverage is only the eastern coastal area, six (6) weather monitoring stations and three (3) tidal gauges, is limited.
- Cyclones have affected not only the eastern coastal areas but also the western coastal areas in Pakistan. The radar at Karachi cannot monitor the western areas including major cities; namely, Jiwani, Gwadar and Pasni.

b. Floods

Pakistan is one of the most disaster-prone countries and a number of people are physically exposed to floods which occur normally due to tropical monsoon depressions from July to September as described in Subsection 3.1.1. The low pressures/depressions originating from the Bay of Bengal passing over lower Central India and Rajputana and cyclones generated in the Indian Ocean as explained in preceding item (a. Cyclones), enter Pakistan and continue towards the north into Kashmir.

The mountain ranges in the extreme north of Pakistan, such as the regions of Gilgit-Baltistan (GB), Azad Jammu and Kashmir (AJK), Khyber Pakhtunkhwa (KP) and the Federally Administered Tribal Areas (FATA), provide a perennial source of inflow into the rivers which finally join the Indus River and flow into the Arabian Sea. In particular, floods hit the plains of Punjab and Sindh while hill torrents tend to affect the hilly areas of KP as well as FATA, Balochistan, AJK, GB, western and northern hilly areas of Punjab and Indian side of Sindh.

Historical records of flood damage in Pakistan are shown in Table 3.6.4. There have been five major flood events in terms of economic aspects – in 1950, 1973, 1976, 1992 and 2010 – which caused huge losses to the national economy.

Table 3.6.4 Historical Flood Damage in Pakistan

Year	Lives Lost (persons)	Villages Affected (number)	Rivers Mainly Affected
2011	520	38,700	Whole of Sindh, parts of Balochistan / Punjab
2010	**1,985**	**17,533**	Kabul, Indus, Jhelum
2009	99	89	
2008	157	800	
2007	586	6,498	
2006	541	2,477	
2005	59	1,931	Indus
2004	85	47	
2003	484	4,376	
2001	219	50	Lai Nullah
1995	591	6,852	
1992	1,008	13,208	Indus, Jhelum, and Chenab
1988	508	1,000	Indus/Jhelum, & Chenab/Ravi/Sutlej
1978	393	9,199	
1976	425	18,390	Indus, Jhelum, Chenab and Ravi
1973	474	9,719	Indus, Jhelum, Chenab, Ravi and Sutlej
1957	83	4,498	Chenab and Ravi
1956	160	11,609	Indus, Jhelum
1950	2,190	10,000	Chenab, Ravi and Sutlej
Total	**10,563**	**156,926**	

Source: FFC for 1950-2010,
NDMA, Preliminary DNA Floods 2010,2011

The flood characteristics in Pakistan can mainly be classified into two categories, i.e., river floods and the flash floods. River floods mainly occur in major rivers: Indus, Kabul, Jhelum, Chenab, Ravi, and Sutlej, and their major tributaries. The 2010 floods in Punjab and Sindh were the river floods. The flash floods occur generally in hill torrents from the hill ranges with small to medium scale catchment tributaries due to heavy rainfalls in short time ranges. The disastrous flood of July 23, 2001 in Lai Nullah in Islamabad-Rawalpindi, having a catchment area of 235 km^2 from the Margalla Hills, was due to a very severe cloud-burst resulting into flashy rains and hence the flash floods. Rainfall of 620 mm (Islamabad) and 150 mm (Rawalpindi) was received in 10 hours of continuous downpour, and with 74 deaths it was the worst flash flood ever experienced in the twin cities.

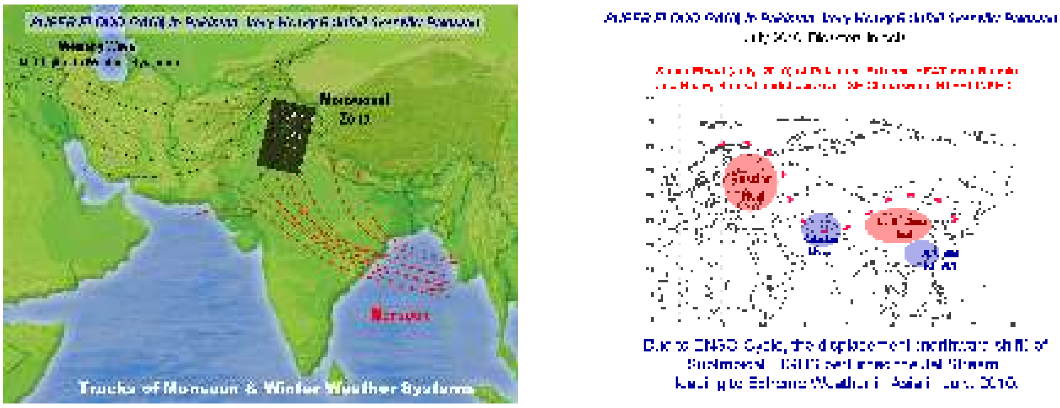
Table 3.6.5 shows flash floods as one of the features of the 2010 Floods which hit the northern and hilly areas and directly claimed lots of lives by the rapid and high water flows. On the other hand, river floods have steadily deteriorated human livelihood by long inundation periods.

Table 3.6.5 Causes of the Death due to the 2010 Floods

District	Province	Person Dead	Causes of the death		
			1st Reason	2nd Reason	3rd Reason
1. Mansehra	KP	36	by high flow velocity	by high water level	Due to lightening
2. Abbotabad	KP	17	by high flow velocity	House collapsed	Landslide
3. Haripur	KP	37	by high flow velocity	by high water level	Landslide
4. Shangla	KP	162	Landslide	by high water level	by high flow velocity
5. Swabi	KP	7	by high flow velocity	House collapsed	-
6. Swat	KP	95	by high flow velocity	by high water level	Landslide
7. Lower Dir	KP	36	by high flow velocity	by high water level	House collapsed
8. Mardan	KP	8	House collapsed	-	-
9. Charsada	KP	66	by high water level	by high flow velocity	House collapsed
10.Peshawar	KP	46	by high flow velocity	by high water level	House collapsed
11.Miawali	Punjab	16	by high water level	House collapsed	-
12. D.I.Khan	KP	47	by high flow velocity	by high water level	-
13.Bhakkar	Punjab	0	Nil	Nil	Nil
14.Layyah	Punjab	2	by high water level	-	-
15.Muzafargarh	Punjab	2	by high water level	House collapsed	-
16.D.G.Khan	Punjab	4	by high water level	-	-
17. Rahimyar Khan	Punjab	8	by high water level	House collapsed	Drown during evcuatn
18. Rajanpur	Punjab	31	by high water level	Drown during evacutn	-
19. Multan	Punjab	1	by high water level	-	-
20. Bahawalpur	Punjab	0	Nil	Nil	Nil
21.Sukkar	Sindh	16	Disease & others	Disease & others	Disease & others
22.Shikapur	Sindh	27	by high flow velocity	-	-
23.Khaipur	Sindh	32	by high water level	Disease & others	-
24.Dadu	Sindh	37	by high water level	Disease & others	-
25.Kashmore	Sindh	2	by high flow velocity	-	-
26.Ghotki	Sindh	30	Disease & others	by high flow velocity	-
27.T.M. Khan	Sindh	4	by high flow velocity	Disease & others	-
28.Barkhan	Balochistan	18	by high flow velocity	Disease & others	-
29.Kohlu	Balochistan	5	by high flow velocity	-	-
30.Naseerabad	Balochistan	97	by high flow velocity	Disease & others	-
31.Sibi	Balochistan	12	by high flow velocity	by high water level	-
32.Jhal Magsi	Balochistan	3	Disease & others	by high flow velocity	-
33.Jafarabad	Balochistan	60	by high water level	Disease & others	-

Source: JICA 2010 flood field survey, in August - October 2010

As explained in Subsection 3.1.1, river and flash floods have mainly resulted from unusual volume of rainfall due to meteorological conditions. In this regard, the Pakistan 2010 Flood occurred based on anomalous climate condition in which low depression area was stagnant for a long period northwest of Pakistan as shown in Figure 3.6.12 (a and b). However, these climate conditions in the 2010 Paksitan Floods could not be detected at that time.

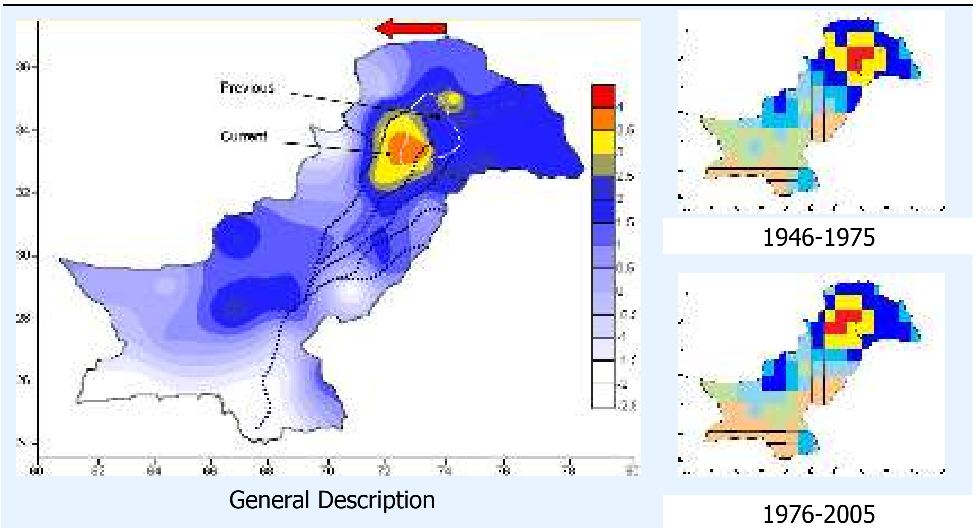


(a) Monsoon and Westerly System **(b) Meteorological/Hydrological Observation Network**

Source: Dr. Hanif, Director NWFC, PMD

Figure 3.6.12 Meteorological Condition in 2010 Pakistan Flood

As for the geographic precipitation tendency in Pakistan, wettest events have increased significantly over higher latitudes, but no significant change has been observed over lower latitudes. A significant westward precipitation shift (80-100 km) was found (see Figure 3.6.13). It means that high annual precipitation zone has shifted from low populated zone (disputed area) to high populated zones, such as AJK, northern Punjab, ICT and KP.



Source: Mr.Azmat Hayat Khan, Director, NDMC, PMD

Figure 3.6.13 Latitudinal Redistribution of Precipitation in Pakistan

Based on the current situations of flood EWSs and hazards and risks by floods, the following are identified:

- Floods occur and hit most parts in Pakistan. Flood is the primary disaster from the viewpoint of number of disasters and number of affected people.

- River floods hamper economic conditions in Pakistan because the inundated areas are expanded widely and remain stagnant for long periods
- Flash floods also hit and directly claimed human lives along the major tributaries and middle and small nullahs. Flash floods also devastated inundated areas due to rapid flow with debris and/or sediment. However, a designated flash flood EWS exists only for Lai Nullah Basin (Rawalpindi-Islamabad).
- Regarding the establishment of new EWS, flash floods shall be concerned rather than river floods since flash floods directly claimed human lives.
- Therefore, the establishment of flash flood EWS for each city/town vulnerable to flash flood shall be considered.
- In addition, general weather information is essential to issue the warning of occurrences of flash floods. Current weather forecasts are qualitative and short-term due to limitation of numerical calculation and few monitoring facilities and equipment.
- Hazard and Risk Maps against flood along major rivers were prepared in 2005. However it is necessary to review and update these maps based on flood events that occurred between 2006 and 2011 including the 2010 Flood and develop GIS based web service for the benefit of end users.
- Except for Rawalpindi City, no precise Flash Flood Hazard Map exists for any other city.

c. Sediment Disasters (Landslides)

Sediment disasters occur after/during heavy rains which weaken the ground. Sediment disasters are mainly landslides, mud and rock slides, and debris flows which can wash out houses and infrastructures and cause damage to lives and properties. When heavy rains occur in the monsoon season, they may become a cause of landslide disasters in the country. In particular, the northern regions of Pakistan such as GB, AJK and KP provinces are vulnerable to landslide disasters because of their steep hilly/mountainous topography, weakness in geology, slope instability and prolonged heavy rains. Table 3.6.6 shows the historical landslide disasters in Pakistan recorded by EM-DAT.

Table 3.6.6 Historical Landslide Disasters in Pakistan by EM-DAT (2000-2010)

Date	Location	Dead Persons	Affected Persons
March 2007	Dir District (North)	80	-
January 2007	Near Kotli (Kashmire)	20	2
July 2006	Ghaeel Village (Kalam area)	29	5
May 2003	Ronala Village (Kohistan)	12	-
July 2001	Karachi, Hyderabad, Sukkur	16	12
July 2001	Chitta Katha, Kaghan Valley	15	-

Source: EM-DAT: The OFDA/CRED International Disaster Database – www.emdat.be – Université Catholique de Louvain – Brussels – Belgium

As to the collection of the past data on sediment damage like landslides, there is no complete statistical data of past landslide disasters in Pakistan except for the landslide studies and hazard maps prepared by GSP in AJK and KP, and the hazard maps prepared by the NDMA and ERRA in Mansehra and Muzaffarabad.

However, the steep relief of the region is a major factor contributing to the high frequency of landslides and debris torrents. Some slides and debris torrents are large enough to dam rivers, such as the enormous 1841 landslides which blocked the Indus River and formed a lake upstream. When the dam was breached, a catastrophic flood wave resulted. Similar events occurred from 1852 to 1858 on the Hunza River. In 1977, a landslide dam was formed, possibly in association with a glacier surge (Hewitt, 1968-1969).

On 4 January 2010, a massive landslide in Attabad in Hunza District caused loss of human lives and property and blocked the flow of the Hunza River converting it into a huge lake (not a glacial lake). The landslide disaster has displaced approximately 357 households from three villages in Upper Hunza. Damming of the Hunza River has created issues and challenges for over 25,000 people stranded in the Gojal valley due to destruction of the Karakurm Highway, the economic lifeline of the region. Cultivable and non-cultivable land, houses and other infrastructure are submerging in the organically expanding lake, resulting in huge loss of livelihood. The lake also poses risks to low-lying parts of villages along the length of River Hunza and River Indus in the downstream areas in case of a lake outburst flood.

Based on the situations with current landslide monitoring and EWS mentioned above, the following can be found:

- Sediment disasters occur after heavy rains at steep mountain slopes in hilly areas.
- Warnings for landslides due to heavy rains have been issued with the general weather information. However, current warning messages are vague with non-specific information due to insufficient monitoring facilities.
- Hazard maps have not been fully prepared yet for all vulnerable areas in Pakistan. (Small-scale hazard maps have been prepared for some cities including Mansehra, Muzaffarabad, Murree etc. by ERRA, GSP and NDMA; See Subsection 3.3.7.)

d. Droughts

Pakistan has a long latitudinal extent and rainfall variability during different seasons is considerably high. The climate in the lower southern half of the country is arid and hyper-arid. Some regions of the country in each season remain drastically dry and are always vulnerable to drought. If subsequent seasons fail to generate significant precipitation, drought conditions emerge in these areas and become more severe. Hence, drought has become an intermittent phenomenon in the country. All the provinces of Pakistan have a history of facing major droughts in the past. In recent years, drought has been reported to bring extensive damage to Balochistan, Sindh and Southern Punjab where average annual rainfall is as low as 200-250 mm.

Pakistan has experienced several drought years like in 1899, 1920, 1935, etc., particularly in the KP areas in 1902 and 1951, and in Sindh which experienced its worst droughts in 1871, 1881, 1899, 1931, etc. The El Niño and La Niña phenomena have caused drought conditions in Pakistan. For instance, the strongest El Niño on record occurred in 1982-1983 when the monsoons in 1983 failed badly. The period of 1997-98 was the worst El Niño year on record and the climatic conditions were comparable to those in 1982-83. The meteorological droughts occurred in these years.

Severe drought episodes during 1999-2002 affected livelihoods, resulted in human deaths, pushed tens of thousands of people to migrate, and killed large numbers of cattle. The drought wreaked havoc in 58 districts of the country, especially affecting the rainfed and rangeland areas. Balochistan was the most affected province where 23 districts were severely hit by the drought. Similarly, Dadu, Tharparker, and Thatta districts in Sindh, and Cholistan in Punjab were the other main areas adversely affected by the prolonged dry spells. Famine-like situation was faced in severely affected areas and consequently over 3.3 million families had been affected and hundreds of thousands had to migrate to "safe areas." Hundreds of people lost their lives due to dust and thirst. Moreover, about 30 million livestock was affected by the scarcity of water and fodder.

Drought differs from other natural disasters (e.g., floods, earthquakes, tropical cyclones, tsunami, etc.) in the sense that the effects of drought often accumulate slowly over a considerable period of time and may linger on for years even after the termination of the event. It is for this reason that drought is often referred to as a "creeping phenomenon." The impacts of drought are less obvious and are spread over large geographical areas than from the damages that result from other natural hazards. Consequently drought affects more people than any other environmental hazard. (National Plan for Multi-Hazard Early Warning System 2006 by PMD)

Based on the current situation of hazards and risks by droughts with existing early warning systems, the following has been identified:

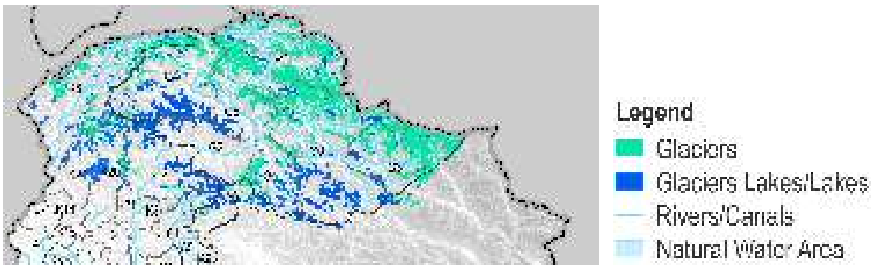
- Drought periodically occurs in hyper-arid, arid and semi-arid areas in Pakistan and has undermined economic and social issues in these areas. In particular, severe drought episodes during 1999-2002 led to 143 deaths and affected 2,200,000 people according to EM-DAT.
- PMD has established the National Drought/Environment Monitoring and Early Warning Centre (NDMC-PMD) to advise on the drought conditions (see Subsection 3.3.5).
- In addition, current weather information should be improved for alleviation of drought damages. Monthly and sub-monthly prediction capacity is required for issuing extended

outlook on drought. The existing numerical weather prediction system in PMD can calculate only 1-3days of weather condition. Meteorological monitoring facilities and equipment in areas vulnerable to drought are insufficient to inform the stakeholders of the meteorological and hydrological data.

4) Other Disasters

a. Glacial Lake Outburst Flood (GLOF)

The bursts of glacial lakes in the upstream of the Indus River Basin due to heat waves, etc., a phenomenon termed as Glacial Lake Outburst Flood (GLOF), are also one of the natural disasters to be concerned with. In particular, the Karakoram region is noted for the destructive effects of GLOF from naturally-dammed lakes. The lower parts of large glaciers in the Upper Indus River Basin can severely disrupt and modify river courses in the valleys below. River channels can be diverted or partially blocked by glaciers advancing in the long term or surging in the short time across their paths from tributary valleys. If channels become completely impeded by glaciers then a lake may form upstream of the dam eventually resulting in catastrophic flooding downstream with incalculable damage to people and property. An associated hazard is the amount of sediment transported during the few hours of such an outburst which can be equivalent to several months of normal sediment transport. Figure 3.6.14 shows the location of glaciers and glacial lakes in Pakistan.



Source: ICIMOD

Figure 3.6.14 Location of Glaciers and Glacial Lakes in Northern Pakistan

According to the NDMA Framework of 2007 and the Glacial Lakes and the Identification of Potential GLOFs Affected by Global Warming in the Mountains of India, Pakistan and China/Tibet Autonomous Region by the ICIMOD[8] found that, of the 2,420 glacial lakes in the Indus Basin, 52 are potentially dangerous and could result in GLOF with serious damages to life and property. The study has also indicated that global warming can increase the potential of GLOF in the future. Figure 3.6.15 indicates the location of potentially dangerous Glacial Lakes subject to modification for periodical updates due to climate change and other issues.

[8] 2004-03-CMY-Campbell, Final Report submitted to APN, J. Gabriel Campbell (Ph.D.), Director General, International Centre for Integrated Mountain Development (ICIMOD), G. P. O. Box 3226, Kathmandu, Nepal, gcampbell@icimod.org, 2005 July, ICIMOD and Asia-Pacific Network for Global Change Research (APN)

Source: ICIMOD

Figure 3.6.15 Potentially Dangerous Glacial Lakes

Climate change is projected to further exacerbate some of these GLOFs and lead to significant impacts on the regions' development. Furthermore, the situations of potentially dangerous glacial lakes have changed year-by-year.

Based on the situations with current GLOF monitoring mentioned above, the following has been found:

- The occurrence possibility of GLOF will increase due to climate change. In fact, 52 out of 2,420 glacial lakes in the Indus Basin are potentially dangerous and could result in GLOF with serious damages to life and property (ICIMOD).
- There is no EWS for GLOFs. In addition, the research and periodical inspection system of glaciers and glacial lakes shall be required prior to the establishment of EWS.

b. Avalanches

Gilgit-Baltistan and Kashmir region experience avalanches on seasonal basis. Local communities surrounding the avalanche area are vulnerable to this disaster. Avalanches are a kind of local natural disaster and their impact is localized to the communities living nearby or in the area where avalanches happen on a regular basis. Therefore, the impact of avalanches is minimal. Table 3.6.7 shows historical avalanche disasters in Pakistan recorded by EM-DAT.

Table 3.6.7 Historical Avalanche Disasters in Pakistan by EM-DAT (1983-2010)

Date	Location	Dead	Affected
18/02/2010	Saidan gutlo, Mula Khail	31	3,705
30/03/2007	Chitral region (Hindu Kus)	43	3
27/12/2005	Dassu (Kohistan district)	24	-
16/03/1996	Kel (Kashmire)	44	-
24/03/1993	Gultar, Thalestal	22	5
14/03/1993	Baday Serai (Swat)	36	309
29/03/1992	Neelum valley, Mansehra	55	200
06/02/1991	Kashmir	25	-
26/03/1988	Arandu Gul - Jammu, Kashmire	50	-
11/03/1983	Phuban (Astor Valley)	95	100

Source : EM-DAT

On the other hand, a study conducted by WAPDA in 1985-89 under the Snow and Ice Hydrology Project, identified the potential avalanche paths.

Based on the situations with current avalanche disaster mentioned above, the following has been found:

- Avalanche disasters have occurred in northern mountain areas in Pakistan and claimed human lives.
- There is no specific EWS for avalanche disaster due to insufficient monitoring data and non-specific information in current weather forecasts.

5) Disease

It is also significant and one of key issues to manage and control epidemics of disease in Pakistan. In the aftermath of the 2010 Pakistan Flood, the massive population displacement, coupled with damage and disruption to infrastructure, raised urgent public health issues (See Table 3.6.5). Waterborne diseases were prevalent. According to the World Health Organization (WHO), in an average year diarrheal diseases are the fourth most common cause of death in Pakistan, accounting for roughly 9 percent of all deaths countrywide. In the 2010 Pakistan Flood, some deaths were caused by diseases in the displacement places in Sindh Province. In 2011, the dengue fever turned into an epidemic due to the number of patients suffering from dengue in Punjab Province. In this connection, the activities for “disease” related to information system in the DRM shall be considered in this Multi-Hazard EWS Plan.

CHAPTER 4 PLANNING ISSUES, CHALLENGES AND CONCEIVABLE PROJECTS

4.1 Introduction

This Chapter identifies the necessity of expanding and rehabilitating the current EWS taking into consideration the existing EWS and disaster conditions described in Chapter 3.

4.1.1 Consideration of Previous and Current EWS Plans

There are several Multi-Hazard EWS improvement plans previously prepared by PMD and FFC. The NDMA Framework 2007 has also designated a five-year implementation plan for EWS. In addition, a project on the "Strategic Strengthening of Flood Warning and Management Capacity of Pakistan" has recently been offered to PMD by UNESCO and the improvement and extension of the existing EWS in Pakistan (Flood Early Warning System: FEWS) has also been proposed as a concept in the Comprehensive Flood Mitigation Plan in response to the 2010 Pakistan Flood by the WB. Moreover, since September 2010, PMD has proposed a EWS program in collaboration with WMO.

These plans and recommendations are discussed in this Chapter based on the hazard and risk assessment results and current EWS of Pakistan described in the previous chapters. The concepts and improvement plans previously proposed are shown in Appendix 4.2.1.

4.1.2 Common Concerns and Remarks on the Multi-Hazard EWS Plan

Following are the common concerns and considerations for the planning of the Multi-Hazard EWS based on the strategies for MHEWS Plan as shown in Chapter 2:

1) Strengthening and Enhancement of Weather Forecasting Capacity

It is indispensable to enhance and strengthen the capacity of the weather forecasting system for the improvement of the early warning system against meteorological disasters, such as floods, landslides, cyclones (with storm surges), GLOFs and avalanches. The occurrences of these disasters can be generally predicted through the processing of weather forecasts. In this connection, the improvement of weather forecasting including dissemination systems is a fundamental recommendation for EWS against meteorological disasters (See item 5, "Perspective of Improvement of Multi-Hazard EWS" in this subsection).

2) Preparation of Hazard Map

Small-scaled hazard maps should be prepared for highly vulnerable areas. However, the agencies mandated to prepare these hazard maps are not clearly defined. For the preparation of hazard maps, NDMA should provide provincial and district governments with a uniform format of a GIS data model as the base map. The hazard maps will serve as the base for the formulation of the government's own disaster management plans.

3) Communication System during Pre-Disasters

Most vulnerable districts have prepared their contingency plans against disasters. However, the contents of these plans/manuals are not unified among districts.

Among others, communications during all phases are not clear among the stakeholders. The communication systems should be defined including tools and facilities to be utilized in their plans/manuals. In this regard, there should be multiple communication systems; i.e., if one type of communication channel fails, the alternate channel is used.

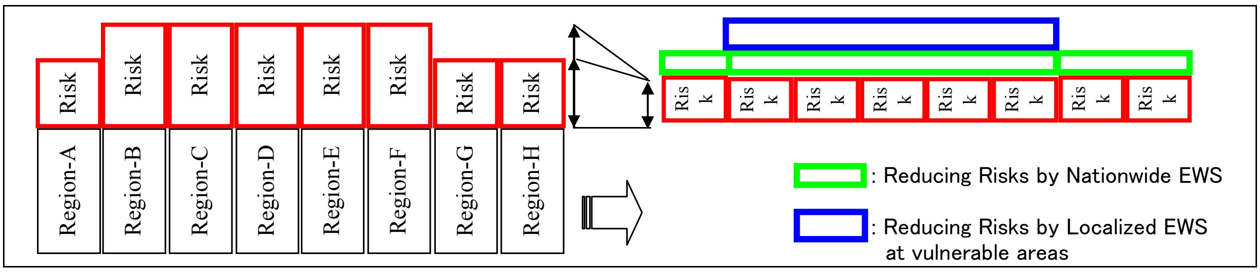
4) Record and Evaluation System

Most agencies have no written operations recording system. All operations done should be recorded in writing for the evaluation and improvement of the system. It is absolutely imperative to establish a review system for EWS.

In addition to the lack of record of operations during warning and evacuation, the damage and loss assessment data have not been collected appropriately by each district government affected by the disaster(s). Hence, neither the federal government (NDMA) nor the provincial governments (F/G/S/PDMAs) have disaster records or chronology accumulated. It is indispensable to correctly record the disaster damage and loss assessment data for the establishment of the EWS.

5) Perspective of Improvement of Multi-Hazard EWS

As the improvement policy, the results of hazard and risk assessment explained in Subsection 3.6.3 should be one of the considerable points, taking into account the existing conditions of the EWS described in Chapter 3. In this connection, hazards throughout the whole of Pakistan shall be mitigated by the improvement of EWS on the national or regional level. On the other hand, high risks concentrating in populated or property-packed areas should be alleviated with localized EWS. This concept is as illustrated or explained below.



Source: JICA Expert Team

Figure 4.1.1 Concept of Risk Reduction Improvement

Table 4.1.1 Examples of Category of Nationwide and Localized EWS

Disaster	Nationwide or Regional EWS	Localized EWS
Floods	Weather Forecast	(AAA) River Flash Flood EWS; Thunderstorm Alert; Preparation of Small-Scaled Hazard Maps
Cyclone w/ Storm Surge	Weather (Cyclone) Forecast	Preparation of Small-Scaled Hazard Maps
GLOF/Avalanche	Weather Information	(BBB) Glacier Warning System; Preparation of Small-Scaled Hazard Maps
Drought	Weather Information/Advisory	
Landslide	Weather Information/Advisory	Preparation of Small-Scaled Hazard Maps
Tsunami	Tsunami EWS	Preparation of Small-Scaled Hazard Maps

Source: JICA Expert Team

6) Formulation of Human Resource Development Plan in Multi-Hazard EWS Plan

It is difficult for the installation of facilities and equipment alone to sufficiently provide appropriate EWS. The proper operations and activities for EWS to foster the achievement of the goal of the Plan depends on not only the facilities and equipment but also human resources capacities in all steps of targeted EWS.

In this regard, each proposed project or program shall include the required personnel capacities to enable operation, communication and maintenance of the established EWS.

4.2 Planning MHEWS

4.2.1 Tsunami and Earthquake

1) Earthquakes

a. Further Installation of Earthquake Observation Stations/Accelerograph Stations

The possibility of impending earthquakes prior to the occurrences cannot be predicted and it is very difficult to establish EWS for earthquakes in terms of technical and economic issues. It is essential for realization of assumed damage extents to grasp the intensities of earthquake at each location. From the viewpoints of Disaster Risk Management, the following have been identified:

- The number of seismographs distributed in Pakistan is still insufficient for the bulletin news and the immediate identification/actions to be taken for relief, rescue and damage extent of earthquakes

Knowing the earthquake location and magnitude as well as the distribution of strong ground motion soon after an earthquake is useful in mounting an effective emergency response. Also, accumulated strong motion records can be used for engineering purposes like in seismic design or seismic hazard and risk analysis.

However, the present number of seismic stations, especially those equipped with accelerographs, is not adequate to estimate the distribution of ground shaking. Here, an attempt is made to examine the distribution of accelerograph stations, as shown in Table 4.2.1.

The number of districts, area coverage, and number of accelerograph stations are classified according to seismic level as evaluated in the building code. Comparing the number of existing stations by area coverage, there are fewer stations for seismic level 3 than for seismic level 2B, though the area coverage for seismic level 3 is wider than that for seismic level 2B. Calculating the average area covered by one station at present, it shows less station density in level 3 areas than in level 2B areas. Since more earthquakes can be expected in level 3 areas, more stations should be allocated to them than the level 2B areas.

As indicated in column "c" in Table 4.2.1, all districts in seismic level 3 and 4 are proposed to have one station each while districts in seismic level 2B, though having a wider area of coverage, will have fewer stations. This will result in a higher station density for the higher seismic level areas.

Table 4.2.1 Number and Area Distribution of Accelerograph Stations

Seismic Level	No. of Districts	a	b	C	d=b+c	e=a/b	f=a/d
		Area (km^2)	Existing & Planned No. of Stations	Proposed No. of Stations	Total No. of Stations	Average Area covered by One Station	Average Area covered by One Station
4	8	33,696	3	5	8	11,232	4,212
3	36	292,454	5	31	36	58,491	8,124
2B	48	231,367	8	14	22	28,921	10,517
2A	47	343,677	5	0	5	68,735	68,735
Total	139	901,194	21	50	71		

Source: JICA Expert Team

b. Improvement of Earthquake SOPs

In current response and contingency plans prepared by NDMA/ F/G/S/PDMAs /DDMAs, actions immediately after earthquake disaster(s) are taken in accordance with declarations of emergency by lower DMAs.

As a reference, Table 4.2.2 shows some guidelines used in Japan for initial response after an earthquake, according to the level of seismic intensity estimated by instruments. Note that seismic intensity up to seven levels is estimated in real time by instruments.

Table 4.2.2 Initial Response according to Observed Instrumental Seismic Intensity in Japan

Seismic Intensity*	Action to Take	Responsible Agency
3 or more	Broadcast earthquake information	TV & radio stations
4 or more	Survey damage situation	Police, fire station
	Run damage estimation system	Cabinet office
5- or more	Survey damage situation	Maritime agency
	Run damage estimation system	Ministry of defence
5+ or more in Tokyo metropolitan area	Gather emergency team	Emergency management center
6- or more in whole Japan	Gather emergency team	Emergency management centre

*: Japanese scale with seven levels.
Source: Japan Meteorological Agency

Earthquake SOPs at each government level shall be revised with the improved real-time accelerograph station network.

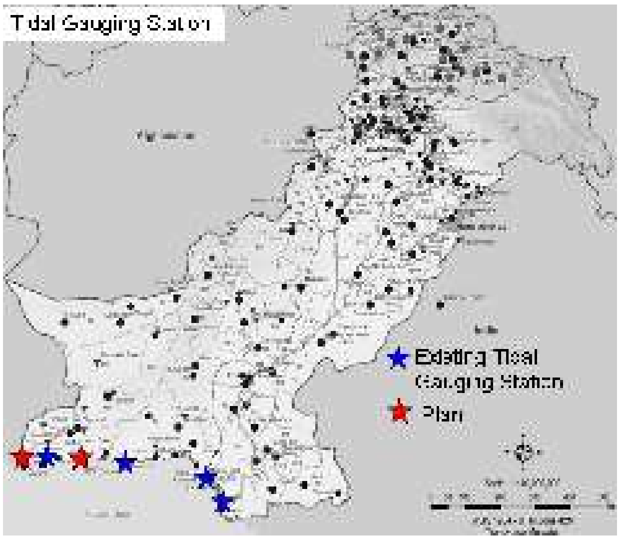
2) Tsunami

a. Installation of Tide Gauge Stations

It is very important for the realization of assumed damage extents to grasp the actual height of tsunami at each location. In addition, it is necessary for the preparation and revision of tsunami hazard maps of each designated area to improve the tsunami simulation utilizing actual dense tsunami observation network. From the viewpoints of Disaster Risk Management, the following has been identified:

- The number of real-time tide gauging stations in highly vulnerable areas along coastal zones is still insufficient for the preparation of bulletin news, immediate identification of damage extent of tsunamis and actions to be taken for relief and rescue activities.

Since the Makran coast is 1,000 km long, the number of existing tide gauge stations is not adequate to cover all populated areas. Therefore, the installation of additional tide gauges at Jiwani and Pasni is proposed. Tide gauges can be used for tide level monitoring for cyclones as well. Since the navy has stations in these cities, tide gauges can be maintained with the help of the navy. Figure 4.2.1 shows proposed locations of real-time tide gauging stations.



Source: JICA Expert Team

Figure 4.2.1 Proposed Location of Additional Real-Time Tidal Gauges at Jiwani and Pasni

b. Training on Tsunami Simulation and Preparation of Hazard Maps

Based on the review of the current tsunami warning system according to the Japanese experience, the following has been identified:

- There is no tsunami hazard map. Based on the tsunami simulation results, tsunami hazard maps for each populated city/town shall be prepared. In addition, the Tsunami EWS should also be improved.

PMD and related agencies should prepare hazard maps at high risk areas (highly populated cities/towns) against Tsunami disasters.

To issue detailed tsunami information, the Makran coast area should be divided into several blocks so that early warning can be issued according to each block as in the case of the Tsunami Warning and Advisory in Japan. Warnings should be issued based on the expected tsunami wave height based on the hazard maps rather than magnitude only. For this purpose, tsunami simulation should be more developed and accumulated in the database.

Different levels of warnings according to expected tsunami wave height should be prepared, as shown in Table 4.2.3. These categories are used by the Japan Meteorological Agency.

Table 4.2.3 Tsunami Warning and Advisory in Japan

Category		Indication	Forecast Tsunami Height
Tsunami Warning	Major Tsunami	Tsunami height is expected to be 3 meters or more.	Forecast heights are specifically indicated for every region, namely; 3m, 4m, 6m, 8m and 10m or more.
	Tsunami	Tsunami height is expected to be up to 2 meters.	Same as above, but 1m or 2m.
Tsunami Advisory		Tsunami height is expected to be about 0.5 meters.	0.5m

Source: Japan Meteorological Agency

Based on Tsunami Hazard Maps, the decision on evacuation dissemination to the public should be made by PMD, rather than by local officials, according to the expected tsunami wave height. Information on this decision should be disseminated by PMD directly using bulletins. Manuals for broadcasting tsunami warnings by radio and TV stations should be developed and enhanced with periodical drills. For this manual, narrative text easily understandable by the public should be prepared.

Since tsunami is a complex and dangerous phenomenon that requires proper understanding, a brief explanation on tsunami should be specified and included in media broadcasts to citizens. Some examples are: "*do not go to the beach even though the water recedes, it is a sign that tsunami wave will come shortly afterwards*;" "*you should not go to the coast to see tsunami as it will be too late to evacuate when the tsunami comes*;" "*stay evacuated until the warning is cancelled, as tsunami waves may last for a few hours*;" "*even 50 cm waves can be dangerous*."

Taking into consideration mentioned above, Tsunami SOP shall be improved with Training on Tsunami Simulation and Preparation of Hazard Maps.

c. Updating of Global Telecommunication System (GTS)

In 2010, JMA conducted a simulation test for Indian Tsunami Warning through GTS. After this test, the following result was obtained:

- Warning message from JMA did not reach the PMD Karachi Office due to some reasons.

As described in Item 2) in Subsection 3.1.5 in Chapter 3, it is necessary to update and replace the existing system of the GTS. This secured communication network by GTS enables real-time exchange of information, critical for forecasting and warnings of tsunami warning generated in the Indian Ocean issued by JMA and hydro-meteorological hazards in accordance with the approved procedures. The information of tsunami warning from JMA and/or USA PTWC through the GTS is very important for warning and alerting activities against the onslaught of tsunami.

The existing and future GTS network with dedicated communication lines between PMD and meteorological agencies of other countries is shown in Figure 4.2.8 in item e in 6) of this Subsection.

4.2.2 Meteorological Disaster

1) Cyclones with Strom Surges

a. Replacement of Existing Karachi Radar Station and Installation of New Weather Radar around Pasni/Gwadar

As described in Subsections 3.6.2 and 3.6.3 3)a., many people died by storms and floods due to the cyclones and these mainly occurred along coastal areas. In this regard, three (3) issues have been pointed out in Subsection 3.6.3 as follows:

- Frequency of Cyclone Generation is on upward trend.
- Karachi Meteorologcial Radar for direct monitoring system is essential but the coverage is limited, and Karachi Radar has become outdated.
- There is no meteorological system to watch and forecast cyclone intensity most information about cyclone except for Karachi radar, information from satellite or overseas agencies.

It is essential for the issuance of warnings and alerts of the cyclones to watch the intensity of cyclones such as rainfall intensity, wind speed, and directions in detail prior to the actual impacts.

The meteorological radars at Pasni/Gwadar and Karachi to cover the coastal areas will be utilized for cyclone observation.

Regarding establishment of the new Meteorological Radar Station at Karachi, other candidate locations; namely, Badin or Thatta, can be conceived. From the viewpoint of coverage by radar, because either one of them is more suitable the ealier detection of rainfall intensity in eastern areas.

From the viewpoint of actual implementation, however, Karachi is the most appropriate location since the present PMD's premises adjacent to the Karachi Airport is already furnished with all the relevant facilities including buildings, seismic/tsunami/cyclone laboratories. On the contrary, the new radar at Badin or Thatta would require shifting of all the facilities and staff of the Karachi premises to the new location which will not be feasible in terms of staff and budget availability. In addition, there are no high-rise-buildings in the vicinity of Karachi premises to restrict weather observation by the meteorological radar. On the basis of the fact, the PMD authorities have recommended Karachi as the most suitable location, which shall be decided taking updated information into consideration.

b. Expansion of AWS Network

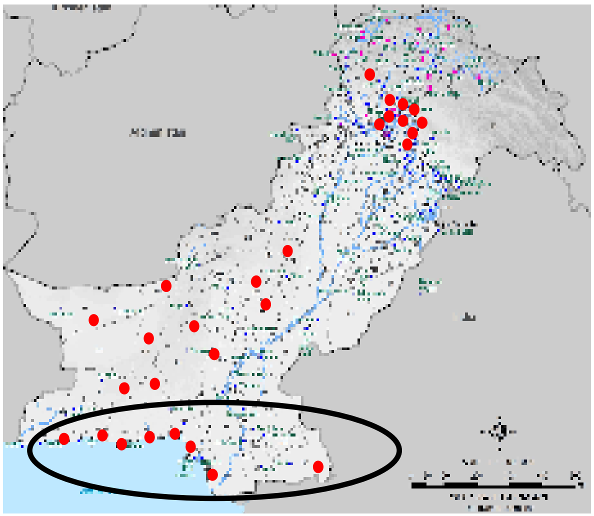
The increase in number of AWS along the coastal zone in Pakistan to watch weather conditions including cyclone phenomena is necessary to monitor real-time situation of cyclones and calibrate the meteorological radar data.

In addition to the two proposed radar stations, namely Pasni/Gwadar and Karachi/Badin/Thatta stations, the augmentation of ground-based observation system is also required for more accurate cyclone forecasting and calibration of meteorological data from radar. Therefore, AWS stations along the coastal area shall be installed with real-time data communication and visualization facility at TCWC, Karachi. The proposed locations of AWS are shown in Table 4.2.4 and Figure 4.2.2.

Table 4.2.4 AWS Stations and High Hazard Cities/Towns against Cyclone

Name of City/Town	Existence of AWS / Real-time Met.Observation	Description
Virawah	Non Existence	Newly Proposed
Mithi	Existence	3-hourly thru Internet
Badin	Existence	3-hourly thru Internet
Keti Bandar	Non Existence	Newly Proposed
Karachi	Existence	
Naka Kharari	Non Existence	Newly Proposed
Khandewari (Brar)	Non Existence	Newly Proposed
Aghore (Rivermouth of Hingol)	Non Existence	Newly Proposed
Ormara	Existence but limited	3-hourly thru Internet (Newly Proposed)
Makola	Non Existence	Newly Proposed
Pasni	Existence	Hourly thru Internet
Kappar	Non Existence	Newly Proposed
Gwadar	Existence	Hourly thru Internet
Jiwani	Existence	Hourly thru Internet

Source: JICA Expert Team and PMD for Meteorological Observation Information



Source: JICA Expert Team based on the data of PMD

Figure 4.2.2 Proposed AWS Observation System for Cyclone

c. Expansion of Tide Level Monitoring Network

It is important to detect the actual tide surge at high populated areas for the calibration of predicted tide level and emergency information to related DRM agencies. In this regard, the following issue has been pointed out:

- The number of real-time tide gauging stations in high vulnerable areas along coastal zones is still insufficient for the preparation of bulletin news, the immediate identification of damage extent of storm surge phenomena and actions to be taken for relief and rescue activities.

The two (2) new tidal level monitoring stations for Tsunami EWS at Jiwani and Pasni where population densities are comparatively high shall also be utilized for cyclone warning activities. (Refer to item 2) in Subsection 4.2.1.)

d. Improvement of SOP of Cyclone EWS

The existing SOPs of the Cyclone EWS will be improved and revised, taking into consideration the two proposed meteorological radars, proposed AWS network systems and the tidal monitoring network to be expanded.

2) Drought

a. Expansion of AWS Network for Drought Monitoring

It is essential in forecasting of drought phenomena to acquire meteorological conditions in drought-affected areas, such as Balochistan and other arid areas, as fundamental activities.

- In arid areas in Pakistan, the number of AWS is still insufficient to provide agricultural advisories and drought warnings.

As shown in Figure 3.1.4, the distribution of AWS is sparse to monitor drought condition. Therefore, appropriate advisories and warnings to farmers and government officials who are feeling desperate needs for seeding, expectations of rainfalls and other information cannot currently be provided. The locations of AWS to be installed shall be concentrated into mainly southern half of the country as shown in Table 4.2.5 and Figure 4.2.3 (see below). AWS for drought monitoring should equip agromet observation apparatus (dew point and soil moisture).

Table 4.2.5 AWS Stations and High Hazard Areas against Drought

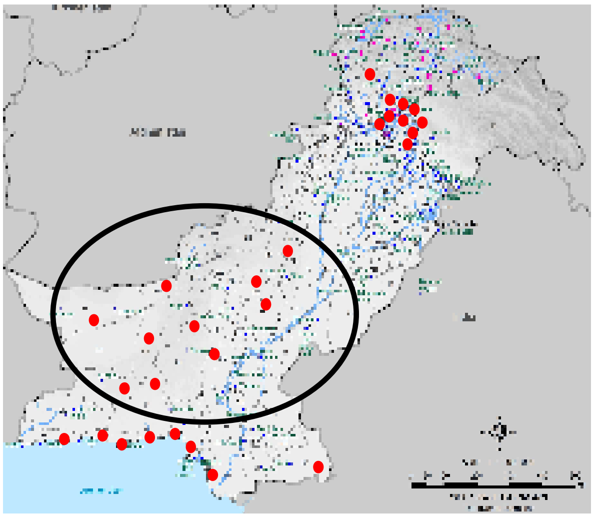
District *[1]	Precipitation	Irrigation Ratio (ha/km^2)	Current AWS *[2]	New AWS to be Installed *[3]
Punjab				
Bahawalpur	Less than 200	0.26	2 +	
Bhakkar	Less than 200	0.56	1 +	
D.G.Khan	Less than 200	0.34	1 ++	
Mianwali	Less than 600	0.46	-	
Rajanpur	Less than 200	0.39	-	
Rawalpindi	Less than 1800	0.06	1 ++	
Balochistan				
Awaran (Mir Hasan)	Less than 200	0.00	-	+++
Chagi	0	0.00	-	+++
Dera Bugti	Less than 200	0.07	-	+++
Kharan	Less than 200	0.00	-	+++
Khuzdar	Less than 200	0.01	1 ++	+++ (Additional)
Kohlu	Less than 200	0.02	-	+++
Musakhel	Less than 200	0.01	-	+++
Nushki	Less than 200	0.00	-	+++
Panjgur	0	0.01	1 ++	+++ (Additional)
Quetta	Less than 200	0.08	1 +	
KP				
D.I.Khan	Less than 200	0.32	1 ++	
Sindh				
Qambar-shaddad Kot	0	0.09	-	+++
Badin	Less than 200	0.24	1 +	
Dadu	0	0.05	1 ++	
Sanghar	Less than 200	0.23	-	
Tharparkar	Less than 200	0.03	-	
Thatta	Less than 200	0.07	-	
Umerkot	Less than 200	0.09	-	

Note : *1 : Districts were selected based on the drought damage during 1999-2002 and previous assessment by NDMA and PMD.

*2 : + : System not including Agromet Observation System
++ : System including Agromet Observation System

*3 : +++ : Selected Districts for the installation of new AWS for drought monitoring

Source : JICA Expert Team based on the information from PMD, NDMA and FAO



Source: JICA Expert Team.

Figure 4.2.3 Proposed AWS Observation System for Drought

b. Improvement of Agro-Meteorological Advisory Service (AAS) and Environmental Monitoring System

Improvement of an agro-meteorological advisory service (AAS) is imperative to advise farmers in advance to undertake various farming activities based on the expected establishment of agro-meteorological advisory service (AAS) units. In this regard, the following issue has been pointed out:

- There is no Data Ingestion System to correctly and promptly analyze and process drought conditions and observation data for the issuance of drought advisories.

The expected establishment of AAS units will be done through the installation of an Agrometeorological Data Processing & Analysis System and environmental monitoring system, to prepare/issue/disseminate the AAS. Based on this system, bulletins regarding weather forecasts will be issued. The commencement of this system will contribute to agricultural production increase through provision of specialized agro-meteorological information.

3) GLOF

a. Establishment of EWS against GLOF

As shown in Subsection 3.6.3., threats of GLOF have existed in GB and KP. In this regard, the following issue has been pointed out:

- There are, however, no EWS and mitigation measures against GLOF. Future global warming might cause deterioration of the glacier lake conditions and increase the number of potential dangerous glacial lakes.

The establishment of EWS for GLOFs is thus necessary. The establishment of EWS against GLOF can be proposed aiming to detect dangerous GLOFs with sufficient lead time to issue a warning to residents who might be affected so they could evacuate to safer ground. In particular, Early Warning System for GLOF including Preparation of Hazard Maps in GB and KP, such as Shyok River, Shigar (Braldu) River, Hunza River (Downstream), Shimshal River and Gilgit River shall be considered.

b. Enhancement of Research Activities for Snow/Glacier/Glacial Lakes including GLOF Data Acquisition and Archiving System

In addition, the current status of glacial lakes might drastically change due to climate change in the region. Glaciers are nature's renewable storehouses of fresh water that benefits hundreds of millions of people in the Himalayan mountain region including Pakistan. However, in the face of accelerated global warming, the glaciers of the region are retreating with rapid accumulation of water in the mountain lakes. Recent studies suggest that the rate of glacial retreat in the Himalayas is as high as 30 to 60m per decade. As glaciers retreat, glacial lakes form behind moraines or ice dams, which can breach suddenly leading to a discharge of huge volumes of water and debris flow. Such outbursts have the potential of releasing millions of cubic meters of water in a short time and causing calamitous debris flow up to hundreds of kilometres downstream. Taking the facts mentioned above into account, the following issue has been identified:

- There is no research and data accumulation of Glaciers and Glacial Lakes to identify the hazardous areas against GLOF taking climate change into consideration.

It is proposed to enhance researches on snow, glacier and glacial lakes in GB and KP using GIS and remote sensing by continuous satellite imagery data as well as periodical site inspection activities taking into account the climate change.

In this connection, the activities required shall include: 1) Identification of critical glacial lakes and potential landslides along major rivers which have high potential of flash flood disaster risks, and 2) Enhancement of Research Activities for Snow/Glacier/Glacial Lakes in GB and KP.

4) Avalanche

a. Establishment/Improvement of Avalanches Advisory Information System

PMD should establish the Avalanche Advisory Dissemination System as a part of general weather forecasts based on meteorological conditions in the future due to the following reason:

- There is no Avalanche Warning System designating certain locations.

Current weather information for avalanches is still vague and there is no detailed guideline for avalanche advisory. Mechanism generating avalanches is complicated but the possible causes of conditions and locations of avalanches has been recognized, such as vegetation and steep slope of more than 35 degrees for topographic condition and extreme up and drop of temperature in general and sudden huge snowfall. Based on the experiences of actual avalanche locations and meteorological phenomena, designated avalanche advisory shall be issued.

5) Landslide

a. Preparation of Hazard Maps based on the Topographical and Geological Points of View

It is necessary to identify landslide risk areas in view of the past landslide records. Landslide risk districts are mainly located in GB (northern area), KP, FATA, AJK and northern Punjab.

The dimension or extent of landslides that might occur in the future can be assumed. The relative safety levels of every slope can also be compared with other slopes. Hence, hazard maps for landslide disasters can be delineated technically. The High Hazard or Risk Areas (districts) and existing hazard maps, susceptibility maps or risk maps achieved by each province/agency against landslide disaster based on the studies in the past are tabulated in Table 4.2.6.

Table 4.2.6 High Hazard or Risk Districts to Landslide and Achievements in the Preparation of Hazard Map

High Hazard and Risk Areas		Result by JICA Project*1		Current Preparation of Hazard Maps	
Province	District	Hazard Analysis	Risk Analysis	Location	Agencies
AJK	Haveli, Poonch, Hattian, Bagh	Very High	Very High	-	-
	Muzaffarabad			Core Area; Area along Highway; Left Bank of Karli Lake	ERRA; GSP; GSP
	Neelum	Very High	High	-	-
	Sudhnoti,	High	Very High	-	-
	Mirpur	High	Medium	-	-
KP	Abbottabad, Haripur, Swat, Upper Dir	Very High	Very High	-	-
	Mansehra	Very High	Very High	Whole District; Karakoram H.W.; Balakot Town	GSP (BGR); GSP; ERRA (NDMA)
	Kohistan, Chitral	Very High	High	-	-
	Buner, Shangla, Batagram	High	High	-	-
	Swabi, Lower Dir, Hangu	High	Medium	-	-
ICT	Islamabad	Very High	Medium	-	-
Punjab	Rawalpindi	Very High	Very High	Murree	NDMA/GSP
	Mianwali	High	High	-	-
	Attock	High	Low		
GB	Diamir, Hunza-Nagar	Very High	High	-	-
	Astore, Skardu, Ghanche, Ghizer, Gilgit	High	Medium	-	-
FATA	Khyber, Mohmand, Orakzai	High	High	-	-
	Kurrum, North Wariziristan	High	Low	-	-

Note: *1: Hazard and Risk Analysis (district-wise) have been conducted and shown in the Main Report of the JICA Project.
Analyses were executed based on past available information and records, vulnerability indices of district-wise population density and hazard indices of district-wise landslide record, slope with location of cities/towns, soil, and annual mean rainfall
These hazard and risk scores shall be further clarified with GSP and NDMA

Source: JICA Expert Team

As indicated in the table above, the following has been pointed out:

- There are many districts still without landslide hazard maps and detailed landslide analysis.

The preparation of landslide hazard maps for these districts is also an indispensable activity. The GSP and NDMA have prepared hazard maps at some designated areas. Comparing the risk of landslide with the area of preparation of hazard maps by the agencies concerned, expanded efforts for preparing hazard maps for the remaining districts are further required.

b. Establishment of Landslide EWS

Most of the landslides are triggered by heavy rainfall on the steep slopes of mountainous or hilly areas. However, threats of landslides have been generally and vaguely issued together with general weather information based on the following reason.

- There is no particular EWS for landslide disaster.

The following table shows the general areas/locations vulnerable to landslide and slope failure.

Table 4.2.7 Factors of Landslide and Slope Failure

Factor	Item	Description
Mechanical Factors	Geology	In addition to the strength of rocks, dominant factors are the level of weathering, alteration, fissure and fracture, direction of layers, conditions of permeable layers, and distribution of loose layers such as a surface layer.
	Topography	Failures tend to occur at slopes of 40-50 degrees and at slopes or locations easy to collect rainwater, such as a concave type slope, the bottom of a long slope, and the bottom of a gentle slope.
	Vegetation	Forests have a collapse prevention effect with regard to surface failures caused by infiltration of torrential rainfall.
Trigger Factors	Rainfall, Snowmelt	The number of slope failures increases if a rainfall of strong intensity occurs when the ground is already moist.
	Earthquake, Volcanic Activity	The ground becomes unstable when stress conditions in the slope are altered due to an earthquake or a volcanic eruption.
	Groundwater	An increase in pore water pressure caused by a subsurface flow due to rainfall leads to a slope failure.
	Artificial Activities	Deforestation, artificial changes of a natural slope by cut and fills.

Source: Guidelines for Development of Warning and Evacuation System against Sediment Disasters in Developing Countries, IDI Japan (2004)

Taking into account the factors shown in the table above, landslides caused by strong rainfall can be predicted up to a certain level.

Landslides triggered by rainfall and snowmelt can be forecast at certain levels of accuracy based on the amount of accumulated rainfall. Therefore, PMD shall be required to establish EWS for landslide disasters based on the preparation of landslide hazard maps and studies on landslides conducted by related responsible agencies, such as the GSP, NDMA, ERRA, NHA, etc.

c. Expansion of AWS Network for Landslide Hazard

It is required that accumulated rainfall observation and real-time rainfall observation network systems are established at designated locations for the landslide EWS. In this refard, the following issue has been identified:

- The existing facilities for the real-time rainfall observation network (such as AWS stations) are inadequate for the accurate forecasting operation of the expected landslide EWS.

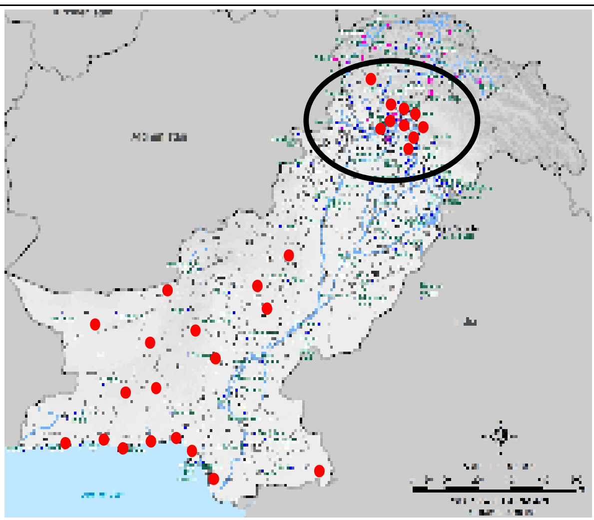
Additional AWS stations should be installed at landslide-vulnerable locations. These stations will also be utilized for other forecasting activities, such as weather and flash flood forecasting. In general, landslide disasters are one of localized disasters except for huge slope failure, such as hunza landslide disaster generating Hunza Lake in 2010. Therefore, the additional locations where AWSs for landslide disaster should be installed are selected based on districts designated as "very high risk area" shown in Table 4.2.6 and Table 4.2.8. These candidate locations and the validity are shown in Figure 4.2.4

Table 4.2.8 Selected Location for Additional AWS Installation

Selected Districts	Current AWS	Disaster Record	Selection *[1]
Haveli	None	Mar. 2007, 37 people died by two landslips in AJK Another 2 women killed by landslide in Jhelum Valley (UNOCHA)	+++
Poonch	None		+++
Hattian	None		+++
Bagh	None		+++
Muzaffarabad	None		+++
Sudhnoti	None		+++
Abbottabad	None		+++
Haripur	None	-	+++
Swat	None	2 people dead in Maniar City	+++
Dir	Exist	Mar. 2007, 2 dead (UNOCHA)	
Mansehra	None	Aug. 2006, more than 12 dead	+++

Note: *1 : +++ : districts in which new AWS shall be installed.

Source: UNOCHA for Name of District and Disaster Record
PMD for Current AWS Status



Source: PMD and JICA Expert Team

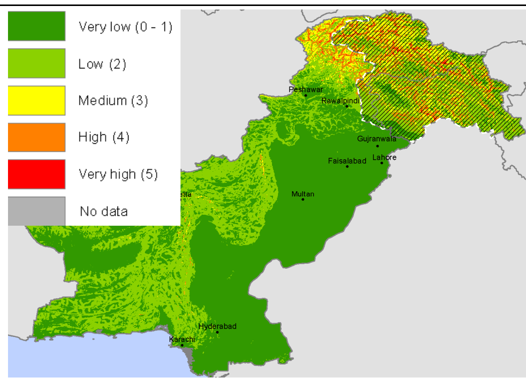


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Figure 4.2.4 Proposed AWS Observation System for Landslide

6) River Flood and Weather Forecast

a. Replacement of Existing Four (4) Meteorological Radar Stations

As described in Chapter 3, the following issue regarding the existing meteorological radars has been poited out:

- Four (4) existing meteorological radars installed in the 1990's; namely, Islamabad, Karachi, R.M.Khan and D.I.Khan, have already been aged and these are almost operating beyond their durable years.

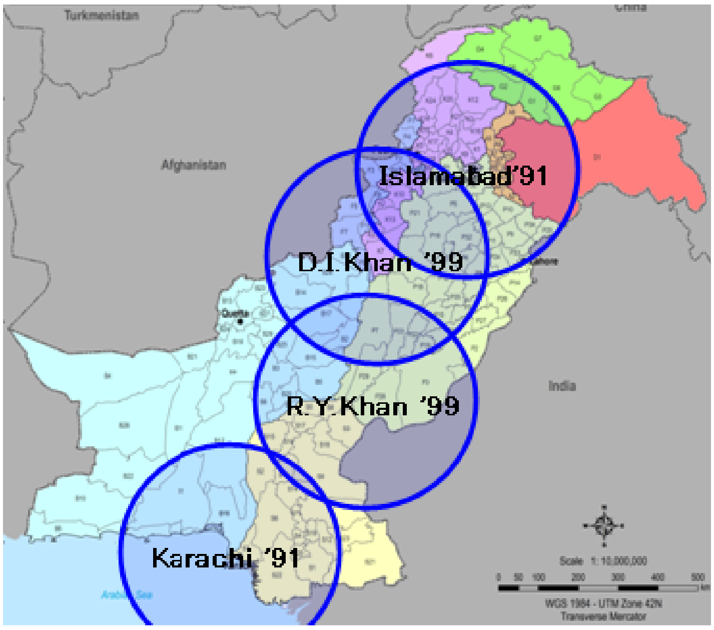
Due to the expiry of the useful life of existing radar systems, these should be replaced. In addition, the adoption of new technology for multiple observations with reliable operation is also required. It is important to solve the problem of the non-availability of spare parts. The old meteorological radar system shall be replaced with Doppler technology for continuation of PMD's activity in flood forecasting to cover observation area in the present conditions.

In this connection, the four meteorological stations constructed in the 1990s as shown in the following table should be replaced:

Table 4.2.9 Meteorological Radar Systems requiring Replacement

Station	Construction	Operational Life (Yr)	Total Operating Hours	Mean Daily Operating Hours
Islamabad	1991	19	75,757	Approx. 10.9
Karachi	1991	19	56,535	Approx. 8.2
D.I. Khan	1999	11	8,594	Approx. 2.2
Rahimyar Khan	1999	11	8,384	Approx. 2.0

Source:PMD and JICA Study Team



Source: JICA Expert Team

Figure 4.2.5 Meteorological Radars requiring Replacement

b. Establishment of New Meteorological Radar Stations

In Pakistan, floods and other disasters related to rainfall have occurred almost everywhere including arid areas. In this regard, the following issues have been pointed out:

- Meteorological Radars are useful to understand the intensity of rainfall and wind speed and the moving direction of rainfall for the issuance of warning of impending floods. However, the current radar network does not cover nationwide meteorological EW needs. Moreover, they do not provide other data except rainfall estimates.

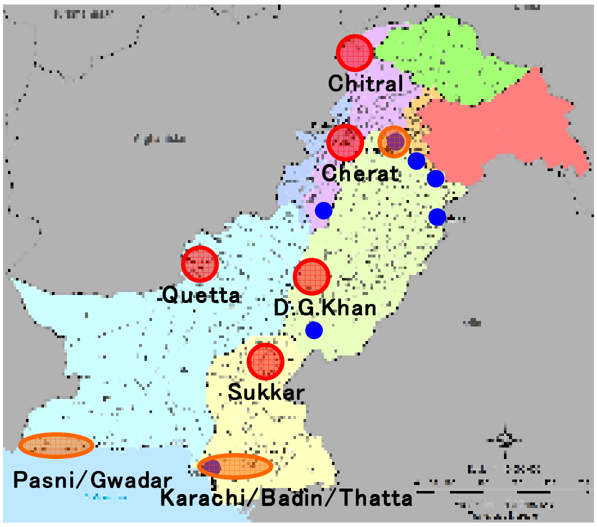
- There are no meteorological radars in KP and Balochistan even though these regions have been experiencing floods quite frequently.

In addition to the existing radar network system, several new meteorological radar systems should be installed to expand the coverage area to improve the accuracy of rainfall prediction in the whole of Pakistan. PMD's plan to expand the coverage of meteorological radar systems shall be considered. In that plan, seven new meteorological radar systems are proposed for the following seven locations:

Table 4.2.10 Meteorological Radars to be Newly Installed

Region/Province	Candidate Location for New Radar Installation
KP	Chitral, Cherat
Punjab	D.G.Khan
Balochistan	Quetta, Pasni/Gwadar
Sindh	Sukkur

Source: NDMA and PMD



Source: JICA Expert Team

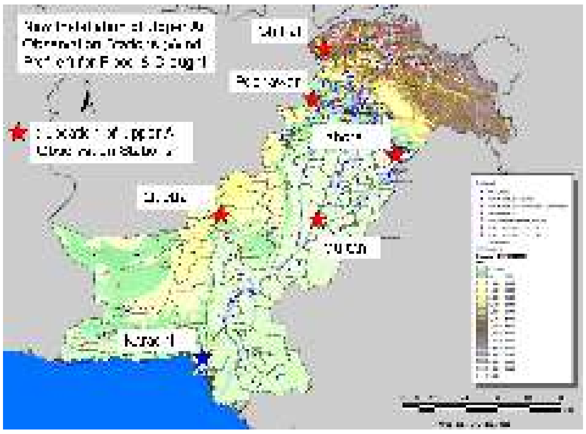
Figure 4.2.6 Establishment of New Meteorological Radar Stations

c. Establishment of Upper Air Observation Stations

As described in Item 4) in Subsection 3.1.3, radiosonde observation is done once daily at 0000 UTC at the PMD Karachi Station. However, the following issues have been identified:

- Upper air observations have not been made properly at other stations due to the lack of budget.

In and around areas where troughs of low pressure used to appear, wind profilers should be installed for increasing the precision of forecast and prediction of weather conditions and floods. For this purpose, upper-air observation stations shall be established at two locations, namely: Lahore and Peshawar. Furthermore, installation of another three (3) wind profilers is proposed to obtain a more accurate upper-air condition in and around Pakistan, at Quetta, Multan and Chitral with the existing station at Karachi.



Source: JICA Expert Team

Figure 4.2.7 Proposed Upper-Air Observation Stations

d. Replacement of Satellite HRPT Data Information System

PMD has not received any high-resolution (1 km mesh) meteorological satellite image broadcast by NOAA satellite because the system has not been functioning well since October 2009. As of 2011, PMD obtains only low resolution NOAA satellite images through the internet and receives images of Feng Yun 2 satellite directly. However, the receiving system of data from Feng Yun 2 is sometimes out of operation. These current issues are summarized below:

- High resolution (e.g. 1km mesh) meteorological satellite image cannot be obtained correctly.

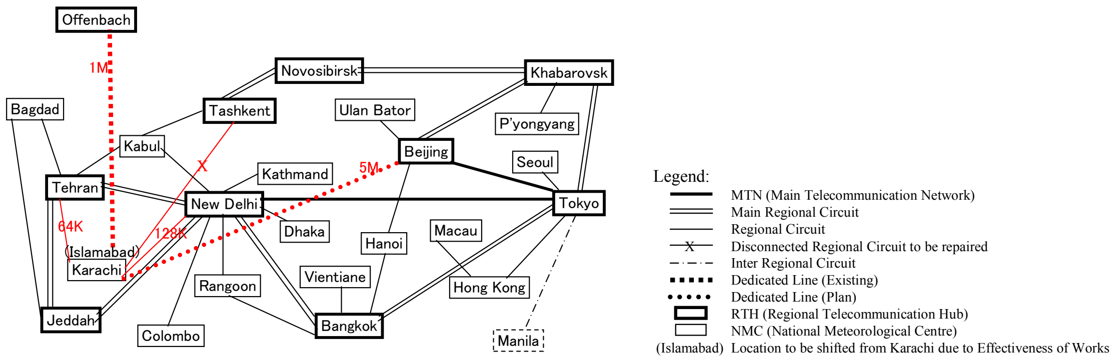
The system of High Resolution Picture Transmission (HRPT) Data Information System from NOAA should be replaced immediately for earlier prediction of regional changes in weather conditions.

e. Updating of Global Telecommunication System (GTS)

A secure communication network by GTS would enable real-time exchange of information critical for forecasting and warnings of hydro-meteorological hazards in accordance with the approved procedures. However, the following issue has been identified:

- As of 2011, most of the main functions of EWS of PMD have been shifted from the old headquarters, Karachi, to the existing headquarters at Islamabad. However, the main GTS is located at Karachi. Therefore, uploading and downloading activities related to GTS are inconvenient for routine works of PMD.

As described in Item 2) in Subsection 3.1.5 and Item 2) in Subsection 4.2.1, it is necessary to update and replace the existing system of the GTS. The main switch of the GTS system is at present installed at the Karachi Office of PMD. In this connection, the main switch of the new GTS System shall have to be installed at the Islamabad Office because the Islamabad Office is the head office of PMD with main centres and sections for the early warnings and forecast activities, such as NWFC, NSMC, NDMC and R&D.



Modified by JICA based on WMO and Techniques of Weather Forecast 1995 (Weather Forecast Technique Reserch)

Figure 4.2.8 Current and Future GTS Network System of PMD

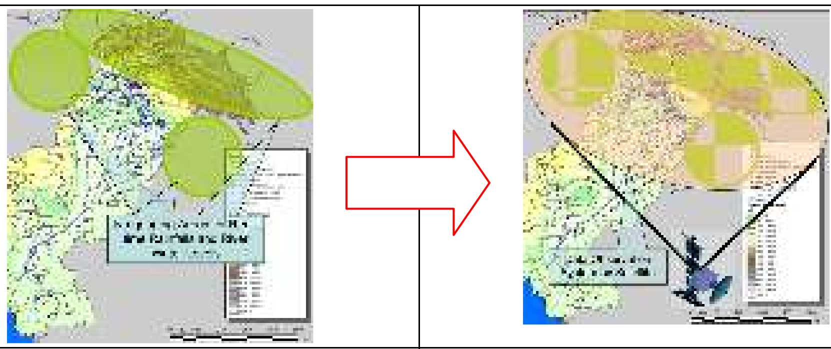
f. Utilization of New Rainfall Monitoring Technology through Satellite Data

In the Upper Indus Basin, rains have been observed on hourly basis by 45 rainfall gauging stations monitored by WAPDA (See Subsection 3.1.4). However, 45 rainfall stations are still sparse and cannot totally grasp the pattern of rainfall in the Upper Indus Basin. Some tributaries and main stretches of the Indus originate from India or Afghanistan.

Regarding these rainfall observation system in the Upper Indus Basin, the follwing issues have been identified:

- Actual rainfall and other related data cannot be obtained in real-time in Afghanistan and India so that it is difficult to predict river discharge originating from these two countries, specifically, from the Kabul, Chenab, Ravi, and Sutlej rivers.
- There are also few real-time observation data in the Kabul and Swat river basins in the KP and the Gilgit-Baltistan area for the estimation of flood discharges immediately after rainfall.
- It is difficult to estimate and forecast accurate flood discharges in the Upper Indus Basin.

Nowadays, semi real-time rainfall data can be obtained through the satellites. To calculate accurate flood discharge and forecast flood warning as early as possible, rainfall observation system utilizing satellite data shall be proposed (see Figure 4.2.9).



Presently, rainfall and river flow data outside of rim stations cannot be obtained	Utilization of satellite data is useful for the earlier warning of Indus River Basins

Source: JICA Expert Team

Figure 4.2.9 Utilizing Satellite Data for Rainfall Observation in Upper Indus Basin

g. EWS Improvement for Indus River Flood by Satellite Information and Hazard Map

Computer models established in the National Flood Protection Plan III (NFPP-III, 1998-2007) by the ADB Fund are used to get outputs from the hydro-meteorological as well as hydrological components of the system. The output from the hydro-meteorological component gives the forecast of flood peaks and flood levels at various downstream sites of the Tarbela and Mangla dams, but doesn't include the Kabul, Swat Rivers and other Upper Indus rivers. The highest flood elevation thus forms the basis of estimating the areas likely to be flooded along both banks of the rivers, by using the flood risk maps prepared for various flood magnitudes. Flood risk maps illustrate the areas flooded in 10- and 50-year return period probabilities along Indus, Jhelum, Chenab, Ravi and Sutlej Rivers. These maps were prepared under the Flood Protection Sector Projects (FPSPs). However, the accuracy of flood forecasting for the Indus Basin based on the computer models was not so high due to the insufficient hydrological observation data and the following reasons:

- The model was developed for the Indus river basin downstream of Tarbela and Mangla dams. Therefore the current model cannot estimate the Upper Indus Flood.
- The current Flood Simulation Model of the Indus River System has a margin of error due to the insufficient observation data in upper basins, unknown glacier melting system and run-off model.

Therefore, actual forecasting is still based on traditional empirical methods. The current system cannot accurately predict the inundation area in case the flood probability exceeds empirical flood levels in the past. This requires improvement of the flood discharge forecasting model and modification of the flood risk maps. For these purposes, the utilization of satellite rainfall data and run-off model is proposed.

h. Clarification of Warning Classification of Indus River Flood

Flood discharge in the Indus Rivers (Indus, Jhelum, Chenab, Ravi and Sutlej) has been classified into five (5) categories; namely, Low, Medium, High, Very High and Exceptionally High as shown in Section 3.3.2. However, the following issue has been identified:

- There are inconsistencies of flood conditions between quantitative warning criteria and actual flood situation.

This classification has been used for long time and all stakeholders have understood it. Therefore, modification is not necessary. However, the relationship between classification and flood condition should be clarified because of the diversification of the basin and flood plain condition. This clarification shall be conducted with the improvement of Indus River EWS activities.

i. Additional Installation of AWS for the Observation of Basic Meteorological Data

Fundamentally, the actual observation of meteorological phenomena is essential to understand the weather and/or climate mechanisms. The “Expansion of the AWS Networks for Cyclone, Drought and Landslide” proposed in previous Items have been confirmed based on the studies on issues of the existing EWS conditions. In this connection, the further expansion of an AWS observation network is also effective to accurately forecast weather and impending/current disasters based on the following issue:

- The number of AWS to monitor the meteorological conditions is quite insufficient. (Refer to Table 4.2.11.)

Table 4.2.11 Comparison of Meteorological Observation Stations between Pakistan and Japan

Item	Pakistan	Japan
Number of Stations	86 (AWS: only 30)	1,300 *1
Land Area (km^2)	796,095	377,930
Population (million) *2	175.31	127.82

Note: *1: The number of Automated Meteorological Data Acquisition System
*2: IMF - World Economic Outlook Databases (2012)

Taking into consideration the current risk of disasters, the nature of the highest risk is “Flood” in Pakistan and the areas with the highest risk are distributed in KP, AJ&K, Punjab and Sindh. Moreover, AWS is useful not only for flood but also for other meteorological disasters to understand weather and climate conditions from actual observed data obtained by AWS. It is crucial to install additional AWS networks in the high-risk areas. According to the Draft NDMP, the 45 districts are categorized as High or Very High Vulnerable Districts subject to Multi-Hazards. The additional AWS network shall be considered in such vulnerable districts.

As a reasonable target for the total number of AWS to be installed by Year 2021, which is the target year of this Plan, it is assumed that approximately five AWSs shall be newly installed per year during the 10 years. As shown in Figure 4.2.3 in this sub-section 4.3.2, 28 AWSs will be newly installed as the “Expansion of AWS Network” and about 30 AWSs are currently being operated by TCWC, NDMC and RMCs. Therefore, 25 more AWSs in high-risk districts as indicated in Table 4.2.12 shall be installed taking into account the prioritization based on the F/S to be conducted in advance of the implementation.

Table 4.2.12 Very High and High Risk Districts for Multi-Hazard Consideration

Name of Provinces	Name of Districts	No. of Districts
AJ&K	Hattian, Muzaffarbad, Bagh, Haveli, Poonch, Sudhnoti,	6
KP	Charsadda, Nowshera, Shangra, Peshawar, Sawat, Bannu, Buner, Mansehra, Swabi, Abbottabad, Mardan	11
Punjab	Multan, Rawalpindi, Sheikhupura, Gujranwala, Gujrat, Muzaffargarh, Okara, Rahim Yar Khan, Sahiwal	9
Sindh	Karachi, Qambar and Shahdadkot, Tando Muhammad Khan, Badin, Hyderabad, Kotli, Mirpur, Thatta, Jacobabad, Kashmore, Matiari, Shikarpur, Tando Allahyar	13
FATA	Bajaur Agency	1
Balochistan	Bolan, Jaffarabad	2
ICT	Islamabad	1
GB	Diamer, Ghizer, Astore	3
Total		46

Source: JICA Expert Team

7) Flash Flood

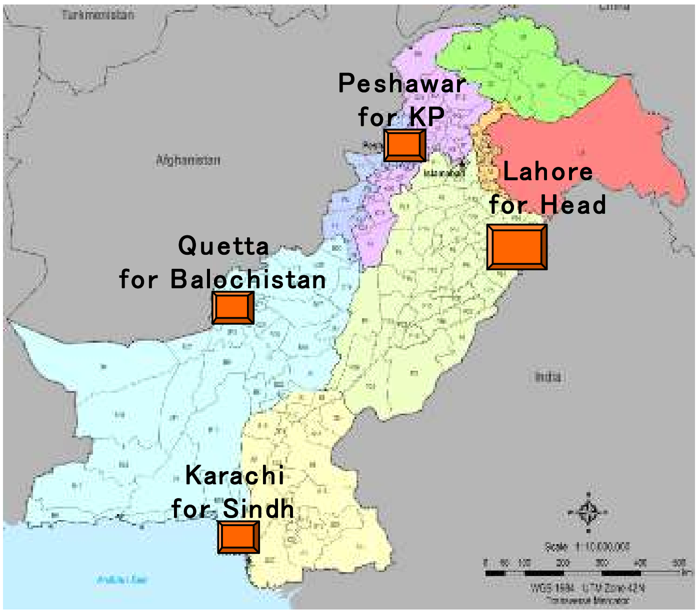
a. Establishment of Regional Flood Forecasting and Warning Centres (RFFWC)

As of 2010, PMD have issued most flood warnings and advisories through the Flood Forecasting Division (FFD) at Lahore. However, there are some EWS problems related to the current situation of floods as follows:

- FFD manages the flood forecasting service for the whole of Pakistan. Therefore, some flood warning issuances/bulletins should be conveyed simultaneously. There is a loss of time during the issuance.
- Long-distance telephone/facsimile lines have a bigger risk in the communication system. For KP, Balochistan and Sindh, it seems that the immediacy of warning/news from other provinces recedes due to social tension.

- It is hard for one office (FFD) to forecast the floods from an expanded and enormous quantity of meteorological data for the whole of Pakistan.

Thus, forecasting and warning tasks should be distributed among the provincial bases under the supervision of FFD, Lahore. Peshawar for KP, Quetta for Balochistan, and Karachi for Sindh are proposed as the Regional Flood Forecasting and Warning Centres (RFFWC). (See Figure 4.2.10.)



Source: JICA Expert Team

Figure 4.2.10 Proposed Regional Flood Forecasting and Warning Centres

b. Establishment of Flash Flood Forecasting and Warning System under Local Flash Flood Forecasting Centres (LFFFC)

At present, PMD makes a lot of effort to predict and forecast the flash flood warning activities for vulnerable areas. However, these activities cannot satisfy and promote the people's awareness against the impending disaster(s) due to the qualitative warning messages through the use of vague warning terms, such as "Strong", "Heavy" and "Long", due to the insufficient observation and prediction techniques in terms of facility/equipment and human resources except for the Lai Nullah Basin. This issue is summarized below:

- Flash Flood warnings currently issued are qualitative and vague excluding the Lai Nullah Basin.

These qualitative flash flood warnings should be improved and changed to individual Flash Flood EWS and/or quantitative warnings in weather information, such as "200 mm/day", "3 days" or "1 meter in depth".

Run-off times of small to medium river basins are quite short for the dissemination of warning and alert messages. Therefore, a short-period frequency rainfall and water level data communication system is required in real-time for each targeted basin or town/city.

As of 2010, a systematic flash flood warning system has been established only in Lai Nullah Basin for Rawalpindi in Pakistan, as described in Subsection 3.3.4. Unfortunately, there are a number of locations perennially affected by flash floods. This requires the establishment of a Lai Nullah Type Flash Flood Forecasting System or equivalent for other flash flood-vulnerable areas.

Targeted basins/locations for the EWS for flash floods are shown in the following Table 4.2.13 in broad terms based on the hazard and vulnerability analysis in coordination with FFC. The areas shown in Table 4.2.13 are affected by perennial flash floods and the residents in flood prone areas have always held their breath in fear whenever heavy rainfall commences.

Table 4.2.13 Areas Vulnerable to Flash Flood in Pakistan

Province	Target Locations (District-Based)
GB	Astore, Diamar, Gilgit, Skardu, Ghizer
KP	D.I.Khan, Bannu, Lower/Upper Dir, Swat, Charsadda, Peshawar, Mansehra, Mardan, Swabi, Chitral, Haripur, Nowshera, Shangla, Buner, Tank, Kohistan, Malakand
FATA	South Waziristan, Kurram, Khyber, Mohmand, Bajaur
AJK	Bagh, Neelem, Muzaffarabad, Poonch, Bhimber, Haveli, Hattian
Punjab	Mianwali, Bahawalpur, Sialkot, Bhakkar, D.G.Khan, Gujrat, Jhang, Muzaffargarh, Rajanpur, Rawalpindi, Gujranwala (Wazirabad), Narowal, Sheikhupura, Khushab
Balochistan	Barkhan, Kohlu, Dera Bugti, Bolan, Gwadar, Jhal Magsi, Kech (Turbat), Kharan, Khuzdar, Lesbela, Nasirabad, Noshki, Sibi, Jaffarabad, Dalbandin, Killa Abdullah, Zhob
Sindh	Dadu, Badin, Qamber-shardahkot, Karachi, Naushero Feroz, Sanghar, Thatta, Larkana

Source: JICA Expert Team in consultation with PMD, FFC, NDMA and F/G/S/PDMAs

Flash flood is a phenomenon in which the intensity of rainfall increases locally and heavily. In this regard, the control offices against flash floods for each targeted location should be strategically placed to promptly manage the alert, warning and evacuation activities.

Based on the above list of districts/cities, further prioritization study and consideration has been done in association with FFC, PMD and NDMA throughout the Project (see Table 4.2.14 and Table 4.2.15 below). As a result, 32 locations have been initially proposed for the preparation of hazard maps and the installation of flash flood forecasting and warning systems.

Table 4.2.14 Selection of Candidate Location of Flash Flood Warning System (1/2)

Province District	2010 Pakistan Flood			2011 Sindh F. Dead	Record by P/DDMA		Regionality	Selected District
	Dead Persons	Total Damages (by NDMA)	Type of Flood (by JICA Study Team)		No. of Flash Flood	Total Person Dead		
GB								
Astore	*1*	Affected	F. Flood	-	6	135		
Diamar	*103*	Affected	F. Flood	-				
Gilgit	*5*	Affected	F. Flood	-				
Skardu	*112*	Affected	F. Flood	-				
Ghizer	*5*	Affected	F. Flood	-				
KP								
D.I.Khan	47	Severely	F.Flood/R. Flood	-	-	-		
Bannu	0	Affected	-	-	-	-		+++
Mardan	8	Affected	F. Flood	-	3	Unknown		+++
Lower/Upper Dir	*113*	Severely	F. Flood	-	-	-		+++
Swat	95	Severely	F. Flood	-	3	45		+++
Charsadda	66	Severely	F. Flood	-	No Statistic Data			+++
Peshawar	46	Severely	F. Flood	-	3	more than10		+++
Mansehra	36	Affected	F. Flood	-	9	224		**
Swabi	7	Affected	F. Flood	-	-	-		
Chitral	*21*	Affected	F. Flood	-	-	-		
Haripur	37	Affected	F. Flood	-	5	22		
Nowshera	*167*	Severely	F. Flood	-	1	23		+++
Shangla	162	Severely	F. Flood	-	No Record			+++
Buner	*22*	Affected	F. Flood	-	-	-		
Tank	*11*	Severely	F. Flood	-	-	-		+++
Kohistan	*85*	Severely	F. Flood	-	-	-		+++
Malakand	*18*	Affected	F. Flood	-	-	-		
FATA								
South Waziristan	*2*	Affected	F. Flood	-	-	-	***	+++
Kurram	*4*	Affected	F. Flood	-	-	-	***	+++
Khyber	*17*	Affected	F. Flood	-	-	-	***	+++
Mohmand	*5*	Affected	F. Flood	-	-	-	***	+++
Bajaur	*25*	Affected	F. Flood	-	-	-	***	+++
AJK								
Bagh	*6*	Affected	F. Flood	-	4	813		
Neelem	*11*	Severely	F. Flood	-				
Muzaffarabad	*14*	Affected	F. Flood	-				
Poonch	*0*	Affected	F. Flood	-			***	+++
Bhimber	*3*	Affected	F. Flood	-				
Haveli	*7*	Affected	F. Flood	-			***	+++
Hattian	*10*	Affected	F. Flood	-				
Sudhnoti	*11*	Affected	F. Flood	-			***	+++

Note :
+ : Selected by NDMA in 2010 as Top 50 Priority DRM Districts
+++ : Slected Districts to further study the establishment of Flash Flood EWS based on the discussion among FFC, PMD and JICA Team
** : Flash Flood EWS by DDMA is being prepared in collaboration with UN Group in Mansehla.
*** : Through the TWG and S/C meetings, districts marked are added based on the regionality consideration.

Souece: JICA Expert Team
NDMA

Table 4.2.15 Selection of Candidate Location of Flash Flood Warning System (2/2)

Province District	2010 Pakistan Flood			2011 Sindh F. Dead	Record by P/DDMA		Regionality	Selected District
	Dead Persons	Total Damages (by NDMA)	Type of Flood (by JICA Study Team)		No. of Flash Flood	Total Person Dead		
Punjab								
Mianwali	16	Severely	R. Flood/F. Flood	-	3	24		+++
Bahawalpur	0	-	R. Flood	-	(3)	0		
Sialkot	*1*	-	(R. Flood/F. Flood)	-	(9)	0		+++
Bhakkar	0	Severely	R. Flood	-	(2)	0		
D.G.Khan	4	Severely	F. Flood	-	8	13		+++
Gujrat	3	-	F. Flood/R. Flood	-	16	25		+++
Jhang	*5*	Affected	(R. Flood/(City Flood))	-	(4)	-		
Muzaffargarh	2	Severely	R. Flood/(City Flood)	-	No Statistic Data			
Rajanpur	31	Severely	F. Flood	-	No Statistic Data			+++
Rawalpindi	0	-	F. Flood	-	1	240		
Gujranwala	*1*	-	(R. Flood/(City Flood))	-	-	-		
Narowal	*1*	-	-	-	-	-		
Sheikhupura	*0*	-	-	-	-	-		
Khushab	*19*	Affected	F. Flood	-	-	-		
Balochistan								
Barkhan	18	Affected	F. Flood	2	-	-		
Kohlu	5	Affected	F. Flood	0	1	19		
Dera Bugti	*0*	-	-	0	-	-		
Kech (Turbat)	*0*	Affected	F. Flood	0	2	15		+++
Bolan	*1*	Affected	F. Flood	0	-	-		
Gwadar	*0*	-	-	0	((5))	((more than11))		
Jhal Magsi	3	Affected	F. Flood	0	-	-		
Kharan	*0*	-	-	0	-	-		
Khuzdar	*0*	-	-	3	-	-		
Lesbela	*5*	-	F. Flood	0	-	-		
Nasirabad	97	Affected	F. Flood	0	3	more than2		+++
Nushki	-	-	-	0	1	2		
Sibi	12	Affected	F. Flood	0	-	-		
Jaffarabad	60	Affected	F. Flood	0	-	-		+++
Chaghi	*0*	-	-	0	-	-		
Killa Abdullah	*0*	Affected	-	0	-	-	***	+++
Zhob	*3*	Affected	-	0	*[1]*	*[5]*	***	+++
Sindh								
Dadu	37	Affected	-	19	No Statistic Data			+++
Badin	*0*	Affected	-	67	((9))	((478))		
Qamber-shardahkot	*16*	Affected	-	6	No Statistic Data			+++
Karachi	*0*	-	(City Flood)	25				
Naushero Feroz	*17*	Affected	R. Flood/F. Flood	26	No Statistic Data			
Sanghar	*24*	Affected	R. Flood/F. Flood	40	1	22		
Thatta	*7*	Affected	R. Flood/F. Flood	15	No Statistic Data			+++
Larkana	*7*	Affected	R. Flood/F. Flood	6	-	-		+++

Note :
+ : Selected by NDMA in 2010 as Top 50 Priority DRM Districts
+++ : Slected Districts to further study the establishment of Flash Flood EWS based on the discussion among FFC, PMD and JICA Team
** : Flash Flood EWS by DDMA is being prepared in collaboration with UN Group in Mansehla.
*** : Through the TWG and S/C meetings, districts marked are added based on the regionality consideration.

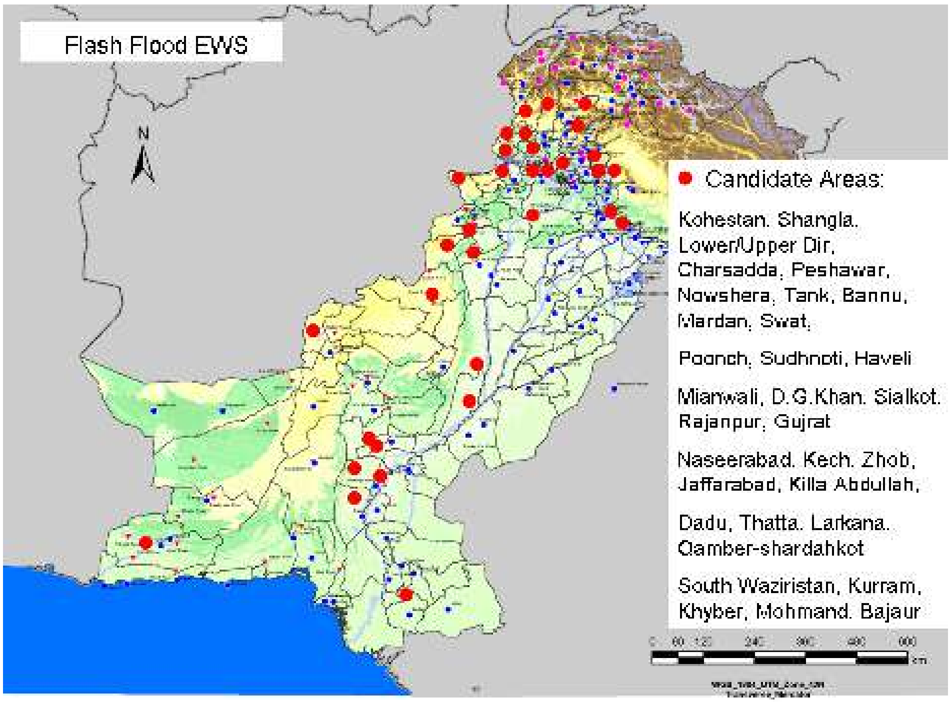
Souece: JICA Expert Team
NDMA

All warning advisories shall be disseminated under the local flash flood forecasting centres (LFFFC) to be established at each location for the area covered with a flash flood forecasting system. These LFFFCs shall be controlled by the regional flood forecasting and warning centres (RFFWC).

Table 4.2.16 Selected Candidate Vulnerable Areas for Flash Flood EWS

Province	Selected Candidate Areas (District-Based) as Priority Location
KP	Bannu, Mardan, Lower/Upper Dir, Swat, Charsadda, Peshawar, Nowshera, Shangla, Kohistan, Tank
Punjab	Mianwali, Sialkot, D.G.Khan, Rajanpur, Gujrat
Balochistan	Kech, Nasirabad, Jaffarabad, Killa Abdullah, Zhob
Sindh	Dadu, Qamber-shardahkot, Thatta, Larkana
AJK	Poonch, Sudhnoti, Haveli
FATA	South Waziristan, Kurram, Khyber, Mohmand, Bajaur

Source: JICA Expert Team in consultation with PMD, FFC and NDMA.



Source: JICA Expert Team.

Figure 4.2.11 Selected Candidate Vulnerable Areas for Flash Flood EWS

c. Establishment of Weather Forecast Guidance System

These qualitative flash flood warnings should be improved and changed to individual Flash Flood EWS and/or quantitative warnings in weather information, such as “200mm/day”, “3 days” and “1 meter in depth”. (See Item d. 1) in Subsection 4.2.5).

d. Preparation of Hazard Map and Capacity Development against Local Flash Flood

As indicated in Table 3.3.11 in Subsection 3.3.7, the location where flash flood hazard maps have been prepared is only the Lai Nullah Basin in Rawalpindi. In addition, the flood-prone areas in Mansehra and Muzaffarabad are identified in susceptibility hazard maps. From these facts, the following issue has been identified:

- Hazard maps for most of the flash flood vulnerable areas have not been prepared yet.

Even if a proper flash flood warning system is prepared in a designated area, the effectiveness would decrease because people cannot identify the floodprone areas and safer areas with evacuation places. In this connection, the hazard maps should be prepared together with the establishment of the Flash Flood Forecasting and Warning System.

After the preparation of the hazard maps and the installation of flash flood forecasting systems, the district governments and local communities should require capacity development for emergency responses through drills by technical cooperation or equivalent support agency(ies) together with information and communication trainings. The district governments can utilize the hazard maps and warning systems for the formulation of regional disaster management plans based on the establishment of the LFFFC and the warning system.

e. Expansion of Rainfall and Water Level Observation Network

As indicated in Table 4.2.13, a number of locations are identified as flash flood-prone areas. The costs for proposed LFFFCs with EWSs are very expensive and their implementations will take several years. Therefore, the establishment of LFFFC will be implemented with detailed feasibility and viable studies from the technical and economical points of view. Hence, the following issue emerges:

- The number of LFFFCs to be established is limited to populated areas. Most of the river basins pass through under-populated areas, such as Balochistan, GB and some parts in KP, which will not be selected although flash floods perennially occurred.

As explained in Subsection 3.1.4 in Chapter 3, PMD has prepared a draft plan to install additional real-time rainfall gauging stations with a corollary function of river flow observation at approximately 30 stations in small to medium river basins. Furthermore, it is recognized that the basic observation system in the Kabul River Basin including the Swat and Kunal *nullahs* is insufficient to predict river flow discharge for the release of flash flood warning. These rivers brought flood damages in the past as shown in Table 4.2.17. In this connection, a total of 34 stations for rainfall and water level observation with real-time transmission system are proposed. (See Table 4.2.17 and Figure 4.2.12.)

The real-time rainfall and water level observation data at 34 stations for targeted stretches will play the role of prelinary flash flood EWS.

Table 4.2.17 Selected Candidate Vulnerable Areas for Flash Flood EWS

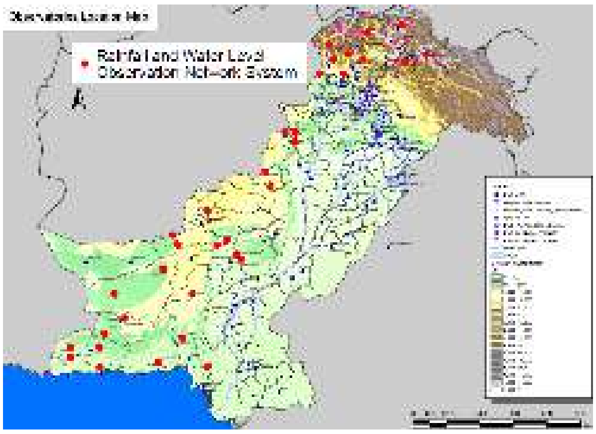
Name of River	Related City	Recent Major Flood Events	Damages
Ghizar River	Ghizar, Gilgit, Punial, etc.	Jul-Aug. 2010	2 dead, crops, houses
Hunza River	Gilgit, Hunza, etc.	Jan. 2010	huge landslide
Matsuj River	Matsuj, Chitral	Jul. 2010	10 houses washed out
Kandia River	Kohistan	Aug. 2011	61 dead at least
Shigar River	Shigar, Skardu	severe flooding and bank erosion for a few decades	
Astore River	Astore	Aug. 2010	5 days flooded
Kaitu River	Thall, Bannu	Aug. 2002	Low Flooded
Tochi River	Hassu Khel, Bannu	Jul. 1988, Jun. 2011	-No Detail Info-
Baran River	Bannu	-	for Dam Operation
Gumal River	D.I.Khan, etc.	Jul. 2010	-No Detail Info-
Zhob River	Zhob, etc.	Jul. 2004	5 dead
		Mar.2005, Sep. 2011, Apr. 2012	-No Detail Info-
Kaman River	Sibi	Jan. 2011	more than 3 dead
Lora River	Pishin, Nushki	Feb. 2011	Houses Washed-out
Pishin River			
Lahri River	Nasirabad, Kohlu	Aug. 2010	Inundation
		Sep. 2011	3 or more dead
Shirin River	Kalat	Sep. 2011	Houses Washed-out
Bolan River	Dadhar	Aug. 2010	Inundation
Chhatar River	Nasirabad	Aug. 2010	Inundation
Baddo River	Kharam	Aug. 2010	-No Detail Info-
Mashkal River	Reg Farang, Bibi Lori	Aug. 2011	Houses and Crop Damaged
Rakhshan River	Panjgur	Feb. 2005, Dec. 2009	Inundation
Kulachi River	Khuzdar	Jun. 2007	250 dead incl. Triburaries
		Sep. 2011	Inundation
Purali River	Bela	1998, 2003 & 2005	-No Detail Info-
Nihang River	Turbat, etc.	Jun. 2007 (Cyclone)	100,000 were affected
Kech River			
Dasht River	Zahren Bug, Suntsur	Jun. 2007 (Cyclone)	-No Detail Info-
Shadi River	Pasni, etc.	Feb. 2005 (dam burst)	70 dead
Bhiajri River		Jun. 2007 (Cyclone)	-No Detail Info-
Hingol River	Hingol	Sep. 2011	Inundation
Hub River	Hub Chowki, Karachi	Sep. 2011	2 dead
Swat River-1	Swat, etc.	Jul. 2010	95 dead
Swat River-2			
Kabul River	Peshawar, etc.	Jul. 2010	46 dead
Kunar River	Chitral, etc.	Jul. 2010	21 dead

Source: PMD for Candidate Rivers
NDMA, EM-DAT, UNOCHA and DDMAs for Disaster Record

Table 4.2.18 Summary of Proposed Rainfall and Water Level Observation Network

S No.	Province/ Agency	Existing Network		**Additional Rainfall/ Water Level Network Proposed (PMD)**
		Meteorological Station (PMD)	Rainfall/ Water Level Station (WAPDA)	
1	Punjab	23	21	**0**
2	Sindh	15	0	**1**
3	KP	15	14	**6**
4	Balochistan	19	0	**20**
5	AJ&K	3	7	**0**
6	FATA	2	2	**3**
7	GB	9	1	**4**
8	ICT	1	0	**0**
Total		87	45	**34**

Source: JICA Expert Team, in consultation with PMD, FFC and NDMA



Source: JICA Expert Team

Figure 4.2.12 Proposed New Water Level and Rainfall Observation System

4.2.3 Dissemination System of Multi-Hazard Early Warning

1) PMD (Pakistan Meteorological Department)

a. Improvement of Weather Information Broadcasting System and Communication System utilizing Cellular Phone and Radio Broadcast Networks

As discussed in the preceding chapter (Chapter 3), most of the warnings for disaster have originally been issued by PMD. PMD has disseminated information on magnitude and significance of anticipated hazards based on the prepared SOPs.

In the SOPs, contact lists for information dissemination including offices and key persons of the central and local government agencies as well as media (e.g., TV and radio stations) have been prepared. The staff in each responsible division/centre of PMD transmits warning messages for each type of hazard as prescribed in the SOPs.

The methods for communicating and disseminating information are mainly by land phone and facsimile to recipients' land phones, fax machines and mobile phones. In addition, an automatic

SMS volley sending system using mobile phone lines and a satellite phone system has also been applied for some hazard information (such as the tsunami early warning system). Furthermore, such warning information has been released through the Internet Web service (http://www.pakmet.com.pk) in semi real-time.

The current status of the PMD disaster information/warning dissemination system and problems and issues on dissemination tools are given below.

Table 4.2.19 Current Status of Dissemination System from PMD to Stakeholders

Hazard	Main Transmission Tool	Recipients to be Contacted
Floods	Fixed Phone, Facsimile, SMS, Internet	Related Central and Provincial Agencies including NDMA/ F/G/S/PDMAs /FFC, Districts to be affected (*1)
Cyclone	Fixed Phone, Facsimile, Internet, Satellite Phone	
Tsunami	Fixed Phone, Facsimile, Internet, Satellite Phone, SMS	

Note : *1 : Detailed lists are given in the Appendix 4.4.1.
Source: JICA Expert Team.

Table 4.2.20 Current Problems and Issues on Dissemination Tools in EWS between PMD and Other Stakeholders

Tool	Problem/Issue	Remarks
Fixed Phone, Facsimile, Cell Phone	Transmission Time	Common tool
Automatic SMS	System Reliability, Cost	No. of characters of letter to be sent is limited.
Satellite Phone	Cost, Transmission Time	Reliability is the highest
Internet	System Reliability, Recipient Capacity	The system is subject to power supply.
V.P.N	Limited Recipients, Cost	Reliability is higher than Internet.
V-Sat	Limited Recipients, Cost	For internal communication (between offices and offices of PMD)
Media	Recipient Capacity, Understanding of meanings of messages by Recipient	Media should be utilized in EW actions with public education.
H.F. Radio System	Cost, Radio Wave Condition	Presently, some districts have utilized it as a common tool.

Source: JICA Expert Team

As shown above, the tools for disseminating information for the EWS have both advantages and disadvantages. The transmission system for warnings, alerts and evacuation orders should be assured, swift and immediate.

Therefore, multiple accessibility or redundancy will be indispensable. Moreover, the utilization of mobile phone, such as SMS, GSM/GPRS, etc. and radio broadcast networks shall be fully considered for the communication mode of EWS as explained in Subsection 3.4.2. In this regard, the following issue has emerged:

- The redundancy for prompt transmission and communication among stakeholders is still insufficient for securement of information network regarding EWS.

Based on the general situation mentioned above, a dissemination system utilizing the SMS (multicast service by cellular phone lines) and electronic media (especially radio broadcasting companies and agencies) might be considered and proposed in harmonization with the mobile phone companies and electronic media companies.

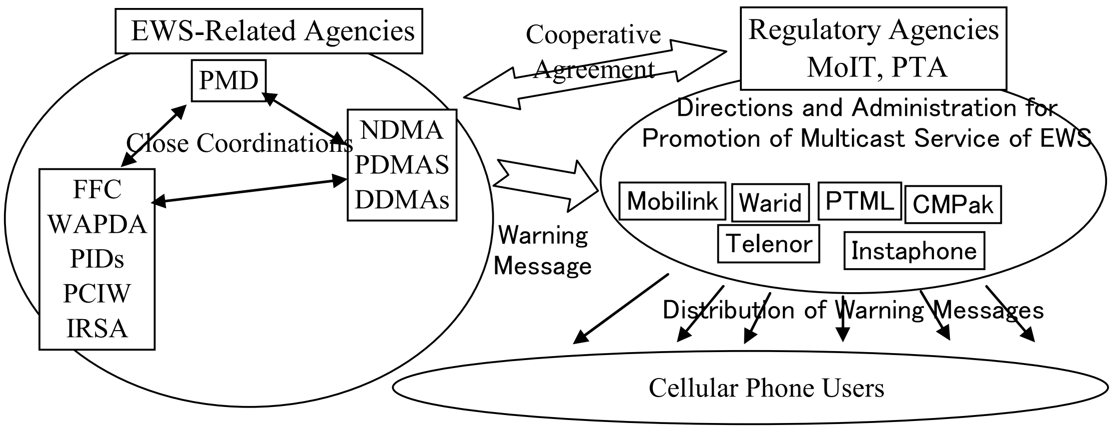


Figure 4.2.13 General Concept of Future Multicast EW Service Utilizing Cellular Phone Network

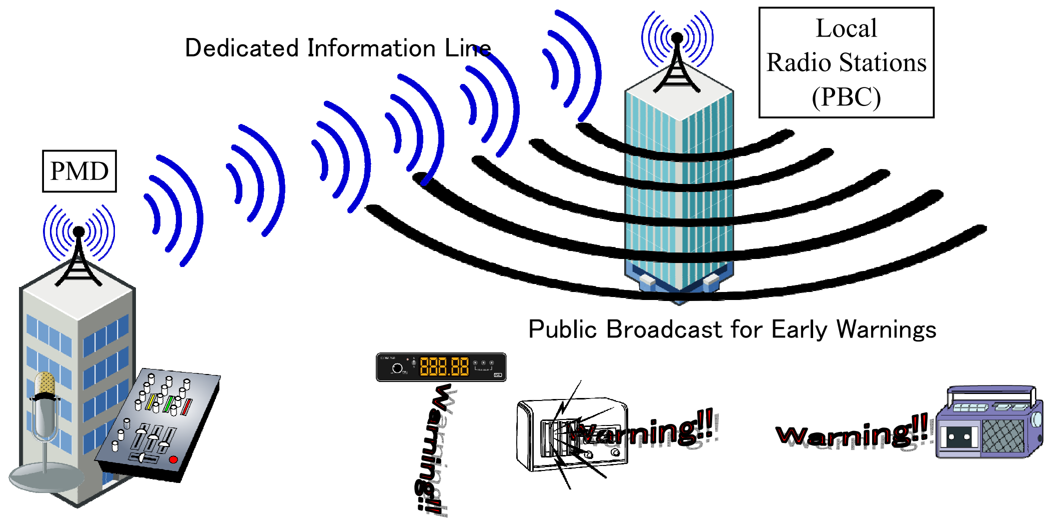


Figure 4.2.14 General Concept of Future Multicast EW Service Utilizing Radio Broadcast Network

Regarding Multicast EW Service utilizing the Cellular Phone Network, several alternatives can be considered. Taking into account the user-friendliness and effectiveness based on the current condition of frequently used functions by Pakistani users, an early warning messaging system using SMS is preferable. As for the sending system, there are two options, a "Cell Broadcast" (SMS-CB) system and a "Point to Point" (SMS-PP) system. SMS-PP was originally defined in GSM. The features of SMS-PP system are shown in Table 4.2.21.

On the other hand, SMS-CB is designed for simultaneous delivery of messages to multiple users in a specified area. Whereas the SMS-PP is a one-to-one and one-to-a-few service, Cell Broadcast is a one-to-many geographically focused messaging service. The features of SMS-CB system are also indicated in Table 4.2.21.

Table 4.2.21 Features of SMS-PP system and SMS-CB System

SMS-PP	SMS-CB
Require specific phone numbers to be input	Does not require phone number input but notice messages to all numbers in designated areas
Takes much traffic load to send message	Can send messages at designated times

Source: JICA Expert Team

Considering these two systems, the SMS-CB system is superior to the SMS-PP system in the ultimate sense as shown in Table 4.2.22 below:

Table 4.2.22 Alternatives of EW Service utilizing Cellular Phone Network

Alternative	Sender of EW	System	Evaluation	Judgement
1	EWS-Related Agencies (PMD/NDMA)	SMS-PP	Technically and administratively available. However, this system places a heavy burden on the sender of EW.	Not Recommended
2	Each Cellphone Company		The system is available. However, the subscribers of cell phones have to register their numbers. In addition, localized warnings will be issued to all subscribers.	
3	EWS-Related Agencies (PMD/NDMA)	SMS-CB	If PMD/NDMA sends an EW by itself, the initial cost of equipment is huge. In addition, it is difficult to administrate the system by PMD/NDMA.	
4	Each Cellphone Company		Warning recipients can be selected by each cellular phone company. The system can be observed and maintained by cellular phone companies themselves.	Recommended

Source: JICA Expert Team

However, utilization of SMS-CB for the dissemination of warnings requires reaching an understanding with each cellular phone company and establishing regulations to mandate the dissemination of the warnings from PMD as soon as possible. Moreover, awareness and education activities are imperative in advance of the commencement of the service so that the recipients of warnings (people likely affected by a disaster) understand the meaning of the message(s) and don’t panic.

Therefore, the dissemination by SMS-PP shall be considered in the first stage. Currently, FFD and NTWC have already started SMS-PP service for the warnings regarding the Indus River Basin flood and tsunami respectively to the officers in related agencies including DDMA likely affected by river flood. NWFC has also planned to commence SMS-PP service intending that the weather forecast will be sent to registered subscribers (30,000 numbers at a maximum) in collaboration with WFP (UN World Food Programs).

In this connection, the cell communication system shall be considered in each EWS project.

b. Production of Weather Information Broadcasting Program

It is necessary to enlighten communities about the significance of the Indus River Flood EWS. During the 2010 Pakistan Flood, much effort regarding earlier flood warning dissemination had been made by all concerned government agencies, such as PMD, PIDs and DDMAs, involving other district departments (police, revenue, irrigation) and the Pakistan Army. However, the residents did not follow earlier evacuation orders in accordance with the Indus River Flood classification, as found out in the latest surveys conducted by the JICA Study Team. (See Table 4.2.23 and Table 4.2.24)

Table 4.2.23 Causes of Suffering and EWS Effectiveness during the 2010 Pakistan Flood (1/2)

District	Province	Persons Dead	Causes of Suffering and Effectiveness of Current EWS
1. Mansehra	KP	36	Disregard of warning by people
2. Abbotabad	KP	17	No EWS for mountain district Not disseminated by the government agencies
3. Haripur	KP	37	Insufficient EWS/Disregard of warning by people/Correctly warned and quickly-disseminated, but no time to evacuate/ No location or very far from residential areas for evacuation/dissemination System was not so quick because of no resources/there is no location for evacuation
4. Shangla	KP	162	Disregard of warning by people
5. Swabi	KP	7	District administration evacuated and warned the vulnerable and evacuated them at proper time and saved the community/ population from further suffering and casualties
6. Swat	KP	95	Disregard of warning by people
7. Lower Dir	KP	36	Correctly warned and quickly-disseminated, but no time to evacuate because floodwater rushed Disregard of warning by people
8. Mardan	KP	8	Correctly warned and quickly-disseminated, but no time to evacuate because floodwater rushed
9. Charsada	KP	66	Disregard of warning by people
10. Peshawar	KP	46	Insufficient early warning (PDMA Representative's thought)/ Correctly warned and quickly-disseminated, but no time to evacuate because floodwater rushed (DCO's thought)
11. D. I .Khan	KP	47	Disregard of warning by people
12. Miawali	Punjab	16	Disregard of warning by people
13. Bhakkar	Punjab	0	*1
14. Layyaha	Punjab	2	Disregard of warning by some people though most people cooperated well
15. Muzaffargarh	Punjab	2	Disregard of warning by people
16. D. G.. Khan	Punjab	4	Disregard of warning by people
17. Rahimyar K.	Punjab	8	Disregard of warning by people (this factor was prominent) (the local people were not expecting such a level of flood intensity)
18. Rajanpur	Punjab	31	Disregard of warning by people
19. Multan	Punjab	1	Disregard of warning by people
20. Bahawalpur	Punjab	0	Disregard of warning by people

Note: *1: When the district management authority announced the flood intensity and level, people cooperated. At first, women and children including basic goods necessary for daily use were evacuated, and men remained in their houses because they feared the loss of their belongings in their absence. However, when water reached the dangerous level, these male members also cooperated and left their residences

Source: JICA 2010 flood field survey in August to October 2010

Table 4.2.24 Causes of Suffering and EWS Effectiveness during the 2010 Pakistan Flood (2/2)

District	Province	Persons Dead	Cause of Suffering and Effectiveness of Current EWS
21. Sukkar	Sindh	16	Disregard of warning by people
22. Shikarpur	Sindh	27	Disregard of warning by people
23. Khairpur	Sindh	32	Disregard of warning by people
24. Dadu	Sindh	37	Disregard of warning by people
25. Kashmore	Sindh	2	Disregard of warning by people
26. Ghotki	Sindh	30	Disregard of warning by people
27. TandoMum. K.	Sindh	4	Disregard of warning by people
28.Barkhan	Blcstn	18	Disregard of warning by people Warned by government, but Dissemination System was not so quick because of no facilities/equipment/human resources
29.Kohlu	Blcstn	5	Disregard of warning by people Correctly warned and quickly disseminated, but no location or very far from residential areas for evacuation
30.Naseerabad	Blcstn	97	Disregard of warning by people Correctly warned and quickly-disseminated, but no location or very far from residential areas for evacuation
31.Sibi	Blcstn	12	Disregard of warning by people
32.Jhal Magsi	Blcstn	3	Disregard of warning by people Correctly warned and quickly disseminated, but no time to evacuate because floodwater rushed
33.Jafarabad	Blcstn	60	Disregard of warning by people

Note: Blctn means Balochistan Province
Source: JICA 2010 flood field survey from August to October 2010

Based on these facts, the following issue has been identified:

- During the 2010 Indus Flood, some communities and people disregarded the flood warnings.

Meaning of each EWS, classification of warnings and risks of which magnitude lies on communities at targeted areas shall be delivered to people through the advocacy activities. For this purpose, the broadcasting programs shall be prepared.

2) Innovation of Communication System between NDMA and PMD

In accordance with each SOP prepared for the early warning systems against disasters, the PMD release and disseminate the warnings and alert messages to all stakeholders by designated modes. Effective communication between the NDMA and the PMD is essential to manage the disaster risk not only in early warning stage but also in evacuation, rescue and response stages since the NDMA shall manage all disaster risks in the DRM cycle. In this regard, the following issue has been identified:

- The communication modes by land phone lines, fax, cellphone lines with SMS and internet between PMD and NDMA are limited. The communication relying on public lines should be improved.

The information, data and analysis results related to disaster management released by the PMD shall be observed and watched in real-time and recorded by NDMA. Internally, the PMD has shared the meteorological and hydrological data with offices through the Internet and other dedicated lines. Hence, the NDMA should also obtain these data through the multiple paths.

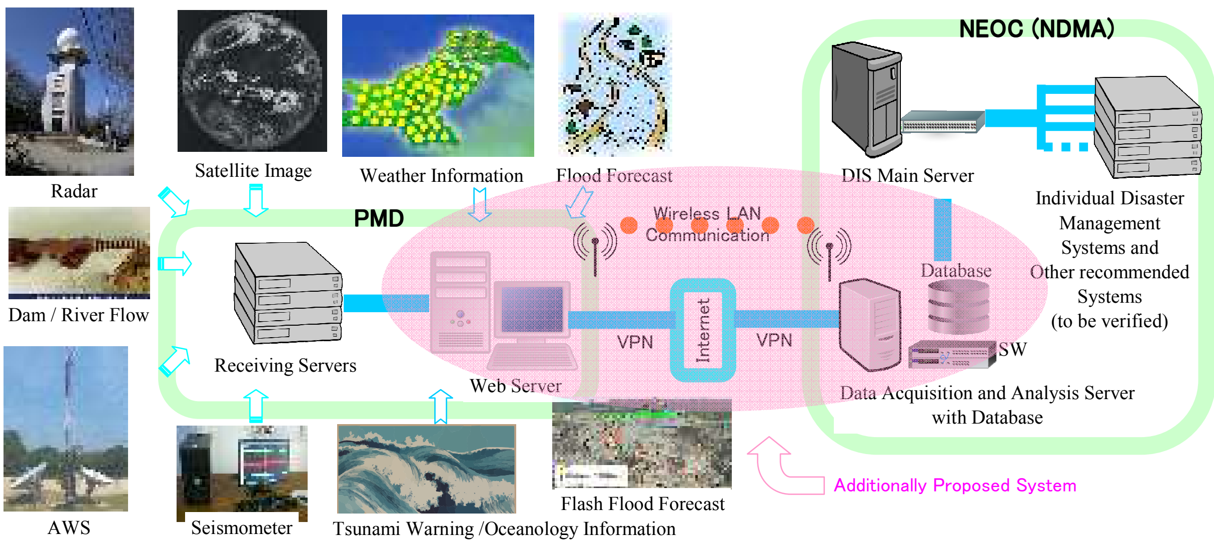
For this purpose, the system showin in Table 4.2.25 and Figure 4.2.15 (VPN and Wireless LAN communications) added to the internal system conceived for the suitable operation of the NEOC shall be proposed.

Table 4.2.25 Additionally Proposed System at the NEOC for Early Warning Communication between NDMA and PMD

Item	Required System to be installed at NEOC	Purpose
Communication System	VPN Communication through Internet between NDMA and PMD	Securement of access to PMD's data regarding the meteorological, hydrological and seismic disasters
	Wireless LAN Communication for Intranet connection between NDMA and PMD	
Data Acquisition and Analysis	Computer Server for Data Acquisition and Analysis (Fault-Tolerant (FT)+Cluster: Triple Redundancy System)	Read web information of the PMD Production of the DIS Database Record of DIS Database

Note : DIS: Disaster Information System

Source: JICA Expert Team



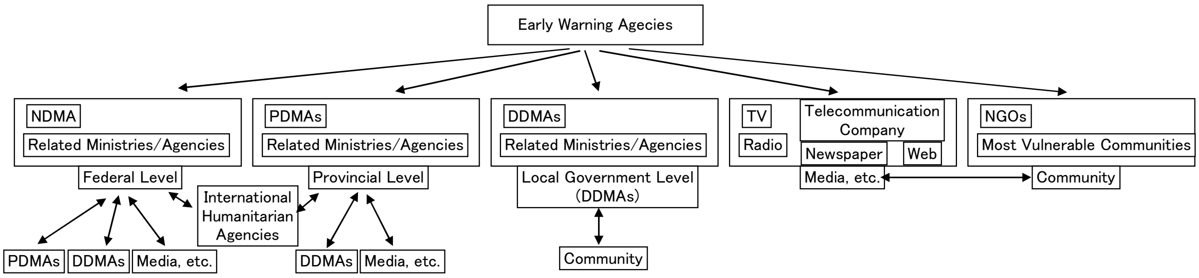
Source: JICA Expert Team.

Figure 4.2.15 Proposed Communication System between NDMA and PMD

3) NDMA, F/G/S/PDMAs and DDMAs

<u>Innovation of Communication System among DMAs (NDMA-F/G/S/PDMAs-DDMA)</u>

Under the current situation, most of the warnings, advisories and information are disseminated directly from PMD to the districts. This communication system and concept shall be sustained and upgraded in terms of promptness and swiftness of dissemination of warning as the basic communication policy. The most important thing is to deliver the warnings/emergencies to all stakeholders simultaneously without hierarchy in a multilayered system.



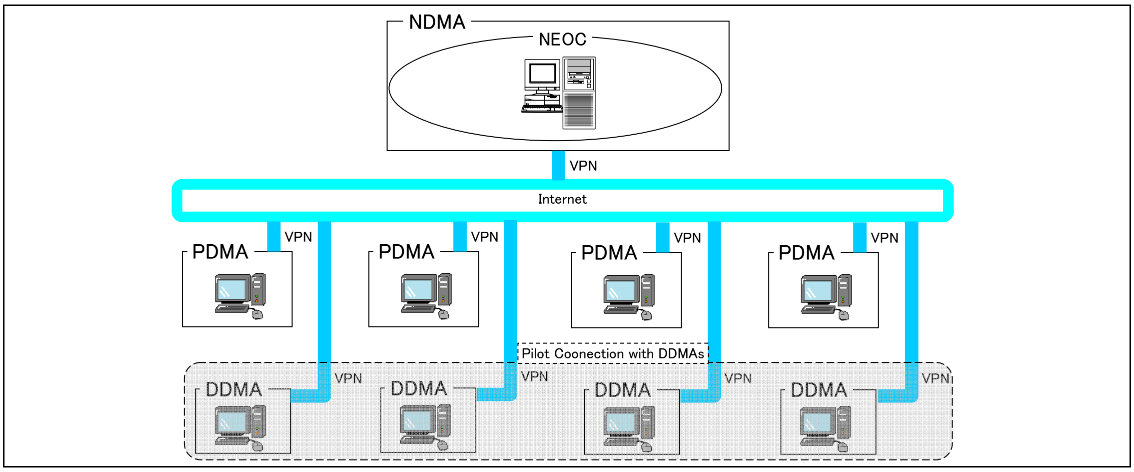
Source: JICA Expert Team.

Figure 4.2.16 Ideal Concept of EW Information and Dissemination System

As shown in Items 4) and 5) in Subsection 3.3.8, the means/modes of information and dissemination to the public of early warning due to disasters by NDMA, F/G/S/PDMAs and DDMAs have relied on the electronic media according to provincial and district DRM plans. On the other hand, contingency plans aiming at the treatment of individual disasters by district governments, such as flood contingency plans, mention secure communication by means of land phone, fax, SMS, wireless radio or verbal communication by staff of the district, police or other related agencies. Considering these facts, the communication system for early warning between DMAs and communities shall be specified clearly based on the premise of multiplexed communications. In this regard, the following issue has been identified:

- The data communication system among NDMA (NEOC), F/G/S/PDMAs and DDMAs is limited and only relies on internet lines.

As of 2010, the NDMA has considered the communication line by VPN between the computer networking system in NDMA and the network system in each F/G/S/PDMA including the network systems of four (4) districts as pilot cases. These quicker and certainly higher communication systems between each DMA shall be established in consideration of cost performance and reliability. (Refer to Figure 4.2.17.)

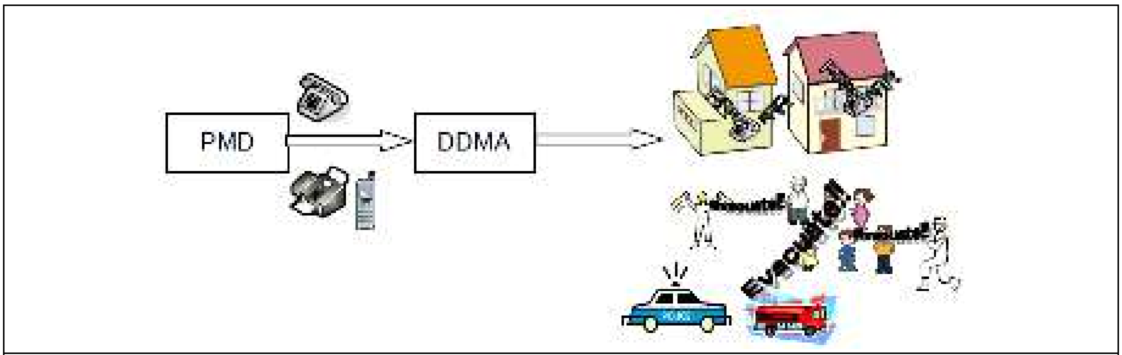


Source: JICA Expert Team.

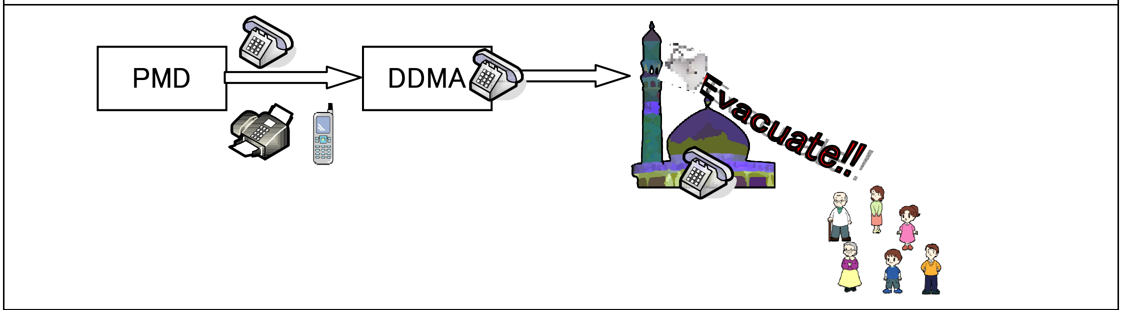
Figure 4.2.17 Expected Communication System by VPN between NDMA and F/G/S/PDMAs with Communication Linkages of Four DDMAs as Pilot Case

On the other hand, DDMAs or their former responsible sections (Revenue Department of each District) have manuals or documents, such as "contingency plan", "preparation plan", "monsoon plan" or "disaster management plan" based on their traditional roles, although these manuals have been utilized only through several oral meetings without practical review.

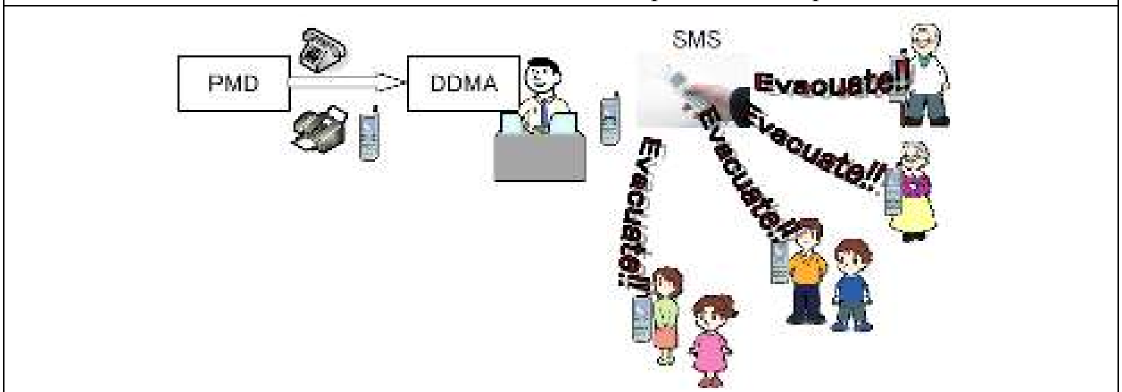
New multiple dissemination systems on early warning activities should be considered for the communication between DDMA and communities/residents to more quickly disseminate information and to secure a redundant/alternative communication system. Most of the districts disseminate warnings, alerts and evacuation orders by phone and oral meetings through the efforts of DDMA staff, Revenue Department staff or cooperating agencies. Therefore, other alternatives of utilizing the speakers of mosques, using the SMS volley system and using wireless radio communication shall be considered based on local community capabilities as shown in Figure 4.2.18. These alternatives are considered by CBDRM and HRDP activities and information drills to be executed by DDMAs and shall be stipulated in related manuals and plans as well as DDRMPs.



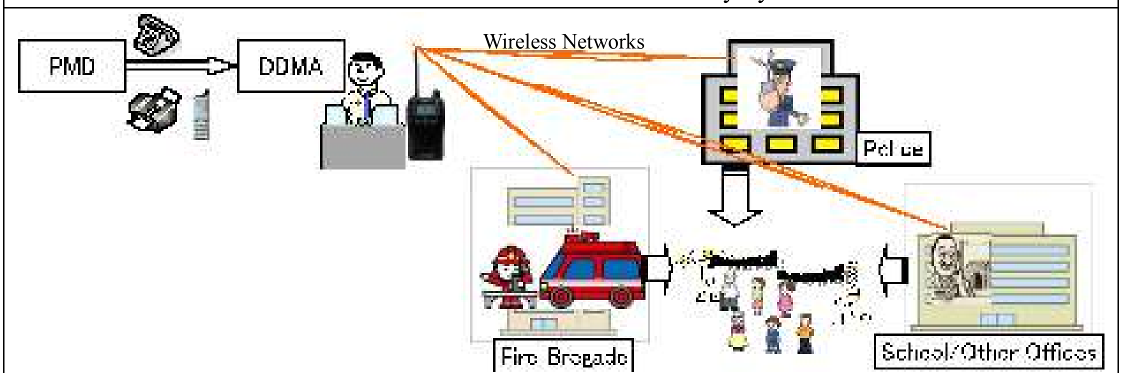
Current Dissemination System (by Phone or in Conversation)



Alternative-1: Utilization of Loudspeaker of Mosque



Alternative-2: Utilization of SMS Volley System



Alternative-3: Utilization of Wireless Radio Communication System

Source: JICA Expert Team.

Figure 4.2.18 Proposed Communication System between DDMA and Communities

4) National Health Emergency Preparedness and Response Network (NHEPRN) (Activities under One UN DRM Program[9])

The health sector disaster risk management program has made sufficient progress in the year 2010. At the beginning of 2010, there was no unit or cell in the Ministry of Health that was specifically dedicated with personnel and funding, with the support of WHO through the DRM programs. In line with this, the Ministry of Health was supported in the establishment of the National Health Emergency Preparedness and Response Network (NHEPRN) centre in March 2010.

After the establishment of the center in the first quarter of 2010, the Ministry of Health and WHO initiated the process of orientating all the Departments of Health and relevant stakeholders on the NHEPR network in March 2010. This process involved provincial orientation meetings in all provinces and in the state of AJ&K. HEPR focal persons from the respective provinces/state as well as at least 5 priority districts from each of the provinces/state were nominated as focal persons to establish the NHEPR Network. These personnel were trained in the field of Management of Public Health Risks in emergencies through the first national training for health emergency managers including other enhancement activities on DRM regarding the health sector. These specific activities done or being operated by One UN Program are given below:

Table 4.2.26 Activities under One UN DRM Program regarding National Health Emergency

Activities
Provincial Orientation
Vulnerability Health Assessments
Mass Casualty Management Plan
First National Training on Management of Public Health Risks in Emergencies
Disease Early Warning System (DEWS)

Source: NHEPRN

a. Disease Early Warning System (DEWS) in Pakistan

In 2008, USAID, along with Pakistan's Ministry of Public Health[10] and the WHO, funded a disease surveillance system of permanent and mobile health clinics and laboratories to track individual cases and respond rapidly to treat and isolate communicable cases from the surrounding populace. If a villager in Dadu District in Sindh Province had acute watery diarrhea, health workers could quickly determine if it was cholera, isolate the patient and his family, step up public health messaging throughout the community, and treat the local water source. An outbreak in one village would not spread inevitably to the next, and appropriate resources could be focused where more cases where reported. DEWS was initially put in place in 37 districts judged

[9] Source: NDMA
[10] In 2011, Ministry of Public Health was dismantled in accordance with the 18th Amendment Devolution. The role of federal health administration has been implemented by Cabinet Division and Ministry of Climate Change.

earthquake and flood-prone, with the aim to expand it to other high risk districts and build the capability of health personnel at the most peripheral level for early detection of epidemics.

At the onset of the emergency, USAID and the WHO expanded the system rapidly. Within two weeks, the DEWS network had more than tripled its coverage and the number of patients seen in medical facilities had increased six-fold. In the first month of the flooding, with data tracked through DEWS, it was confirmed that a trend of acute watery diarrhea cases rising rose, well outside normal seasonal trends. Recognizing the dangers of an epidemic outbreak, diarrhea treatment centres (DTCs) were established immediately in the most at-risk districts, setting up 63 centers in 41 districts. In three months, more than 60,500 patients were treated and 15,000 were admitted for longer-term care at DTCs, and among those admitted, only 58 diarrhea-related deaths were recorded.

As a result of DEWS and a lot of hard work, the staff related to DEWS avoided a large-scale disease outbreak in Pakistan in 2010. The investment in disaster risk reduction made two years earlier was the key to this achievement. An ounce of prevention bought much more than a pound of cure.

As of 2011, DEWS has been expanded and put in place in 48 districts.

b. Development of the EWS National Plan, Guidelines and SOPs for Health Emergency Preparedness and Response (HEPR)

However, it is still required to renew and refocus on DRM programs in a forward-looking manner for the following reason.

- The Disease Early Warning System (DEWS) in Pakistan has been rushly established during/after the 2010 Pakistan Flood with the cooperation of Pakistan Government agencies, WHO and UNDP. However, the management of diseases and epidemic control and management system should be created together with its policies, goals and institutional arrangements.

In this regard, WHO and NDMA have planned to support the Ministry of Regulations and Services in the following key areas: and these activities shall be included as one of Projects in this Plan:

Table 4.2.27 Expected Components in the HEPR Project

Expected Components
Establishing policy, legal and institutional arrangements for disaster risk reduction within the health centre
Development of the national plan, guidelines and SOPs for Health Emergency Preparedness and Response
Hazard mapping and vulnerability health assessments
Development and regularly updating of the Health Emergency Management Information System (HEMIS)
Development and regularly updating of the Health Sector Contingency Plan
Supporting the Global Safe Hospital Initiative: One Million Safe Hospitals, Schools and Cities Campaign (Including patient safety, structural and non-structural safety, Mass Casualty Management Plan)
Human Resource Development of various cadres on Health Emergency Preparedness and Response
Health related community based disaster risk management including community awareness raising, training and equipping on first aid at community level, health education and promotion, etc.

Source: NHEPRN

5) Summary of Improvement of Dissemination System

As shown above, the current dissemination system shall be improved based on the following six (6) approaches:

<u>Improvement of Weather Information Broadcasting System</u>

<u>Improvement of Weather Information Broadcasting System</u>

<u>Communication System utilizing Cellular Phone and Radio Broadcast Networks</u>

<u>Innovation of Transmission System between PMD and NDMA</u>

<u>Innovation of Transmission System among DMAs (NDMA- F/G/S/PDMA- DDMA)</u>

<u>Improvement of Transmission System between the Community and Government</u>

4.2.4 DRM Education and Public Awareness (Enhancement of Community Enlightenment for EWS with Execution of Training and Drills)

It is emphasized that a perfect and thorough EWS against natural disasters does not exist based on only public-help efforts. "Self-help efforts" and "mutual-help efforts" are also indispensable to save the life of people affected by the disasters with or without early warning by government(s). In this context, activities on DRM education and public awareness shall be promoted and enhanced to grasp the phenomena and predictive information of disasters and acquire the knowledge of saving lives. The following tables (Table 4.2.28 and Table 4.2.29) give examples on how to detect predictive information and to confirm the occurrence of impending disasters.

Table 4.2.28 Examples of Predictive Information of Disasters

Disaster	Predictive Information for Disaster without Governmental Warnings
Flash Flood	Localized tremendous rainfall Turbid/muddy river water including driftwood Rumbling sound of mountain Lowering of water level in the river, though rain is continuing
Landslide / Slope Failure	Appearance of cracks on the ground Muddy water in a well or a valley Water gushing out from a precipice or a slope Falling of small stones Sounds heard from a precipice or a slope
Tsunami	Occurrence of strong earthquake Abnormal receding of tide

Source: JICA Expert Team

Table 4.2.29 Actions to Confirm the Occurrence of Disaster

Action	When Actions are Needed	Information to be Confirmed
Turning on the Radio or TV Access to PMD/NDMA Websites	Heavy rains are continuing; Feeling of earthquake	Weather Information Warning Issuance
Checking of SMS	Feeling of earthquake	Warning Issuance
Contact with Community Leader(s)	All of the above phenomena	Information from DDMA/ F/G/S/PDMAs

Source: JICA Expert Team.

With support from NDMAs, F/G/S/PDMAs and DDMAs, educational institutions and other relevant institutions shall provide disaster risk reduction education mentioned in the tables above to local communities together with other essential information and knowledge. To enhance public awareness of disaster risk reduction, visual materials and simulation experiences shall be utilized in cooperation with the mass media. These activities shall be conducted taking into account the CBDRM and HRDP.

Based on these facts, the following has been recognized:

- It is imperative to further enhance and promote self-help and mutual-help against disaster preparedness and responses.

Actions which peoples conducted during 2010 Pakistan Flood are considered in DRM Education, Public Awareness and Enhancement of Community Enlightenment for EWS.

It is necessary to secure a multiple communication system among stakeholders and improve the current communication modes for earlier and quicker dissemination of warning messages taking into consideration the development of technology and engineering innovation. In this regard, it is also recommended that dissemination/communication drills and practices be executed. In particular, the new EWS setups in recent years, such as those involving tsunamis and flash floods, shall be specifically considered. Provincial and district DRMPs have stipulated periodical drills including early warning activities as shown in the following table.

Table 4.2.30 Current Requirement of Drills in DRMPs by F/G/S/PDMAs and DDMAs

Government	Definition of Drill	Requirement of Drill Interval
PDMA Punjab	Drills on various scenarios to assess the procedures defined by PDRMP	There should be at least two drills per year.
PDMA Sindh	Drills in coordination with civil defence organizations at provincial level and district level	There should be at least six monthly drills for different disaster risks.
PDMA Balochistan	Drills on various scenarios to assess the procedures defined by PDRMP	There should be at least two drills per year.
SDMA (AJ & K)	Drills on various scenarios to assess the procedures defined by SDRMP	There should be at least one/two drills per year lead by DMA which shall combine and coordinate the sector and contingency response plans for regions.
GBDMA (GB)	Drills on various scenarios to assess the procedures defined by GBDRMP	There should be at least one/two drills per year lead by GBDMA
DDMA Badin	Drills for: Development of rapid response force, Preparation of skilled human resources for rapid emergency response, Assessment of available potentials and areas of improvement, Making the emergency response more effective, timely and cost effective, and Provision of procedural guidelines for the involvement of affected communities in the emergency response	No mention about interval of drills.
DDMA Kech	Exercises and drills with other stakeholders on various conditions to assess the procedures.	The frequency of the drills is recommended to be once every six month.

Note : Preparations of DRPs of KP and FATA are in process. Therefore, Table shall be updated when the plans are issued.
Source: Summarized by JICA Expert Team.

All trainings and drills shall be coordinated with community-based activities. NDMA, F/G/S/PDMAs, and DDMAs shall conduct disaster management drills during the Disaster Risk Reduction Day (8th of October) or Week.

In this context, the execution of periodical and sustainable training and drills regarding the EWS at all levels (federal, provincial, district and community) is indispensable for the alleviation of damage by disasters.

4.2.5 Human Resources Development

1) PMD

As shown in Subsection 3.1.6, the human capacity to administer early warning systems including weather and disaster forecasts should be enhanced and strengthened through training and human resource development activities. The types and items to be strengthened regarding human resource development of PMD are as follows:

a. Education Program for Advanced Hydrology for PMD Staff

One of the mandatory tasks of PMD is to carry out the forecast discharges of major rivers and floods along all rivers (nullahs) including secondary disasters, such as landslides, avalanches and GLOF in terms of hydrological aspects as well as meteorological and geophysical observations. In particular, flood warning systems for middle and small rivers (nullahs) passing through the built-up areas in Punjab, KP, Balochistan, Sindh and AJ&K are still insufficient and the establishment of the systems for each vulnerable area is strongly required to save human lives. Regarding the staff arrangement issue, the following has been recognized:

- The number of qualified hydrologists is few compared to the number of meteorologists in PMD.

The augmentation of staff capacity of PMD regarding hydrological matters is imperative to properly forecast and issue the warnings of floods across the whole of Pakistan.

b. Implementation of Capacity Development Activities for each proposed Program and Project

Regardless of how good their facilities and equipment may be, the systems will not work appropriately unless the human capacity is adequate. It is indispensable for the proper operation of each EWS to develop the human resources of the PMD staff. Therefore, the focal staff of PMD shall be enhanced and strengthened in the establishment of new early warning systems as the main counterparts.

c. Acquirement of Advanced Meteorology and Hydrology Methods

PMD, a main organization of EWS, always needs well-trained human resources in the areas of its concern. Highly trained and qualified manpower should improve their skills in the field of weather and flood forecasting and the issuance of early warnings of related disasters concerning agro-meteorology, meteorology, seismology, hydrology, climate change, glacier melting and should ultimately enhance the research & development activities in the organization.

The skilled and well-educated professional will be able to provide more accurate weather forecasts and reliable information to the public and private sectors.

In this connection, PMD should prepare a plan for overall human resource development, such as education programs for focal officers.

d. Acquirement of Advanced Forecasting Techniques

All of new systems proposed in this Sections 4.2 for the improvement of EWSs against each disaster shall include training on how to operate and maintain them appropriately as one of the main capacity development activities. In addition, the following activities regarding advanced forecasting techiques shall be considered:

i) <u>Education Program of Advanced Meteorology for PMD Staff</u>

From the staff assignment point of view, the following has been ideintified:

- The number of qualified meteorologists should be increased for the improvement of weather forecast and early warning abilities in line with the new EWS.

Knowledge of basic meteorology and hydrology will be acquired through the educational activities (M/S and PhD courses) in some institutes and/or academes as explained above. This should also be included in capacity development.

In addition, the improvement of the accuracy of weather forecasts is indispensable to render to the people more understandable information for awareness of impending disaster(s). Among the improvement activities for weather forecasting, the most significant issues are to obtain accurate NWP and further the effective utilization of the NWP, namely Improvement of Accuracy of NWP and Establishment of Weather Forecast Guidance Systems.

ii) Improvement of Accuracy of NWP

As described in item no. 2) in Subsection 3.1.6, PMD has conducted the NWP using the HRM with a grid length of 11km developed by DWD. However, it is very difficult to further modify the model to make it consistent with actual weather phenomena because the existing model is hydrostatic and cannot be revised to a non-hydrostatic model by PMD staff. In addition, the computer processor capacity is limited resulting in expansion of the calculation time. Adoption of a non-hydrostatic model such as WRF and JMA Models is required. The issue is summarized below.

- Current NWP model cannot be transferred to a non-hydrostatic model and computer processor capacity is limited to adopt a non-hydrostatic model.

Therefore, it is required to renew and add computer processor systems with capacity development activities to effectively use the NWP system

Various parameters of the model introduced from foreign countries are set to adapt to the meteorological condition of the country that produced the model. Therefore, the model introduced should be adjusted to adapt the parameters of the model to the meteorological conditions in Pakistan.

Then, the improvement on the initial condition of the model augments the accuracy of NWP. For improvement of the initial condition of the model, local observation data such as the data from WPR and AWS should be imported into the model and to carry out objective analyses and initialization methods for the observation data.

iii) Establishment of Weather Forecast Guidance System

As described in item no. 1) in Subsection 3.1.6, PMD has processed a great deal of basic data (weather charts, NWP, radar observations, AWS and other systems and equipment) for the weather forecasts as well as warning issuance. These "translations" from the data and estimations to the forecasts are the most essential work for PMD regarding disaster mitigation. For the forecasters of PMD, the time is limited and insufficient to forecast weather and warn of the impending disaster from such data including a number of prognostic charts, several NWP results and actual observed meteorological values. In this regard, the following has been identified:

- Due to inadequate advanced technologies and equipment, observed meteorological data have not been fully and effectively utilized to immediately issue and forecast meteorological disaster.

In this connection, weather forecast guidance systems shall be introduced and established by the MOS (Model Output Statistics) Method.

MOS refers to the materials obtained by processing statistical NWP results. First, it is required to accumulate the NWP results and actual meteorological data (such as rainfall data) for at least 1~2 years. Then, statistic relational expression(s) between NWP results as explaining variables (predictor variables) and actual meteorological data observed as objective variables (criterion variables) are prepared. The NWP results can be translated to weather forecasts or early warnings by multiple regression correlation expressions. Based on this MOS method in the new weather forecast guidance systems to be established, PMD could carry out the changeover from qualitative to quantitative weather forecasts.

When the model is changed, the regression equation should be newly produced because of statistical particularity. The reproduction of the regression equation is a troublesome job.

Therefore, a calculation method such as the Kalman Filter should be introduced to automatically change the coefficients of the regression.

2) Media

PMD, in collaboration with WFP & the Sustainable Land Management Project (SLMP), have started a series of workshops in various cities of the country, namely National Workshops on the "Role of Media in Strengthening Early Warning Systems for Floods & Droughts". Two workshops have already been held in Islamabad on 17 – 18 May 2011 and on 14 – 15 September 2011 in Peshawar. The workshops aimed to bring awareness to the media (both electronic & print) community about the importance of early warnings and how to disseminate this reliable information in time to the local community. As a result, it was confirmed that the media will act like a bridge between the PMD and local communities and bring awareness to them about the importance of early warnings. In addition, the following recommendations to media were confirmed in the wrap-up meeting at Islamabad in the workshops:

- Timely and accurate information at district level,
- Share best ways and means of communication with PMD including all contact information,
- Priority of news by using alerts and breaking news, etc.

These activities are essential to properly release the warnings and alerts directly to the communities likely affected by the disaster(s) and for them to fully understand the significance of harmonization between PMD and the media including other related agencies. Therefore, these workshops should be held periodically.

3) GSP

GSP is responsible for the study of the geology of the country in all pertinent details and to assess its resource potential including:

- Environmental geology and hydrological studies,
- Natural hazards and engineering geology,
- Ground water and soil condition, and
- Environmental studies.

In accordance with these tasks, GSP has already conducted the preparation of geo-hazard maps in several areas vulnerable to landslides, such as Muzaffarabad and Mansehra. These maps are prepared under the Project on Geo-hazard Assessment in the Northern Area of Pakistan in association with the GBR. The staff of GSP have some capacity to prepare the hazard maps but further capacity development activities regarding the preparation of complete landslide hazard maps in highly vulnerable areas is imperative. There are still lots of vulnerable locations (districts) where the landslide hazard maps still have not been prepared as shown in Table 4.2.6. These capacity developments will contribute to the preparation of hazard maps.

4) FFC

One of the major functions under the charter of duties for FFC as given in the Resolution dated 04-01-1977 is:

- Preparation & updating of flood plain maps,
- Development of flood plain extent rules/river law,
- Measures for improvements in the Flood Forecasting and Warning System, and
- Revision of River Flood Classification

In this connection, it is required to develop the abilities of focal staff of FFC to keep up with the advancements in the latest techniques of flood early warning systems. Based on the lucubration regarding flood EWS, FFC has responsibility for the revision and update of this Multi-Hazard EWS Plan in collaboration with PMD, NDMA and the other agencies concerned.

5) WAPDA

WAPDA is actively involved in the flood forecasting process by providing the much needed river and rain data from its telemetric gauge sites within the upper catchments of the Indus, Jhelum and Chenab Rivers. WAPDA's telemetric network is directly linked to FFD and is looked after by an officer of the level of research officer whose office is located within the premises of FFD. Therefore, WAPDA is required to maintain the staff for O&M of these telemetric systems under general fiscal budget without special human resource development activities.

However, WAPDA also has very important responsibilities regarding flood mitigation activities in which WAPDA has managed/administrated the operations of gates on the Mangla and Tarbela Dams with the operation of Chashma Barrage. In this regard, the WAPDA shall be required to develop the capacity of its staff regarding the modification of dam operation procedures, mainstreaming flood mitigation or management in terms of hydrological and meteorological considerations. These developments should be conducted under the project or studies related to the Indus River Flood Control including the consideration of dam operation.

6) NDMA

NDMA is the leading federal government agency to take initiatives for DRM including early warning activities. The "Human Resource Development Plan on Disaster Management" (HRDP) has been prepared and published together with this Multi-Hazard EWS Plan as Annexes of NDMP. Under the HRDP, the capacity of staff of NDMA is enhanced including the early warning activities. In this capacity development, the activities shall include the acquirement of the knowledge of the outline of the systems, mechanisms and warning classifications of each early warning, and fundamental principles of generation mechanism of each disaster, such as meteorological, geological and hydrological situations.

7) F/G/S/PDMAs and DDMAs

The capacity of staff of F/G/S/PDMAs and DDMAs shall be enhanced under the HRDP as well as the staff of NDMA. In addition, the staff of F/G/S/PDMAs and DDMAs shall play crucial roles as messengers for early warnings and alerts and arbiter(s) of decisions of evacuation. Hence, the F/G/S/PDMAs and DDMAs shall be involved in the establishment of new early warning systems as related counterparts and strengthened in terms of human capacity development.

4.2.6 Other Considerations

1) Meteorological Radars Constructions

Taking into consideration the current status of the aging four (4) radar stations being operated at a fringe area, the replacement of existing meteorological stations should be considered comprehensively together with PMD's new radar system installation plan as an arrangement planning of location of radar stations. As a result, the scenario of augmentation of forecasting capacity by radar stations shall be reconstituted and divided into two (2) components as follows:

a. Replacement of Existing Meteorological Radar Stations and Importance of the Radars located along Coastal Zones

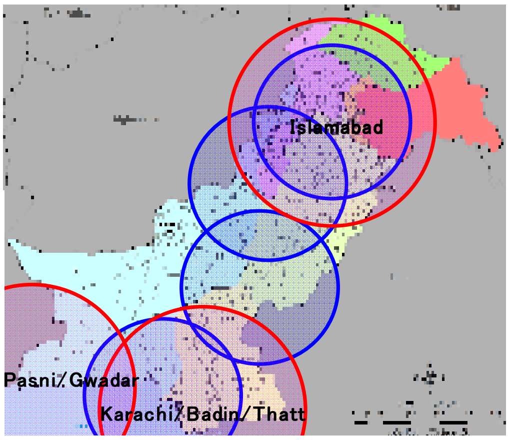
The most indispensable action regarding the meteorological radar systems is to sustain the weather forecasting capacity of PMD. In this connection, four (4) existing radar stations shall be replaced and/or augmented urgently. In addition, the installation of radar systems along the coastal areas is also important for the following reasons:

i) Coastal zones are vulnerable to cyclone hazards that should be predicted by the Radar Network for tracking route and strength (amount of rainfall and wind speed).

ii) The current radar system could not cover all coastal zones.

Therefore, the radars at Islamabad, D. I. Khan and Rahim Yar Khan stations shall be replaced and/or augmented. Pasni/Gwadar and Karachi/Badin/Thatta radar stations shall also be considered instead of the existing Karachi radar station.

As explained in Sub-section 4.2.2, there are three (3) alternatives for the replacement of the existing Karachi Radar, Karachi, Badin or Thatta. From the viewpoint of coverage by radar, Badin or Thatta is more suitable because rainfall intensity in the eastern area areas can be recognized earlier. From the viewpoint of actual implementation, however, Karachi is the most appropriate location since the present PMD's premises adjacent to the Karachi Airport is already furnished with all the relevant facilities including buildings, seismic/tsunami/cyclone laboratories. On the contrary, the new radar at Badin or Thatta would require shifting of all the facilities and staff of the Karachi premises to the new location which will not be feasible in terms of staff and budget availability. In addition, there are no high-rise-buildings in the vicinity of Karachi premises to restrict weather observation by the meteorological radar. On the basis of the fact, the PMD authorities have recommended Karachi as the most suitable location, which shall be decided taking updated information into consideration.



Source: JICA Expert Team

Figure 4.2.19 Replacement of Existing Meteorological Radar Stations

b. Establishment of Other New Meteorological Radar Stations

As discussed in (ii) above, Chitral, Cherat, D.G.Khan, Quetta and Sukkur radar stations are proposed as new meteorological radar stations to expand the coverage of meteorological data based on the PMD's original plan. These plans shall be considered based on the confirmation of priority order of their installation.

2) Alternative of Local Flash Flood EWS

It costs a great deal of money and takes a long time (2~3 years) to establish a Lai Nullah-Type flash flood EWS (refer to Table 5.2.20 in Chapter 5). Therefore, an alternative in which the implementation cost and time can be minimized and the effectiveness is still acceptable should be considered. The concepts of the said alternative system are as follows:

Table 4.2.31 Comparative Table of Flash Flood Early Warning System with Alternative

Item	Proper System	Alternative
Hydrological Data Collection Subsystem	Due to Reliability of communication, **V-Sat** or **Radio telemetry** systems are selected.	To reduce the project cost, **GME/GPRS** telemetry system is considered. To secure the data confirmation, human activities for the support is imperative.
Data Processing/Transmission Subsystem from LFFFC (site office) to DDMA /PMD office in charge.	Due to Reliability of communication, **V-Sat** or **LAN** systems are selected.	To reduce the project cost, **land line (ISDN/VPN), Internet and cellular phone lines** are considered for the data communication.
Flood Evacuation and Warning Subsystem	Due to Reliability of communication, dedicated audible alarm system with **Radio control system**s are selected.	To reduce the project cost, utilization of existing facilities (**speakers of Mosques**) and **community networks** are fully promoted.
Assumed Total Project Cost	In case of 5 rainfall and 2 water level gauging stations with 10 sirens by 3 control rooms, it takes approx. PKR 500 million for the system.	In case of 5 rainfall and 2 water level gauging stations, it takes less than PKR 20 million including minimized control facilities (a few computers with monitors).

Source: JICA Expert Team

Considering need for the reliability and credibility of the system, none of the alternatives shall be adopted as long-term solutions. However, notwithstanding the fragility and weaknesses of the alternative systems, it is worth considering their application for the short term until a proper system can be established because their project cost is quite economical. This alternative shall not be included in this Plan, but considered as a pilot project.

3) Weather Information/Forecast and Response to Climate Change

As described in Subsections 3.1.1, 3.6.3 and 4.2.2, it is necessary to improve the accuracy of weather forecast, prediction for the preparation against disasters, the issuance of earlier warning and evacuation advisories in not only a short-period forecast but also medium and long-period forecasts. Moreover, it is indispensable to watch and observe the tendency and effects of climate change in Pakistan.

Some actions and methods proposed in Subsections 4.2.2 and 4.2.5 for the improvement of EWS capacity against meteorological disasters will contribute to the enhancement and strengthening of meteorological prediction, particularly, for medium to long-term weather prediction, and to the confirmation of the effects of climate change in Pakistan. The actions and methods contributing to the predictions against meteorological disasters and climate changes are listed in the following table.

Table 4.2.32 System Upgrading/Improvements contributing to Climate Change Observation

Actions, Facilities and Equipment	Description and Reference
Improvement of Upper Air Observation System (Wind Profiler System)	Refer to 4.2.2 6) c
Updating of Satellite HRPT Data Information System	Refer to 4.2.2 6) d
Sustainment and Expansion of Existing Meteorological (Doppler) Radar Network System	Refer to 4.2.2 6) a, b
Establishment of Rainfall and Water Level Observation Network	Refer to 4.2.2 7) d
Expansion of AWS Network Including Communication System	Refer to 4.2.2 1) c, 2) a, 5) c 6) i
Improvement of NWP and the Process	Refer to 4.2.5 1) d
Weather Forecast Guidance System	Refer to 4.2.5 1) d
Agro-meteorological Data Processing and Analysis System	Refer to 4.2.2 2) b
Environmental Monitoring System	Refer to 4.2.5 1)
Enhancement of Research Activities for Snow/Glacier/Glacial Lakes	Refer to 4.2.6 1)

Note: Refer to Table 3.1.1

Source: JICA Expert Team

In particular, the components, facilities and equipment currently proposed in the Project for Specialized Medium-Range Forecasting Centre (SMRFC) are conducive to the improvement of the weather forecasting ability of PMD including the promotion of safe operation of civil aviation, marine and land transport, and the provision of general public and governmental organizations with meteorological information. (See Subsection 5.2.1 for details.)

4) Requirement of Human Resource Development and Further Improvement of Weather Forecasting Capacity

In addition to the installation of facilities and equipment, the projects shall include the human resources development activities for suitable and effective operations and maintenance of the systems to be established and further improvement of weather forecasting. To be more precise, the modification and improvement of NWP and the establishment of weather information guidance systems by MOS (Model Output Statistics) shall be adopted in the near future. The improvement policies for human resources development are described in Subsection 4.2.5 in detail.

CHAPTER 5 PLANNING FRAMEWORK

5.1 Introduction

5.1.1 Conceptual Planning

1) Relevant and Responsible Agencies

The activities for the Multi-Hazard Early Warning System should be executed with the involvement of a number of stakeholders so that effective operations resulting in numerous benefits are expected in the cycle of the whole system. In this regard, the agencies given in the table below are to be involved.

Table 5.1.1 Relevant and Responsible Agencies in Multi-Hazard Early Warning System

Category	Relevant and Responsible Agencies
Central Government	NDMA, FFC, PMD, WAPDA, GSP, Army, NIO, PCIW, IRSA, SUPARCO, (ERRA)
Provincial Government	F/G/S/PDMAs, Irrigation Departments, Civil Defence, Rescue 1122 (Fire Brigades), Police, Information Deptt and C&W Deptt
District Government	DDMAs (DCs/DCOs, Revenue Offices, etc.), Police, C&W, Civil Defence
Others	NGOs, INGOs, Mosques, Schools, Media, PRCS

Source: JICA Expert Team

2) Role of Concerned Agencies

In this Multi-Hazard EWS Plan, organizations related to EWS mainly mentioned in Table 5.1.1 are classified based on three functional categories, namely; (1) decision-making, (2) technical support, and (3) capacity development in the pre- and post-disaster stages, as well as (1) decision-making, (2) technical support, and (3) dissemination and evacuation during -disaster (in the operation stage) (see Table 5.1.2).

Table 5.1.2 Roles and Responsibilities of Agencies Concerned in the Multi-Hazard Early Warning System

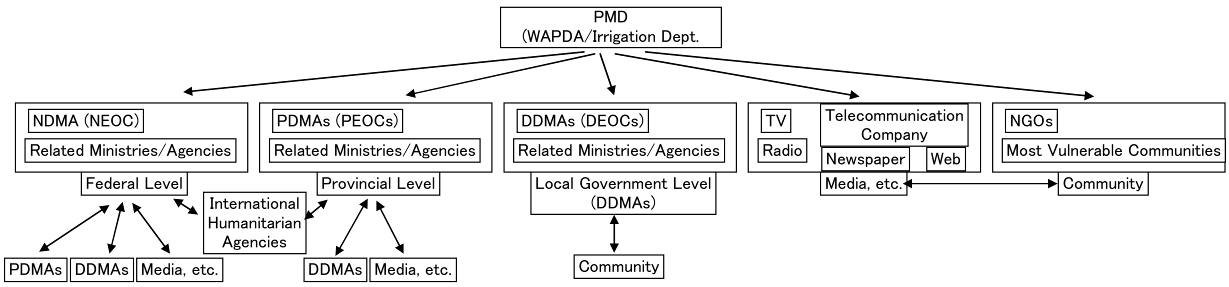
Stage/Role	Responsible Agencies	Mandate
Pre- and Post-Disaster		
Decision- Making	NDMA	• Act as the implementing, co-ordinating and monitoring body for disaster management • prepare the National Plan and lay down the guidelines (including EWS Plan) • Provide necessary technical assistance to the provincial agencies
	F/G/S/PDMAs	• Formulate the provincial disaster management policy (including EWS Plan) • Coordinate and monitor the implementation of related policy and plans • Examine the vulnerability against disaster in the Province • Evaluate preparedness at all levels • Promote general education, awareness and community training • Provide necessary technical assistance or give advice to related agencies • Ensure communication systems
	DDMAs	• Prepare a disaster management plan including response plans (EWS Plan) • Coordinate and monitor the implementation of related policy and plans • Ensure and monitor the vulnerable areas against disasters with identification of risk and measures to be taken • Facilitate community training and awareness programs
Technical Support	PMD, FFC, GSP, WAPDA, NIO, IRSA, SUPARCO, PCIW, ERRA, PIDs	• Innovation/Improvement of EWS • Preparation/Review of Hazard Map
Capacity Development	NDMA, F/G/S/PDMAs, DDMAs, NGOs, INGOs, Mosque, School	• Map Exercise and Evacuation Drill • Dissemination of Hazard Map • Enlightenment of Significance of EWS (Education, Awareness, Advocacy)
During Disaster (Operation Stage)		
Decision-Making	NDMA	• Coordinate response in the event of any threatening disaster situation or disaster
	F/G/S/PDMAs	• Coordinate response in the event of disaster • Give directions to any provincial department or authority regarding actions to be taken in response to disaster
	DDMAs	• Establish stockpiles of relief and rescue materials • Provide information to the provincial Authority relating to disasters
Technical Support	PMD, FFC, WAPDA, PCIW, PIDs	• Observation of Natural Phenomena • Technical Information on Hazard
Dissemination and Evacuation	PMD, F/G/S/PDMAs, DDMAs, Civil Defence, Rescue 1122 (Fire Brigade), Police, C&W, NGOs, PRCS, INGOs, Mosques, Schools, Army, Media	• Dissemination of Alert and Evacuation • Support of Dissemination and Evacuation • Preparation of Evacuation Centres

Source: JICA Expert Team

3) Basic Communication Route

a. Warning Policy Issued by PMD and Related Agencies to the DDMAs Likely Affected

PMD shall disseminate information on magnitudes and significances of anticipated hazards based on the prepared SOPs with other observed data, such as water discharge passing through the barrages from Provincial Irrigation Departments, water level and releasing discharge of the dams administrated by the WAPDA and river flow of the Indus River System and upstream condition of eastern rivers from India by the PCIW. These warnings and alerts with related data shall be all together disseminated to related agencies and vulnerable districts (DDMAs) likely affected by the expected disasters. As basic policy, PMD and agencies observing essential data regarding disasters shall directly issue the warning(s) to DDMAs and related other agencies in close coordination with NDMA and F/G/S/PDMAs as shown in Figure 5.1.1 by means of the communication system proposed in Section 5.2.



Source: JICA Expert Team.

Figure 5.1.1 Proposed Communication and Dissemination Concept of Multi-Hazard EWS

b. Warning Policy from the DDMAs to Communities and Vulnerable Persons

DDMAs, for which the warnings are issued by PMD, should disseminate the information on magnitudes and significances of anticipated hazards based on the prepared DDMPs and contingency plan(s) for expected disaster(s) without any delay.

When evacuation activities are required, the DC/DCO or chairperson of DDMA likely affected by disaster has responsibility of the evacuation order in accordance with its DDMP. DC/DCO or chairperson of DDMA shall consult with PMD or upper DMA(s) when he/she cannot make a decision on an evacuation order.

c. Roles of Media for the Communication

Media, particularly electronic media (TV and radio stations), should play an important role as disseminating agencies in the EWS. The media shall send warning messages in a ticker or news flash in accordance with the request from PMD and/or NDMA/ F/G/S/PDMAs.

4) Basic Communication Mode

As described in Section 4.4, the communication mode for all types of EWSs should be multiplexed for the securement of reliable communication and information between early warning agencies (PMD) and end users (communities and vulnerable persons).

The available modes should be adopted as much as possible. The main mode(s) for each EWS to be used are as follows:

Table 5.1.3 Main Mode of Each EWS

Disaster	Forecasting/Warning Agency	Recipients	Main Mode	Other Alternative Modes
River Flood	FFD_PMD (RFFWCs)*1 Islamabad_PMD	F/G/S/PDMAs DDMAs Related Agencies	Phone/Fax	Mobile Phone/SMS Internet web
	DDMA	Community Vulnerabilities	Word of Mouth (Public-Address)	Mobile Phone/SMS H.F. Radio wave
Flash Flood (Islamabad/ Rawalpindi)	Lai Nullah FWFC_PMD	DDMAs Related Agencies	Phone/Fax	Mobile Phone/SMS Internet web
	DDMA_Rawalpindi	Community Vulnerabilities	Siren	Word of Mouth through Civil Defence/Rescue1122
Flash Flood (Other Basins)	LFFFWC_PMD*2	F/G/S/PDMAs DDMA	Phone/Fax	Mobile Phone/SMS
		Community Vulnerabilities	Alarming Sound Media Speaker of Mosque	Word of Mouth through Civil Defence/ Police/ Fire Brigade
Landslide	Islamabad_PMD FFD_PMD (RFFWCs)*2	F/G/S/PDMAs DDMAs	Phone/Fax Media (TV/Radio)	Media (Newspaper) Internet Web
	DDMA	Community Vulnerabilities	Public-Address by Civil Defence/ Police/ Fire Brigade	Mobile Phone/SMS Speaker of Mosque
Cyclone (Storm Surge)	TCWC-PMD	F/G/S/PDMAs DDMAs Related Agency	Phone/Fax Media (TV/Radio)	Media (Newspaper) Internet Web
	DDMA	Community Vulnerabilities	Public-Address by Civil Defence/ Police/ Fire Brigade	Mobile Phone/SMS Speaker of Mosque
Tsunami	NSMC-PMD NTWC-PMD	F/G/S/PDMAs DDMAs Related Agency	SMS	Mobile Phone Phone/Fax
		Community Vulnerabilities	SMS	Mobile Phone Phone/Fax
	DDMA	Community Vulnerabilities	Public-Address by Civil Defence/ Police/ Fire Brigade	Mobile Phone/SMS Speaker of Mosque
Drought	NDMC-PMD	N/F/G/S/P/DDMAs Community Vulnerabilities	Media (FM Radio)	Media (Newspaper) SMS Internet web
All Disasters	NDMA/ F/G/S/PDMAs	F/G/S/PDMAs /DDMAs	Phone/Fax VPN	Mobile Phone/SMS

Note: *1: Presently, Flood Forecasting has been issued only Islamabad and Lahore (FFD). In the future, Regional Flood Forecasting Warning Centres (RFFWCs) at Peshawar, Quetta and Karachi will be established additionally and issue warnings for each region.

*2: For each vulnerable catchment basin, PMD shall establish a Local Flash Flood Forecasting Warning Centre (LFFFWC).

Source: JICA Expert Team

5) Policy on Warning Communication Criteria

Basically, current warning communication criteria should be sustained to avoid any confusion or complicated situations because current criteria have no fatal errors when sending warnings on the targeted disaster from engineering and social points of views as discussed in Sub-Section 4.2.2. However, the criteria of the warning communication shall be reviewed annually by the PMD in association with FFC, PCIW, WAPDA and other focal stakeholders. Successively, the revision of warning criteria shall be concurred by NDMA and F/G/S/PDMAs when revisions are required based on the propriety evaluation and verification to be conducted by the PMD, FC, PCIW, WAPDA and other focal stakeholders. The warning communication criteria of each EWS are tabulated below:

Table 5.1.4 Criteria of Each EWS

Disaster	Situation/ Type of Forecast	Criteria	Remarks
River Flood	Qualitative Forecast	3 Criteria: Blue Alert, Yellow Alert, Red Alert	Due to the location of depressions. Due to inflow/outflow from eastern rivers in India
	Quantitative Forecast	Low Flood Medium Flood High Flood Very High Flood Exceptionally High Flood	By Routine Daily Flood Forecast (RDFF) Due to inflow/outflow from eastern rivers in India
	Other Early Warnings	Significant Flood Forecast Areal Flood Inundation Flood Forecast Weather Information for Farmers	With names of designated locations/villages likely affected
	Miscellaneous Flood Forecast/Information	Weather Information Flood Information for Media Special Press Briefings	With warning for other disasters, such as landslides, flash floods
Flash Flood	Lai Nullah Basin	3 Criteria: Pre-Alert, Alert, Evacuation	Due to water level and precipitation volume in the basin
	Other Areas (General Information)	Warning Messages with General Weather Info.	At certain designated locations likely affected by landslides
	Planned New System for Vulnerable Locations	3 Criteria recommended: Pre-Alert, Alert, Evacuation	With new installation of real-time precipitation & water level observation system
Landslide	For Whole Pakistan	Warning Messages with General Weather Info.	At certain designated locations likely affected by landslides
	Planned New System for Vulnerable Locations	Pre-Alert Alert	With Flash Flood Warnings
Cyclone (Storm Surge)	General Warnings	3 Criteria: Watching, Alert, Warning	With other flash flood warnings
	Others	Warning Bulletins	For Ships, Ports and Fishery
Tsunami	For Arabian Sea or For Indian Sea (In case > M8)	Bulletin-1: Information of Earthquake Bulletin-2: Tsunami Arrival Time Bulletin-3: Any Change of Information Bulletin-4: Cancellation	With tsunami evaluation expected With evaluation of intensity or cancellation of warning in case of confirmation of tsunami
	For Indian Sea (In case < M8)	Bulletin-1: Watch Bulletin-2: Confirmation / Cancellation	With earthquake parameters With observation of tsunami
Drought	Drought Advisory	Drought: Update Reservoir Status and etc.	With SPI, ETO, soil moisture
GLOF	Present Condition	Warning Messages with General Weather Info.	At certain designated locations likely affected by landslides
	Planned New System for Vulnerable Locations	3 Criteria recommended: Pre-Alert, Alert, Evacuation	At certain designated locations likely affected by GLOFs
Avalanche	Present Condition	Warning Messages with General Weather Info.	With name of provinces/regions
	Planned New System for Vulnerable Locations	Alert	With name of provinces/regions in detail.
Other Concerns	Present and Future Condition	Fog Alert Thunderstorm and Lightning Advisory Weather Info. should be forecasted with quantitative rainfall amount	Alerts/Advisories shall be issued by SOPs to be newly established

Source: JICA Expert Team

6) Policy on Outline of System Formulation

a. Observed Data Transmission System

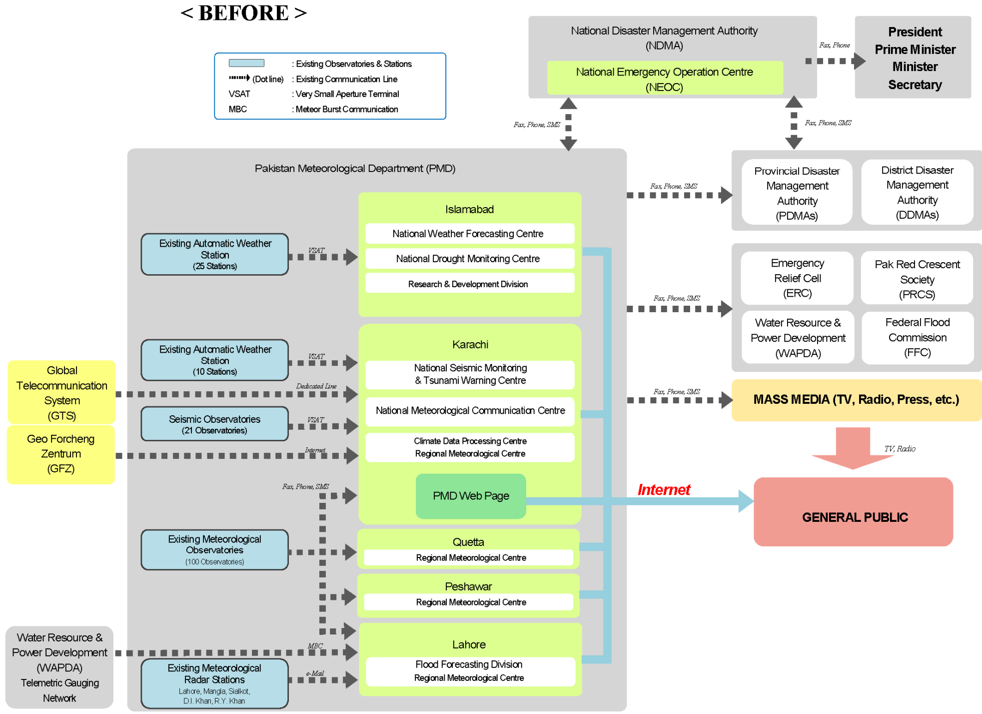
Observed data related to the forecast approach can be transmitted by appropriate communication system in terms of reliability, economic efficiency and maintenance aspects. The GPRS with Internet, SMS, Meteor Burst Communication, H.F. radio wave and satellite V-Sat shall be adopted for the ground observation data including the data from meteorological radar systems and wind profilers.

b. Integrated Early Warning Communication System

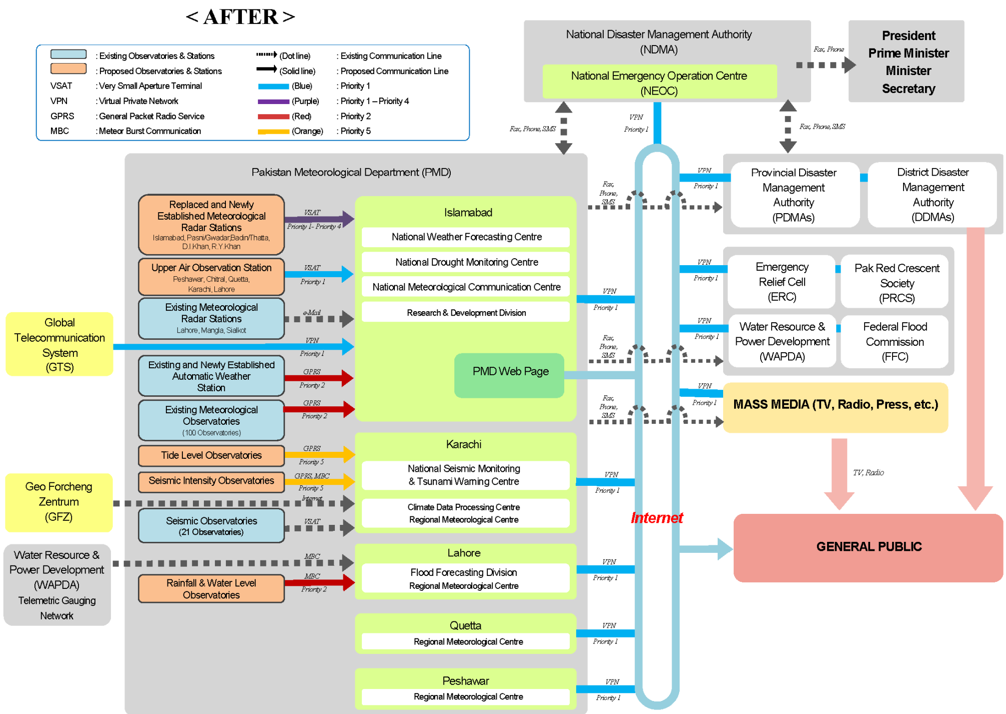
Integrated communication systems for each EWS steps, such as observation, forecasting process, dissemination of warning, judgment of direction, communication with end users, to be achieved in the implementation of the Multi-Hazard EWS Plan are shown in accordance with policies and approaches prescribed previously.

c. Weather Information from Qualitative to Quantitative Forecast

As described in Chapter 3 and Chapter 4, PMD has been adequate in releasing the forecast and warning to its maximum abilities. The Plan proposes not only more improvement along with its extension of capacity but also shifting of warning contents from qualitative to quantitative forecasts. The people cannot understand the intensity of impending disaster(s) by the vague terms, such as heavy, strong and/or robust. In this connection, the improvement by the introduction of Weather Guidance System has been proposed in the Plan (see Subsection 4.2.5 and 5.2.10 as one of human capacity development projects).



Current Communication and Dissemination System



Proposed Communication and Dissemination System

Source: JICA Expert Team

Figure 5.1.2 Proposed Communication and Dissemination System of Multi-Hazard EWS

5.1.2 Cooperation and Coordination in Other Related Activities

1) Necessity

The Multi-Hazard Early Warning System cannot be properly operated alone and its effectiveness will be reduced if the acceptance and orientation of the EWS are not recognized by target communities. Suitable operation of the EWS can be achieved in collaboration with other related activities on a routine basis.

2) Related Activities

In addition to innovation and enhancement of the Multi-Hazard EWS based on review of the current EWS, it is essential to undertake the following activities for more efficient operation of the system:

- Preparation of Hazard Map
- Enhancement of DRM Education and Public Awareness (Community Enlightenment) for EWS
- Capacity Development of the Staff of Early Warning Agency(ies)

The activities enumerated above shall be considered and included in the Multi-Hazard EWS Plan as basic activities.

a. Preparation of Hazard Map

Even if the alerts or evacuation orders are correctly disseminated, activities in EWS will not be effective if the target communities do not understand the hazards and risks of the disaster or do not know safe places where they should evacuate. Therefore, responsible agencies should prepare the hazard maps for each type of disaster together with the EWS. The required scales of hazard maps are as given in the table below.

Table 5.1.5 Multi-Hazard Maps to be Prepared by Concerned Agencies

Level	Required Scale of Map
National Level	Any scale applicable
Provincial Level	More than or equivalent to 1:1,000,000
District Level	More than or equivalent to 1:250,000
Town/Tehsil Level	1:20,000 ~ 1:50,000

Source: JICA Expert Team.

In the Project for National Disaster Management Plan by JICA, several hazard maps with risk at the national level have been prepared. The NDMA should update and improve these national level hazard maps as its mandatory responsibility at proper intervals. Based on these national level maps, hazard maps of high priority areas (districts or towns/*tehsils* with high vulnerability) should be prepared as soon as possible, together with the development of the Multi-Hazard Early Warning System Plan.

In this regard, the agencies responsible for the preparation of large-scaled hazard maps against each disaster are given in the table below.

Table 5.1.6 Responsible Agencies for the Preparation of Large-Scaled Hazard Maps

Target Disaster	Coordination Agency	Agency Preparing Maps	Supporting Agency
Flood	NDMA and FFC	FFC, PIDs	F/G/S/PDMAs /DDMAs, PMD
Landslide	NDMA	NDMA/GSP (ERRA)	F/G/S/PDMAs DDMAs
Tsunami	NDMA	PMD/GSP	PDMAs /DDMAs, Pakistan Coast Guard
GLOF	NDMA	GSP	F/G/S/PDMAs /DDMAs, PMD, WAPDA
Avalanche	NDMA	GSP	F/G/S/PDMAs /DDMAs, PMD
Earthquake	NDMA	GSP	F/G/S/PDMAs /DDMAs, PMD

Source: JICA Expert Team

As shown above, all preparations for the hazard maps shall be coordinated by the NDMA and provided by technical agencies as preparing agencies. In addition, the F/G/S/PDMAs and the DDMAs administrating the vulnerable area(s) shall support the preparation of maps throughout the activities.

b. DRM Education, Public Awareness and Enhancement of Community Enlightenment for EWS

As shown in Sub-section 4.2.4, it is necessary to enlighten communities about the EWS via CBDRM and HRDP activities. It is recognized that further enlightenment and knowledge acquisition activities are still needed for the community.

c. Capacity Development/Building of PMD and NDMA Officers in Multi-Hazard EWS

The development/building of capabilities of PMD staff in the multi-forecast system is also essential to keep up with the latest prediction techniques and knowledge. The detailed contents to be achieved have been discussed in Sub-Section 4.2.5. These activities will be improved and revised through the periodical evaluation. The schemes have been proposed in Subsection 5.2.8.

5.2 Programs and Projects Proposed in the Multi-Hazard Early Warning System Plan

5.2.1 General

Based on the discussions in Chapter 4, the indispensable improvement/ enhancement activities on the Multi-Hazard EWS have been clarified. The proposed programs and projects to be implemented are as given in the table below.

Table 5.2.1 Indispensable Activities for the Improvement and Enhancement in the Multi-Hazard EWS

Type of Hazard	Programs and Projects
Earthquake and Tsunami (Seismic Disasters)	
Tsunami	Establishment of Tide Level Monitoring Network
	Training on Tsunami Simulation and Preparation of Hazard Maps
	Updating of Global Telecommunication System (GTS)
Earthquake	Establishment of Seismic Intensity Reporting System
Meteorological Disasters	
Weather Information	Establishment of Specialized Medium Range Forecasting Centre (SMRFC)
	(Improvement of NWP and the Process (Meteorological Data Processing, Analyzing Forecasting System with main frame computer; Forecast Support System with Plotting Apparatus by main frame computer); Upper Air Observation Stations; Satellite HRPT Data Receiving System; Updating of GTS (Duplication with Tsunami); Agro-meteorological Data Processing and Analysis System, Weather Info. Broadcasting System and Weather Information Broadcasting Program Production System and etc.) (See Item 1) in this Subsection in detail)
	Expansion of Automatic Weather Station (AWS) Network for Weather Information
	Additional Installation of AWS for the Observation of Basic Meteorological Data
	Replacement of Existing Meteorological Radar Stations
	Establishment of New Meteorological Radar Stations
	Establishment of (Additional) Upper Air Observation Stations (*Duplication with Weather Information*)
River Flood	Strengthening of Flood Warning and Management Capacity by Utilizing Satellite Data including Flood Hazard Maps along the Indus Rivers (UNESCO Project)
	Replacement of Existing Meteorological Radar Stations (*Duplication with Weather Information*)
	Establishment of new Meteorological Radar Stations (*Duplication with Weather Information*)
	Establishment of Regional Flood Forecasting and Warning Centres (RFFWC)
	Expansion of Rainfall and Water Level Observation Network
Flash Flood	Establishment of Local Flash Flood Forecasting Centres (LFFFC) including Flash Flood Forecasting and Warning System
	Preparation of Hazard Map and Capacity Development against Local Flash Flood
	Expansion of Rainfall and Water Level Observation Network (*Duplication with River Flood*)
Landslide *1	Preparation of Landslide Hazard Maps based on the Topographical and Geological Points of View
	Establishment of Landslide EWS
	Expansion of AWS Network for Landslide Hazard (*Duplication with Weather Information*)
Cyclone with Storm Surge	Expansion of AWS Network (*Duplication with Weather Info., Drought and Landslide*)
	Establishment of Tide Level Monitoring Network (*Duplication with Tsunami*)
	Replacement of Karachi existing Meteorological Radar Station (*Duplication with Weather Info.*)
	Finalization of SOP of Cyclone EWS
Drought	Set-up of Agro-Meteorological Advisory Service (*Duplication with Weather Information*)
	Expansion of AWS Network for Drought Monitoring (*Duplication with Weather, etc.*)
GLOF	Early Warning System for GLOF and Snow Melt Flash Flood including Preparation of Hazard Maps
	Enhancement of Research Activities for Snow/Glacier/Glacial Lakes including GLOF data acquisition and archiving system
Avalanche	Establishment/Improvement of Avalanches Advisory Information System
Others	
Dissemination & Capacity Development	Innovation of Communication System between PMD and NDMA
	Innovation of Communication System among DMAs (NDMA- F/G/S/PDMAs -DDMA)
	Communication System utilizing Cellular Phone and Radio Broadcast Networks
	Weather Info. Broadcasting System and Weather Information Broadcasting Program Production System (*Duplication with Weather Info.*)
	Education Program for Advanced Meteorology and Hydrology for PMD Staff
	Establishment of Weather Forecast Guidance System
	Enhancement of Community Enlightenment for EWS with Execution of Training and Drills
	Development of the EWS National Plan, Guidelines and SOPs for Health Emergency Preparedness and Response (HEPR)

Note: *1: Landslide Disasters are caused by earthquake and heavy rain. However, landslides due to heavy rain can be predictable. Therefore, landslide disaster is included in meteorological disasters in this plan.

Source: JICA Expert Team. In consultation with PMD, FFC and NDMA.

In the proposed programs and projects, the following two considerations shall be taken into account.

1) Establishment of Specialized Medium-Range Forecasting Centre (SMRFC)

A Specialized Medium Range Forecasting Centre (SMRFC) has already been proposed to upgrade weather and flood forecasting with drought advisory improvement in the country. This proposed SMRFC would also contribute to minimizing damage due to natural disasters, such as flood and drought, and to the protection of people's lives and property. In addition, the augmentation of weather forecasting capacity in the short and medium terms is useful not only for drought issues but also for the prediction of flood-related issues. In view thereof, the establishment of SMRFC should be proposed as part of the disaster mitigation approach.

Table 5.2.2 Actions, Facilities and Equipment in the Components of the SMRFC (based on the Original Proposal of PMD)

Proposed Actions, Facilities and Equipment	Outputs Expected
GTS Message Switching System	-Synoptic Observation Data -Grid Point Value (GPV) Data -Tsunami Warning
Upper-Air Observation System	-Upper-Air Observation Data (Wind Velocity, Wind Direction, Temperature)
NOAA HRPT Receiving and Display System	-High Resolution Visible Image of Cloud, Ice and Snow Distribution -High Resolution Infrared Image of Sea Surface Temperature and Cloud Distribution
Meteorological Radar System (X Band Mobile Radar)	-Rainfall Intensity Data
Meteorological Data Processing, Analysis & Forecast System with Main Frame Computer	-Grid Point Value (Wind Velocity and Direction, Rainfall, Temperature) -Short-Medium Range Meso-Scale Prediction (Wind Velocity, Wind Direction, Rainfall, Temperature) -Storm Surge Forecast
Forecast Support System with Plotting Apparatus by Main Frame Computer	-Surface Chart -Upper-Air Chart -Forecast Chart -Thermodynamic Chart
Agro-Meteorological Data Processing and Analysis System	-Medium Range Forecast (Rainfall, Temperature)
Meteorological and Hydrological Information Dissemination System	-Dissemination of Weather Forecast, Drought Advisory, Cyclone Warning, Flood Forecast & Warning, Tsunami Warning, Storm Surge Warning through FM Radio Stations
Weather Information Broadcasting Program Production System	-Weather Forecast Program -Drought Advisory Program -Cyclone Warning Program -Flood Warning Program -Disaster Information Program -Educational Program -Publicity Program
Environmental Monitoring System	-Air Pollution Monitoring Data -Climate Change Trend Analysis Data (Rainfall, Temperature)

Source: JICA Expert Team

2) Consideration of Climate Change

Taking climate change into consideration, cyclones are expected to intensify due to global warming and hit the coastal areas of Pakistan with increased heights of storm surges due to the increased sea level. Climate change or global warming would also induce an increase in the number of GLOFs in glacial areas and extreme drought phenomena in arid areas in Pakistan.

Therefore, observations and watching the meteorological situation shall be conducted and collected by related agencies (such as R&D of PMD and GCISC) utilizing the meteorological observation system that is to be enhanced and strengthened by proposed projects or programs in this Multi-Hazard EWS Plan.

All the programs and projects mentioned in Table 5.2.1 regarding meteorological disasters contribute to the observation of climate change. In particular, programs/projects for weather information and GLOF are indispensable.

5.2.2 Tsunami and Earthquake

1) Establishment of Tide Level Monitoring Network Including Data Communication System (Procurement of Equipment)

In order to record and analyze the relativity of tide level (height of tsunami) and earthquake, it is necessary to establish the tide level stations given in the table below.

Table 5.2.3 Description and Rough Cost Estimate for the Tide Level Monitoring Network Project

No.	Description	Qty.	Remarks
1	Automatic Tide Level Station	2	Including AWS/AWO for High Tide Monitoring
2	Data Communication System	1	
3	Data Receiving and Analyzing System	2	Karachi and Islamabad
Estimated Cost		Rs. 10,000,000	
Main Responsible Agency		PMD	

Source: JICA Expert Team

Regarding human resources development activities (training and educational activities), it is not necessary for this network establishment to specifically conduct special trainings except for the adjustment, test drive, and initial O&M guidance at the installation.

2) Training on Tsunami Simulation and Preparation of Hazard Maps (Study and Technical Cooperation with Capacity Development)

Tsunami Hazard Maps at five (5) selected priority areas vulnerable to tsunami with trainings and capacity development for the stakeholders regarding the early warning based on tsunami simulation shall be prepared.

Table 5.2.4 Description and Rough Cost Estimate for Training on Tsunami Simulation and Preparation of Hazard Maps

No.	Description	Qty.	Remarks
1	Bathymetric Survey	5	5 locations
2	Simulation Study on Tsunami Disaster	5	At cities/towns vulnerable to tsunami
3	Preparation of Hazard Map	5	At cities/towns vulnerable to tsunami
4	Enhancement of CBDRM & EWS	1	Together with drills and Training
5	Revision and Improvement of Tsunami SOP	1	Based on the lessons learnt of project activities
Estimated Cost		Rs. 200,000,000 (including Capacity Development)	
Main Responsible Agency		PMD/GSP	
Related Agencies		PDMA-Balochistan, PDMA-Sindh, DDMAs along coastal areas, Karachi Port Trust and Pakistan Navy	

Source: JICA Expert Team

This program is a capacity development activity to mitigate tsunami disasters as one of the human resources development programs. In this program, the following concepts will be set in terms of human capacity development.

Project Purpose: EWS System and Hazard Maps are established and prepared for the target areas that enable mass evacuations in the event of tsunamis.

Outputs of the Program: (1) Capacity of PMD is strengthened enough to prepare tsunami hazard maps for an effective early warning system, (2) Capacity of local authorities is developed enough to promote people's awareness and preparedness for the tsunamis utilizing tsunami hazard maps, and (3) Capacity of related organizations is strengthened enough to mitigate the damage of tsunami disasters.

3) Updating of Global Telecommunication System (GTS)

The GTS message switching system shall be updated for the reliable communication with foreign early warning agencies. This updating activity has also been included in Table 5.2.30.

Table 5.2.5 Description and Rough Cost Estimate for Updating of GTS

No.	Description	Qty.	Remarks
1	GTS Message Switching System	1	
Estimated Cost		Rs. 22,000,000	
Main Responsible Agency		PMD	

Source: JICA Expert Team

Regarding human resources development activities (training and educational activities), it is not necessary for this updating establishment to specifically conduct special training except for the adjustment, test drive, and initial O&M guidance at the installation.

Prior to the replacement of equipment, the problems will be scrutinized and only faulty parts will be repaired or reinstalled.

4) Establishment of Seismic Intensity Reporting System including Data Communication System (Procurement of Equipment)

By establishing this system, the seismic intensity in 50 priority districts can be displayed at the monitoring agencies within a short time from the time of occurrence of an earthquake.

Table 5.2.6 Description and Rough Cost Estimate for Establishment of Seismic Intensity Reporting System

No.	Description	Qty.	Remarks
1	Accelerometer and Data Logger	50	For 50 Priority Districts
2	Data Archiving and Analyzing System	3	Islamabad, Karachi and NDMA
3	Intensity Display System	3	Islamabad, Karachi and NDMA
4	Data Communication System	1	
Estimated Cost		Rs. 180,000,000	
Main Responsible Agency		PMD	
Related Agencies		NDMA, F/G/S/PDMAs, GSP	

Source: JICA Expert Team

Regarding human resources development activities (training and educational activities), it is not necessary for this updating establishment to specifically conduct special training except for the adjustment, test drive, and initial O&M guidance at the installation.

5.2.3 River Flood

1) Strengthening of Flood Forecasting by Satellite Information and Hazard Maps of Indus River including Preparation of Flood Hazard Maps along the Indus River (Study and Software Application with Capacity Development)

The current Indus River Basin flood simulation model and warning system shall be improved utilizing a satellite information system, such as GsMap or IFAS. This project is already underway by UNESCO

Table 5.2.7 Description and Rough Cost Estimate for Strengthening of Flood Forecasting by Satellite Information and Hazard Maps

No.	Description	Qty.	Remarks
1	Warning Communication and Dissemination System	1	Runoff Calculation Software by Satellite Data
2	Updating of Software	1	Technical Assistance
3	Restoration of Damaged Automatic Weather Station	10	In flood affected areas
4	Restoration of Damaged Conventional Meteorological Observatories	10	In flood affected areas
Estimated Cost		Rs. 300,000,000 (including Capacity Development)	
Main Responsible Agency		PMD with FFC	

Source: JICA Expert Team

As described in Subsection 4.2.5, there are fewer hydrologists qualified in PMD than qualified meteorologists. In this connection, the programs shall include human resource development activities to focus the training and education of PMD staff on the improvement of hydrology with knowledge of utilization (operation and maintenance) of the software to be installed. The concepts of this project from the capacity development aspects are as follows:

Project Purpose: (1) Strategic strengthening of the country's flood early warning system (FEWS) is established to ensure safe recovery and return to the livelihoods of the affected population. This also includes timely sharing of precipitation data on transboundary rivers, and (2) floodplain risk and hazard maps are developed and implemented at the community level

Outputs of the Program: (1) Capacities of PMD with related agencies are augmented enough to forecast floods and prepare hazard maps for flood and geo-hazards, (2) Knowledge platforms for sharing transboundary data and community flood risk information are established, and (3) Capacity of PMD's staff is strengthened adequately through training courses in foreign countries to develop Flood Forecasting and Hazard Mapping.

2) Replacement of Existing Meteorological Radar Stations including Data Communication System (Procurement of Equipment and Facility Construction)

Due to the expiry of durable years of the existing meteorological radar systems, these shall be replaced. In addition, the adoption of new technology for multiple observations with reliable operation is required. Moreover, it is essential to solve the problem of the non-availability of spare parts. In view thereof, the old meteorological radar systems shall be replaced with Doppler technology for the continuation of PMD's activities in flood forecasting.

Table 5.2.8 Description and Rough Cost Estimate for Replacement of Islamabad Meteorological Radar

No.	Description	Qty.	Remarks
1	Meteorological Radar	1	C-Band Doppler Radar
2	Radar Data Display Unit	3	Radar Station, Lahore, Islamabad
3	Data Communication System	1	
4	Radar Tower Building	1	40m
Estimated Cost		Rs. 980,000,000	
Main Responsible Agency		PMD with FFC	

Source: JICA Expert Team

Table 5.2.9 Description and Rough Cost Estimate for Replacement of D. I. Khan and Rahim Yar Khan Meteorological Radars

D. I. Khan Meteorological Radar

No.	Description	Qty.	Remarks
1	Meteorological Radar	1	C-Band Doppler Radar
2	Radar Data Display Unit	3	Radar Station, Lahore, Islamabad
3	Data Communication System	1	
4	Radar Tower Building	1	40m
Estimated Cost		Rs. 900,000,000	

Rahim Yar Khan Meteorological Radar

No.	Description	Qty.	Remarks
1	Meteorological Radar	1	C-Band Doppler Radar
2	Radar Data Display Unit	3	Radar Station, Lahore, Islamabad
3	Data Communication System	1	
4	Radar Tower Building	1	40m
Estimated Cost		Rs. 900,000,000	
Main Responsible Agency		PMD with FFC	

Source: JICA Expert Team

Table 5.2.10 Description and Rough Cost Estimate for Establishment of Pasni/Gwadar and Karachi/Badin/Thatta Meteorological Radars for Coastal Area

Pasni/Gwadar and Badin/Thatta Meteorological Radars instead of Karachi Meteorological Radar

No.	Description	Qty.	Remarks
1	Meteorological Radar	2	S-Band Doppler Radar
2	Radar Data Display Unit	5	2 Radar Stations, Karachi & Lahore, Islamabad
3	Data Communication System VSAT Data Communication System	1 (5)	 2 Radar Stations, Karachi & Lahore, Islamabad
4	Radar Tower Building	2	40m
Estimated Cost		Rs. 1,800,000,000	
Main Responsible Agency		PMD with FFC	

Source: JICA Expert Team

In the project for the replacement of each existing radar installation, the training in the operation and maintenance of updating radar for staff managing the radars including the adjustment, test drive, and initial O&M guidance at the installation shall be conducted. It is necessary to newly learn the manual for O&M activities because the radar and appurtenant facilities for transmission, imaging and processing of data cannot be operated and maintained by current techniques. These capacity development activities will be conducted in parallel with the construction and installation of new radar stations.

3) Establishment of New Meteorological Radar Stations including Data Communication System (Procurement of Equipment and Facility Construction)

To enhance flood forecasting capabilities in various parts of the country, the meteorological radar stations shown in the table below need to be established for a denser national meteorological radar network.

Table 5.2.11 Description and Rough Cost Estimate for Establishment of Cherat and Chitral Meteorological Radars for KP

For Khyber Pakhtunkhwa Province (Cherat and Chitral)

No.	Description	Qty.	Remarks
1	Meteorological Radar (Cherat)	1	S-Band Doppler Radar
2	Meteorological Radar (Chitral)	1	C-Band Doppler Radar
3	Radar Data Display Unit	5	2 Radar Station, Peshawar, Lahore and Islamabad
4	Data Communication System	1	
5	Radar Tower Building	2	40m
Estimated Cost		Rs. 1,800,000,000	
Main Responsible Agency		PMD with FFC	

Source: JICA Expert Team

Table 5.2.12 Description and Rough Cost Estimate for Establishment of Quetta Meteorological Radars for Balochistan

For Balochistan Province (Quetta)

No.	Description	Qty.	Remarks
1	Meteorological Radar	1	C-Band Doppler Radar
2	Radar Data Display Unit	4	Radar Station, Quetta, Lahore and Islamabad
3	Data Communication System	1	
4	Radar Tower Building	1	40m
Estimated Cost		Rs. 800,000,000	
Main Responsible Agency		PMD with FFC	

Source: JICA Expert Team

Table 5.2.13 Description and Rough Cost Estimate for Establishment of Sukkar and D. G. Khan Meteorological Radars

For Sindh Province (Sukkar)

No.	Description	Qty.	Remarks
1	Meteorological Radar	1	S-Band Doppler Radar
2	Radar Data Display Unit	4	Radar Station, Karachi, Lahore and Islamabad
3	Data Communication System	1	
4	Radar Tower Building	1	40m
Estimated Cost		Rs. 900,000,000	

For Punjab Province (Dera Ghazi Khan)

No.	Description	Qty.	Remarks
1	Meteorological Radar	1	S-Band Doppler Radar
2	Radar Data Display Unit	3	Radar Station, Lahore and Islamabad
3	Data Communication System	1	
4	Radar Tower Building	1	40m
Estimated Cost		Rs. 900,000,000	
Main Responsible Agency		PMD with FFC	

Source: JICA Expert Team

As well as the replacement of existing radar systems, the training in the operation and maintenance of the new radar systems for staff managing the radar including the adjustment, test drive, and initial O&M guidance at the installation shall be conducted. The O&M activities to be newly learned will be taught because the radar and appurtenant facilities for transmission, imaging and processing of data shall be newly operated and maintained by new staff and operators of PMD. These capacity development activities will be conducted in parallel with the construction and installation of the new radar stations.

4) Establishment of Regional Flood Forecasting and Warning Centres (RFFWC), (Procurement of Equipment and Facility Construction with Capacity Development)

To implement a stronger river flood forecasting in the country, the regional flood forecasting and warning centres shown in the table below need to be established in addition to the existing Flood Forecasting Division (FFD), Lahore.

Table 5.2.14 Description and Rough Cost Estimate for Establishment of Regional Flood Forecasting and Warning Centres (RFFWCs)

For Khyber Pakhtunkhwa Province (Peshawar)

No.	Description	Qty.	Remarks
1	Data Communication System	1	
2	Data Display System	1	
3	High Performance PC Work Station for Flood Forecasting Model	1	
4	RFFWC Building	1	
	Estimated Cost	Rs. 90,000,000 (with Capacity Development)	

For Sindh Province (Karachi)

No.	Description	Qty.	Remarks
1	Data Communication System	1	
2	Data Display System	1	
3	High Performance PC Work Station for Flood Forecasting Model	1	
4	RFFWC Building	1	
	Estimated Cost	Rs. 90,000,000 (with Capacity Development)	

For Balochistan Province (Quetta)

No.	Description	Qty.	Remarks
1	Data Communication System	1	
2	Data Display System	1	
3	High Performance PC Work Station for Flood Forecasting Model	1	
4	RFFWC Building	1	
	Estimated Cost	Rs. 90,000,000 (with Capacity Development)	
	Main Responsible Agency	PMD with FFC	
	Related Agencies	PDMAs (Khyber Pakhtunkhwa, Balochistan and Sindh)	

Source: JICA Expert Team

The capacity development activities are essential for these projects. The building(s) and equipment are only tools for the flood forecasting. Proper forecasting activities will be delivered by well-trained meteohydorologists. In this connection, the projects shall include the human resources development activities to focus the training and education of PMD staff to be qualified as meteorologists or hydrologists with knowledge on utilization (operation and maintenance) of software to be installed. The concepts of this project from the capacity development aspects are as follows.

Purpose of Human Resource Development in these projects: (1) PMD’s well trained meteorologists and hydrologist along with other engineers are assigned to each RFFWC, and (2) Flood Warning Activities are commenced in each province as main activities of RFFWCs.

Outputs of the Program: (1) The staff of PMD are trained as qualified Meteorologists and Hydrologists and assistant and/or junior meteorologists are to be assigned in each RFFWC, and

(2) Standard Operating Procedures (SOPs) for flood forecasting issuance for each RFFWC are prepared and staff to be assigned acquire the knowledge regarding the SOPs.

The targeted number of staff to be engaged and educated in each post are shown in the table below:

Table 5.2.15 The Targeted Number of Officers to be Engaged and Educated in RFFWCs

Name of Post	Peshawar	Karachi	Quetta	Remarks
Director (Principal. Meteorologist)	1	1	1	Promotion from Existing Sr. Meteorologists
Sr. Meteorologists (Sr. Hydrologists))	2	2	2	Promotion from Meteorologists/Hydrologists
Meteorologists (Hydrologists)	4	4	4	Promotion from Assistant Meteorologists/Hydrologists
Assistant Meteorologists (Assistant Hydrologists)	4	4	4	New employment
Total	11	11	11	

Source: PMD and JICA Expert Team

5) Expansion of Rainfall and Water Level Observation Network (Procurement of Equipment)

Likewise, to enhance flood forecasting capabilities in various parts of the country, the rainfall and water level observation network shown in the table below needs to be established.

Table 5.2.16 Description and Rough Cost Estimate for Expansion of Rainfall and Water Level Observation Network

No.	Description	Qty.	Remarks
1	Automatic Rainfall and Water Level Observation Stations	34	
2	Data Control System	2	Including Backup System
3	Data Communication System	1	
Estimated Cost		Rs. 250,000,000	
Main Responsible Agency		All over the country PMD	

Source: JICA Expert Team

Regarding human resources development activities (training and educational activities) for this project, the adjustment, test drive, and initial O&M guidance at the installation shall be conducted.

6) Establishment of Upper Air Observation Stations (Procurement of Equipment)

The establishment of upper-air observation stations shown in the table below will make jet stream observation possible and will contribute to the improvement of numerical weather prediction (NWP) results.

Table 5.2.17 Description and Rough Cost Estimate for Establishment of Upper-Air Observation Stations

For Peshawar

No.	Description	Qty.	Remarks
1	Wind Profiler	1	For Observation
2	Data Communication System	1	For Data Communication Network
Estimated Cost		Rs. 103,000,000	

For Chitral

No.	Description	Qty.	Remarks
1	Wind Profiler	1	For Observation
2	Data Communication System	1	For Data Communication Network
Estimated Cost		Rs. 103,000,000	

For Quetta

No.	Description	Qty.	Remarks
1	Wind Profiler	1	For Observation
2	Data Communication System	1	For Data Communication Network
Estimated Cost		Rs. 103,000,000	

For Lahore

No.	Description	Qty.	Remarks
1	Wind Profiler	1	For Observation
2	Data Communication System	1	For Data Communication Network
Estimated Cost		Rs.103,000,000	

For Multan

No.	Description	Qty.	Remarks
1	Wind Profiler	1	For Observation
2	Data Communication System	1	For Data Communication Network
Estimated Cost		Rs. 103,000,000	
Main Responsible Agency		PMD	

Source: JICA Expert Team

Regarding human resources development activities (training and educational activities), the adjustment, test drive, and initial O&M guidance at the installation shall be conducted.

7) Replacement of Weather Information System Utilizing Satellite HRPT Data (Duplication: such as Drought and Weather Information), (Procurement of Equipment)

PMD currently obtains only low-resolution NOAA satellite images through the Internet and uploads them to the PMD website, but they are not used for forecasting. PMD has usually utilized FY-II satellite images for the weather forecasting but the receiving system for FY-II has often developed trouble. In order to complement FY-II imagery data and detect detailed cloud conditions correctly for forecasting, the rehabilitation of the NOAA meteorological satellite image receiving system is to be carried out.

Table 5.2.18 Description and Rough Cost Estimate for Replacement of Weather Information System Utilizing Satellite HRPT Data

No.	Description	Qty.	Remarks
1	NOAA HRPT Receiving System	1	250m mesh, Islamabad
Estimated Cost		Rs. 40,000,000	
Main Responsible Agency		PMD	

Source: JICA Expert Team

Regarding human resources development activities (training and educational activities), the adjustment, test drive, and initial O&M guidance at the installation shall be conducted.

5.2.4 Flash Flood

1) Establishment of Local Flash Flood Forecasting Centres (LFFFC) including Flash Flood Forecasting and Warning System (Study, Procurement of Equipment and Facility Construction with Capacity Development)

Based on historical data, flash floods have occurred at a number of local *nullahs*/small rivers at the regions shown in the table below. The establishment of local flood forecasting centres in these regions is necessary to disseminate alerts within a short span of time as well as the establishment of RFFWCs at each province.

In the Multi-Hazard EWS Plan, the EWS with LFFFCs at the ten (10) significant locations shall be implemented up to 2021. The candidate locations for LFFFCs and Systems are as given in the table below.

Table 5.2.19 Candidate Locations for the Establishment of LFFFCs and EWS for Flash Flood

Province	Selected Candidate Areas (District/Agency-Based) as Priority Location
KP	Bannu, Mardan, Lower/Upper Dir, Swat, Charsadda, Peshawar, Nowshera, Shangla, Kohistan, Tank
Punjab	Mianwali, Sialkot, D.G.Khan, Rajanpur
Balochistan	Kech, Nasirabad, Jaffarabad
Sindh	Dadu, Qamber-shardahkot, Thatta, Larkana
FATA	South Waziristan, Kurram, Khyber, Mohmand, Bajaur

Source: JICA Expert Team in consultation with PMD, FFC and NDMA.

Table 5.2.20 Description and Rough Cost Estimate for Establishment of LFFFC including Flash Flood Forecasting and Warning System

For each Candidate Location

No.	Description	Qty.	Remarks
1	Automatic Rain Gauge Station	3	At appropriate location in upper basin
2	Automatic Water Level Station	2	At immediate upstream location to be protected
3	Observation Data Archiving System	1	At PMD and District Office
4	Observation Data Processing System	1	At PMD Office
5	Data Display System	3	At PMD and District Office
6	Warning Post	5	At areas vulnerable to flash flood
7	Data Communication System	1	Between offices and stations
8	LFFFC Building	1	At designated location in the basin
Estimated Procurement Cost		Rs. 250,000,000	
Study on EWS including Hazard Map		Rs. 80,000,000	
Total Estimated Cost		Rs. 330,000,000	
Main Responsible Agency		PMD with FFC	
Related Agencies		F/G/S/PDMAs with related DDMAs	

Source: JICA Expert Team

In the projects, the adjustment, test drive, and initial O&M guidance at the installation for the systems shall be conducted as human resources development activities. Technical issues on the improvement of hydrological and meteorological analysis to forecast the flash floods by PMD staff shall be considered in the project for preparation of hazard maps and capacity development against local flash floods as explained below.

Preparation of the Hazard Map and Capacity Development against Local Flash Flood (Study and Technical Cooperation with Capacity Development) shall be executed for each location together with the establishment of the LFFFCs as described in Table 5.2.21 as well as concepts of capacity development below.

Table 5.2.21 Description and Rough Cost Estimate for Finalization of Flash Flood Hazard Maps with Capacity Development for Flash Flood EWS

No.	Description	Qty.	Remarks
1	Finalization of Hazard Map	1	For selected ten (10) locations
2	Capacity Development of PMD	1	
3	Capacity Development of Local Governments	1	For selected ten (10) locations
4	CBDRM Development	1	For selected ten (10) locations
Estimated Cost		Rs. 100,000,000 (with Capacity Development)	

Source: JICA Expert Team

For the targeted vulnerable areas where the LFFFCs are established, the capacity development activities are to be conducted based on the following concepts

Project Purpose: (1) Strategic strengthening of the country's flash flood early warning systems (FEWSs) is established to ensure safe recovery and return of the livelihoods of the affected population at targeted locations, and (2) floodplain risk and hazard maps for flash floods are developed and implemented at the community level along with preparation of a manual for the hazard map production.

Outputs of the Program: (1) Capacities of PMD with related agencies are augmented enough to forecast floods and prepare hazard maps for flood and geo-hazards, (2) Knowledge Platforms for Sharing Transboundary Data and Community Flood Risk Information are established, and (3) capacity of PMD staff is strengthened enough to develop Flood Forecasting and Hazard Mapping through training courses in Pakistan and foreign countries.

In addition to the projects proposed above, the alternatives for the establishment of flash flood warning systems in which the project costs are minimized shall be considered (see Table 4.2.31 in Chapter 4). In the activities of the alternative, the simplified EWSs for flash floods with capacity development for appropriate commencement and O&M of the systems are established as pilot projects. These pilot projects shall be considered in the Feasibility Study to be conducted in advance of the implementation of the proposed projects of which viabilities, feasibilities and detailed conditions will be reconfirmed through the further studies as described in Chapter 6.

2) Expansion of Rainfall and Water Level Observation Network (Procurement of Equipment)

To enhance flash flood forecasting capabilities in various parts of the country, the Rainfall and Water Level Observation Network needs to be established. The description and rough cost estimate is shown in Table 5.2.16 collectively. The assumed locations for flash flood warning are enumerated in Table 4.2.18.

5.2.5 Landslide due to Heavy Rainfall

1) Preparation of Landslide Hazard Maps based on the Topographical and Geological Points of View (Study and Preparation of Hazard Map with Capacity Development)

According to the hazard and risk analysis by the JICA Project, some districts having very high hazard of landslide disasters have not conducted any detailed hazard analysis or prepared maps. Therefore, landslide hazard maps shall be prepared for their districts.

Table 5.2.22 Description and Rough Cost Estimate for Preparation of Landslide Hazard Maps

No.	Description	Qty.	Remarks
1	Review of Vulnerability Assessment and Identification of Priority Areas	1	5 priority areas (Haveli and Poonch for AJK; Abbottabad and Haripur for KP and ICT)
2	Preparation of Base Map	5	In association with SOP
3	Study & Analysis (Risk Assessment)	5	Including disaster records in the past
4	Preparation of Hazard Map	5	Scale of 1:50,000
5	Dissemination and CBDRM Support	1	With workshops and drills for citizens
	Estimated Cost	Rs. 200,000,000 (including Capacity Development)	
	Main Responsible Agency	GSP with Capacity Development	
	Other Related Agencies	PMD and NDMA (F/G/S/PDMAs and DDMAs)	

Source: JICA Expert Team

For the targeted vulnerable areas tabulated in Table 4.2.6, the preparation of landslide hazard maps will be executed based on the following concepts:

Project Purpose: (1) Strategic strengthening of understanding of the country's landslide vulnerabilities is established to ensure safe recovery and return of the livelihoods of the affected population in targeted locations, and (2) landslide hazard maps are developed and provided at the community level along with preparation of a manual for the hazard map production.

Outputs of the Program: (1) Capacities of GSP with related agencies are augmented enough to forecast floods and prepare hazard maps for landslides and geo-hazards, and (2) Knowledge platforms for the establishment of landslide EWS and Community landslide risk Information is established.

2) Establishment of Landslide EWS (Study with Capacity Development)

Based on the detailed hazard assessment at locations vulnerable to landslide, the PMD shall establish the EWS for landslide due to accumulated rainfall with the installation of Automatic Weather Observation Network.

Table 5.2.23 Description and Rough Cost Estimate for Establishment of Landslide EWS

No.	Description	Qty.	Remarks
1	Study on the Establishment of Landslide EWS	1	With disaster records in the past
2	Preparation of SOP for Landslide Warning	1	Setup of rainfall intensities for warning
3	Capacity Development of PMD	1	Including Hydrology and Geology
4	Capacity Development of Local Government	1	Including mechanism of landslides and understanding SOP
5	CBDRM Development	1	Including Education Campaigns
Estimated Cost		Rs. 100,000,000 (including Capacity Development)	
Main Responsible Agencies		PMD and GSP with Capacity Development	

Source: JICA Expert Team

This program aim is to establish the Landslide EWS with a capacity development activity against landslide disaster as one of the human resources development programs. In this program, the following concepts will be applied.

Project Purpose: an EWS System that enables warning and evacuation in advance of the event of landslide is established and prepared in mainly mountainous areas.

Outputs of the Program: (1) The SOP regarding landslide EWS is prepared, and (2) Capacity of PMD is strengthened enough to prepare landslide hazard maps for effective early warning systems.

3) Expansion of Automatic Weather Observation Station (AWS) Network including Communication System for Preparation of Landslide EWS (Procurement of Equipment)

To observe the accurate meteorological condition taking into consideration the current distribution of AWS Network, particularly for the warning of landslide disaster, AWSs shall be installed at the following locations:

- Haveli, Poonch, Hattian, Bagh, Muzaffarabad, Sudhnoti, Abbottabad, Haripur, Swat, and Mansehra

Table 5.2.24 Expansion of Automatic Weather Observation System Station (AWS) Network

No.	Description	Qty.	Remarks
1	Automatic Weather Station	28	10/28 for vulnerable points of landslide 10/28 for vulnerable points of drought 8/28 for vulnerable points of cyclone
2	Data Communication System	1	Between Stations and PMD office
Estimated Cost		Rs. 100,000,000	
Main Responsible Agencies		PMD	

Source: JICA Expert Team

Regarding human resources development activities (training and educational activities), the adjustment, test drive, and initial O&M guidance at the installation shall be conducted in parallel with the installation works.

5.2.6 Cyclone and Storm Surge

1) Expansion of AWS Network including Communication System (Duplication: such as Drought and Landslide), (Procurement of Equipment)

As shown in Subsection 5.2.5, the present AWS Network shall be expanded in consideration of the enhancement of the Cyclone EWS. Eight (8) AWS s shall be installed at the locations given in the following table.

Table 5.2.25 Candidate Locations for New AWSs in consideration of the Enhancement of Cyclone EWS

Province	Candidate Location
Sindh	Virawah, Keti Bandar, Naka Kharari
Balochistan	Khandewari (Brar), Aghore, Ormara, Makola, Kappar

Source: JICA Expert Team

The description and rough cost estimate for the expansion of AWS network are shown in Table 5.2.24, collectively.

2) Establishment of Tide Level Monitoring Network including Data Communication System shared with other EWSs (Duplication: such as Tsunami), (Procurement of Equipment)

As shown in Subsection 5.2.2, new tide level stations should be installed at two (2) locations (Jiwani and Pasni) for storm surge observation due to cyclone as well as tsunami observation. The description and rough cost estimate for the establishment of the tide level monitoring network is shown in Table 5.2.3.

3) Replacement of Existing Karachi Meteorological Radar Station including Data Communication System shared with Other EWSs (Duplication: such as River Flood), (Procurement of Equipment and Facility Construction)

Due to expiry of the durable years of the existing Karachi Meteorological Radar, the need to adopt new technology for multiple observation and reliable operation, and to solve the problem on the non-availability of spare parts, the old meteorological radar systems needs to be replaced with Doppler technology for the continuation of PMD's activities in flood forecasting. Instead of Karachi, new meteorological radar systems need to be installed in the Pasni/Gwadar and Karachi/Badin/Thatta areas. The description and rough cost estimate for the replacement of the existing Karachi Meteorological Radar Station is shown in Table 5.2.10.

4) Finalization of SOP of Cyclone EWS (Study and Technical Cooperation)

Taking into account the new radar and AWS network systems, the SOP of Cyclone EWS should be updated.

Table 5.2.26 Description and Rough Cost Estimate for Finalization of SOP of Cyclone EWS

No.	Description	Qty.	Remarks
1	Capacity Development of PMD	1	With outlook of cyclone track forecast
2	Improvement and Finalization of Draft SOP.	1	With the utilization of new radar systems
3	Improvement of Dissemination System	1	In association with PDMAs
Estimated Cost		Rs. 20,000,000	
Main Responsible Agencies		PMD	
Related Agencies		NDMA, PDMA-Sindh, PDMA-Balochistan and DDMAs	

Source: JICA Expert Team

This project mainly consists of the capacity development activities with the following concepts:

Project Purpose: Strategic strengthening of country's cyclone early warning system is improve to ensure safer evacuation and return to livelihoods of the affected population.

Outputs of the Program: (1) Capacities of PMD with related agencies are augmented enough to forecast flood and prepare hazard maps for flood and geo-hazards, and (2) Capacity of PMD's staff is strengthened enough to deliver the cyclone EW in association with national and local disaster management authorities.

5.2.7 Drought

1) Establishment of Agro-Meteorological Advisory Service (AAS), (Procurement of Equipment with Capacity Development)

An Agro-meteorological Advisory Service (AAS) should be commenced to contribute to the increase of agricultural production through provision of specialized agro-meteorological information. For the AAS, an Agrometeorological Data Processing & Analysis System shall be procured and installed. Cost estimates are shown in the table below.

Table 5.2.27 Description and Rough Cost Estimate for Agro-Meteorological Advisory Service (AAS)

No.	Description	Qty.	Remarks
1	Agro-meteorological Data Processing and Analysis System	1	Duplicated in Table 5.2.30
Estimated Cost		Rs. 37,000,000	
Main Responsible Agencies		PMD	

Source: JICA Expert Team

The establishment shall include not only the procurement services but also the human resources development activities to focus the training and education of PMD staff on the improvement of agro-meteorological forecasting through knowledge on utilization (operation and maintenance) of software to be installed. The concepts of this project from the capacity development aspects are as follows:

Project Purpose: Strategic strengthening of the country's agro-meteorological advisory service is established to ensure minimizing the agricultural damage and return of the livelihoods of the affected population.

Outputs of the Program: (1) Capacities of PMD are augmented enough to deliver the agro-meteorological advisory, and (2) Knowledge platform is established for the adjustment, test drive, and initial O&M guidance of equipment/facilities.

2) Expansion of Automatic Weather Observation Network including Communication System for Drought Monitoring (Duplication: such as Cyclone/Storm Surge and Landslide), (Procurement of Equipment)

As shown in Subsections 5.2.5 and 5.2.6, the present AWS network shall be expanded in consideration of the enhancement of the drought advisory system as well as the cyclone and landslide EWSs. Ten (10) AWSs shall be installed at locations shown in the following table.

Table 5.2.28 Candidate Locations for New AWSs in Consideration of the Enhancement of Drought EWS

Province	Candidate Location
Balochistan	Punjgar, Awaran (Mir Hasan), Khuzdar, Chagai, Kharan, Kohlu, Musakhel, Dera Bugti, Nashki
Sindh	Qamber-shardahkot

Source: JICA Expert Team

The description and rough cost estimate for the expansion of AWS network are shown in Table 5.2.24, collectively.

5.2.8 Weather Information

1) Duplicated Projects and Programs for the Improvement of Weather Forecasting Capacity

Most of the projects and programs proposed in previous subsections are also useful and effective for the enhancement and strengthening of weather forecast capacity. The followings are duplicated with the enhancement and strengthening of weather forecast capacity.

Table 5.2.29 Duplicated Projects/Programs for the Enhancement and Strengthening of Weather Forecast Capacity

Table No.	Candidate Location
Table 5.2.5	Replacement of Islamabad Meteorological Radar
Table 5.2.8	Replacement of Islamabad Meteorological Radar
Table 5.2.9	Replacement of D. I. Khan and Rahim Yar Khan Meteorological Radars
Table 5.2.10	Establishment of Pasni/Gwadar and Karachi/Badin/Thatta Meteorological Radars for Coastal Area
Table 5.2.11	Establishment of Cherat and Chitral Meteorological Radars for KP
Table 5.2.12	Establishment of Quetta Meteorological Radars for Balochistan
Table 5.2.13	Establishment of Sukkar and D. G. Khan Meteorological Radars
Table 5.2.16	Establishment of Rainfall and Water Level Observation Network
Table 5.2.17	Establishment of Upper Air Observation Stations

Source: JICA Expert Team

2) Establishment of Specialized Medium Range Forecasting Centre (SMRFC), (Procurement of Equipment with Capacity Development)

As explained in Subsection 5.2.1, PMD’s original proposal for the establishment of SMRFC will contribute to the improvement of the accuracy of weather forecasting. Based on PMD’s original plan, the items and facilities to be installed in this SMRFC Project are listed together with cost estimates in the table below.

Table 5.2.30 Original Description and Rough Cost Estimate for Establishment of SMRFC

No.	Description	Qty.	Remarks
1	Meteorological Data Processing, Analyzing Forecasting System with main frame computer	1	
2	Forecast Support System with Plotting Apparatus by main frame computer	1	
3	GTS Message Switching System	1	Duplicated in Table 5.2.5
4	Agro-meteorological Data Processing and Analysis System	1	Duplicated in Table 5.2.27
5	Upper Air Observation System	2	Partly duplicated in Table 5.2.17
6	Mobile X Band Meteorological Radar	1	
7	NOAA HRPT Receiving System	1	250m mesh, Islamabad Duplicated in Table 5.2.18
8	Meteorological Information Dissemination System	1	Duplicated in Table 5.2.36
9	Weather Information Broadcasting Program Production System	1	Duplicated in Table 5.2.42 Duplicated in Table 5.2.37
10	Environmental Monitoring System	2	
11	Meteorological Products Display System	2	
12	Network Management System	1	
13	Data Communication System	2	
Estimated Cost for Facilities		Rs. 682,000,000	
Training and Capacity Development		Rs. 100,000,000 (Duplicated in Table 5.2.42)	
Grand Total		Rs. 772,000,000	
Operation and Maintenance Cost		Rs. 11,800,000 /year incl. staff salary & allowance	
Main Responsible Agencies		PMD	

Source: JICA Expert Team

As indicated in the Remark section of the table above, some items are duplicated for other disasters.

Regarding capacity development, the enhancement of forecasting abilities is conducted in line with the series of procurements of facilities and equipment. In particular, the improvement of numerical weather products is one of the main objectives of capacity development to properly and timely forecast general meteorological disasters. The concepts of this project from the capacity development aspects are as follows:

Project Purpose: (1) Strategic strengthening of country's early warning systems is achieved to ensure the safety of human lives and return of the livelihoods of the affected population. This also includes timely sharing of meteorological data to be observed by new equipment procured, and (2) Communication and information service between PMD and local community people is augmented through radio broadcasting networks by well-trained PMD staff.

Outputs of the Program: (1) Capacities of PMD are augmented enough to forecast weather in advance of likely occurrence of actual disasters, (2) Knowledge platform is created for the adjustment, test drive, and initial O&M guidance of equipment/facilities, and (3) Capacities of

PMD staff with related agencies are strengthened enough to communicate weather information, early warnings and disaster education programs.

3) Additional Installation of AWS for the Observation of Basic Meteorological Data

In addition to "Expansion of AWS Network including Communication System" for Cyclones, Droughts and Landslides, further AWS shall be installed in high risk districts as shown in Section 3).

Table 5.2.31 Additional Installation of AWS for the Observation of Basic Meteorological Data

No.	Description	Qty.	Remarks
1	Automatic Weather Station	25	In Very High and/or High Risk Districts shown in Draft NDMP
2	Data Communication System	1	
Estimated Cost		Rs. 100,000,000	
Main Responsible Agencies		PMD	

Source: JICA Expert Team

Regarding human resources development activities (training and educational activities), the adjustment, test drive, and initial O&M guidance at the installation shall be conducted in parallel with the installation works.

5.2.9 Other Disasters and Considerations

1) Glacial Lake Outburst Flood (GLOF), Snowmelt Flash Flood and Landslides in Gilgit-Baltistan (GB) and Khyber Pakhtunkhwa (KP)

a. Early Warning System for GLOF in GB and KP including Preparation of Hazard Maps (Study and Procurement of Equipment with Capacity Development)

i) Establishment of GLOF Sensing System

The sensing system detects the occurrence of a GLOF and transmits relevant information to the transmitter station to initiate the warning process. Hence, several water level sensors shall be installed at the immediate downstream of the lake outlet in river channels identified as dangerous lakes or natural dams. The sensors are to be connected by armoured and shielded cables to a transmitter station located at a higher elevation within an allowable distance from the sensors. In the event of a GLOF, the system shall detect and immediately relay the information. The information is to be received by all warning stations located downstream within a few minutes of initiation of the flood. It is recommended that the warning system shall be fully automated and redundant requiring no human intervention.

In the system, one or several remote station(s) at suitable beneficial town(s)/ village(s) shall be established. Such remote station(s) shall have the dual function of forming part of the GLOF sensing system and providing local warning to the residents at the target town(s)/village(s).

ii) Establishment of GLOF Warning System

In the project, GLOF sensing stations and remote station(s) to be established and relay stations to be required are installed at designated locations as explained above. In addition, a meteor-burst or equivalent transmission system master station shall be set up to provide a communication link between each remote station and the system monitoring station at a designated location.

The GLOF warning systems shall be based on appropriate radio technology (such as VHF or equivalent transmission system). Each beneficiary town/village shall have a suitable communication unit (such as transceiver or equivalent). The master station should have multi-receiver antennas and one or more transmitter antenna(s).

iii) Description and Rough Cost Estimate for the Establishment of the System

Items of the EWS for GLOFs and snowmelt flash floods with related disasters (landslides) and enhancement of research activities for snow/glacier/glacial lakes in GB and KP to be installed and prepared are as shown in the table below.

Table 5.2.32 Description and Rough Cost Estimate for Establishment of Early Warning System for GLOF including Preparation of Hazard Maps

No.	Description	Qty	Remarks
1	Automatic Water Level Station	25	For 5 glacier lakes
2	Observation Data Archiving System	1	
3	Observation Data Processing System	1	
4	Data Display System	3	PMD H/O & Regional Office, NDMA
5	Warning Post	30	
6	Data Communication System	1	
7	Data Control System	2	Including Backup System
Estimated Procurement Cost		Rs. 270,000,000	
Preparation of Hazard Map		Rs. 150,000,000 (including Capacity Development)	
Total Estimated Cost		Rs. 420,000,000	
Main Responsible Agencies		PMD	
Related Agencies		PDMA-KP, GBDMA-GB, related DDMAs	

Source: JICA Expert Team

iv) Capacity Development Activities

As described in Table 5.2.32 mentioned above, capacity development activities are undertaken to ensure operations and maintenance of the system, including the support of the preparation of hazard maps. The capacity development activities are conducted with the following policies.

Project Purpose: (1) Strategic strengthening of GLOF early warning system (FEWS) in northern Pakistan is established to ensure safe evacuation by the affected population. This also includes timely sharing of water level data in targeted glacial lakes, and (2) GLOF risk and hazard maps are developed and presented at the community level.

Outputs of the Program: (1) Capacities of PMD with related agencies are augmented enough to forecast GLOF and prepare hazard maps for GLOF, (2) Knowledge Platforms for Sharing Transboundary Data and Community GLOF Risk Information are established, and (3) Capacity of PMD's staff is strengthened enough to develop GLOF Forecasting and Hazard Mapping through training courses in Pakistan and foreign countries.

b. Enhancement of Research Activities for Snow/Glacier/Glacial Lakes including GLOF data acquisition and archiving system (Technical Cooperation and Procurement of Equipment with Capacity Development)

This program is mainly composed of research and capacity development activities to grasp the climate change and analyze the glaciers and glacial lakes in Pakistan. The following activities are conducted with the enhancement and strengthening of capabilities of PMD staff.

i) Accumulation of Trends of Glacier in GB

High-resolution satellite images in GB are obtained quarterly or more for the following activities:

- Seasonal Variation of Glacier Extension
- Annual Variation of Glacier Extension (Retreat)
- Existence and Dimension of Glacial Lakes
- Existence and Dimension of Natural Dams
- Amount of Annual Snowfall

ii) Preparation and Updating of Hazard Maps for GLOF

Based on the results of analysis of high-resolution satellite imageries, the hazard maps for each dangerous lake and dam are established and reviewed every year.

iii) Establishment of Meteorological Stations on the Ground

In the Snow and Ice Hydrology Project Phases I and II, a total of 22 weather observation stations are being operated to observe the snow water equivalent and other related meteorological data in mountain areas in GB. These observation systems should be expanded to formulate more accurate GLOF warning for other related disasters, such as landslides and avalanches.

iv) Description and Rough Cost Estimate for the Establishment of the System

Items of the Enhancement of Research Activities for Snow/Glacier/Glacial Lakes in GB and KP to be installed and prepared are given in the table below.

Table 5.2.33 Description and Rough Cost Estimated for Enhancement of Research Activities for Snow/Glacier/Glacial Lakes in GB and KP

No.	Description	Qty.	Remarks
1	Automatic Weather Station	22	Including snowfall observation system
2	Observation Data Archiving System	1	At PMD and related agency offices
3	Observation Data Processing System	1	At PMD and related agency offices
4	Data Communication System	1	Between PMD and stations
5	Data Control System	1	At PMD head quarter office
Estimated Procurement Cost		Rs. 200,000,000	
1	Accumulation of Trends of Glacier in GB	1	GLOF records and trend study
2	Preparation and Update of Hazard Map for GLOF	1	In association with Survey of Pakistan
Estimated Technical Cooperation Cost		Rs. 120,000,000 (with Capacity Development)	
Total Estimated Cost		Rs. 320,000,000	
Main Responsible Agencies		PMD	
Related Agency		Global Change Impact Studies Centre (GCISC)	

Source: JICA Expert Team

2) Dissemination System Improvement

a. Establishment of Communication System between NDMA and PMD

Real-time communication system between NDMA and PMD consists of the system and cost shown in the table below.

Table 5.2.34 Description and Rough Cost Estimate for Establishment of Dissemination System between NDMA and PMD

No.	Description	Qty.	Remarks
1	VPN Communication through Internet	1	For internal communication system in PMD
2	Network for Intranet connection	1	Between PMD and NDMA
3	Computer Server for Data Acquisition and Analysis	1	Fault-Tolerant (FT)+Cluster: Triple Redundancy System with software
Estimated Cost		Rs. 50,000,000	
Main Responsible Agencies		PMD and NDMA	

Source: JICA Expert Team

Regarding human resources development activities (training and educational activities) for this project, the adjustment, test drive, and initial O&M guidance at the installation shall be conducted.

b. Establishment of Communication System among NDMA, F/G/S/PDMAs and DDMAs

As explained in Subsection 4.2.33), VNP communication between NDMA and PDMAs with four (4) district governments will be established in the near future as a pilot project. These communication systems shall at least be expanded at least with fifty (50) priority districts (DDMAs) vulnerable to disasters.

Table 5.2.35 Description and Rough Cost Estimate for Establishment of Communication System among NDMA, F/G/S/PDMAs and DDMAs

No.	Description	Qty	Remarks
1	VPN Communication through Internet	50	For 50 DDMAs vulnerable to disasters
Estimated Cost		Rs. 100,000,000	
Main Responsible Agencies		PMD and NDMA	

Source: JICA Expert Team

c. Establishment of Radio Communication System between PMD and Communities

Currently, the communication modes between PMD and the Communities have been established by traditional ways, such as land phones, fax, cellular phones or direct verbal communications through DDMAs, SMS messaging alerts directly to subscribers (mainly for national and local government officers) and a broadcasting system through TV and/or radio networks.

PMD has already established the SMS warning alert system for the tsunami warning system by NTWC and river flood warning system by FFD. In addition, PMD has also planned the SMS message warning system for weather forecasts and warnings by the NWFC in cooperation with WFO. In this connection, no project adopting SMS is applied for this Plan.

As shown in Section 4.2.3, the project for the establishment of the radio broadcasting network, especially utilization of the local FM radio networks of which the system includes the communication tools and equipment between PMD and local FM stations in vulnerable districts, shall be proposed.

Table 5.2.36 Description and Rough Cost Estimate for Establishment of Radio Communication System between PMD and Communities

No.	Description	Qty	Remarks
1	FM Radio Communication System	1 L.S	For vulnerable districts to disasters
Estimated Cost		Rs. 25,000,000	
Main Responsible Agencies		PMD	

Source: JICA Expert Team

Regarding human resources development activities (training and educational activities), the adjustment, test drive, and initial O&M guidance at the installation shall be conducted in parallel with the installation works.

d. The Preparation of Weather Information Broadcasting Program

To broadcast quicker weather information as well as early warning dissemination, PMD shall product weather information and early warning program by itself. In addition, the activities on site are one of the essential methods for the DRM education and public awareness regarding early warning. As well, the broadcasting of early warning education programs through TV and radio are also effective approaches so that the people who are living in vulnerable areas can acquire the knowledge and learn early warning, evacuation places and preparedness activities against impending disasters. The electronic media shall be utilized for not only early warning dissemination but also broadcasts of education programs of DRM. In this connection, the weather information broadcasting program shall be prepared and installed in PMD head office.

Table 5.2.37 Description and Rough Cost Estimate for Preparation of Weather Information Broadcasting Program

No.	Description	Q'ty	Remarks
1	Weather Information Broadcasting Program	1 L.S	
Estimated Cost		Rs. 60,000,000	
Main Responsible Agencies		PMD	
Related Agencies		M/O Information & Broadcasting	

Source: JICA Expert Team

3) Development of the EWS National Plan, Guidelines and SOPs for Health Emergency Preparedness and Response (HEPR)

In addition to the setup of EWS against natural disasters, the establishment of an EWS for disease is one of the key issues for NDMA.

As of 2010, the NDMA has conducted a series of projects for the establishment of a disease early warning system at the community level in collaboration with the WHO. This Disease EWS Project aims at the establishment of the Disease EWS and the warning transfer system at the community level in 95 prioritized districts. This Multi-Hazard EWS Plan shall further consider this Disease EWS Project as one of the priority projects of the NDMA.

In the wake of the establishment of Disease EWS, a “One Million Safe Hospitals and Schools Campaign” has been initiated since November 2011 in line with the series of supporting the Global Safe Hospital Initiative activities by NDMA and F/G/S/PDMAs in collaboration with WHO. The chain of these activities against disease epidemics by NDMA shall be adopted in the Plan as one of the essential issues.

Table 5.2.38 Description and Rough Cost Estimate for Development of the EWS National Plan, Guidelines and SOPs for HEPR

No.	Description	Q’ty	Remarks
1	Development of the EWS National Plan, Guidelines and SOPs for HEPR	1 L.S	In line with “One UN Program” including Development of policy, legal/institutional arrangements, HEMIS, contingency plan(s),
Estimated Cost		To be considered by NDMA	
Main Responsible Agencies		NDMA, F/G/S/PDMAs and DDMAs	
Relted Agencies		NHEPRN	

Source: JICA Expert Team

All these activities shall be considered with CBDRM activities. Regarding human resources development activities (training and educational activities) for this project, the adjustment, test drive, and initial O&M guidance at the installation shall be conducted.

5.2.10 Capacity Development/Building of PMD, GSP and DMA Officials in Multi-Hazard EWS

1) Capacity Development/Building of PMD

a. General

It is essential to develop the capacity of PMD for not only the appropriate operation and management of the improved early warning systems against disasters but also the improvement of forecasts and warnings activities, quicker and more accurate warning processes and communications. There are two (2) approaches to enhance the capacity of PMD in terms of human resources development, as discussed below.

i) Capacity Development Activities for each Proposed Program and Project

In this Section 5.2, a number of programs and projects are proposed to improve and enhance the early warning capacity for the alleviation of damage due to disasters. These are explained with items and systems to be required as shown from Table 5.2.3 to Table 5.2.33. The contents for capacity development activities attached with the programs or projects previously proposed are as described in the table below.

Table 5.2.39 Capacity Development Activities Required with Proposed Programs and Projects

Target Disaster	Name of Programs / Projects	Contents of Capacity Development
Tsunami	Training on Tsunami Simulation and Preparation of Hazard Maps	The related agencies (counterpart agencies) acquire knowledge on the preparation of tsunami hazard maps and methodology of tsunami simulation.
River Flood	Strengthening of Flood Warning and Management Capacity	New technologies utilizing satellite data for obtaining rainfall data and calculating runoff discharge are applied in this Project. Methodologies for these systems shall be transferred to the staff of PMD in the Project.
Flash Flood	Establishment of LFFFC including Flash Flood Forecasting and Warning System	In this project, LFFFCs are established in each location vulnerable to flash floods with the warning system. It is necessary for the staff of PMD to be assigned to know the warning system. The methodology of preparation of hazard maps shall also be transferred.
	Preparation of Hazard Map	
Landslide	Preparation of Hazard Map	The methodology of the preparation of hazard maps and warning systems shall be transferred to the staff of related agencies.
	Establishment of Landslide EWS	
GLOF	EWS for GLOF	It is necessary for the staff of PMD to be assigned to know the mechanisms of the warning system. The methodology of preparation of hazard maps shall also be transferred.
	Research Activities for Snow/Glacier/Glacial Lakes	The capacity of officials and staff of agencies related to research on glaciers (NDMA, PMD, WAPDA and Suparco) shall be enhanced and strengthened.
Weather Information	Establishment of SMRFC	Methodologies of numerical forecast and general weather information utilizing new facilities shall be enhanced.

Source: JICA Expert Team

In addition to the capacity development activities tabulated above, each project shall include the adjustment, test drive, and initial O&M guidance at the installation. It is recommended that the capacity development activities for every program and project shall be conducted as extensively as possible, because the updated forecasting and predicting technologies utilizing all accumulated technologies and knowledge in terms of scientific and engineering progress are imperative for a better EWS system.

All the costs for the capacity development regarding proposed projects and programs are inclusive of the cost indicated in each related table.

ii) Education Program for Advanced Meteorology and Hydrology

Besides the capacity development activities for independent Programs or projects to be implemented, basic upgrading and improvement of the staff of PMD is essential to improve the EWS against disasters. It is required that the number of qualified personnel of the PMD shall be augmented for meticulous warning activities. In this connection, capacity building and development of PMD officials in drought forecasting and hydro-meteorology should be executed. For this purpose, higher educational trainings and programs shall be enhanced. The selected staff of PMD shall join and receive the trainings and programs shown in the following table.

Table 5.2.40 Capacity Development Activities of the PMD by Higher Education

Required Course of Education	M/S Course	PhD Course
Numerical Weather Prediction / Forecast	5	2
Hydrometeorology/Hydrology	10	3
GIS/Remote Sensing	5	-
Glacier Monitoring/Snow Melting	5	1
Climate Change/Monitoring	5	1
Total	30	7

Source: JICA Expert Team in consultation with PMD, FFC and NDMA

Table 5.2.41 Description and Rough Cost Estimate for Acquirement of Advanced Meteorology and Hydrology

No.	Description	Qty.	Remarks
1	M/S Course	30	
3	Ph D Course	7	
Estimated Cost		Rs. 370,000,000	
Main Responsible Agencies		PMD	

Source: JICA Expert Team

iii) Establishment of Weather Forecast Guidance System

(1) Introduction of Non-Hydrostatic Model

PMD has conducted the NWP using the HRM with a grid length of 11km developed by DWD. However, it is very difficult to further modify the model to make it consistent with actual weather phenomena because the existing model is hydrostatic and cannot be revised to a non-hydrostatic model by PMD staff. In addition, the computer processor capacity is too limited to extend the calculation time or to adopt the non-hydrostatic models such as WRF and JMA Models. Therefore, it is required to renew and add computer processor systems with capacity development activities to effectively use the NWP system.

As a result, the improvement of the initial condition of the model augments the accuracy of NWP. For the improvement of the initial condition of the model, the local observation data such as the data from WPR and AWS needs to be improved into the model to carry out objective analysis and an initialization method for the observation data.

(2) Introduction of Weather Guidance

For the forecasters of PMD, the time is too limited and insufficient to forecast weather and warn of impending disasters from the plethora of NWP results and actual observation data. In this connection, a weather forecast guidance system shall be introduced and established using the MOS (Model Output Statistics) Method.

MOS refers to the materials obtained by statistically processing NWP results. At first, it is required to accumulate the NWP results and actual meteorological data (such as rainfall data) for at least 1~2 years. Then, statistic relational expression(s) between NWP results as explaining variables (predictor variables) and actual meteorological data observed as objective variables (criterion variables) are prepared. The NWP results can be translated to weather forecasts or early warnings by multiple regression correlation expressions. Based on this MOS method, the new weather forecast guidance system is to be established. PMD could carry out the changeover from qualitative to quantitative weather forecasts.

When the model is changed, the regression equation should be newly produced due to statistical particularity. The reproduction of the regression equation is a troublesome job.

Therefore, training on a calculation method such as the Kalman Filter should be introduced to automatically change the coefficients of the multi regression equation.

Table 5.2.42 Description and Rough Cost Estimate for Establishment of Weather Forecast Guidance System

No.	Description	Qty.	Remarks
1	Introduction and Adjustment of Non-Hydrostatic Model	1 L.S.	
2	Production of Guidance (Multiple Regression Equation) with GPV and Rainfall	1 L.S.	
3	Taking Observation Data into the Model	1 L.S.	
4	Verification and Analysis of Test Operation	1 L.S.	
5	Collection of coefficients for multi-regression equations with Kalman Filter	1 L.S.	
Estimated Cost		Rs. 100,000,000	
Main Responsible Agencies		PMD	

Source: JICA Expert Team

b. Integrated Targets to be Achieved During Next 10 Years

Through the capacity development activities mentioned above, the goals are described below:

i) Classified Staff

During the next 10 years, the number of qualified staff will be increased in parallel with the augmentation of early warning capacities as follows:

Table 5.2.43 The Number of Staff Classification of PMD

No.	Classification	No. of Staff	
		Current	Targeted
1-1	Meteorologist (Senior Level)	64	80
1-2	Meteorologist (Mid Level)	160	200
1-3	Meteorologist (Jr. Level)	112	150
2-1	Engineering Cadre (Electrical, Mechanical) (Senior Level)	15	40
2-2	Engineering Cadre (Electrical, Mechanical) (Mid Level)	42	70
2-3	Engineering Cadre (Electrical, Mechanical) (Jr. Level)	42	70
3	Meteorological Technician	360	400
4	Hydrologist	30	60
5	Hydrological Technician	65	100

Source: JICA Expert Team in consultation with PMD

ii) Forecast Capacities

Based on the improvement of PMD staff's capacity, the specific augmentations of forecast abilities are as follows:

Table 5.2.44 Capacity Development Targets through Capacity Development Activities

Target Disaster	Current Abilities	Expectations in the Future
Tsunami	Only early waning activities	• More accurate early warning • Acquirement of Preparation of Hazard Maps • Provision of Hazard Maps
River Flood	Provision of Flood EW from Lahore and Islamabad Early warning without hydrometorological data outside the country	• Provision of Flood EW from Lahore, Islamabad, Peshawar, Quetta and Karachi • Flood Forecasts based on not only internal data but also data outside the country utilizing satellite and GTS
Flash Flood	General Broad Flash Flood Warning Limited Flash Flood Hazard Maps (Only Lai Nullah Basin)	• Provision of Flash Flood EWS at more than 10 vulnerable locations • Acquirement of Preparation of Hazard Maps • Provision of Hazard Maps
Landslide	General Landslide Warning	• Establishment of Landslide EWS at Designated Locations
GLOF and Avalanche	No constant watching of GLOF General Avalanche Warning	• Establishment of GLOF EWS • More accurate EW for Avalanche
Weather Information	<u>Duration</u> Ordinary: 1~2days (Max. 3days) <u>Forecast Method</u> Qualitative Method (Such as Heavy, Strong, Moderate….)	<u>Duration</u> • Weekly Forecast will be available <u>Forecast Method</u> • Expansion of Available Areas of Very-Short Time Forecasts • Establishment of Quantitative Forecasts (Such as 200mm/day, 30m/s, 1m in depth, etc.) <u>Others</u> • More Detailed Prehension of Climate Change

Source: JICA Expert Team

2) Capacity Development / Building of GSP

As shown in Table 5.1.1 and Table 5.1.2, GSP (Geological Survey of Pakistan) is one of the focal agencies to establish appropriate multi-hazard EWS through technical support. In this regard, early warnings, alerts and orders/instructions shall be enhanced by the effective hazard maps against targeted disaster(s) to be prepared by GSP. In this connection, the capacity of the focal staff of GSP shall be enhanced and strengthened in terms of the preparation of hazard maps and the establishment of landslide EWS.

The costs of these activities are inclusive of the estimated costs indicated in the projects, namely "Preparation of Landslide Hazard Maps based on the Topographical and Geological Points of View (Study and Preparation of Hazard Map with Capacity Development)" and "Establishment of Landslide EWS (Study with Capacity Development)" as shown in Table 5.2.22 and Table 5.2.23.

3) Capacity Development / Building of DMAs

a. NDMA

The NDMA shall undertake training and capacity building and also develop core competencies at the federal level and capacity in the provinces to tackle all kinds of disasters including developing its own capacity. For this purpose, the staff of NEOC and the F/G/S/PEOCs shall be enhanced and strengthened in terms of abilities and capacities on early warning systems. In particular, it is indispensable to maintain close communication between the federal, provincial, district and community levels and establish their communication structures including the mass media. To achieve this end, NDMA shall promote the enhancement of community enlightenment for the EWS. All these activities shall be executed together with comprehensive capacity development of the NDMA, taking into consideration the DRM system in the series of the implementation of "Human Resources Development Plan on Disaster Management" (HRDP) prepared together with this Multi-Hazard EWS Plan as Annexes of NDMP.

The cost of capacity development of NDMA shall include the individual costs of HRDP activities.

b. F/G/S/PDMAs and DDMAs

As explained immediately above in item a. "NDMA" in this section, F/G/S/PDMAs shall enhance and strengthen the staff of F/G/S/PEOCs regarding early warning systems. In addition to F/G/S/PDMAs, DDMAs shall also have responsibility for the establishment of communication systems between the federal, provincial, district and community levels. Furthermore, F/G/S/PDMAs and DDMAs are responsible agencies for dissemination and communication of early warning messages from PMD and/or NDMA to communities and citizens as quickly as possible. Hence, capacity development activities for targeted staff of F/G/S/PDMAs and DDMAs shall be involved in the proposed projects and programs as well as the activities of HRDP to be implemented in parallel with the activities of Multi-Hazard EWS.

The costs of capacity development of F/G/S/PDMAs and DDMAs shall be inclusive of the costs of the independent HRDP activities and allocated in each related proposed project/program.

4) Enhancement of Community Enlightenment for EWS

The activities on DRM education and public awareness shall be promoted and enhanced to grasp the phenomena and predictive information of disasters and acquire the knowledge for saving lives. Table 4.2.28 and Table 4.2.29 give examples on how to detect predictive information and to confirm the impending occurrence of disasters.

It is also proposed that dissemination/communication drills and practices are executed. In particular, the new EWS setups, such as those involving tsunamis and flash floods, shall be specifically considered. Provincial and district DRMPs have also stipulated periodical drills including early warning activities.

These activities are to be conducted perennially to maintain awareness of the hazards and risks in vulnerable areas.

Table 5.2.45 Description and Rough Cost Estimate for Establishment of Radio Communication System between PMD and Communities

No.	Description	Q'ty	Remarks
1	Enhancement of Community Enlightenment for EWS	1 L.S	Annually
2	Training and Drills	1 L.S	Annually
Estimated Cost		Rs. 20,000,000 / year	
		Rs. 200,000,000	

Source: JICA Expert Team

5.2.11 Summary of Integrated Multi-Hazard Early Warning Dissemination System

As Table 5.2.46 shows below, the total cost of all the projects and programs proposed would exceed Rs. 18 billion. The viability of these projects and programs shall be verified with prioritization and cost affordability as the fundamental conditions in Pakistan.

Table 5.2.46 List of Proposed Projects for the Multi-Hazard EWS Plan

Target Hazard	Project/Study Title	Cost (in million PKR)		
		Procurement Construction	Duplicate	Study/T.C. Capacity D.
Tsunami	Establishment of Tide Level Monitoring Network	10		
	Tsunami Simulation and Hazard Maps			200
	Upgrading of Global Telecommunication System (GTS)		22	
Earthquake	Seismic Intensity Reporting System w/ Data Communication System	180		
Weather Info. & Indus River Flood	Establishment of SMRFC	682		
	Expansion of AWS Network including Communication System	100		
	Additional Installation of AWS for the Observation of Basic Meteorological Data	100		
	Replacement of Existing Radar Stations	4,580		
	Islamabad Meteorological Radar	*980*		
	D. I. Khan and Rahim Yar Khan Meteorological Radars	*1,800*		
	Pasni/Gwadar and Karachi/Badin/Thatta forExisting Karachi	*1,800*		
	Establishment of new Meteorological Radar Stations	4,400		
	For Khyber Pakhtunkhwa Province (Cherat and Chitral)	*1,800*		
	For Sindh Province (Sukkar) and For Punjab Province (Dera Ghazi Khan)	*1,800*		
	For Balochistan Province (Quetta)	*800*		
	Establishment of Upper Air Observation Stations	309	206	
	For Peshawar and Chitral (Included in SMRFC)	*0*	*206*	
	For Lahore, Quetta and Karachi	*309*		
	Flood Forecasting by Satellite Info. and Hazard Maps of Indus River (UNESCO Project)			300
	Establishment of RFFWC	210		60
	For Khyber Pakhtunkhwa Province (Peshawar)	*70*		*20*
	For Balochistan Province (Quetta)	*70*		*20*
	For Sindh Province (Karachi)	*70*		*20*
	Expansion of Rainfall and Water Level Observation Network	250		
	Replacement of Satellite HRPT Data Information System		40	
Flash Flood	Establishment of LFFFC	2,500		800
	10 locations as priority projects will be selected from candidate sites,	*250x10*		*80x10*
	Finalization of Hazard Maps and CD against Local Flash Flood			100
	Expansion of Rainfall and Water Level Observation Network		320	
Landslide	Preparation of Landslide Hazard Maps			200
	Establishment of Landslide EWS			100
	Expansion of AWS Network including Communication System		100	
Cyclone Storm Surge	Expansion of AWS Network including Communication System		100	
	Establishment of Tide Level Monitoring Network		10	
	Replacement of Existing Radar Stations		1,800	
	Pasni/Gwadar and Karachi/Badin/Thatta forExisting Karachi		*1,800*	
	Finalization of SOP. of Cyclone EWS			20
Drought	Establishment of Agro-Meteorological Advisory Service (AAS)		37	
	Expansion of AWS Network including Communication System		100	
GLOF, etc.	EWS for GLOF and Snow Melt Flash Flood w/ Hazard Maps	270		150
	Research Activities for Snow/Glacier/Glacial Lakes in GB & KP			320
Dissemination	Communication System between PMD and NDMA/ F/G/S/PDMAs	50		
	Communication System among DMAs (NDMA- F/G/S/PDMAs -DDMAs)	100		
	Radio Communication System between PMD and Communities		20	
	Weather Information Broadcasting Program		60	
Capacity Development	Education Program for Meteo-Hydrology for PMD Staff			370
	Establishment of Weather Forecast Guidance System			100
	Enhancement of Community Enlightenment for EWS			200
	Development of the EWS National Plan, Guidelines and SOPs for Health Emergency Preparedness and Response (HEPR)			To be confirmed
Total		13,741		2,920

Source: JICA Expert Team

5.3 Prioritized Multi-Hazard EWS

5.3.1 Policy on the Prioritization of Proposed Components

For the Multi-Hazard EWS Plan, approximately 30 programs and/or projects including duplications have been selected, as described in Sections 5.1 and 5.2, based on the implementation policies prescribed in Section 2.1. These conceivable projects/Programs shall be prioritized taking into consideration the factors explained below.

1) Risk of Damage

As explained above, the appropriate EWS greatly contributes to the alleviation of damage due to disasters. It is expected that reducing the number of suffering people rather than the loss of infrastructures will be attributed to EWS. EWS(s) in higher risk areas shall be prioritized. All proposed Programs and projects enumerated in Sections 5.1 and 5.2 have been extracted based on the results of risk and issues analysis regarding current disaster and EWS conditions described in Chapter 3 and Chapter 4.

2) Fund Consideration

It is also important to adequately consider financial aspects in the formulation of the Multi-Hazard EWS Plan. Most of the proposed projects will be implemented by PMD in cooperation with NDMA, FFC and other related agencies. The following table shows the development budget approved for FFC and PMD in recent years.

Table 5.3.1 Implementation Budget Statement of FFC and PMD

Fiscal Year	FFC Budget for Normal/Emerging Flood Program (in million Rs.)	PMD Development Budget (in million Rs.)
2000 – 2001	200.000	---
2001 – 2002	58.025	---
2002 – 2003	45.174	---
2003 – 2004	350.000	---
2004 – 2005	500.000	90.302
2005 – 2006	797.200	184.481
2006 – 2007	947.219	259.371
2007 – 2008	1,381.840	467.066
2008 – 2009	859.971	662.716
2009 – 2010	575.110	88.003
2010 – 2011	740.798	165.136

Source: PMD

Judging from past experiences of PMD's project management, it is assumed that the maximum annual development budget to be considered should be set at Rs. 1,000 million a year. With this, the grand total cost of prioritized projects to be proposed is set at Rs. 7 billion for six (6) years (2012-2017). Therefore, the total estimated implementation cost of the proposed framework projects of over Rs. 15 billion for procurement and construction projects will be reduced based on the selection of prioritized projects.

On the other hand, most of the capacity development activities can be executed and pursued in parallel with prioritized project implementations since cost is minimal and their effectiveness is independently expressed.

3) Integrated Pakistan Government Policy and Regional Aspects

Inequitable geographic developments will generate some regional conflicts even though the development scheme will be based on proper risk assessment. Relevant regional development policies will also be considered to select the prioritized projects.

4) Urgent Programs and Projects for Immediate Implementation

As described in Chapter 2, the following projects and programs are highly prioritized:

- Projects and Programs for the Sustainability of the Current System
- Projects and Programs for the Establishment of the New EWS for High Hazard and Risk [same as "(a) Risk of Damage" in the subsection explained above]
- Proactive Adoption of Community-Based Programs

5.3.2 Policy on Implementation as the Short to Medium-term Projects of the Multi-Hazard Early Warning System Plan

As shown in Section 2.1 in Chapter 2, the implementation of the Multi-Hazard EWS Plan should be divided into two term plans (Short to Medium Plan and Long-term Plan) and potential projects (Super Long-term Projects) with due consideration of priority and policy. Urgent programs and projects to be implemented, which have already been identified in the preceding section, shall be further classified into Short to Medium-term and Long-term Projects/Programs.

The manner of term identification is as explained below.

1) EWS for Flood Damage Mitigation

According to historical disaster records in Pakistan referring to one of the factors of disaster risk consideration, the EWSs for floods is a higher priority than those for other disasters. In particular, the EWS against flash floods due to heavy rainfalls and poor drainage/nullah systems passing through built-up or high density property areas and the enhancement and strengthening of forecast capacity shall be established and conducted as the first priority.

According to the EM-DAT database, flooding is the most critical disaster of the natural disasters to be considered for the establishment of EWS. In particular, the flash floods originating from hill torrents and/or middle-small class river flows (nullahs) have caused a number of deaths and lots of citizens have suffered flash floods. Therefore, the establishment of flash flood EWS is a higher priority compared to other disasters followed by river floods, landslides, cyclones with storm surges, tsunamis and GLOFs/avalanches.

Table 5.3.2 Prioritization of Set-up of EWS for Each Disaster

Priority	Disaster
1	Flash Flood
2	River Flood
	Landslide by Rainfall
3	Drought
	Cyclone with Storm Surge
	Tsunami & Earthquake related Disaster
4	GLOF/Avalanche

However, the occurrences of GLOF and drought will increase and the strengths of each tropical cyclone will intensify due to climate change. Therefore, these disasters cannot be neglected when considering the prioritization.

2) Presence of F/S

Projects or Programs which require further F/S for the preliminary design and other clarification matters should be included in Long-term or Super Long-term plans since the projects cannot be completed within 2-3 years including the period for the F/S.

3) Rehabilitation/Replacement Projects for Short to Medium-term Plan

Rehabilitation and replacement projects are the most urgent projects to be contained in the Short to Medium-term Plan. Among the priority programs and projects, the restoration works for the damaged AWSs included in the "Strengthening of Flood Warning and Management Capacity by Utilizing Satellite Data including Flood Hazard Maps along the Indus Rivers" and "Replacement of Existing Meteorological Radar Stations" for existing aging radars are significant projects.

Regarding the "Replacement of Existing Meteorological Radar Stations", five (5) sites are proposed, namely; Islamabad, D.I. Khan, Rahimyar Khan, Pasni/Gwadar and Karachi/Badin/Thatta. These radar systems should be replaced or rehabilitated as soon as possible due to their aged condition (see Figure 3.1.2).

PMD has conducted emergency treatment works for their radar instruments including the Karachi Meteorological Radar with JICA assistance. However, these treatment works have not included fundamental solutions but have consisted of life-prolongation works. In particular, replacements of the Islamabad and Karachi radar systems are the most urgent activities from the aging point of view. In addition, Islamabad, Pasni/Gwadar and Karachi/Badin/Thatta are essential radar sites for the observation by radars covering areas of the Indus River Basin for accurate river flood forecasting and the coastal area for earlier cyclone observation and the determination of intensity.

The Islamabad radar system can be replaced without a detailed feasibility study because PMD has already prepared the site for construction in its head office and the staff have been assigned. Therefore, PMD can implement the replacement project for the Islamabad radar system with the preparation and approval of PC-1.

On the other hand, a feasibility study for the construction of Pasni/Gwadar and Karachi/Badin/Thatta radar is required to confirm the viabilities and other issues in terms of alternative studies on the site including the possibility of renewal of Karachi Radar, the availability of sites and staff, the study on a suitable height of the radar tower and radio wave propagation tests for data communication, etc. Preliminary evaluation has concluded that replacement of Karachi Radar is the most viable alternative among two (2) sites, namely Pasni/Gwadar and Karachi/Badin/Thatta as described in Chapter 4.

In view of the present setting of the Karachi radar located in PMD's premises in a sub-urban area of Karachi and adjacent to Karachi Airport, all relevant facilities including building, seismic/tsunami/cyclone laboratories are also present. There are no high-rise buildings in the vicinity. Also new radar at Badin/Thatta which is close to Karachi would require shifting of all the facilities and staff of Karachi premises to the new location which will not be feasible in terms of staff and budget availabilities. A final decision on this matter shall be based on separate comparative analysis and study.

Based on the current situations mentioned above, in particular taking into account the aging issue on radar systems of Islamabad and Karachi, the constructions of Islamabad and Karachi/Badin/Thatta are adopted in the Short to Medium Term Plan.

As for the replacement of the D.I. Khan and Rahimyar Khan radar systems, the equipment does not need to be replaced as soon as Islamabad and Karachi. Therefore, the priority of replacement of the D.I. Khan and Rahimyar Khan radar systems is lower than the priority of replacement of the Islamabad and Karachi radar systems (the installation of new Pasni/Gwadar and Karachi/Badin/Thatta radar).

However, the updating or modification of the data processing systems of these two radar systems at D.I.Khan and Rahimyar Khan is one of the matters requiring haste because they have not been digitized. The digitization of data obtained by the radar, and integration and unification of data from each meteorological radar station will help in the improvement of accuracy of weather information including general disaster warnings. Therefore, only the system modification of the D.I. Khan and Rahimyar Khan radars is adopted in the Short to Medium-term Plan together with the replacement of Islamabad Radar, provided that the PC-1 is prepared and approved.

Furthermore, the establishment of the Upper-Air Observation System utilizing SODARs/wind profilers is one of the rehabilitation/replacement projects required to properly observe upper-air conditions currently obtained by the deteriorated radiosonde observation system for the detection of locally concentrated downpour causing river and flash floods. Thus, the establishment of the upper-air observation system is also adopted in the Short to Medium-term Plan.

4) Projects and Programs Approved in PC-I and PC-II

Projects and Programs of which PC-I or PC-II has been already submitted or approved shall compose a part of the Short to Medium-term Plan. In this respect, the establishment of the Specialized Medium-Range Forecasting Centre (SMRFC) is a significant activity to enhance and strengthen the prediction of meteorological disasters by improving the accuracy of medium to long-term weather forecasts as explained in Subsections 5.2.1. PC-I of the SMRFC was approved by the Planning Commission (CDWP) on November 3, 2007. In addition, PC-I the establishment of meteorological radar at Cherat, which is expected to be highly effective in coverage for flash flood vulnerable areas including territories of FATA, is also being evaluated by the planning commission. Therefore, the establishment of the SMRFC and the establishment of Cherat Meteorological Radar are adopted in the Short to Medium-term Plan.

5) Projects and Programs being Prepared for Immediate Execution in Cooperation with Foreign Donors

Some projects proposed in Section 5.2 have already been supported or planned by expected executing agencies in cooperation with foreign donors or cooperation agencies. It is expected that the following projects or programs will be implemented in the near future:

- Strengthening of Flood Forecasting by Satellite Information and Hazard Maps of Indus River including Preparation of Flood Hazard Maps along the Indus River
- Strengthening Multi-Hazard and Disease Early Warning System and Warning Transfer at Community Level
- Establishment of Communication System between NDMA and PMD

The Pakistan 2010 flood caused tremendous damage in areas along the Indus River. To strengthen flood forecasting, the augmentation of flood simulation capacity in the Indus River Basin utilizing the latest updated hydro-meteorological observation and calculation system is thus an anxious issue in Pakistan. This project will contribute to the accurate risk identification of areas vulnerable to river floods and earlier and quicker warning activities are expected based on the river flood model to be prepared in the project.

On the other hand, it is essential to enhance the early warning transfer system at the community level not only for disease but also for other disasters as fundamental critical path for comprehensive establishment of the early warning communication system. Therefore, the NDMA has proposed strengthening of the multi-hazard and disease EWS.

Moreover, the NDMA has finally planned to construct building complexes including the National Institute of Disaster Management (NIDM) and the National Emergency Operation Centre (NEOC), with facilities to enhance their capacity and operation. In this regard, the establishment of a communication system between NDMA and PMD is indispensable as one of the basic facilities for the smooth operation of the NEOC.

The NEOC can provide related stakeholders with required data and information in real time to support the early warning and evacuation activities of the PMD and local governments and to manage emergency cases including rescue and relief activities. At present, however, the NEOC utilizes the original sources as well as data from PMD and other agencies without making any arrangements or integration of data.

It is necessary for NEOC to make smooth decisions to coordinate stakeholders against targeted disasters and provide related agencies with composite and arranged data based on the established communication system between NDMA and PMD. Three (3) projects are to be executed in the Short to Medium-term Plan, provided that the PC-1 is prepared and approved.

6) Programs and Projects to be included in the Short to Medium Term Plan

Taking into consideration the current status of each proposed project and the urgent needs described in the preceding paragraph, the following Programs and projects shall be included in the Short to Medium-term Plan.

Table 5.3.3 Projects and Programs in the Short to Medium-term Plan

Hazard	Types of Project	Title of Projects/Programs	Estimated Cost (in million Rs.)
General Meteorological Disasters	Procurement and Capacity Development	Establishment of Specialized Medium Range Forecasting Centre (SMRFC)	782 (including CD)
	Procurement	Establishment of Upper Air Observation System (at additional three (3) locations)	309
	Procurement and Construction	Replacement of Existing Meteorological Radar Stations at Islamabad with Updating of Data Modification system including Data Communication System	980
		Establishment of new Meteorological Radar Station at Cherat	900
Indus River Flood and Cyclone	Study and Software Application with Capacity Development	Strengthening of Flood Forecasting by Satellite Information and Hazard Maps of Indus River including Preparation of Flood Hazard Maps along the Indus River	300
Dissemination	System Improvement	Establishment of Communication System between NDMA and PMD	50
Disease	Study with Capacity Development	Development of the EWS National Plan, Guidelines and SOPs for Health Emergency Preparedness and Response (HEPR)	To be confirmed

Note : CD: Capacity Development Activities
Source: JICA Expert Team with PMD/FFC

5.3.3 Selection of Prioritized Projects

Through the initial discussions among PMD, FFC, NDMA and GSP with policies prescribed in Subsections 5.3.1 and 5.3.2, the prioritized projects to be implemented in the short to medium term or the long term have been identified. This initial set of projects for the Multi-Hazard EWS Plan will be discussed and scrutinized in detail throughout the project activities.

1) Improvement of EWS for Earthquake and Tsunami

Initially, four (4) priority projects/programs for earthquake and tsunami are lined up for implementation. Of these projects/programs, two (2) are adopted as priority projects as shown in the table below.

Table 5.3.4 Prioritized Projects and Programs for Earthquake and Tsunami

Project/Study Title (Implementing Agency)	Result of Adoption/No Adoption		Rough Cost to be included in Prioritized Projects (in million Rs.)
	Adoption in Prioritized Projects	Reason	
Establishment of Tide Level Monitoring Network (PMD)	Not Adopted	For the time being, network by 4 stations is acceptable.	-
Tsunami Simulation and Hazard Maps (PMD)	Adopted	High Risk (UNESCO has already conducted a project with preparation of hazard map for Gwadar.)	200
Upgrading of Global Telecommunication System (GTS) (PMD)	Adopted	Indispensable to obtain information on tsunami warning from foreign agencies	22 (duplicated in SMRFC)
Seismic Intensity Reporting System with Data Communication System (PMD)	Not Adopted	Contribution to Whole Pakistan but less contribution to Early Warning.	-

Source: JICA Expert Team

2) Improvement of Weather Information and EWS for Indus River Flood

Initially, nine (9) priority projects/programs are lined up for weather information and Indus River flood forecasting improvement. Of these projects/programs, those excluding the establishment of new meteorological radar stations are fully or partly adopted as priority projects as shown in the following table.

Table 5.3.5 Prioritized Projects and Programs for Weather Information and Indus River Flood

Project/Study Title (Implementing Agency)	Result of Adoption / No Adoption		Rough Cost to be included in Prioritized Projects (in million Rs.)
	Adoption in Prioritized Projects	Reason	
Establishment of SMRFC (PMD)	Adopted	Contribution to Whole Pakistan Contribution to other disasters	682 (duplicated in other EWS)
Expansion of AWS Network including Communication System (PMD)	Adopted	Contribution to Whole Pakistan Contribution to High risk of other disasters	100 (duplicated in other EWS)
Additional Installation of AWS for the Observation of Basic Meteorological Data (PMD)	Partly Adopted	Due to implementing Schedule Based on the detailed priority survey (F/S), several AWSs are installed	100
Replacement of Existing Radar Stations (PMD)			2,780 (duplicated in other EWS)
• *Islamabad Meteorological Radar*	Adopted	Replacement of Aging Facilities	*900*
• *D. I. Khan Meteorological Radar* • *Rahim Yar Khan Meteorological Radar*	Partly Adopted	Aging Facilities but radar body still can be utilized. Data Processing System adopted in prioritized projects	*80* *(To be evaluated)*
• *Pasni/Gwadar and Karachi/Badin/Thatta for Existing Karachi*	Adopted	Replacement of Aging Facilities, Expansion of Coverage by Radar Systems	*1,800*
Establishment of New Meteorological Radar Stations (PMD)			-
• *For Khyber Pakhtunkhwa Province (Cherat)*	Adopted	Contribution to Flash Flood Prone Area including FATA	900
• *For Khyber Pakhtunkhwa Province (Chitral)*	Not Adopted	Suitable Site to be clarified in F/S Operation and Maintenance Activities should be clarified.	
• *For Sindh Province (Sukkar)*	Not Adopted	Overlapping with Other Radar Systems (Karachi)	
• *For Balochistan Province (Quetta)*	Not Adopted	Suitable Site to be clarified in F/S Less frequency in use due to dry climate condition	
• *For Punjab Province (DG Khan)*	Not Adopted	Overlapping with Other Radar Systems (D. I. Khan)	
Establishment of (Additional) Upper Air Observation Stations (PMD)	Adopted	Upper air observation is fundamental to grasp the change in weather	309 +206 (partly duplicated in SMRFC)
Flood Forecasting by Satellite Info. and Hazard Maps of Indus Rivers (PMD with UNESCO)	Adopted	The augmentation of flood simulation capacity in the Indus River Basin is an anxious issue.	300
Establishment of RFFWC (PMD)	Adopted	Flood Forecasting Policy	270
Expansion of Rainfall and Water Level Observation Network (PMD)	Adopted	Contribution to Whole Pakistan	250 (duplicated in other EWS)
Replacement of Satellite HRPT Data Information System (PMD)	Adopted	Contribution to Whole Pakistan	40 (partly duplicated in SMRFC)

Source: JICA Expert Team

3) Flash Flood

Conceived are three (3) priority projects/programs for flash flood forecasting improvement. These projects/programs shall be selected mostly as prioritized projects except for half of the project for the establishment of LFFFC as shown in the table below.

Table 5.3.6 Prioritized Projects and Programs for Flash Flood

Project/Study Title (Implementing Agency)	Result of Adoption / No Adoption		Rough Cost to be included in Prioritized Projects (in million Rs.)
	Adoption in Prioritized Projects	Reason	
Establishment of LFFFC (PMD) *10 locations as priority projects will be selected from candidate site*	Partly Adopted	Due to time schedule and budget limitation, the highest priority five (5) locations are selected and implemented	1,650 *1,250 for project* + *400 for study*
Finalization of Hazard Map and CD Against Local Flash Flood (PMD)	Adopted	It is necessary to support the project for sustainability	100
Expansion of Rainfall and Water Level Observation Network (PMD)	Adopted	Contribution to Whole Pakistan	250 (duplicated in other EWSs)

Source: JICA Expert Team

4) Landslide

Landslide disasters have occurred all over the mountainous areas in Pakistan. Efforts to quickly and periodically disseminate hazard information and warnings are indispensable mandatory works for related agencies. However, the upgrading of weather forecast/information will also contribute to the mitigation of damage due to landslide disasters, together with the installation of AWS networks. In this connection, the preparation of landslide hazard maps and expansion of the AWS network including the communication system shall be included in the prioritized projects.

Table 5.3.7 Prioritized Projects and Programs for Landslide

Project/Study Title (Implementing Agency)	Result of Adoption / No Adoption		Rough Cost to be included in Prioritized Projects (in million Rs.)
	Adoption in Prioritized Projects	Reason	
Preparation of Landslide Hazard Maps (GSP)	Adopted	Preparation of Hazard Map is an essential task	200
Establishment of Landslide EWS (PMD)	Not Adopted	EWS should be established as PMD Policy	-
Expansion of AWS Network including Communication System (PMD)	Adopted	Contribution to Whole Pakistan; Contribution to high risk of other disasters	100 (duplicated in other EWSs)

Source: JICA Expert Team

5) Cyclone with Storm Surge

As prioritized projects, cyclone observation and the issuance of warning can be strengthened by means of radar and AWS facilities/equipment along the coastal areas in Pakistan together with the upgrading of the Cyclone SOP.

Table 5.3.8 Prioritized Projects and Programs for Cyclone with Storm Surge

Project/Study Title (Implementing Agency)	Result of Adoption / No Adoption		Rough Cost to be included in Prioritized Projects (in million Rs.)
	Adoption in Prioritized Projects	Reason	
Expansion of AWS Network including Communication System (PMD)	Adopted	Contribution to Whole Pakistan; Contribution to other disasters	100 (duplicated in other EWSs)
Establishment of Tide Level Monitoring Network (PMD)	Not Adopted	For the time being, a network of 4 stations is acceptable.	-
Replacement of Existing Radar Stations (PMD) • *Pasni/Gwadar and Karachi/ Badin/Thatta forExisting Karachi*	Adopted	Replacement of Aging Facilities	1,800 (duplicated in other EWSs)
Finalization of SOP for Cyclone EWS (PMD)	Adopted	The cyclone observation system should be strengthened.	20

Source: JICA Expert Team

6) Drought

The middle to long-range weather forecasting system can be improved with certain accuracy and enhancement of the drought monitoring system will not only contribute to the Drought EWS but also to the total strengthening of PMD's EWS capacity. Therefore, two (2) projects for the drought damage mitigation shall be proposed as prioritized projects.

Table 5.3.9 Prioritized Projects and Programs for Drought

Project/Study Title (Implementing Agency)	Result of Adoption / No Adoption		Rough Cost to be included in Prioritized Projects (in million Rs.)
	Adoption in Prioritized Projects	Reason	
Establishment of Agro-meteorological Advisory Service (AAS) (PMD)	Adopted	Contribution to Whole Pakistan; Contribution to other disasters	37 (duplicated in other EWSs)
Expansion of AWS Network including Communication System (PMD)	Adopted	Contribution to Whole Pakistan; Contribution to other disasters	100 (duplicated in other EWSs)

Source: JICA Expert Team

7) GLOF and Snowmelt Flash Flood

At present, the most considerable issues on GLOF and snowmelt flash floods are the consolidation of research, identification of current status and enhancement of observation on glacier phenomena in the northern parts taking climate change into consideration. In addition, the GLOF EWS projects should be also considered as prioritized projects.

Table 5.3.10 Prioritized Projects and Programs for GLOF and Snow Melt Flash Flood

Project/Study Title (Implementing Agency)	Result of Adoption/No Adoption		Rough Cost to be included in Prioritized Projects (in million Rs.)
	Adoption in Prioritized Projects	Reason	
EWS for GLOF and Snowmelt Flash Floods in GB with Hazard Maps (PMD)	Adopted	To be considered on ad-hoc basis	420
Research Activities for Snow/Glacier/ Glacial Lakes in GB (PMD)	Adopted	As fundamental activities, research should be augmented as Policy	320

Source: JICA Expert Team

8) Early Warning Dissemination System

The early warning dissemination system is one of the significant considerations for the proper operation of the NEOC in obtaining real-time information from early-warning agencies (especially PMD), such as seismic, meteorological and hydrological data as well as warning and alert messages and evacuation advisories. In this connection, the security of the communication system between NDMA and PMD should be ensured in the prioritized projects as vital foundation of the NDMA.

NDMA had conducted a pilot project to install a communication system utilizing the VPN system among NDMA, F/G/S/PDMAs (7 offices), and four selected district governments (DDMAs). These network systems should be expanded further to the whole of Pakistan. In addition, it is also essential to establish an appropriate dissemination system between DDMAs and communities, or directly release information from the central government. In this regard, a community-oriented transmission system for warning should be considered in the CBDRM, HRD (Human Resources Development on DRM) and training/drills activities.

Table 5.3.11 Prioritized Projects and Programs for Early Warning Dissemination System

Project/Study Title (Implementing Agency)	Result of Adoption / No Adoption		Rough Cost to be included in Prioritized Projects (in million Rs.)
	Adoption in Prioritized Projects	Reason	
Communication System between PMD and NDMA/ F/G/S/PDMAs (PMD/NDMA)	Adopted	Under process as a NDMA pilot project	50
Communication System among DMAs (NDMA- F/G/S/PDMAs -DDMAs)	Adopted	As fundamental activities, system should be augmented as Policy	100
Radio Communication System between PMD and Communities (PMD)	Adopted	As fundamental activities, system should be augmented as Policy	25 (duplicated in SMRFC)
Weather Information Broadcasting Program (PMD)	Adopted	As fundamental activities, system should be augmented as Policy	60 (duplicated in SMRFC)

Source: JICA Expert Team

9) Capacity Development and Other Activities

Capacity development activities in all sectors from government to local communities regarding EWS should be augmented as one of the prioritized projects. Regarding a project related to disease EWS, the establishment and enhancement of the EWS is still crucial as shown in Table 3.6.5.

Table 5.3.12 Prioritized Projects and Programs for Capacity Development Activities

Project/Study Title (Implementing Agency)	Result of Adoption/No Adoption		Rough Cost to be included in Prioritized Projects (in million Rs.)
	Adoption in Prioritized Projects	Reason	
Education Proramme for Meteo-Hydrology for PMD Staff (PMD)	Adopted	As fundamental activities, capacity of PMD staff should be augmented as Policy	370
Establishment of Weather Forecast Guidance System (PMD)	Adopted	As fundamental activities, capacity of PMD staff should be augmented for the accurate weather forecast & warnings	100
Enhancement of Community Enlightenment on EWS (PMD/NDMA)	Adopted	As fundamental activities, capacity of CBDRM should be augmented as Policy	200
Development of the EWS National Plan, Guidelines and SOPs for Health Emergency Preparedness and Response (HEPR)	Adopted	Treatment of Disease (Epidemic) is essential in Pakistan	

Source: JICA Expert Team

10) Summary of Prioritized Projects

The list of prioritized projects is given in Table 5.3.13 below.

Table 5.3.13 List of Prioritized Projects/Programs for the Multi-Hazard EWS Plan (as of October 2011)

Target Hazard	Project/Study Title	Cost (in million PKR)		
		Proc. Const.	Duplicate	Study/T.C.
Tsunami	Tsunami Simulation and Hazard Maps			200
	Upgrading of Global Telecommunication System (GTS)		22	
Weather Info. & Indus River Flood	Establishment of SMRFC	682		
	Expansion of AWS Network including Communication System	100		
	Additional Installation of AWS for the Observation of Basic Meteorological Data	-		
	Replacement of Existing Radar Stations	2,780		
	Islamabad Meteorological Radar	*900*		
	D. I. Khan Meteorological Radar and Rahim Yar Khan Meteorological Radar	*80*		
	Pasni/Gwadar and Karachi/Badin/Thatta for Existing Karachi	*1,800*		
	Establishment of New Meteorological Station	309	206	
	For Cherat	900		
	Establishment of Upper Air Observation Stations	*900*		
	For Peshawar and Chitra (included in SMRFC)l	*0*	*206*	
	For Lahore, Quetta and Karachi	*309*		
	Flood Forecasting by Satellite Info. and Hazard Maps of Indus River			300
	Establishment of RFFWC	210		60
	For Khyber Pakhtunkhwa Province (Peshawar)	*70*		*20*
	For Sindh Province (Karachi)	*70*		*20*
	For Balochistan Province (Quetta)	*70*		*20*
	Expansion of Rainfall and Water Level Observation Network	250		
	Replacement of Satellite H.R.P.T Data Information System	0	40	
Flash Flood	Establishment of LFFFC	1,250		400
	5 locations as priority projects will be selected from candidate sites,	*250x5*		*80x5*
	Finalization of Hazard Map and CD against Local Flash Flood			100
	Expansion of Rainfall and Water Level Observation Network		250	
Landslide	Preparation of Landslide Hazard Maps			200
	Establishment of Landslide EWS			100
	Expansion of AWS Network including Communication System		100	
Cyclone/ Storm Surge	Expansion of AWS Network including Communication System		100	
	Replacement of Existing Radar Stations		1,800	
	Pasni/Gwadar and Badin/Thatta for Karachi		*1,800*	
	Finalization of S.O.P. of Cyclone EWS			20
Drought	Establishment of Agro-Meteorological Advisory Service (AAS)		37	
	Expansion of AWS Network including Communication System		100	
GLOF, etc.	EWS for GLOF and Snowmelt Flash Flood w/ Hazard Maps	270		150
	Research Activities for Snow/Glacier/Glacial Lakes			320
Dissemination	Communication System between PMD and NDMA/ F/G/S/PDMAs	50		
	Communication System among DMAs (NDMA- F/G/S/PDMAs -DDMAs)	100		
	Radio Communication System between PMD and Communities		20	
	Weather Information Broadcasting Program		60	
Capacity Development	Education Program for Meteo-Hydrology for PMD Staff			370
	Establishment of Weather Forecast Guidance System			90
	Enhancement of Community Enlightenment for EWS			200
	Development of the EWS National Plan, Guidelines and SOPs for Health Emergency Preparedness and Response (HEPR)			To be confirmed
Total		6,901		2,510

Source: JICA Expert Team

5.3.4 Result of Prioritization

1) Project Prioritization Results

As described in Subsections 5.3.1 to 5.3.3, prioritized projects/programs to be implemented earlier have been determined and projects/programs to be executed in the short to medium-term without a feasibility study have also been confirmed. Based on this assortment of studies, all projects or programs have been divided further into five (5) priorities as shown in the table below.

Table 5.3.14 Project Prioritization for Multi-Hazard EWS Plan

Prioritization	Definition	Adopted Project and Schedule
Prioritized Projects / Programs		
Priority-1	The concept of proposed projects has already been fixed and the immediate implementation of projects is required.	Short to Medium-term Projects enumerated in Table 5.3.13
Priority-2	The immediate implementation of projects is required but it is necessary to conduct feasibility studies (F/S) to clarify and fix their concepts such as location and quantities.	Long-term Projects enumerated in Table 5.3.13 except for Short to Medium-term Projects
Recurring Activities	As basic enhancement and strengthening of activities for EWS, the projects/program proposed should be conducted throughout the entire term up to the target year.	Recurring Activities:
Other Projects / Programs		
Priority-3	The priority of projects is lower than Priority 1 and 2 due to maturity, degree of contribution of hazard and risk aversion, and rapidity of response or effectiveness of the project.	Super Long -term Projects except for Prioritized Projects
Priority-4	The priority of projects is lower than Priority 1, 2 and 3 due to maturity, degree of contribution of hazard and risk aversion and rapidity of response or effectiveness of the project.	
Priority-5	The priority of projects is lower than Priority 1, 2, 3 and 4 due to maturity, degree of contribution of hazard and risk aversion and rapidity of response or effectiveness of the project.	

Source: JICA Expert Team

The projects/programs to be applied for each priority are as tabulated below.

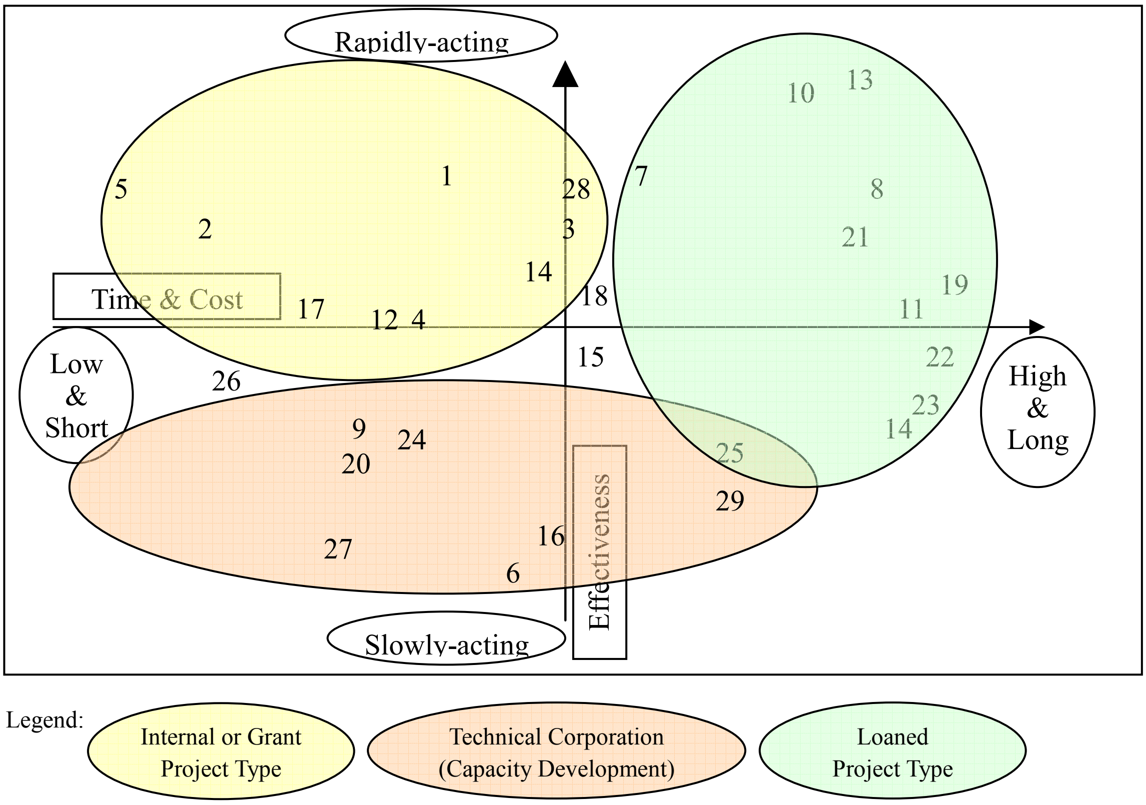
Table 5.3.15 Projects and Programs Prioritization for Multi-Hazard EWS Plan

Priority No.	No.	Adopted Projects / Programs
Priority-1	1	Establishment of Specialized Medium Range Forecasting Centre, including Upgrading of Global Telecommunication System (GTS) and Replacement of Satellite HRPT Data Information System, Radio Communication System, Agro Meteorological Data Processing and Analysis System, Weather Info. Broadcasting System and Weather Information Broadcasting Program Production System between PMD and Communities, (Hereinafter, referred to as "SMRFC Project")
	2	Establishment of (Additional) Upper-Air Observation System
	3	Replacement of Existing Radar Stations Phase-I (Islamabad and Karachi/Badin/Thatta Meteorological Radars), including Modification System for D.I. Khan and Rahim Yar Khan Radars. (Hereinafter, referred to as "Islamabad Radar Construction Project")
	4	Strengthening of Flood Forecasting by Satellite Info. and Hazard Maps of Indus River (Hereinafter, referred to as "Strengthening of Indus Flood Forecasting") (UNESCO Project)
	5	Establishment of Communication System between PMD and NDMA
	6	Development of the EWS National Plan, Guidelines and SOPs for Health Emergency Preparedness and Response (HEPR)
	7	Establishment of New Meteorological Radar Stations Phase-1 (Cherat)
Priority-2	8	Tsunami Simulation and Hazard Maps
	9	Expansion of AWS Network including Communication System (Some stations shall be installed in Medium Term subject to the study)
	10	Establishment of New Meteorological Radar Stations Phase-II (Pasni/Gwadar), including Finalization of SOP. of Cyclone EWS
	11	Establishment of RFFWC
	12	Expansion of Rainfall and Water Level Observation Network
	13	Establishment of Local Flash Flood Forecast and Warning System (LFFFC) Phase-1, including Finalization of Hazard Map and CD against Local Flash Flood
	14	EWS for GLOF and Snowmelt Flash Flood in GB w/ Hazard Maps
	15	Research Activities for Snow/Glacier/Glacial Lakes in G.B.
	16	Preparation of Landslide Hazard Maps
	17	Establishment of Communication System among DMAs (NDMA- F/G/S/PDMAs -DDMA)
	18	Establishment of Weather Forecast Guidance System
Priority-3	19	Establishment of New Meteorological Radar Stations Phase-III (for Chitral and Quetta)
	20	Additional Installation of AWS for the Observation of Basic Meteorological Data
	21	Establishment of Local Flash Flood Forecast and Warning System (LFFFC) Phase-2
Priority-4	22	Replacement of Existing Radar Stations Phase-II (D.I. Khan and Rahim Yar Khan Radars)
	23	Establishment of New Meteorological Radar Stations Phase-4 (for D. G. Khan and Sukkar)
Priority-5	24	Establishment of Tide Level Monitoring Network
	25	Establishment of Seismic Intensity Reporting System
	26	Establishment of Landslide EWS
	27	Establishment of Avalanche EWS
Recurring Activities	28	Education Program for Meteo-Hydrology for PMD Staff
	29	Enhancement of Community Enlightenment for EWS with training and drills

Source: JICA Expert Team

2) Orientation and Road Map of the Proposed Projects/Programs

Each proposed project has specific characteristics, such as low-cost oriented, rapidly-acting oriented, etc. The orientation of effectiveness of proposed projects is illustrated as Figure 5.3.1 and the road map of this Plan is shown in Figure 5.3.2.



1 : Project No. mentioned in Table 5.3.15

Note:

1. Projects of No. positioned on the top in the Figure will bring benefits immediately after the completion of the Project.
2. No. positioned along low-side of Figure will bring benefits slowly.
3. Projects of No. positioned on the right side in the Figure will cost much and take time for the implementation.
4. Implementation and cost of the Project of No. positioned on the left side in the Figure will be short and less.
5. Projects of less cost and showing immediately benefits after the completion shall be categorized as "Internal or Grant Aid Project Type".
6. Projects positioned in slow-acting area for the effectiveness and less cost shall be categorized as "Type of Technical Corporation Type".
7. High-cost projects shall be categorized as "Loaned Project Type".

Source: JICA Expert Team.

Figure 5.3.1 Assumed Orientation of Effectiveness of Proposed Projects

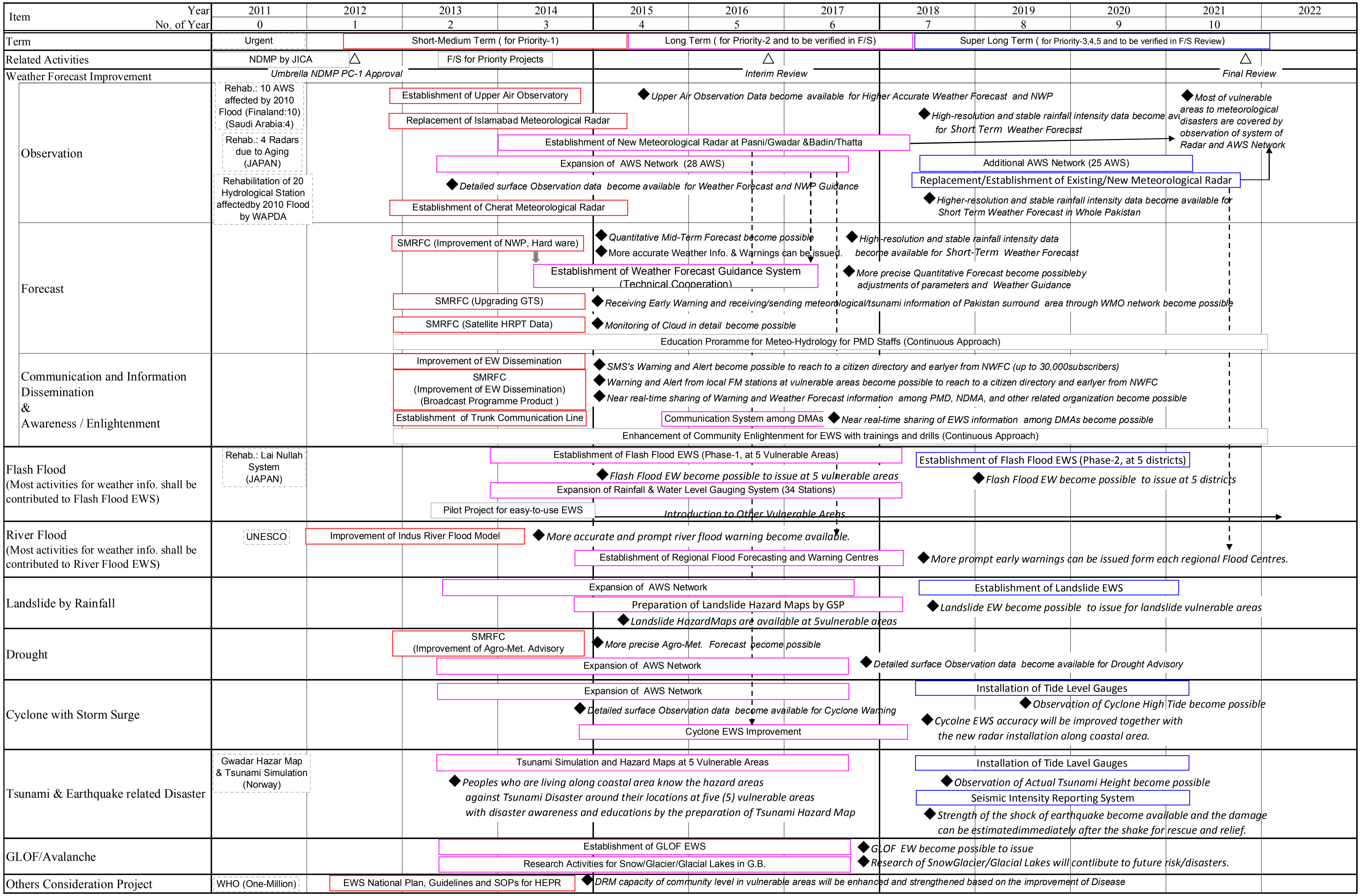


Figure 5.3.2 Road Map of Multi-Hazard EWS Plan

5.4 Proposed Implementation Scheme

The project implementation schedule has been tentatively set, as shown in Table 5.4.1 below.

Table 5.4.1 Prioritization of Projects and Programs for Multi-Hazard EWS Plan

Project/Study Title	Cost (PKR in million)		Implementation Schedule		
	Procurement Construction	Study/T.C. Capacity D.	Short-Medium Priority-1	Long Term Priority-2	Super Long Priority-3, 4, 5
Establishment of Tide Level Monitoring Network	10				10
Tsunami Simulation and Hazard Maps		200		200	
Seismic Intensity Reporting System w/ Data Communication System	180				180
Establishment of SMRFC (incl. Upgrading of Global Telecommunication System (GTS))	682		682		
Expansion of AWS Network including Communication System	100		5	195	
Additional Installation of AWS for the Observation of Basic Meteorological Data	100			10	90
Replacement of Existing Radar Stations	4,580		1,880	900	1,800
Islamabad Meteorological Radar	*980*		*980*		
D. I. Khan Meteorological Radar and Rahim Yar Khan Meteorological Radar	*1,800*				*1,800*
Pasni/Gwadar andKarachi/ Badin/Thatta for Existing Karachi	*1,800*		*900*	*900*	
Establishment of New Meteorological Radar Stations	4,400		900		3,500
For Khyber Pakhtunkhwa Province (Cherat and Chitral)	*1,800*		*900*		*900*
For Sindh Province (Sukkar) and For Punjab Province (Dera Ghazi Khan)	*1,800*				*1,800*
For Balochistan Province (Quetta)	*800*				*800*
Establishment of Upper Air Observation Stations	309		309		
For Peshawar and Chitral (included in SMRFC)	*0*		*0*		
For Lahore, Quetta and Karachi	*309*		*309*		
Flood Forecasting by Satellite Info. and Hazard Maps of Indus River (UNESCO Project)		300	300		
Establishment of RFFWC	210	60		270	
For Khyber Pakhtunkhwa Province (Peshawar)	*70*	*20*		*90*	
For Balochistan Province (Quetta)	*70*	*20*		*90*	
For Sindh Province (Karachi)	*70*	*20*		*90*	
Expansion of Rainfall and Water Level Observation Network	250			250	
Establishment of LFFFC	2,500	800		1,650	1,650
10 locations as priority projects will be selected from candidate sites,	*250x10*	*80x10*		*1,650*	*1,650*
Finalization of Hazard Maps and CD against Local Flash Flood		100		100	
Preparation of Landslide Hazard Maps		200		200	
Establishment of Landslide EWS		100			100
Finalization of SOP of Cyclone EWS		20		20	
EWS for GLOF and Snowmelt Flash Flood in GB w/ Hazard Maps	270	150		420	
Research Activities for Snow/Glacier/Glacial Lakes in G.B.		320		320	
Communication System between PMD and NDMA/PDMAs	50		50		
Communication System among NDMA- F/G/S/PDMAs -DDMAs)	100			100	
Establishment of Weather Forecast Guidance System		100		100	
Education Program for Meteo-Hydrology for PMD Staff		370	100	170	100
Enhancement of Community Enlightenment for EWS with Trainings and Drills		200	50	80	70
Development of the EWS National Plan, Guidelines and SOPs for HEPR			To be confirmed		
Total	13,741	2,920	4,276	4,885	7,500
	16,661				

Source: JICA Expert Team

CHAPTER 6 SCOPE OF FEASIBILITY STUDY

6.1 Introduction

As shown and explained in Chapter 5, programs and projects proposed have been classified into 5 priorities. Among these priorities, Priority-1 refers to a collective consisting of proposed projects which has already been fixed and the immediate implementation of projects is required. In this connection, applications or requests for the implementation of the projects/programs in Priority-1 shall be prepared immediately provided that the following strategy can be pursued.

Table 6.1.1 Strategy for the Earlier Implementation of Projects Proposed in Priority-1

No.	Adopted Projects / Programs	Strategy
P-1-1	SMRFC Project	PC-1 has been already approved by the Planning Committee. PMD shall submit immediately to cooperative foreign donor(s) (such as JICA)
P-1-2	Establishment of Upper-Air Observation System	This project shall be included in the above P-1-1.
P-1-3	Replacement of Existing Radar Stations Phase-I	
	Islamabad Radar Construction Project	This project shall be integrated as an application in the above P-1-1.
	Karachi/Badin/Thatta Radar Construction Project	Karachi is tentatively selected subject to clarification and evaluation studies to select the most suitable location. PMD should prepare a PC-1 to execute this project.
P-1-4	Strengthening of Indus Flood Forecasting (UNESCO Project)	For this project, UNESCO proposed it to the Pakistan and Japanese governments. PMD and NDMA should support these activities for earlier commencement.
P-1-5	Establishment of Communication System between PMD and NDMA	This project shall be included in the above P-1-1.
P-1-6	Development of the EWS National Plan, Guidelines and SOPs for HEPR	NDMA should propose it to the cooperative agencies (such as UN group, WHO or other candidate donors)
P-1-7	Establishment of New Meteorological Radar Stations Phase-1	The Project for the Construction of Charat Meteorological Radar Station. PMD has already submitted the PC-1 to the Planning Commission.

Source: JICA Expert Team

On the other hand, projects and programs in Priorities-2 to 5 shall be further elaborated and scrutinized for their viabilities and feasibilities including preliminary designs. In particular, projects and programs in Priority-2 recognized as high priority or of immediate urgency shall be clarified.

Accordingly, the scope of works for a feasibility study on Multi-Hazard EWS to immediately be implemented has been prepared. These contents are described in the next sections.

6.2 General Scope of Feasibility Study

In this Project, the Formulation of Multi-Hazard EWS Plan has been categorized as Component-3 out of 4 components. Based on the scope of the Project, the following items have already been studied through Chapters 3 to 5:

- Consideration of direction and separation of roles of relevant organizations for Early Warning,
- Consideration of direction, procedure and route for Dissemination of Disaster Information
- Consideration of direction and standards of Warning and Evacuation Call
- Consideration of the outline of Early Warning System and Equipment Plan
- Experimental implementation of priority activities such as communication and evacuation drills based on the Early Warning System Plan

Based on the study results listed above, the issues and gaps on current Multi-Hazard EWS hasve been identified with challenges to be achieved in collaboration with main C/Ps (namely NDMA, FFC and PMD) and the prioritized projects and programs to solve the issues and to avert each hazard (floods, cyclones, tsunamis, landslides, droughts, etc.) have been abstracted from all conceived ideas.

The prioritized projects and programs in Priority-2 of which the F/Ss are required are confirmed as follows:

Table 6.2.1 Projects and Programs of which FS shall be Immediately Implemented

Priority No.	Adopted Projects / Programs	Component
Priority-2	Tsunami Simulation and Hazard Maps	Study on Tsunami Simulation at Prioritized Locations Preparation of Tsunami Hazard Maps at Prioritized Location
	Expansion of AWS Network including Communication System	Automatic Weather Observation System, and Calibration Instruments for Automatic Weather Observation System, with: Meteorological Data Communication System (GPRS)
	Establishment of New Meteorological Radar Stations	Pasni/Gwadar and Karachi/Badin/Thatta for Karachi, including Finalization of SOP of Cyclone EWS
	Establishment of RFFWC	Establishment of Regional Flood Forecasting and Warning Centres Improvement of River Flood Forecast and Warning System Rainfall and Water Level Observation System by MBC System
	Expansion of Rainfall and Water Level Observation Network	Establishment of Rainfall and Water Level Observation Network at 30-40 stations for middle and small class river basins
	Establishment of LFFFC	Establishment of Local Flash Flood Forecast and Warning Centres with EWS at Designated Locations (about 5 locations) Preparation of Flash Flood Hazard Maps Capacity Development of Local Government and Community
	EWS for GLOF and Snowmelt Flash Flood	Early Warning System for Glacial Lake Outburst Flood (GLOF) Early Warning System for Snow Melt Flash Flood Preparation of Hazard Maps
	Research Activities for Snow/Glacier/Glacial Lakes in G.B.	Research Activities for Snow/Glacier/Glacial Lakes for perennial situations with water resources aspects.
	Preparation of Landslide Hazard Maps	Preparation of Landslide Hazard Maps at Locations vulnerable to Landslide Disasters
	Establishment of Government Communication System	Establishment of Communication System among DMAs (NDMA-F/G/S/PDMAs -DDMA)
	Communication System between Community and Government	Establishment of Multi-Hazard SMS for Whole Pakistan Execution of Information and Dissemination Drills
	Enhancement of Community Enlightenment for EWS	Awareness and Education Activities for CBDRM

Source: JICA Expert Team

The scope of F/S for the prioritized projects and programs enumerated above are described including necessary experts and terms for the required studies as follows:

6.3 Terms of Reference of the Feasibility Study on Multi-Hazard EWS in Pakistan

6.3.1 Background and Objective of the Study

1) Background

Pakistan is at risk to various types of natural disasters of which river & flash floods, cyclones, landslides, earthquakes and droughts are the most common. Pakistan experienced extraordinary rainfall in mid-July 2010, which continued until September 2010. The result was unprecedented floods affecting the entire length of the country. The said floods were assessed as the worst since

1929, affected 78 districts and more than 20.1 million people, (over one-tenth of Pakistan's population) with 1,985 persons dead and 2,946 persons injured. About 1.6 million houses were damaged, and over 2.0 million ha of cropped areas were affected with major soil erosion happening in some areas. The country's seismic risk vulnerability was demonstrated in October 2005 when a major earthquake measuring 7.6 on the Richter scale hit nine (9) districts in Khyber Pakhtunkhwa (KP, formerly NWFP) and Azad Jammu Kashmir (AJK), killed over 73,000 people and damaging/destroying about 450,000 houses. Droughts are also a serious hazard in the country, especially the droughts of 2000-2002 caused serious damages in agricultural products. Fourteen cyclones have also been recorded between 1971 and 2001 which caused considerable damage.

In this connection, the establishment of a Multi-Hazard Early Warning System is indispensable and should be carried out immediately.

2) Executing Agency(ies) and the Status of the Ability and Capacity

PMD is mainly responsible for recording meteorological observations round the clock and providing weather information necessary for the mitigation and prevention of meteorological disasters like river floods, flash floods, cyclones, and tsunamis, as well as utilizing scientific knowledge as an effective instrument to ensure the development and promotion of socio-economic activities for the well being and economic security of the people. PMD also provides meteorological information for aviation and shipping. Scheduled and daily weather forecasts are also issued to the agricultural sector and the general public through the PMD Website. Concerning impending flood disasters caused by heavy rains in the area, PMD provides warnings & advisories to all administrative divisions' concerned agencies especially NDMA and the mass media.

PMD is striving towards the improvement of its capabilities by upgrading and modernizing its weather forecasting system for flood warning services in KP & other parts of the country and also for adaptation of climate change. The project is in line with the overall measures, being adopted by the government, designed to improve flood forecasting and to establish meteorological & hydrological observation and an early warning network for reducing flood disaster risks. In order to forecast the occurrence of floods in the country, PMD is monitoring snow cover, rainfall amounts, stream flows, daily temperatures and river conditions. Data and information are collected and analyzed to determine possible runoff amount, predict water levels, ice breakups and ice jams. Information needed for flood forecasting includes installation of a radar network in the country, stream stage level (the height of water level in the stream above an arbitrary value), the telemetry system, and the amount and distribution of precipitation. This information together with the Quantitative Precipitation Measurement (QPM) Doppler Radar will allow more accurate estimations of the amount and distribution of precipitation.

Failure in any one of these elements means a less effective early warning system. According to the UN Global Survey of Early Warning Systems-2006, considerable progress has been made in developing the knowledge and technical tools required to assess risks and to generate and communicate predictions and warnings, particularly as a result of growing scientific understanding that utilizes modern information and communication technologies. Early warning system technologies are now available for almost all types of natural hazards and are in operation in some parts of the world.

However, the experiences of the Indian Ocean tsunami, the hurricanes on the Gulf of Mexico, and many other recent events such as heat waves, droughts, famines, wildfires, floods and mudflows point to significant inadequacies in the existing early warning systems.

In many cases, especially in developing countries like Pakistan, the existing warning systems lack the basic capacities of equipment, skills and resources. Among both developed and developing nations, the weakest element is the warning dissemination and preparedness to act against natural disasters. Warnings may fail due to inadequate political commitment, weak coordination among the various actors, and lack of public awareness and participation in the development and operation of early warning systems.

The higher reliability of flood forecast and additional lead time would result in better flood disaster risk management including optimal control of dam or reservoir management and operations, flood combating and evacuation of people from areas likely to be affected by floods and other risks. This would reduce the huge damages to the irrigation systems, road networks and other vital infrastructures, the number of casualties and suffering of the people.

3) Objective s of the Study

The establishment of the proposed meteorological & hydrological observation and early warning network for disaster prevention in Pakistan will serve as a country-based early warning and response system. Such a system is needed not only for the protection for citizens and national assets, but also because it provides the building blocks of a global early warning system. The recommendation addresses the need for a national plan based on a survey of capabilities, a warning dissemination strategy, community-based approaches, and public education and exercises.

The projects aim at predicting river & flash flood, cyclone, GLOF and tsunami events thereby providing a valuable lead time that allows for the development of mitigation works and, in severe events, evacuation of the public and crew mobilization for emergency works in the disaster prone areas.

Presently, PMD does not have the capabilities to design such a sophisticated and developed system for meeting multi-hazards like river & flash floods, cyclones, tsunamis or other weather associated hazards.

6.3.2 Methodology of the Study

1) Tsunami Simulation and Hazard Maps

a. Outline of the Project and Purpose of the Study

In the project, tsunami simulations at five (5) selected priority areas vulnerable to tsunami disasters shall be conducted first. Subsequently, Tsunami Hazard Maps shall be prepared for the said five (5) priority areas based on the simulation results of the assumed tsunami and local information on the possible location of escape routes and shelters.

Therefore, main activities of the F/S are to select the priority areas against tsunami disasters with a pilot project and establishment of tsunami hazard maps.

b. Methods of the Study

The terms of the F/S for "Tsunami Simulation and Hazard Maps" are as follows:

Table 6.3.1 Items and Required Expert for Study on Tsunami Simulation and Hazard Maps

Study Term	Expert to be Required	Length of Term
Review on Vulnerability of Tsunami Disaster in Pakistan	Expert for Tsunami EWS	0.5 months
Collection of Available Data and Source	Expert for Tsunami EWS	0.5 months
Selection of Five (5) Vulnerable Areas against Tsunami	Expert for Tsunami EWS	0.5 months
Study on Planning Scheme for the Simulation including Analysis of Intensity and Magnitude to be assumed and Prerequisites of Simulation to be considered	Expert for Tsunami EWS	0.5 months
Execution of Pilot Project with Technology Transfer of Simulation and hazard mapping		
Selection of Location/City for Pilot Project	Expert for Tsunami EWS	0.5 months
Bathymetry and Topographic Survey	Survey Engineer with Survey Subcontracting	2.0 months
Formulation of Simulation Model for Targeted Area(s)	Tsunami Simulation Engineer	2.0 months
Execution of Tsunami Simulation based on the Preconditions	Tsunami Simulation Engineer	1.0 month
Preparation of Tsunami Hazard Map(s)	Tsunami Simulation Engineer GIS Engineer	1.0 month 2.0 months
Awareness and Educational Campaign for Tsunami Disaster to All Related Stakeholders at Pilot Project Site(s)	Expert for Tsunami EWS	2.0 months
Detail Cost Estimates and Economic Evaluation	Cost Estimator Economist	1.0 month 1.0 month
Total	Expert for Tsunami EWS Tsunami Simulation Engineer Cost Estimator Economist Survey Engineer GIS Engineer Total	4.5 months 4.0 months 1.0 month 1.0 month 2.0 months 2.0 months 14.5 months

Note: For Bathymetry and Topographic Survey, subcontracting is necessary for the F/S Study
Source: JICA Expert Team

2) Expansion of AWS Network including Communication System

a. Outline of the Project and Purpose of the Study

As of 2011, there have been 48 Automatic Weather Observation Systems (AWS) in total managed by NDMC or TCWC of PMD as shown in Annex 3.1.1 of this report. However, the current AWS network is insufficient for predicting impending disasters, forecast and understand weather conditions for the whole of Pakistan. It is necessary to expand and strengthen this network to observe meteorological conditions in more detail. NDMC has planned to install approximately 30 new AWSs for weather observation.

The main purpose of the F/S is to confirm the conditions of installation of the AWS.

b. Methods of the Study

The required study items and terms for "Expansion of AWS Network" are tabulated below:

Table 6.3.2 Items and Required Expert for Study on Expansion of AWS Network including Communication System

Study Term	Expert to be Required	Length of Term
Review of the Location of the Proposed AWS	Meteorologist	0.5 months
Determination of AWS Installation Point/Site at each Location	Meteorologist	1.0 month (*1)
Study on the Data Communication and Transfer System with Transmission Interval	Meteorological System Engineer	0.5 months
Detail Cost Estimates and Economic Evaluation	Cost Estimator Economist	0.3 months 0.3 months
Total	Meteorologist System Engineer Cost Estimator Economist Total	1.0 month 0.5 months 0.3 months 0.3 months 2.1 months

Note: *1: For the determination of locations of AWS, two (2) local experts for each 1month are required.
Source: JICA Expert Team

3) Establishment of New Meteorological Radar Stations

a. Outline of the Project and Purpose of the Study

Due to the aged condition of the existing radar systems, namely those at Islamabad and Karachi, these should be replaced. In addition, the adoption of new technology for multiple observations with reliable operation is required. It is important to solve the problem of the non-availability of spare parts. The old meteorological radar systems shall be replaced with Doppler technology for continuation of PMD's activity in flood forecasting. In this connection, the said two (2) meteorological stations constructed in the 1991 should be replaced. Furthermore, the installation of radars along the coastal areas is also important since the coastal zones are vulnerable to cyclone hazards that should be predicted by the Radar Network for tracking route and strength (amount of rainfall and wind speed). Hence, Two (2) Radars to be located at Pasni/Gwadar and Karachi/Badin/Thatta shall be considered instead of present Karachi radar station.

The clarification items to select the most suitable sites for the construction of new radar at Pasni or Gwadar and Karachi, Badin or Thatta, if necessary, are indicated below:

Visibility or Coverage: Wider extents to be monitored are preferable.

Area Availability for Tower: Minimum required area to construct tower with equipments is secured.

Sustainability of Electrical Supply: Stable Electrical Supply is recommended.

- Data Transmission Accessibility: broad band data transmission can be accessed.
- Radar Station Accessibility: Accessibility to radar site stations are available to construct, maintain and operate radar equipment.
- Lighting strike frequency: less lighting strikes are desirable.

- Staff Availability: whether staff for operation and maintenance works can be assigned at candidate site or not.
- Budget Availability: whether adequate budgets for operation and maintenance can be secured or not.

In addition to the existing radar network system, several new meteorological radars should be installed to expand the coverage area to improve the accuracy of rainfall prediction in the whole of Pakistan. A prioritized plan to expand the coverage of meteorological radar systems shall be considered. In this regard, Chitral, Cherat and Quetta radar stations shall be considered based on the confirmation of priority order of their installation. In the MHEWS Plan, Cherat has been designated as First Priority. However, these prioritizations shall be re-evaluated in F/S unless the Cherat Radar is constructed.

In F/S, the viabilities for each proposed radar locations shall be clarified in detail with basic features of radar systems as preliminary designs and reprioritizing radar sites for the implementation.

b. Methods of the Study

Terms to be studied for "Establishment of New Meteorological Radar Stations" are listed as follows:

Table 6.3.3 Items and Required Expert for Study on Establishment of New Meteorological Radar Stations

Study Term	Expert to be Required	Length of Term
Study on Specification of Radar Equipment (Type (C or S) of band and Display System) for each Proposed Radar	Meteorologist	1.5 months
Communication (Transmission) System (Propagation Test) for each Proposed Radar	Meteorological System Engineer	1.5 months (*1)
Preliminary Design of Towers (height, location) for each Proposed Radar	Structural Engineer	2.5 months
Detail Cost Estimates and Economic Evaluation	Cost Estimator Economist	1.0 month (*2) 1.0 month
Total	Meteorologist Meteorological System Engineer Structural Engineer Cost Estimator <u>Economist</u> Total	1.5 months 1.5 months 2.5 months 1.0 month <u>1.0 month</u> 7.5 months

Note: *1: For the determination of dissemination system, two (2) local experts for each 1.5months are required.
*2: For the cost estimates, one (1) local cost estimator for 1 month is required.

Source: JICA Expert Team

4) Establishment of RFFWC

a. Outline of the Project and Purpose of the Study

As of 2011, PMD have issued most flood warnings and advisories through the Flood Forecasting Division (FFD) at Lahore. However, there are some EWS problems related to the current situation of floods as follows:

- FFD manages the flood forecasting services for the whole of Pakistan. Therefore, some flood warning issuances/bulletins should be conveyed simultaneously. There is a loss of time during the issuance.
- Long-distance telephone/facsimile lines have a bigger risk in the communication system. For KP, Balochistan and Sindh, it seems that the immediacy of warning/news from other provinces recedes due to social tension.
- In the future, it will be hard for one office (FFD) to forecast the floods from the expanded, enormous quantity of meteorological data for the whole of Pakistan.

Thus, forecasting and warning tasks should be distributed among the provincial bases under the supervision of FFD, Lahore. Peshawar for KP , Quetta for Balochistan, and Karachi for Sindh are proposed as the regional flood forecasting and warning centres (RFFWC)

b. Methods of the Study

The items to be scrutinized in the F/S for "Establishment of RFFWC" are as follows:

Table 6.3.4 Items and Required Expert for Study on Establishment of RFFWC

Study Term	Expert to be Required	Length of Term
Study on Specification of Equipment and Facilities to be Installed in each RFFWC	Meteorologist	1.0 month
Communication (Transmission) System for each Proposed RFFWC	Meteorological System Engineer	1.0 month (*1)
Preliminary Design of RFFWC (dimension of building, location)	Structural Engineer	2.0 month
Detail Cost Estimates and Economic Evaluation	Cost Estimator Economist	1.0 month (*2) 1.0 month
Total	Meteorologist Meteorological System Engineer Structural Engineer Cost Estimator Economist Total	1.0 month 1.0 month 2.0 months 1.0 month 1.0 month 6.0 months

Note: *1: For the determination of dissemination system, two (2) local experts for each 1.0months are required.
*2: For the cost estimates, one (1) local cost estimator for 1 month is required.

Source: JICA Expert Team

5) Expansion of Rainfall and Water Level Observation Network

a. Outline of the Project and Purpose of the Study

The purpose of the Study is to install about 30~40 gauging stations in small to medium river basins together with a real-time transmission system in order to improve rainfall and water level observation networks for enhancing flood forecasting capabilities in various parts of the country for both Indus River floods and general flash flood forecasting.

The main purpose of the F/S is to confirm the conditions of installation of the Rainfall and Water Level Observation Network.

b. Methods of the Study

The items to be scrutinized in the F/S for "Establishment of Rainfall and Water Level Observation Network" are as follows:

Table 6.3.5 Items and Required Expert for Study on Expansion of Rainfall and Water Level Observation Network

Study Term	Expert to be Required	Length of Term
Study on the Flood Forecasting Capabilities of Small and Medium River Basins and Select the Target River Basins	Hydro-Meteorologist	1.0 month
Study on the Selection of Locations of Rainfall and Water Level Gauging Stations	Hydro-Meteorologist	1.0 month
Study on Specification of Equipment and Facilities to be Installed	Hydro-Meteorologist	0.5 month
Preliminary Design of Observation Facilities	Civil Engineer	1.0 month (1*)
Study on optimum real-time transmission systems	System Engineer	1.0 month
Detail Cost Estimate and Economic Evaluation	Cost Estimator Economist	1.0 month (2*) 1.0 month
Total	Hydro-Meteorologist Civil engineer System Engineer Cost Estimator Economist Total	2.5 months 1.0 month 1.0 month 1.0 month 1.0 month 6.5 months

Note: *1: For the design of observation facilities, one (1) local civil engineer for 2 months required.
*2: For the cost estimates, one (1) local cost estimator for 1 month is required.

Source: JICA Expert Team

6) Establishment of LFFFC

a. Outline of the Project and Purpose of the Study

There are numerous areas vulnerable to flash floods in Pakistan. Run-off times of small to medium river basins are quite short for the dissemination of warning and alert messages. Therefore, a short-period frequency rainfall and water level data communication system is required in real-time for each targeted vulnerable basin or high-risk town/city. It is necessary to improve the flash flood disaster risk management of the country. The Multi-Hazard EWS has proposed the establishment of Local Flash Flood Forecast and Warning Centres (LFFFC) including flash flood forecasting and warning systems at ten (10) significant locations by 2021.

The main purposes of the F/S are to confirm the conditions of implementation of the LFFFC with EWS including (Study, Procurement of Equipment and Facility Construction with Capacity Development) for five (5) designated locations from the candidates.

b. Methods of the Study

The items to be scrutinized in the F/S for "Establishment of LFFFC" are as follows:

Table 6.3.6 Items and Required Expert for Study on Establishment of LFFFC

Study Term	Expert to be Required	Length of Term
Study on Selection of five (5) priority Locations for LFFFC	Expert for Flash Flood EWS	1.0 month
Selection of the Tentative Sites of Rainfall and Water Level Observation Network for five (5) Priority Locations	Hydro-meteorologist	3.0 months (*1)
Study on EWS for each LFFFC	Hydrologist	1.0 month
Preparation of Guidelines for Flash Flood Hazard Map	Hydrologist GIS Engineer	1.0 months 1.0 months (*2)
Study on Specification of Equipment and Facilities	Hydro-meteorologist	1.0 month (*3)
Study on the Optimum Real-time Transmission System	System Engineer	1.0 month
Preliminary Design of LFFFC (dimension of building, location)	Structural Engineer	2.0 months (*4)
Detailed Cost Estimation and Economic Evaluation	Cost Estimator Economist	1.0months (*5) 1.0 month
Study on CBDRM	CBDRM Expert	1.0 month
Study on CD of PMD, Local Governments and Communities	Expert for Flash Flood EWS	1.0 month
Total	Expert for Flash Flood EWS Hydro-meteorologist Hydrologist GIS Engineer System Engineer Structural Engineer Cost Estimator Economist CBDRM Expert Total	2.0 months 4.0 months 2.0 months 1.0 months 1.0 month 2.0 months 1.0 months 1.0 month 1.0 months 15.0 months

Note: *1: For selection of the of rainfall and water level gauges; one (1) local engineer for 1.5 months required
*2: For preparation of flash flood hazard maps; one (1) local engineer for 2 months required
*3: Study on specification of equipment : one (1) local engineer for 1 months required
*4: Preliminary design of LFFFC: one (1) local engineer for 2 months required
*5: Cost estimation: one (1) local expert for 1.0 months required

Source: JICA Expert Team

7) EWS for GLOF and Snowmelt Flash Flood

a. Outline of the Project and Purpose of the Study

It is reported that there are 2,420 glacial lakes in the Indus Basin, of which 52 are potentially dangerous and could result in GLOF with serious damages to life and property. In addition, global warming can increase the potential of GLOF in the future. However, neither EWS nor mitigation measures have been established or prepared for GLOF in GB. It is necessary to prepare EWS for GLOF disasters.

The main purposes of the F/S are to confirm the conditions of installation of the Automatic Water Level Stations for five (5) rivers (the Shyok River, Shigar (Braldu) River, Hunza River (downstream), Shimshal River and Gilgit River) and other equipment for establishment of EWS for GLOF and snowmelt flash floods.

b. Methods of the Study

The items to be scrutinized in the F/S for "EWS for GLOF and Snowmelt Flash Flood" are as follows:

Table 6.3.7 Items and Required Expert for Study on "EWS for GLOF and Snowmelt Flash Flood"

Study Term	Expert to be Required	Length of Term
Study on high resolution Satellite Imageries in GB and locations of critical glacial lakes	Meteorologist	2.0 months
Study on optimum location of 25 Automatic water level gauges at Five (5) Rivers*	Hydrologist	1.0 months
Study on observation data , data processing and communication system and data control system	System Engineer	0.5 month
Study on Specification of Equipment and Facilities	Hydrologist	0.5 month
Study on Preparation of hazard maps	Hydrologist GIS Engineer	2.0 months 2.0 months
Detailed Cost Estimation and Economic Evaluation	Cost Estimator Economist	1.0 months (*1) 1.0 month
Study on CBDRM	CBDRM Expert	2.0 month (*2)
Study on CD of PMD, Local Government and communities	Hydrologist	1.0 month
Total	Meteorologist Hydrologist System Engineer GIS Engineer Cost Estimator Economist CBDRM Expert Total	2.0 months 4.5 months 0.5 months 2.0 months 1.0 months 1.0 month 2.0 months 13.0 months

Note: *1: For Detailed Cost Estimate: one (1) local engineer for 2.0 months required
*2: For Study on CBDRM: one (1) local engineer for 2.0 months required

Source: JICA Expert Team

8) Research Activities for Snow/Glacier/Glacial Lakes

a. Outline of the Project and Purpose of the Study

The purpose is to grasp the trends of glaciers in GB in order to reduce the GLOF disasters and to grasp the conditions of glacier and snow cover from water resources management aspects by monitoring the trends of glaciers.

The main purposes of the F/S are to confirm: the methods of monitoring the conditions of glaciers by high-resolution satellite images obtained quarterly or more often, the conditions of the installation of 22 Automatic Weather Stations, and preparation and updating of hazard maps for GLOF.

b. Methods of the Study

The items to be scrutinized in the F/S for "Research Activities for Snow/Glacier/Glacial Lakes in GB" are as follows:

Table 6.3.8 Items and Required Expert for "Study on Research Activities for Snow/Glacier/Glacial Lakes in GB"

Study Term	Expert to be Required	Length of Term
Study on Accumulation of Trends of Glacier in GB by high resolution satellite imageries	Meteorologist	2.0 months
Study on optimum location of 22 Automatic Weather Stations	Meteorologist	0.5 month
Study on Specification of Equipment and Facilities	Meteorologist	0.5 month
Study on Preparation and Updating of Hazard Maps for GLOF	Hydrologist GIS Engineer	2.0 months 2.0 months
Detailed Cost Estimation and Economic Evaluation	Cost Estimator Economist	1.0 month 1.0 month
Study on CD of Stuff of Agencies related	Meteorologist	1.0 month
Total	Meteorologist Hydrologist GIS Engineer Cost Estimator Economist Total	3.0 months 2.0 months 2.0 months 1.0 month 1.0 month 9.0 months

Source: JICA Expert Team

9) Preparation of Landslide Hazard Maps

a. Outline of the Project and Purpose of the Study

According to the hazard and risk analysis by the JICA Project, there are districts that have very high risks for landslide disasters; however, detailed hazard analysis and preparation of hazard maps have not been conducted. Therefore, landslide hazard maps shall be prepared for the five (5) priority areas and the Automatic Weather Observation (AWO) Network including the communication system shall be expanded to cover the priority vulnerable areas of landslides in order to establish the landslide EWS.

The main purposes of the F/S are to confirm the priority vulnerable areas of landslide and the conditions of the AWO Network including the communication system for establishing the landslide EWS.

b. Methods of the Study

The items to be scrutinized in the F/S for "Preparation of Landslide Hazard Maps" are as follows:

Table 6.3.9 Items and Required Expert for Study on "Preparation of Landslide Hazard Maps"

Study Term	Expert to be Required	Length of Term
Study on the Locations and Priority Areas Vulnerable to Landslide Disasters	Expert for Landslide Disaster	1.0 month
Study on Preparation of Hazard Maps for the Priority Areas	Expert for Landslide Disaster GIS Engineer	2.0 months 2.0 months
Study on Automatic Weather Observation (AWO) Network for vulnerable areas of landslide	Meteorologist	0.5 month
Study on the Specification of Equipment and Facilities	Meteorologist	0.5 month
Study on Establishment of Landslide EWS for the Priority Areas	Expert for Landslide Disaster	1.0 month
Study on CD of GSP/PMD and Local Governments	Expert for Landslide Disaster	1.0 month
Study on CBDRM Development for the Priority Areas	CBDRM Expert	2.0 months
Detailed Cost Estimation and Economic Evaluation	Cost Estimator Economist	1.0 month 1.0 month
Total	Expert for Landslide Disaster Meteorologist GIS Engineer CBDRM Expert Cost Estimator Economist Total	5.0 months 1.0 month 2.0 months 2.0 months 1.0 month 1.0 months 12.0 months

Source: JICA Expert Team

10) Establishment of Government Communication System

a. Outline of the Project and Purpose of the Study

Most of the warnings for natural disasters have originally been issued by PMD, which has disseminated information on magnitudes and significances of anticipated hazards.

The methods for communicating and disseminating information are mainly by land phone and facsimile to recipients' land phones, fax machines and mobile phones. In addition, an automatic SMS volley sending system using mobile phone lines and a satellite phone system has also been applied for some hazard information (such as the tsunami early warning system). Furthermore, such warning information has been released through the Internet Web service (http://www.pakmet.com.pk) in real-time.

The transmission system for warnings, alerts and evacuation orders should be assured, swift and immediate. Therefore, multiple accessibility or redundancy will be indispensable for the dissemination system for EWS.

The main purposes of the F/S are to confirm the conditions of the communication system between NDMA and PMD and the communication system among DMAs (NDMA- F/G/S/PDMAs -DDMAs).

b. Methods of the Study

The items to be scrutinized in the F/S for "Establishment of Government Communication System" are as follows

Table 6.3.10 Items and Required Expert for Study on "Establishment of Government Communication System"

Study Term	Expert to be Required	Length of Term
Study on the Current Government Communication System	System Engineer	1.0 month
Study on the Specification of Communication Systems (PMD-NDMA) and (NDMA-F/G/S/PDMAs /DDMAs)	System Engineer	1.0 month
Cost Estimation and Economic Evaluation	Cost Estimator Economist	1.0 month 1.0 month
Study on Operation and Maintenance Program for the Communication System	System Engineer	1.0 month
Total	System Engineer Cost Estimator Economist Total	3.0 months 1.5 months 1.5 months 6.0 months

Source: JICA Study Team

11) Communication System between Community and Government

a. Outline of the Project and Purpose of the Study

The EW communication system at the community level should be improved between DDMA and communities/residents to more quickly disseminate information. Most of the districts disseminate warnings, alerts and evacuation orders by phone and oral meetings through the efforts of DDMA staff, Revenue Department staff or cooperating agencies. Therefore, other alternatives of utilizing the speakers of mosques, using the SMS volley system and using wireless radio communication shall be considered based on local community capabilities.

The main purposes of F/S are to confirm the conditions of the communication system between the government and community, and the execution of Information and Dissemination Drills.

b. Methods of the Study

The items to be scrutinized in the F/S for "Communication System between Community and Government" are as follows

Table 6.3.11 Items and Required Expert for Study on "Communication System between Community and Government"

Study Term	Expert to be Required	Length of Term
Study on Communication System at Community Level and Selection of Pilot Communities	EWS Expert	1.0 month
Study on Information and Dissemination Drills	CBDRM Expert HRD Expert	2.0 months (*1) 2.0 months (*2)
Cost Estimation and Economic Evaluation	Cost Estimator Economist	1.0month 1.0 month
Total	EWS Expert CBRM Expert HRD Expert Cost Estimator Economist Total	1.0 month 2.0 months 2.0 months 1.0 months 1.0 month 7.0 months

Source: JICA Study Team

12) Enhancement of Community Enlightenment for EWS

a. Outline of the Project and Purpose of the Study

During the 2010 Pakistan Flood, early warning dissemination had been done by all concerned government agencies, such as PMD, PIDs and DDMAs, involving other district departments (police, revenue, irrigation) and the Pakistan Army. However, the residents did not follow early evacuation orders in accordance with the early warning system according to the latest surveys conducted by the JICA Study Team. It was stated that in many areas people ignored warnings about impending disasters for various reasons. It is recognized that further enlightenment and knowledge acquisition activities are still needed for the community. In order to reduce flood disaster risks it is necessary to take necessary measures to enhance community enlightenment for EWS.

The main purposes of the F/S are to confirm optimum way to enhance public awareness for natural disasters and conduct HRD at community level to establish CBDRM for EWS.

b. Methods of the Study

The items to be scrutinized in the F/S for "Enhancement of Community Enlightenment for EWS" are as follows

Table 6.3.12 Items and Required Expert for Study on "Enhancement of Community Enlightenment for EWS"

Study Term	Expert to be Required	Length of Term
Selection of Pilot Communities for Study	EWS Expert	1.0 month
Study on Optimum Program to Enhance Public Awareness for DRM at Community Level	EWS Expert	1.0 month
Study on Optimum Measures for HRD at Community Level and Establishing of CBDRM for EWS	CBDRM Expert HRD Expert	2.0 months 2.0 months
Cost Estimation and Economic Evaluation	Cost Estimator Economist	1.0 month 1.0 month
Total	EWS Expert CBDRM Expert HRD Expert Cost Estimator Economist Total	2.0 months 2.0 months 2.0 months 1.0 months 1.0 month 8.0 months

Source: JICA Expert Team

13) Establishment of Weather Forecast Guidance System

a. Outline of the Project and Purpose of the Study

i) Improvement of NWP

PMD has conducted the NWP using the HRM with a grid length of 11 km developed by DWD. However, it is very difficult to further modify it to make it consistent with actual weather phenomena. The existing model is hydrostatic and cannot be revised to be a non-hydrostatic model by PMD staff. In addition, the computer processor capacity is limited resulting in expansion of the calculation time. Adoption of a non-hydrostatic model such as WRF and JMA Models is required. Therefore, it is required to renew the computer system with capacity development activities to ensure effective use of the NWP system. In addition, various parameters of the model introduced from foreign countries are set to adapt to the meteorological condition of the country that produced the model. Therefore, the model introduced should be adjusted to adapt the parameters of the model to the meteorological conditions in Pakistan. Then, the improvement of the initial condition of the model will augment the accuracy of NWP. For the improvement of the initial condition of the model, local observation data, such as the data from WPR and AWS, needs to be imported into the model to carry out objective analysis and an initialization method for the observation data.

ii) Introduction of Weather Guidance System

For the forecasters of PMD, time is limited and insufficient to forecast weather and warn of impending disasters due to the plethora of NWP results and actual observation data. Any NWP model has errors resulting from the difference between NWP results and real observation data. Weather guidance is used to reduce the difference. In addition, weather guidance can forecast the meteorological elements NWP cannot predict such as maximum temperature and minimum humidity. In this connection, a weather forecast guidance system shall be introduced and established using the MOS (Model Output Statics) Method. MOS refers to the materials obtained by statistically processing NWP results. At first, it is required to accumulate the NWP results and actual meteorological data (such as rainfall data) for at least one year. Then the statistic relational expression between NWP results as explaining variables (predictor variables) and actual meteorological data observed as objective variables (criterion variables or predictant variables) are prepared. The NWP results can be translated into weather forecast guidance systems or early warnings by multiple regression correlation expressions with the statistical relation expression (multiple regression equation). Based on this MOS method, the new weather forecast guidance system is to be established. PMD could carry out the changeover from qualitative to quantitative weather forecasts. When the model is changed in the future, the regression should be newly produced due to statistical particularity. The reproduction of the multiple egression equation is a troublesome job. Therefore, learning a method such as the Kalman Filter should be introduced to automatically change the coefficients of the multiple regression equation.

b. Methods of the Study

The items to be scrutinized in the Technical Cooperation Project for "Establishment of Weather Forecast Guidance Systems" are as follows:

Table 6.3.13 Items and Required Experts for Technical Cooperation for "Establishment of Weather Forecast Guidance System"

Study Term	Expert to be Required	Length of Term
Installation and Adjustment of Non-Hydrostatic Model	Computer System Expert	1.0 month
Introduction of Non-Hydrostatic Model and Running Test	NWP Model Expert	4.0 months
Verification of Output of New Model(GPV) and Adjustment of Parameters	NWP Model Expert	2.0 months
Verification and analysis between NWP Result and Observation Data.	NWP Model Expert	1.0 month
Production of Guidance (Multiple Regression Equation) with GPV and Rainfall	NWP and Statistics Expert	2.0 months
Data Processing, Objective Analysis and Initialization Method	Objective Analysis Expert	3.0 months
Verification and Analysis between Guidance Result and Observation Data.	NWP Model Expert	1.0 month
Correction of the Multiple Regression with Kalman Filter	Statistics Expert	1.0 month
Total	4 Experts	15.0 months

Source: JICA Expert Team

6.3.3 Study Schedule

1) Required Man-months

The required man-months of international experts for the F/S engineering services are obtained by sum of the total from each study. In this regard, several terms are duplicated in each study, such as cost estimate and economic evaluation. Therefore, the total man-months of each expert are re-evaluated as follows:

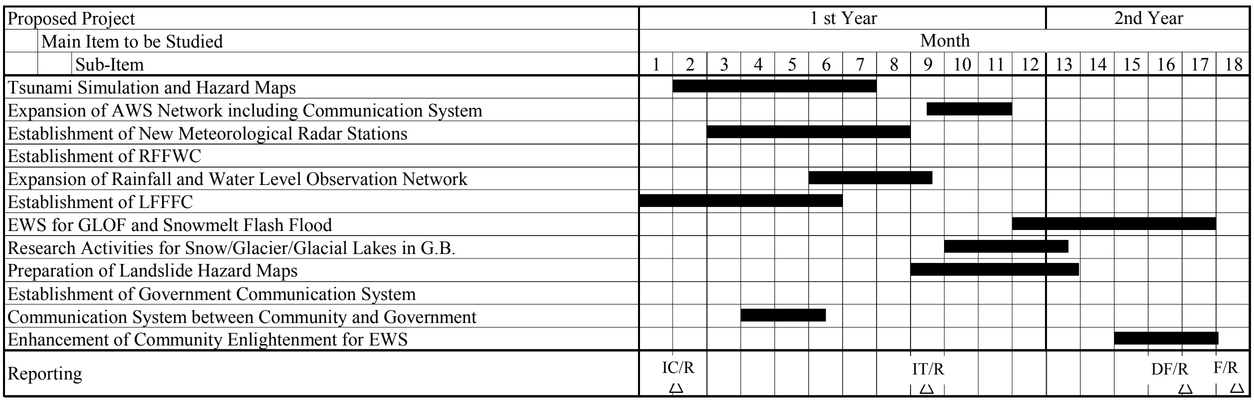
Table 6.3.14 Required Total Expert Man-months for F/S

Name of Expert	Sum-up Original M/M	Revised M/M for a F/S
Meteorologist	9.5 months	7.0 months
Hydrologist	15.0 months	12.0 months
Meteorological System Engineer	8.5 months	6.0 months
EWS Expert	3.0 months	3.0 months
Tsunami Simulation Engineer	4.0 months	4.0 months
Expert for Tsunami EWS	4.5 months	4.5 months
Expert for Flash Flood EWS	2.0 months	2.0 months
Expert for Landslide Disaster	5.0 months	5.0 months
Computer System Expert	1.0 months	1.0 months
NWP Model Expert	9.0 months	9.0 months
Statistics Expert	2.0 months	2.0 months
Objective Analysis Expert	3.0 months	3.0 months
Civil Engineer	1.0 month	1.0 months
Structural Engineer	6.5 months	5.0 months
Cost Estimator	10.8 months	6.0 months
Economist	11.8 months	7.0 months
Survey Engineer	3.0 months	3.0 months
GIS Engineer	9.0 months	7.0 months
CBDRM Expert	9.0 months	9.0 months
HRD Expert	4.0 months	4.0 months
Total	121.6 months	100.5 months

Source: JICA Expert Team

2) Required Study Period

The study schedule of the engineering services for the F/S is as shown below:



Source: JICA Expert Team

Figure 6.3.1 Proposed Study Schedule

6.3.4 Reporting

The Study Team shall prepare and submit the following reports in the English language within the period indicated, as follows:

1) Inception Report

Inception Report (30 copies) shall be submitted in the 2nd month of the services, presenting the detailed work plan and program of the services including recommendations for possible alternative plans and/or designs, if any, for discussion.

2) Bimonthly Progress Report

Monthly Progress Report (10 copies) shall be submitted from the 1st month to the 18th month until the start of the study, presenting the details of expert personnel mobilization, study progress, problems encountered, countermeasures taken and anticipated services for the next period of services.

3) Interim Report

Interim Report (20 copies) shall be submitted in the 9th month of the services, presenting the progress of preparative plans for individual studies.

4) Draft Final Report

At one (1) month prior to the completion of service, Draft Final Report (20 copies) shall be submitted in the 17th month of the services, presenting draft final results of plans.

5) Final Report

At the completion of all the engineering services, giving a summary of the services provided and the studies completed, including preliminary project costs and project evaluation, Final Report (30 copies) shall be submitted.