National Disaster Management Authority

Government of Pakistan

Ministry of Climate Change

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NDMA POLICY GUIDELINES FOR CONDUCT OF MULTI HAZARD VULNERABILITY AND RISK ASSESSMENT (MHVRA)

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Major General Asghar Nawaz, HI(M)
(Chairman, NDMA)

Editorial Team

Ehtisham Khalid Khan
Project Director,
Project Management Unit, NDMA

Syed Muhammad Tayyab Shah
Project Officer,
Project Management Unit, NDMA

Members of National Disaster Management Plan (NDMP) Steering Committee

PREFACE

The geography of Pakistan is extremely diverse, ranging from snowcapped mountains to plains, plateaus, deserts, wetlands and coastal areas. While this diverse landscape is a matter of blessing, it also seldom acts as a menace for the Country during extreme hazardous events. Most prominent disasters which the Country is facing, includes earthquake, flood, drought, landslide, avalanche, GLOF and cyclones with frequent return period. The changing climatic pattern is also likely to aggravate the hazard portfolio in coming years both in terms of intensity and frequency.

Realizing Pakistan's vulnerability to these impending hazards coupled with other natural and anthropogenic events, taking information driven Disaster Risk Reduction (DRR) initiatives is inevitable for efficient and sustainable disaster management. For this reason, a coordinated approach is required to be undertaken for efficient and integrated procedures for hazard and risk reduction for which Multi Hazard Vulnerability and Risk Assessment (MHVRA) is mandatory. However, it has been observed that various organizations, even though working along the same sets of aspirations, tend to adopt non-participatory and non-coordinating approach towards execution of risk assessment studies. This can be attributed to the absence of standard execution mechanism for risk assessment and mapping at National scale due to which these studies cannot be correlated with each other.

To plug these gaps, National Disaster Management Authority (NDMA) took an initiative to develop multi-dimensional, holistic and unified guidelines for the conduct of MHVRA. These guidelines constitute an important part of NDMA's effort towards provision of unified standards and procedures for the hazard, exposure, vulnerability and risk assessments.

The effort will pave the way for centralized risk information management system providing unified sets of databases and tools for informed decision support system at the National Level and will provide substantial foundation for optimizing resources for DRR, capacity building and community resilience initiatives. It will lead the way for development of central MHVRA repository and will be beneficiary for all associated organizations by offering a forum for data sharing, data acquisition, data synchronization, provision of access to government endorsed datasets, avoidance of domain overlap and data replication.

NDMA, being disaster management policy formulation body at National Level, has prepared these guidelines in accordance with National Disaster Management Plan (NDMP). These guidelines have been endorsed by Steering Committee formulated to oversee implementation of NDMP. This Authority acknowledges the contributions of the members of NDMP Steering Committee, Development Partners, NGOs/INGOs and academia for their valuable inputs during development of this document. A profound acknowledge to the United Nation World Food Program, Pakistan for their support and cooperation for initiating and pioneering MHVRA initiatives in Pakistan.

TABLE OF CONTENTS

SECTION - I

DEFINITIONS AND ACRONYMS

SECTION - II

POLICY GUIDELINES

SECTION - III

MONITORING AND EVALUATION OF MHVRA STUDIES

SECTION - IV

MHVRA TECHNICAL GUIDING STEPS

ANNEXURES

LIST OF FIGURES

LIST OF TABLES

SECTION - I
DEFINITIONS AND ACRONYMS

ACRONYMS

AAI	Aridity Anomaly Index
AJ & K	Azad Jammu and Kashmir
AWO	Automatic Weather Observation
AWS	Automatic Weather Station
C&W	Communication & Works
CBA	Cost Benefit Analysis
CBDRM	Community Based Disaster Risk Management
CBEWS	Community-Based Early Worming System
COMCOT	Cornell Multi-grid Coupled Tsunami (Model)
CRI	Composite Risk Index
DC	Deputy Commissioner
DCO	District Coordination Officer
DDMA	District Disaster Management Authority
DDMRP	District Disaster Risk Management Plan
DEWS	Disaster Early Warning System
DM	Disaster Management
DRI	Drought Reconnaissance Index
DRR	Disaster Risk Reduction
DSHA	Deterministic Seismic Hazard Assessment
EDI	Extreme Drought Index
EWS	Early Warning System
F/G/S/PDMAs	FATA/Gilgit-Baltistan/State (AJ & K)/Provincial Disaster Management
FATA	Federally Administered Tribal Area
FEWS	Flood Early Warning System
FFC	Federal Flood Commission

FFD	Flood Forecasting Division
FGDs	Focus Group Discussions
GB	Gilgit Baltistan
GBDMA	Gilgit Baltistan Disaster Management Authority
GCISC	Global Change Impact Study Center
Geo SFM	Geospatial Stream Flow Model
GIS	Geographic Information System
GLOF	Glacial Lake Outburst Flood
GME	Global Weather Forecast Model (German Term)
GMPE	Ground Motion Prediction Equation
GOERE	Government Officer Emergency Response Exercise
GPS	Global Positioning System
GSP	Geological Survey of Pakistan
GUITAR	It is the name of Tsunami Simulation Software by Germany
HEC-HMS	Hydrologic Engineering Center-Hydrologic Monitoring System
HFA	Hyogo Framework for Action
HTC	Hydro-Thermal Coefficient
IFAS	Integrated Flood Analysis System
INGOs	International Non-governmental Organizations
IPCC	Inter-governmental Penal on Climate Change
IRSA	Indus River System Authority
KII	Key Informant Interview
KP	Khyber Pakhtunkhwa
KPI	Key Performance Indicator
LSWI	Land Surface Water Index
M&E	Monitoring and Evaluation
MBT	Main Boundary Thrust
MCE	Maximum Considered Earthquake
MGDs	Millennium Development Goals
MHEWS	Multi-Hazard Early Warning System

MHVRA	Multi Hazard Vulnerability and Risk Assessment
MKT	Main Karakorum Thrust
MMT	Main Mantle Thrust
MOS	Model Output Statistics
MOVERE	Mobilization of Volunteer for Emergency Response Exercise
MPE	Most Probable Earthquake
MSSP	Micro Seismic Study Program (Pakistan Atomic Energy Commission)
Mw	Moment Magnitude
NARC	National Agriculture Research Council
NCEG	National Center of Excellence in Geology
NDI	NOAA Drought Index
NDMA	National Disaster Management Authority
NDMC	National Disaster Management Commission
NDMC	National Drought Monitoring Centre
NDMP	National Disaster Management Plan
NDMP-SC	National Disaster Management Planning- Steering Committee
NDRIS	National Disaster Risk Information System
NDVI	Normalized Difference Vegetation Index
NDWI	Normalized Difference Water Index
NEOC	National Emergency Operations Centre
NFPPs	National Flood Protection Plan
NHA	National Highway Authority
NHEPRN	National Health Emergency, Preparedness and Response Network
NIDM	National Institute of Disaster Management
PARC	Pakistan Agriculture Research Council
PASSCO	Pakistan Agricultural Services and Storage Corporation
PBC	Pakistan Broadcasting Corporation
PBS	Pakistan Bureau of Statistics
PCIW	Pakistan Commissioner for Indus Waters
PCRWR	Pakistan Center for Research on Water Resources

PDMA	Provincial Disaster Management Authority
PDSI	Palmer Drought Severity Index
PGA	Peak Ground Acceleration
PHDI	Palmer Hydrological Drought Severity Index
PIPD	Provincial Irrigation and Power Department
PMD	Pakistan Meteorological Department
PMU	Project Management Unit
PRA	Participatory Risk Assessment
PSC	Project Steering Committee
PSHA	Probabilistic Seismic Hazard Assessment
PTA	Pakistan Telecommunication Authority
PTCL	Pakistan Telecommunication Company Limited
PTWC	Pacific Tsunami Warning Center
R&D	Research and Development
RDMC	Regional Drought Monitoring Centre
RP	Return Period
SFDRR	Sendai Framework for Disaster Risk Reduction
SMA	Soil Moisture Anomaly
SMDI	Soil Moisture Deficit Index
SMRFC	Specialized Medium Range Forecasting Centre
SOP	Survey of Pakistan
SoVI	Social Vulnerability Index
SPEI	Standardized Precipitation Evapotranspiration
SPI	Standard Precipitation Index
SPI	Stream Power Index
SPT	Standard Penetration Test
SRSI	Standardized Reservoir Supply Index
SSFI	Standardized Stream Flow Index
SSI	Semi Structured Interviews
SUPARCO	Space and Upper Atmospheric Research Commission

SWI	Standardized Water-Level Index
SWS	Soil Water Storage
SWSI	Surface Water Severity Index
SWSI	Surface Water Supply Index
TCI	Temperature Condition Index
TMA	Tehsil Municipal Administration
UC	Union Council
UN	United Nations
VCI	Vegetation Condition Index
VegDRI	Vegetation Drought Response Index
VIC	Variable Infiltration Capacity
WAPDA	Water and Power Development Authority
WASA	Water and Sanitation Agency
WFP	World Food Program
WHO	World Health Organization
WMO	World Meteorological Organization
WOE	Weight of Evidence (Statistical Model)
WRF	Weather Research and Forecast (Name of Numerical Calculation Model)

DEFINITIONS

Acceptable Risk	The level of potential losses that a society or community considers acceptable given existing social, economic, political, cultural, technical and environmental conditions.
Accountability	Obligation to demonstrate that work has been conducted in compliance with agreed rules and standards or to report fairly and accurately on performance results vis a vis mandated roles and/or plans. This may require a careful, even legally defensible, demonstration that the work is consistent with the contract terms.
Activity	Actions taken or work performed through which inputs, such as funds, technical assistance and other types of resources.
Adaptation	The adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.
Affected Area	An area or part of country affected by disaster.
Avalanche	An avalanche (also called a snow slide) is a rapid flow of snow down a sloping surface of a mountain. Avalanches are triggered due to mechanical failure of the snow when the forces on the snow exceed its cohesion strength.
Base-Line Study	An analysis describing the situation prior to a development intervention, against which progress can be assessed or comparisons made.
Capacity	The combination of all the strengths, attributes and resources available within a community, society or organization that can be used to achieve agreed goals.
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	(a) The Inter-governmental Panel on Climate Change (IPCC) defines climate change as: "a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external force or to persistent anthropogenic changes in the composition of the atmosphere or in land use". (b) The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods".
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.
Critical Facilities	The primary physical structures, technical facilities and systems which are socially, economically or operationally essential to the functioning of a society or community, both in routine circumstances and in the extreme circumstances of an emergency.
Cyclone	A large-scale system of winds that spiral in toward a region of low atmospheric pressure. Because low-pressure systems generally produce clouds and precipitation, cyclones are often simply referred to as storms. A tropical cyclone is one that forms over warm tropical waters. Such a system is characterized by a warm, well-defined core and can range in intensity from a tropical depression to a tropical cyclone. While tropical cyclones can produce extremely powerful winds and torrential rain, they are also able to produce high waves and damaging storm surge.
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.
Disaster	A catastrophe or a calamity in an affected area arising from natural or man-made causes or by accident which results in substantial loss of life or human suffering or damage to, and destruction of property. A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources.
Disaster Management	Managing the complete spectrum of disaster including preparedness, mitigation, response, recovery, relief and rehabilitation.
Disaster Risk	The potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period.
Disaster Risk Management (DRM)	The systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster.
Disaster Risk Reduction	The concept and practice of reducing disaster risks through systematic efforts to analyses and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events.
Drought	A drought is an extended period when an area notes a deficiency in its water supply when the demand for water exceeds the supply. Generally, this occurs when an area receives consistently below average precipitation. It can have a substantial impact on the ecosystem and agriculture of the affected region.

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.
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.
Effectiveness	The extent to which the development intervention's objectives were achieved, or are expected to be achieved, taking into account their relative importance
Efficiency	A measure of how economically resources/inputs (funds, expertise, time, etc.) are converted to results.
Element at Risks	Elements at Risk include all tangible (population, essential and critical infrastructure, building, crops and so on) and intangible elements (monetary values) that are at risk to any potential damage during extreme events.
Emergency Management	The management and deployment of resources for dealing with all aspects of emergencies, in particularly preparedness, response and rehabilitation.
Entity	Any government or non-government organization, national or international stakeholders including Federal, Provincial and District agencies and United Nations' agencies relevant to Disaster Management as described in Section 23-2 [(a) and (d)] of NDM Act 2010, which is interested in the execution of MHVRA activity hereinafter referred to as Entity.
Evaluation	The systematic and objective assessment of an on-going or completed project, program or policy, its design, implementation and results. The aim is to determine the relevance and fulfillment of objectives, development efficiency, effectiveness, impact and sustainability. An evaluation should provide information that is credible and useful, enabling the incorporation of lessons learned into the decision making process of both recipients and

	donors.
Exposure	People, property, systems, or other elements present in hazard zones that are subject to potential losses.
Flash Flood	A flash flood is a phenomenon of 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.
Flood	Flood is a phenomenon of inundation by water coming from a direct rainfall or river, drainage or other water bodies, such as lakes or seas due to overflowing from ordinary boundary between land and water or water surging.
Forecast	Estimate of the occurrence of a future event (UNESCO, WMO). The term is used with different meanings in different disciplines.
Geospatial Data Bank	Relevant data is vital to manage disasters. Data integration is one of the strongest points of GIS. To deal disasters following types of data is required: i. Data on the disastrous phenomena (e.g. landslides, floods, earthquakes), their location, frequency, magnitude etc. ii. Data on the environment in which the disastrous events might take place: topography, geology, geomorphology, soils, hydrology, land use, vegetation etc. iii. Data on the elements that might be destroyed if the event takes place: infrastructure, settlements, population, socioeconomic data etc. iv. Data on the emergency relief resources, such as hospitals, fire brigades, police stations, warehouses etc.
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)
Hazard	A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of

	livelihoods and services, social and economic disruption, or environmental damage.
Hazard Analysis	Identification, studies and monitoring of any hazard to determine its potential, origin, characteristics and behavior.
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.
Human-Induced Disasters	Natural disasters that are accelerated/aggravated by human influence. A landslide, for example, may be purely natural, as a result of a heavy rainfall or earthquake, but it may also be human induced, as a result of an over steepened road-cut.
Human-Made Disasters	Events which are caused by human activities (such as atmospheric pollution, industrial chemical accidents, major armed conflicts, nuclear accidents, oil spills etc.)
Impacts	Positive and negative, primary and secondary long-term effects produced by a development intervention, directly or indirectly, intended or unintended.
Indicators	Indicators are variables or parameters used to describe drought conditions. Examples include precipitation, temperature, streamflow, groundwater and reservoir levels, soil moisture, snowpack, etc.
Indices	Indices are typically a computed numerical representation of drought severity, assessed using climatic or hydro-meteorological inputs including the indicators listed above. In short, they aim to measure the qualitative state of drought on the landscape for a given time period. Indices are technically indicators as well. Monitoring the climate at various timescales allows identification of short-term wet periods within long-term droughts or short-term dry spells within long-term wet periods.
Irrigation Sources	It refers to the source(s) by means of which the cultivated area is irrigated partially or wholly.

Landslide	A landslide is a phenomenon in which the movement of a mass of rock, debris, or earth down a slope due to gravity. The materials may move by falling, toppling, sliding, spreading, or flowing. Since a large amount of soil mass usually moves, serious damage can occur.
Land-Use Planning	The process undertaken by public authorities to identify, evaluate and decide on different options for the use of land, including consideration of long term economic, social and environmental objectives and the implications for different communities and interest groups, and the subsequent formulation and promulgation of plans that describe the permitted or acceptable uses. 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.
Mitigation	The lessening or limitation of the adverse impacts of hazards and related disasters.
Monitoring & Evaluation (M&E)	A continuing function that uses systematic collection of data on specified indicators to provide management and the main stakeholders of an ongoing development intervention with indications of the extent of progress and achievement of objectives and progress in the use of allocated funds.
Mouza / Deh	Mouza / Deh: It is a territorial unit with a separate name, definite boundaries, and area precisely measured and divided into plots / khasras / survey numbers. Each mouza is a revenue estate and has a cadastral map maintained in the land revenue record with a Hadbast Number except Sindh Province. Mouza, Deh, Village, Killi and Chak are the names commonly used for it. The term mouza / deh is widely used in the settled areas while the term village and or killi are used in the unsettled areas. There may be one or more settlements, abadies, basties, dhokes, goths, etc. in the territory of a mouza / deh. The mouzas / dehs may also have scattered inhabitation while

	there may be some mouzas without population as well.
Multi Hazard Vulnerability And Risk Assessment (MHVRA).	Multi Hazard Vulnerability and Risk Assessment is a comprehensive study which intends to evaluate the expected vulnerabilities, risks and losses due to different hazardous events; both natural or man-induced.
Multi Hazards	The term Multi Hazards, as the name would suggest, are the hazards evolved from multiple sources, either inter-related or independent phenomena, and are subject to joint probability theory and analysis.
National Authority	National Authority means National Disaster Management Authority (NDMA).
Natural Disasters	Events which are caused purely by natural phenomena such as earthquakes, floods, cyclones etc.
Nullah	A Pakistani term. Rivers excluding huge rivers in the Indus River System.
Performance Indicator	A variable that allows the verification of changes in the development intervention or shows results relative to what was planned.
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.
Prescribed	Prescribed means rules prescribed by these guidelines
Prevention	Activities to ensure complete avoidance of the adverse impact of hazards.
Quality Assurance	Quality assurance encompasses any activity that is concerned with assessing and improving the merit or the worth of a development intervention or its compliance with given standards. Note: examples of quality assurance activities include appraisal, RBM, reviews during implementation, evaluations, etc.
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.
Reliability	Consistency or dependability of data and evaluation judgments, with reference to the quality of the instruments, procedures and analyses used to collect and interpret evaluation data.
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.
Residual Risk	The risk that remains in unmanaged form, even when effective disaster risk reduction measures are in place, and for which emergency response and recovery capacities must be maintained.
Resilience	The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.
Retrofitting (or Upgrading)	Reinforcement of existing buildings and structures to become more resistant and resilient to the forces of natural hazards.
Risk	The combination of the probability of an event and its negative consequences.
Risk Assessment	A methodology to determine the nature and extent of risk by analyzing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment on which they depend.
Risk Management	The systematic approach and practice of managing uncertainty to minimize potential harm and loss.
Risk Transfer	The process of formally or informally shifting the financial consequences of particular risks from one party to another whereby a household, community,

	enterprise or state authority will obtain resources from the other party after a disaster occurs, in exchange for ongoing or compensatory social or financial benefits provided to that other party.
River	A river is a natural waterway, usually freshwater, flowing toward lower level of water surface such as a lake, a sea, or another river.
Riverine 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.
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.
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".
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).
Tsunami	A tsunami is a series of waves in a water body caused by the displacement of a large volume of water, generally in an ocean or a large lake. Earthquakes, volcanic eruptions and other underwater explosions, landslides, avalanche, meteorite impacts and other disturbances above or below water all have the potential to generate a tsunami.
Urban Flood	Flood and inundation phenomena occurring in the city or built-up areas.
Veterinary Facility	It refers to the availability of veterinary facilities for livestock with qualified veterinarian (Doctor / Assistant) for provision of medical facilities for farm animals.
Vulnerability	The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard.
Wheat Procurement Centre	These centres are established every year at the time of wheat harvest in surplus wheat producing areas particularly of the Punjab and Sindh provinces by the Provincial Food Departments and or Pakistan Agricultural Services and Storage Corporation (PASSCO) at appropriate locations. These centres are not permanent in nature and their number in a tehsil / district varies on year to year basis depending upon the procurement policy.

PURPOSE OF THE DOCUMENT

1. NDMA has developed National Guidelines for executing Multi-Hazard Vulnerability and Risk Assessment (MHVRA), covering areas such as: detail step by step Execution Methodology, Governing Policies & SOPs, Monitoring & Evaluation Process and Standardization of Data Structure for all implementation partners to follow.
2. Main purpose of these guidelines is to set standard benchmarks, for all set of procedures to be followed, outlining datasets & tools to be used for carrying out MHVRA exercise in the country to ensure unanimity for development of one National Risk Picture for sustainable DRR planning.
3. Further, NDMA has developed National MHVRA database, in which all studies carried out till date and are to be carried out in future will be incorporated for provision of Risk & Vulnerability data. Because of these factors, it is very important to follow standard methodology defined in National MHVRA guidelines to ensure all studies are compatible with National MHVRA Database.

SECTION - II
POLICY GUIDELINES

1. **Short Title**. The Document will be named as "NDMA Policy Guidelines for Conduct of Multi Hazard Vulnerability and Risk Assessment (MHVRA)".
2. **Applicability**. These Guidelines shall be applicable to all provinces of Pakistan, Azad Jammu & Kashmir (AJ&K) and Gilgit Baltistan (GB).
3. **Compliance**. The Compliance of these Guidelines is mandatory and binding for any Entity (vide the definition of Entity) on carrying out either MHVRA or single hazard assessment within the geographical boundaries of Pakistan, AJ&K and GB.
4. **Policy Domain and its Relationship with Sectorial Objectives**. MHVRA is an important undertaking aligned to the National as well as International commitments with regard to frameworks/policies i-e. National Climate Change Policy 2012, National Disaster Management Plan (NDMP) 2012-2022, National DRR Policy 2013, Sendai Framework for Disaster Risk (SFDRR) 2015-2030, Sustainable Development Goals (SDGs) 2016-2030, UN Resolutions and Pakistan Vision 2025. The relevance is given in tabulated form at **Annex A**.
5. **Objectives**. The objectives of these Policy Guidelines are as under:-
   a. Maintain uniformity in the risk assessment methodologies across the Country and AJ&K.
   b. Ensure that all data collected under MHVRA activity is compatible with National MHVRA database, which will serve as central repository for data acquisition, data dissemination, data integration, data consolidation, data authentication and data management of MHVRA related activities.
   c. Monitor and evaluate all risk assessment studies conducted in the Country through a centralized, stage wise Monitoring and Evaluation (M&E) Process for quality assurance.
   d. Prohibit use of non-endorsed data by any Entity in order to uphold the absolute standards of risk assessment.
   e. Benchmark National Composite Risk Index (CRI) of all hazards and risks for identifying their impact and associated probability of occurrence(s).
   f. Enforce use of prescribed Standard Hazard Modeling methodologies as explicitly mentioned in Technical Guidelines of this Document.

g. Ensure production of maps and study report on an approved format using standardized legends (for maps) to maintain uniformity at National level.

6. **<u>Policy for Execution of MHVRA Interventions</u>**. MHVRA has a pronounced bearing for Disaster Risk Management hence its credibility, authenticity and usefulness must be absolute. NDMA reserves the right to exercise its power assigned by NDMA ACT 2010, Section **9 [(a),(b),(c),(d) & (g)]** and Section **23-2 [(a),(b) & (d)]**. The following procedures shall be strictly followed for execution of MHVRA Intervention by any organization.

a. The Policy Parameters outlined in these Guidelines are mandatory to be followed by all organizations undertaking any MHVRA Interventions in Pakistan and AJ&K.

b. **<u>Project Cycle</u>**. The MHVRA Project will follow the logical sequence given in **Figure 1**.

Figure 1: Project Cycle

c. NDMA will be approached and apprised with the following information about any Intervention related to MHVRA by respective PDMA:-

(1) Total funds available for the Intervention and source of funding.

(2) Name of districts for which MHVRA study is being undertaken.

(3) Strong justification in case selected area is not in accordance with priority set in NDMP Implementation Road Map 2016-2030.

(4) Hazards to be assessed in the Intervention with rationale.

(5) Particulars of implementation entity to include last experience of carrying out any similar Intervention.

(6) Submission of undertaking by Implementing Entity that shall follow NDMA's MHVRA policy guidelines for compliance.

(7) A detailed desk review of methodology and work plan to be adopted for the execution of Intervention.

d. Based on the information provided by the Organization, NDMA will allocate districts as per the priority list given by NDMP Roadmap 2016-2030 (vide **Annex B**).

e. Ensure thorough scrutiny, vetting and approval by all concerned stake holders through the forum of NDMP (National Disaster Management Plan) Steering Committee.

f. **Approval of NDMP Steering Committee**. The approval will be required at following stages:-

(1) On Receipt of Study / Project Proposal through PDMAs.

(2) On finalization of Study.

g. After hazard assessment, the selected area should be indexed as ***no risk*, *very low, low, medium, high or very high*** (with numeric values 0 to 5) category as reflected in macro-level risk assessment outlined in National Disaster Management Plan.

h. NDMA will have dual responsibilities i.e. **Implementing Entity** itself through its Project Management Unit (PMU) for MHVRA Study on self-execution basis, as well as **Approving and Monitoring Body** for all projects undertaken by other implementing entities.

i. Interventions must be executed for the entire district down to the level of Union Council and should not be limited to a part of it.

j. After approval of execution methodology, Organization must advertise ToRs based on MHVRA policy guidelines for selecting the Implementation Partner. To this end, 1 x representative of NDMA will participate during selection process for shortlisting, scrutiny and selection of Implementation Partner.

k. All the data, analysis, results, research, atlases, info-graphs, maps, datasets and geo databases collected or prepared by the Entity will be submitted to NDMA-PMU for their evaluation which include:

(1) Dataset layout and data relationship diagram.

(2) Collected datasets in raw format tagged with their sources.

(3) Risk/ Vulnerability classification/ indexing.

(4) Risk assessment methodology.

l. Key Performance Indicator (KPI) will be formulated by NDMA by considering the implementation plans, timelines, milestones achieved and components &subcomponents of the Interventions.

m. Upon completion of the activity, Entity will be solely responsible to provide all data and their original sources, as per standards laid down in MHVRA execution methodology and guidelines, to NDMA and respective F/S/G/PDMAs.

n. The output data of study should be in prescribed format for ensuring its portability to National MHVRA database. Entity must ensure data compatibility during stages of data collection, preparation, conversion and analysis.

o. Any person, individual or firm handling, accessing or taking the data on behalf of the Entity will strictly understand the confidentiality agreement decreed and exchanged by, between the NDMA and Entity **(Vide Annex C).**

p. Final products should be integrated and stored in MHVRA central repository.

q. Following the completion of the activity, a technical evaluation and review of the activity shall be undertaken by NDMA for monitoring its compliance with MHVRA policy and execution guidelines.

r. Entity should provide any support required by NDMA during evaluation of the activity in terms of the arrangement of software license including hazard modeling tools and risk assessment software used in the study.

s. Entity should be responsible to bound consultants hired for study to cooperate with NDMA during evaluation period.

t. After Project's completion, final endorsement of NDMP Steering Committee be solicited for the publication of study, online hosting of study data and their subsequent disseminations to the intended target audience.

u. **<u>Acquisition of Spatial and Non Spatial Data</u>**

(1) The executing agency may access central MHVRA database for spatial and non-spatial data acquisition. For this purpose data request, as given in **Annex D**, form shall be submitted to NDMA through proper channel along with a signed non-disclosure agreement.

(2) Any data shared or disseminated will be subjected to approval of NDMA.

(3) Primary data collection strategies, tools, and methodologies adopted should be submitted, with complete detail in inception report.

(4) Data techniques must follow the available standards established by national and provincial authorities. In case of unavailability or outdated status, the executing agency will perform Data Gap Analysis (GAP) as per prescribed format given in **Annex E**.

SECTION - III
MONITORING AND EVALUATION OF MHVRA STUDIES

1. **Policy Pillars**

   a. Monitoring and Evaluation (M&E) is a sophisticated discipline of Project Management which intends to constantly improve the performance of any sector through informed decision making, monitoring, and assessment of project outcomes on every step of project life cycle.

   b. The process includes both qualitative and quantitative analyses and incorporates auditing, resource allocation procedures, project performance indices, policy compliance, quality assurance and wide range of other performance metrics.

   c. M&E policy is devised to improve the implementation mechanism of MHVRA processes and to ensure quality standards are met on each milestone.

   d. NDMA is committed to incorporate both Result Based and Implementation Based, M&E practices in performance assessment procedures.

2. **Purpose of M&E**

   a. To assess the overall progress, efficiency and effectiveness of MHVRA exercises in reference to its outcomes and impacts; and where required, to determine the sustainability of MHVRA Products.

   b. To streamline the efforts of development partners on the basis of National priorities.

   c. To ensure compliance of National standards laid down for data compatibility with National MHVRA databases.

   d. To ensure compliance of MHVRA procedures laid down in the standard MHVRA guidelines.

   e. To facilitate execution partners in compliance of standards and methodologies while carrying out MHVRA through third party vendors.

   f. To facilitate continuous improvement in MHVRA practices.

   g. To share and encourage best MHVRA practices.

   h. To ensure outcome/results of study is utilized in mainstream planning.

3. **<u>Roles and Responsibilities</u>.** For smooth and uniform execution of MHVRA intervention, NDMA has devised a framework for systematic coverage of all risk assessment related interventions. The framework will be governed and managed through Project Steering Committee (PSC) and Project Management Unit (PMU), NDMA respectively. The structural framework for monitoring and evaluation of MHVRA products is shown in Figure 2. The roles and responsibilities of each segment in carrying out MHVRA exercise are:-

a. **Project Steering Committee (PSC)** has been formulated as a governing body for regulating and monitoring progress made in regards to MHVRA interventions. The PSC role is to:

(1) Review implementation progress.

(2) Review project legal compliance and procedures.

(3) Monitor relationships among all project stakeholders.

b. **Project Management Unit (PMU)** has been established to function as an overall management body. Prime responsibilities of PMU include:

(1) Self-execution of MHVRA related interventions.

(2) Monitoring and evaluation of similar interventions carried out by any development partners to regulate its compliance with National Standards.

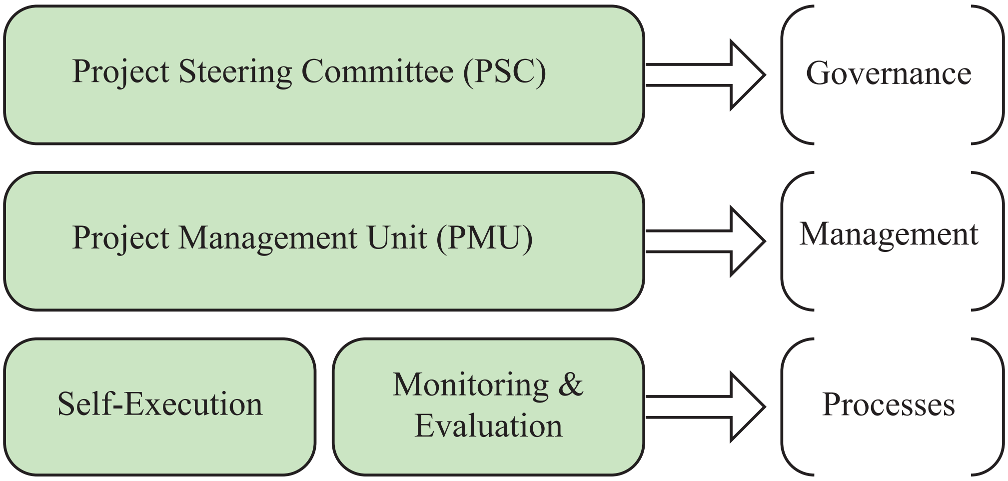


Figure 2: Structural Framework for MHVRA Interventions

4. **<u>M&E Cycle</u>**. For all project executions, PMU will function as a focal point at the National Level to monitor and evaluate implementation progress of all risk assessment related interventions. For this purpose, a specialized team has been enrolled in PMU-NDMA for building strong in-house capacity for self-execution as well as subsequent M&E of interventions undertaken by other development partners. M&E cycle broadly covers following steps as shown in Figure 3:

Figure 3: Project Cycle

a. **<u>Study Area Selection</u>**

(1) The Study Area must fall under Priority Districts identified in NDMP Implementation Roadmap 2016-2030.

b. **<u>Request For Proposal (RFP) Approval and Firm Selection</u>**

(1) Any Executing Agency interested to undertake MHVRA exercise must submit RFP to NDMA covering list of hazards to be covered in the assessment, the proposed execution methodology, implementation contours, budgeting constraints and expected deliverables.

(2) The execution methodology, study area selection, hazard, vulnerability, exposure, capacity and risk dynamics must be in accordance with the technical guidelines specified in **Section IV** of this document.

c. **Execution Methodology Approval**

(1) NDMA through PMU would approve the methodology provided by the Execution Agency. PMU would examine the correlation of proposed methodology, study parameters and project deliverables with the methodologies and mechanisms defined herewith in this document.

d. **Stage Wise Monitoring.** Stage wise monitoring shall encompass:-

(1) Monthly monitoring reports.

(2) Random spot checks in the field.

(3) Critical control points monitoring.

(4) Critical stage completion reports as per project cycle.

e. **Validation & Evaluation.** Following the completion of the activity, a technical evaluation and review of the activity shall be undertaken by PMUto:

(1) Validate study results.

(2) Check authenticity of data used for processing results.

(3) Ensure compliance with MHVRA guidelines.

(4) Check compatibility of dataset with MHVRA database.

f. **Consolidation with National MHVRA database**

(1) Final product shall be integrated and stored in MHVRA central repository. The output data of study should be in prescribed format for ensuring its portability to National MHVRA database.

(2) The Executing Agency must ensure data compatibility during all stages of data collection, processing, analysis and projections.

g. **Publication and Advocacy**

(1) After Project's conclusion, final endorsement of NDMP Steering Committee shall be solicited before publication of study, online hosting of study data and their subsequent disseminations to the intended target audience.

(2) Quality assurances of publication shall be guaranteed by the Executing Agency before distribution.

(3) Executing Agency shall be responsible to undertake training and awareness activities for respective Government Offices, Local Community representatives, Line Departments and other relevant Stakeholders. Curriculum of training shall be duly approved by NDMA.

(4) Advocacy &awareness campaigns shall be launched after seeking NDMA's formal approval.

(5) All publications, whether in hard or soft form, should carry clearly visible logo of NDMA and respective PDMA.

SECTION - IV

MHVRA TECHNICAL GUIDING STEPS

Note:

This is a living document and will be revised periodically or whenever a need for amendment/ revision is felt by NDMA. In this regard, NDMA will value the proposals submitted by anyone for improvement of this document. The proposal, if any, may be submitted at **dirimp@ndma.gov.pk** and **spm@ndma.gov.pk**.

SECTION - IV
MHVRA TECHNICAL GUIDING STEPS

1. **Introduction to MHVRA**

   a. Multi Hazard Vulnerability and Risk Assessment is a comprehensive analytical tool which intends to assess the degree of vulnerability, exposure and risk of study area to multiple impending hazards.

   b. While carrying out MHVRA, a complicated set of data is to be analyzed on multidimensional matrix covering various aspects such as space, time and other triggering factors.

   c. The MHVRA intervention covers numerous scientific, technical and participatory activities, including a review of existing and ongoing study of hazards and disasters.

   d. The study includes important disciplines such as hydrological, meteorological, climatological, social economical, geophysical and geological phenomena. In most cases, numerical modeling approach is recommended to be exploited for conducting probabilistic hazard assessments.

   e. In multi hazard & risk assessment approach, exposure, vulnerability, coping capacity and risk assessments are considered in context of **socio-economic dimension of the study area including livelihood, agriculture, population, buildings, communication, transportation, infrastructure** and **strategic assets**.

   f. Note that, this document covers only natural disasters, however procedures adopted for hazard assessment for man-made disasters shall also be carried out with the consent of NDMA.

2. **MHVRA Methodology**

   a. In these guidelines, one of the primary objectives is to quantify ***Risk*** down to UC level, which is the lowest administrative division in the Country. Therefore, MHVRA should be based on an in-depth review of all dimensions of Risk to include:

      (1) Hazards i.e. location, intensity, frequency/probability etc.

      (2) Analysis of the physical, social, economic and environmental dimensions of vulnerability and exposure,

(3) Coping capacities, which make people and communities resilient against adverse effects of disasters.

b. A detailed comprehensive model adopted by NDMA in these guidelines for conduct of MHVRA study is given in **Figure 4** and **Figure 5**.

c. The MHVRA methodology described in these guidelines is based on the premise that multiple factors contribute to the overall risk. In this methodology four separate dimensions of risk are considered as "**factor Components**" i.e. *hazard, exposure, vulnerability and capacity*. To analyze the value of factor components, a combination of quantitative, qualitative and contextual indicators should be assigned to each factor component. Each factor must be composed of a number of indicators which should cover aspects of risk as comprehensively as possible. The Risk Index may have "**n**" number of indicators (for exposure, vulnerability and capacity) to cover physical, economic, demographic, social, environmental and economic dimensions of risk. The selection of indicators should be based on the availability of consistent district and tehsil wise data.

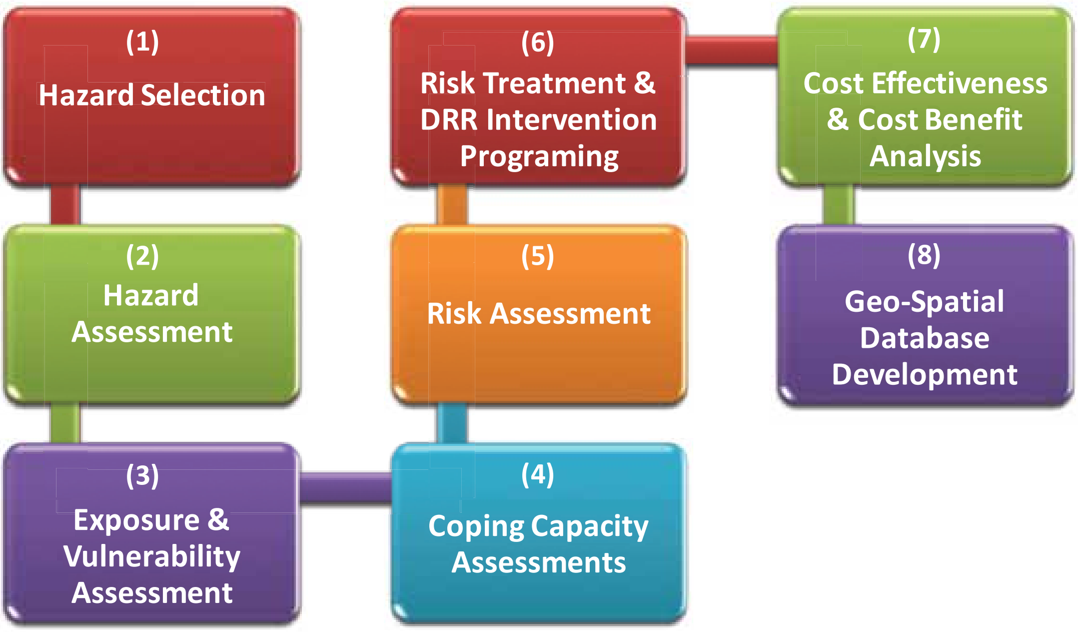


Figure 4: MHVRA Model

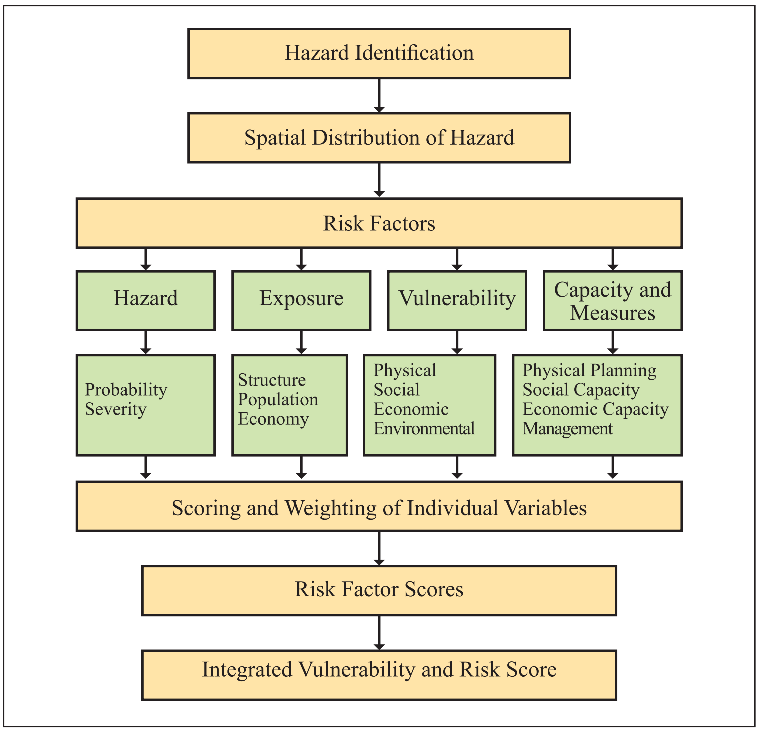


Figure 5: Integrated MHVRA Methodology

d. The Return Periods should be calculated according to the methodology described in **Annex F**. Recurrence period of 100 years or more corresponds to **rare scenarios** with annual exceedance probability of occurrence of more than 1%, similarly recurrence period of less than 25 years corresponds to **frequent scenarios** with annual exceedance probability of occurrence of more than 4 %.

e. For assessment wherever applicable high resolution Digital Elevation Model (DEM) of minimum of 8m or lower resolution should be used.

f. Image resolution of 5 x meter or lower is recommended for the Study.

3. **<u>Hazard Selection</u>**. Hazard Selection should be based on following criteria:-

a. NDMP Hazard & Risk Indexing

b. NDMP Implementation Roadmap 2016-2030

c. Historical Profile

d. Climate Change Scenarios

e. Local Community Consultation

4. Hazard Assessment

a. Hazard is characterized by **probability** and **severity**, while exposure elements are structures, population and economy and so on. Therefore, for quantifying hazards and its consequences it is important to understand that all hazard events have a probability of occurrence within a specified period of time and within a given area, and have a given intensity or magnitude which has potential to impact the population, economy, infrastructure and environments.

b. Accordingly, for precise estimation of hazard score the hazard extent maps of various return periods must be generated and elements at risk per mapping unit should be determined by overlaying the hazard footprint map with the mapping unit maps of all the districts.

c. A severity of Impact rating scale on elements at risk must be followed for determining hazard severity, with values from **0- *No impact* to 5-*catastrophic impacts*,** highlighting the severity.

d. In order to know what impact a hazard with a given intensity might have on people, infrastructure, environments and economy, historical record and past hazard events must be scrutinized.

e. The likelihood rating or return period estimation should be based on ***Annual Exceedance Probability****, which* assigns values from **1-5** for a specific return period.

f. The final score is a sum of severity of impacts and probability of occurrence. The scale varies from *0- No consequences to 100- extreme*. A final score is then achieved in shape of "c*onsequences"* of a given hazard

g. **Hazard Probability and Severity of Impact "Consequences"**

(1) To quantify likely consequences, the assessment should consider interaction of possible impacts and hazards likelihood of occurrence. Generating hazard extent maps of various return periods (RP) and overlaying these on elements at risk maps at UCs level.

(2) The hazard severity, extent and magnitude of various return periods would indicate the degree to which the elements at risk are exposed to a particular hazard.

(3) Severity of impact rating scale with values from 0 (No impact) to 4 (Catastrophic Impacts), highlighting the severity of hazard be used as reflected in **Table 1**.

Table 1: Impact Severity Score

Impact	**Severity**	**Score**
Catastrophic	Serious Effect	4
High	Major Effects	3
Moderate	Minor Effects	2
Low	Negligible Effects	1
Very Low	No Effects	0

(4) The likelihood rating of hazard should be taken as ***Annual Exceedance Probability, which*** is assigned values from 0-5 for a specific return period as referred in **Table 2** below.

Table 2: Likelihood of Hazards Score

Likelihood	**Return Period (Year)**	**Probability of Occurrence in Given Year**	**Annual Exceedance Probability %**	**Score/ Rating**
Extremely Unlikely	475	1 in 475	0.2 %	0.5
Unlikely	250	1 in 250	0.4 %	1
Rare	100	1 in 100	1%	2
Possible	50	1 in 50	2%	3
Likely	25	1 in 25	4%	4
Almost Certain	10	1 in 10	10%	5

h. **<u>Hazard Consequences</u>**. The score should be obtained as a sum of severity of impacts and probability of occurrence in shape of "*Consequences*" of a given hazard. The scale varies from 0- *No Consequences* to 100- *Extreme Consequences.* An example of Catastrophic Impact on various elements at risk for flood of return period 10 is shown in Table 3.

Table 3: Probability and Severity "Consequences"

Hazard	Floods 10 Years RP		
Elements at Risk	Impact Severity Score	Likelihood Return 10 years	Consequence Impact x Likelihood
Population	4	5	20
Agriculture Based	4	5	20
Infrastructure & Community Assets	4	5	20
Local Economy	4	5	20
Environment	4	5	20
			100

Highest impact scale and hazard most likely to happen within 10 years RP

5. **Earthquake Hazard Assessment Methodology**

a. **General Guiding Steps**

(1) Seismic sources (i.e. active geological faults and area sources) that are the main cause of earthquakes should be identified in the Study. For this purpose, the instrumental/historical earthquake catalogue and geological maps should be scrutinized.

(2) The next step is the development of seismicity model for each of the seismic sources that help to quantify the number of possible earthquakes of specified magnitude on annual based (i.e. recurrence model, typically represented by G-R model).

(3) Empirical ground motion prediction equation(s), also known as attenuation equations, should be used to quantify the earthquake ground motion intensity (peak ground acceleration or spectral acceleration) for randomly generated earthquake scenarios on each source. The analysis should be carried out in a probabilistic mathematical framework that quantify the annual rate of exceedance of each ground motions for all the possible sources and scenarios, taking into account all the uncertainties in earthquake process modeling and seismic intensity calculation.

(4) The annual rate (frequency) to annual probability transformation should be carried out using the Poisson Model and the ground motion corresponding to various return period (reciprocal of the annual rate) can be obtained directly from the hazard curve.

(5) Furthermore, de-aggregation should be carried out to identify the earthquake scenario that has more likelihood (chances) of occurrence and contribute the most to the site hazard i.e. **Most Probable Earthquake** (MPE) scenario events. The GMPEs are used to calculate ground motions for MPE scenario.

(6) The active faults must be identified in the near vicinity (particularly in the area of influences i.e. within 200 km of the area of interest).

(7) Available empirical relationships[1] should be used to calculate, probabilistically, the size of **Maximum Considered Earthquake** (MCE). The GMPEs are used to calculate ground motions for the MCE.

(8) Geotechnical investigation data (borehole, SPT) should be obtained for the target region to perform site-soil profiling on the basis of shear wave velocity and specific weight of soil.

(9) Acceleration records should be retrieved from the locally available or online global strong ground motions database[2], specifying the search criterion on the basis of fault focal mechanism, earthquake magnitude and source-to-site distance.

(10) The acceleration records should be analyzed and processed for the target region hazard compatibility (i.e. spectral matching of the acceleration records with the code specified spectrum).

(11) The compatible accelerograms should be employed for site soil response analysis, using dynamic time history analysis of 1D soil column, to obtain the site-specific ground motion on site soil surface. The ratio of the Site Amplified Ground Motion to the bedrock/outcrop motion gives estimate of site amplification factor.

(12) Earthquake Hazard Severity Score should be scaled as per the **Table 4.**

[1]Wells, D.L. and Coppersmith, K.J. (1994) "New empirical relationships among magnitude, rupture length, rupture width, rupture area, and surface displacement." Bulletin of the Seismological Society of America, Vol. 84, No. 4 pp. 974–1002.
[2]PEER NGA strong ground motion database

Table 4: Earthquake Hazard Severity Score

Magnitude	Seismic Zone	Severity
3.0-3.9 Richter Scale	1	Very Low
4.0–4.9 Richter Scale	2A	Low
5.0–5.9 Richter Scale	2B	Moderate
6.0–6.9 Richter Scale	3	High
7 more Richter Scale	4	Very High

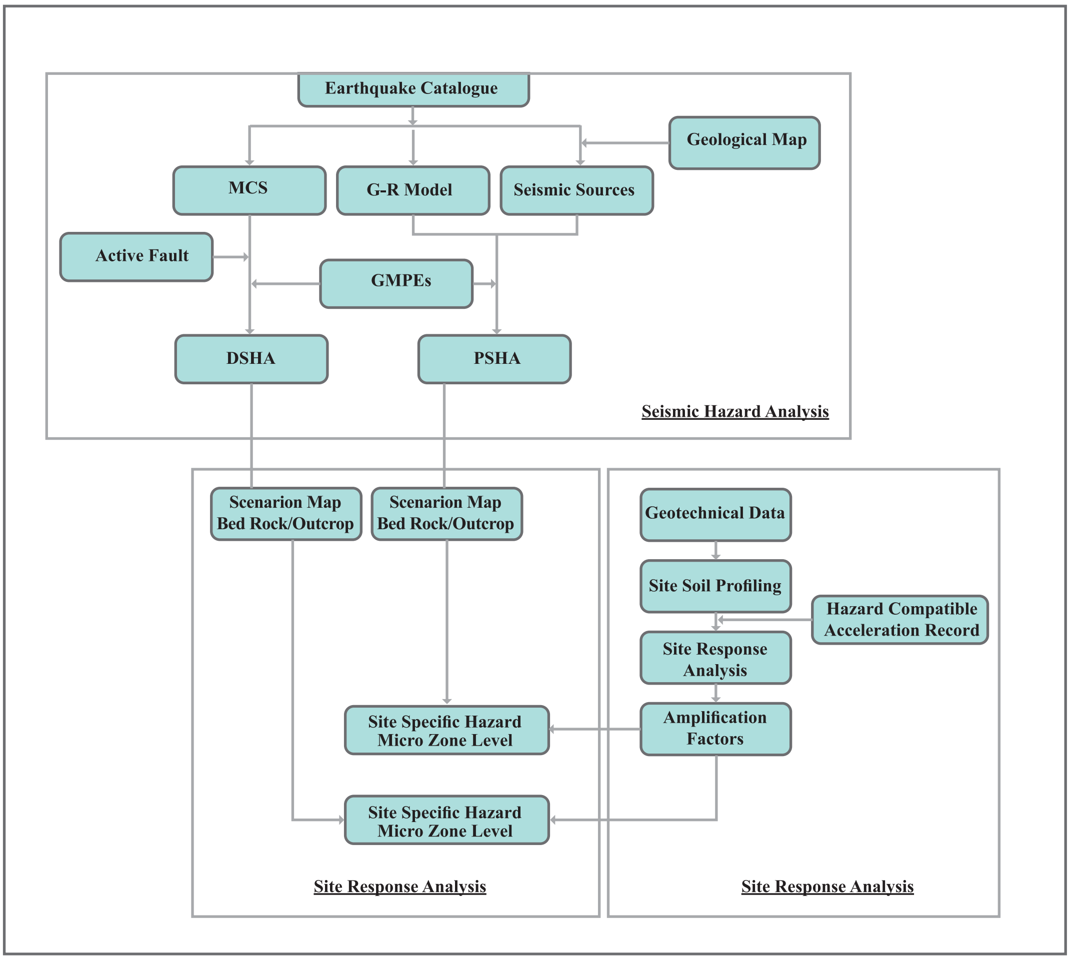


Figure 6: Seismic Hazard Assessment Methodology

b. **Required Tools/ Parameters for Earthquake Hazard Assessment**

(1) **Data Parameters**

(a) Earthquake Catalogues

(b) Seismic Sources

(c) Geology (Rock Types)

(d) Soil Data

(e) Bore Hole Data

(f) Building Codes

(g) Fault Zones/Lines

(2) **Data Sources**

(a) Geological Survey of Pakistan (GSP)

(b) National Center of Excellence in Geology(NCEG)

(c) Pakistan Meteorological Department (PMD)

(d) Provincial Soil Survey Departments

(e) Space and Upper Atmosphere Research Commission (SUPARCO)

(f) National Engineering Services Pakistan (Pvt.) Limited

(g) Pakistan Atomic Energy Commission (PAEC)

(h) National Highway Authority (NHA)

(i) Water and Power Development Authority (WAPDA)

(j) Pakistan Engineering Council (PEC)

(k) Communication and Works (C&W) Departments

(l) Local Municipalities

(3) **Model Selection**. List of recommended models for earthquake hazard assessment are given below:-

(a) EZ-FRISK

(b) CRISIS

(c) OpenSHA

(d) SeisRisk III

(e) Deep Soil

c. **Final Outputs**. The outputs must be generated for 50, 100, 250, 475, 1000 and 2500 year's recurrence periods. The final outputs shall include the following for the selected return period:-

(1) Hazard Map

(2) Peak Ground Acceleration (PGA)

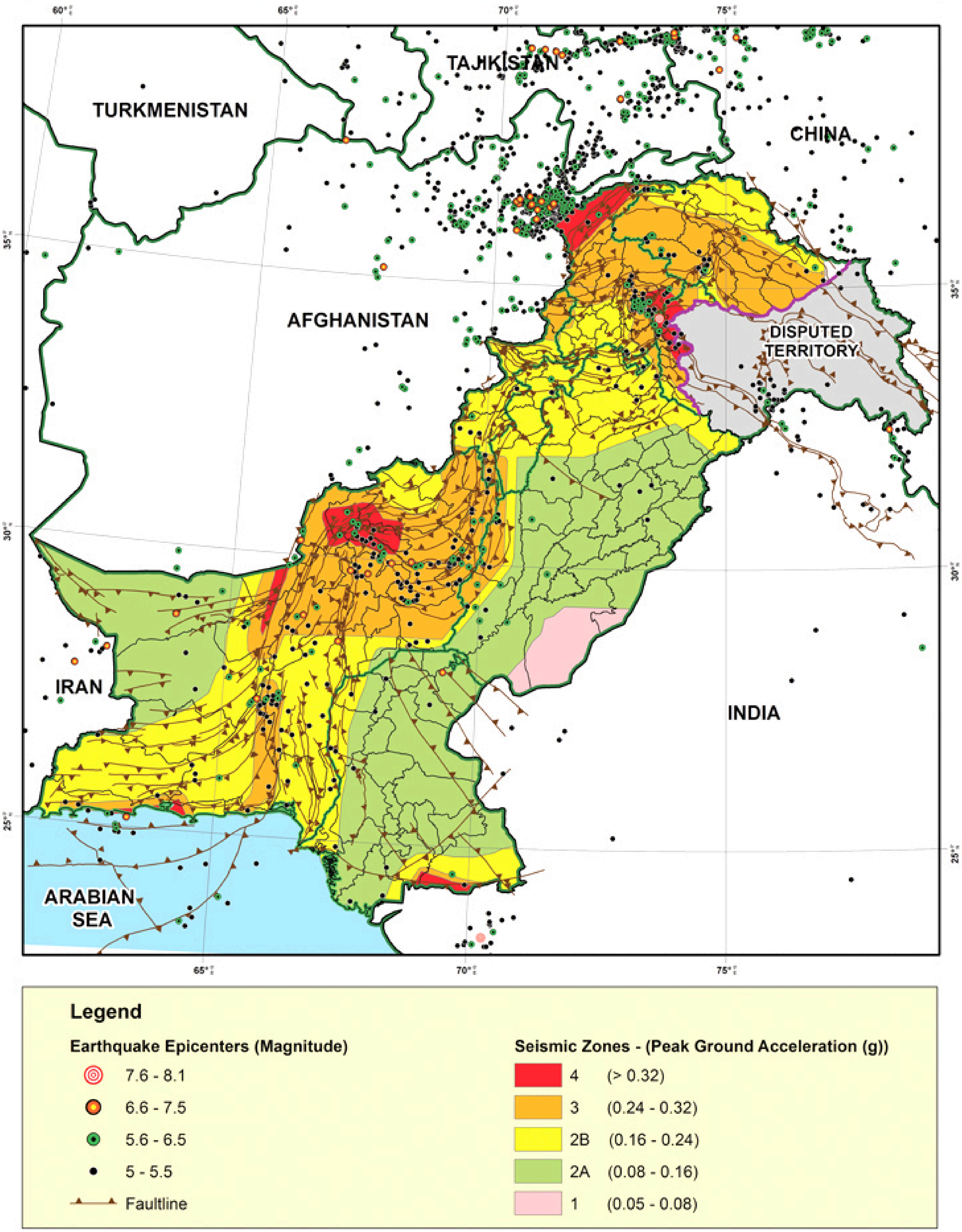
(3) Spectral Acceleration (SA)

(4) Deaggregation (Magnitude-distance)

(5) Most Probable Earthquake (Size/ Magnitude)

(6) Maximum Considered Earthquake (MCE)

SEISMIC HAZARD ZONATION MAP OF PAKISTAN



6. Flood Hazard Assessment Methodology

a. General Guiding Steps

(1) **Data Preparation**. This stage involves the following steps:

(a) **DEM Processing**. For Flood Hazard analysis, Digital Elevation Model (DEM) should be used and processed. Following processing on DEM should be performed: -

i. Flow direction and Flow accumulation

ii. Stream definition grid, stream grid segmentation, combine stream link and sink link, and catchment grid delineation

iii. Conversion of DEM into Triangulated Irregular Network (TIN)

iv. Basin and Sub Basin delineations

v. Extraction of X-cuts and L-Sections

(b) **Satellite Image Processing**. Satellite images of best available spatial and spectral resolution should be utilized in the assessment to:-

i. Carry out Land Use/ Land Cover classification for roughness coefficient analysis

ii. Analyze watershed boundary and delineated features in order to create the geometric data required for hydraulic modeling features.

(c) **Geometric Data Development for Hydraulic Modeling**. For hydraulic modeling following geometric data should be prepared. These data should be acquired through basic editing techniques and based on secondary data acquired from NDMA approved authentic sources.

i. Stream centerline

ii. Flow paths

iii. Left and right banks of the channel

iv. Cross section cut line

(d) **Hydraulic Modeling**. For the purpose of hydraulic modeling, Conservation of mass and Conservation of momentum equations between adjacent cross- sections should be employed to derive the equation for 2D energy equation.

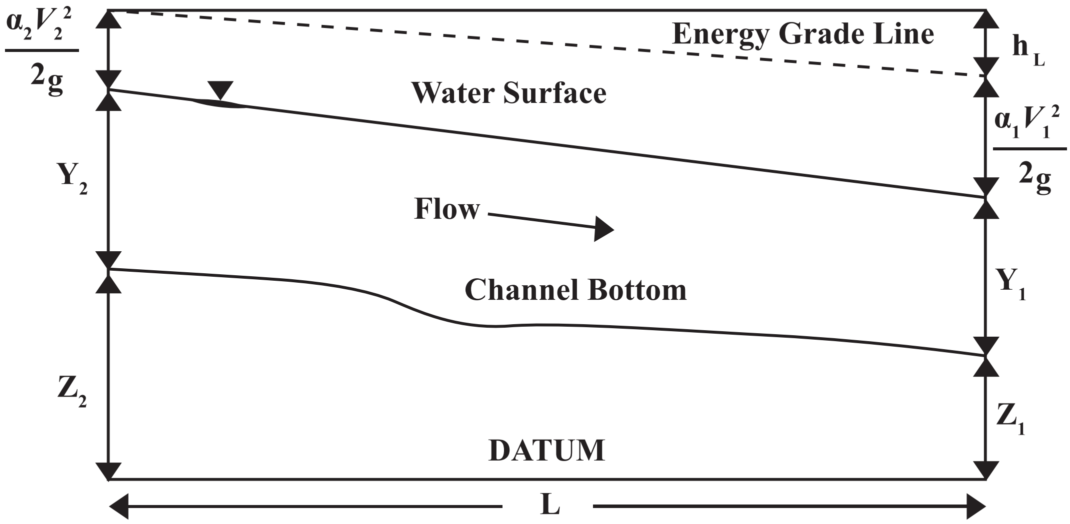


Figure 7: Energy Equation between two X-Section

$$Z_2 + Y_2 + \frac{\alpha_2 V_2^2}{2g} = Z_1 + Y_1 + \frac{\alpha_1 V_1^2}{2g} + h_e$$

Where:

Z_1, Z_2 = elevations of the main channel in meter at cross section 1 and 2 respectively, Y_1, Y_2 = depths of water in meter at cross section 1 and 2 respectively, V_1, V_2= averages velocities (total dischare/total flow area) in m/s at cross section 1 and 2 respectively, α_1, α_2= velocity weighting coefficients at cross section 1 and 2 respectively,

g= Gravitational acceleration in m/s2 and h_e = energy head loss in m.

The energy head loss $h_e$estimation is given by the Manning's equation, which is considered to be empirical

$$h_e = LS_f + C\left|\frac{\alpha_2 V_2^2}{2g} - \frac{\alpha_1 V_1^2}{2g}\right|$$

Where L is discharge weighted reach length in m; Sf is representative friction slope between two adjacent sections; C is contraction or expansion loss coefficient. The representative friction slope using the average conveyance equation and the distance weighted reach length are defined in equation given below, respectively.

$$S_f = \left(\frac{Q_1 + Q_2}{K_1 + K_2}\right)$$

$$L = \frac{L_{lob}Q_{lob} + L_{ch}Q_{ch} + L_{rob}Q_{rob}}{Q_{lob} + Q_{ch} + Q_{rob}}$$

Where K is conveyance, L_{lob},L_{ch}, and $L_{rob}$are cross-section reach lengths for flow in the left over-bank, main channel, and right over-bank, respectively, and Q_{lob}, Q_{ch}, and $Q_{rob}$are arithmetic average of the flows between sections for the left over-bank, main channel, and right over-bank, respectively.

$$Q = KS_f^{1/2}$$

$$K = \frac{1.486}{n}AR^{2/3}$$

Where: K is conveyance for the subdivision; n is Manning's roughness coefficient for the subdivision; A is flow area for the subdivision; R is hydraulic radius for each subdivision. Solving these equations requires knowledge of the geometry of the stream, its roughness characteristics, the flow rate and boundary conditions.

(e) **Boundary Condition**. The steady 2-Dimensional flow model should be used to calculate subcritical, supercritical and mixed flow regime water surface profiles. For subcritical flow, one condition for downstream boundary to be use ad for mixed flow regime, both downstream and upstream boundary conditions should be employed for computation. For boundary conditions following parameter should be employed: -

i. Critical depth
ii. Normal depth
iii. Flow depth or given depth of downstream of the channel

(f) **Manning Coefficient.** Manning Coefficient should be used to define the roughness for each cross section in the model. These values should be extracted from the land use attributes and the Manning's Table.

The recommended values of manning coefficient of land cover along water channel and water course is given in **Table 5** and **Table 6** respectively.

Table 5: Manning Roughness Coefficient values for Overbanks Area along Streams

Channel Description	**Average Values of n**
Grassland	
Short grass	0.03
Tall grass	0.035
Cultivated Ground	
Bare ground	0.03
Mature row crops	0.035
Mature field crops	0.04
Brushy Areas	
Dense weeds and sparse brush	0.05
Brush-covered with some trees (winter)	0.05
Brush- covered with some trees (summer)	0.06
Dense brush (winter)	0.07
Dense brush (summer)	0.1
Forested	
Densely covered with willows(summer)	0.15
Cleared land with stumps; no new growth	0.04
Cleared land with stumps; dense new growth	0.06
Dense stands of large trees; flood stage below branches	0.1
Dense stands of large trees; flood stage reaching branches	0.12

Table 6: Manning Roughness of Coefficient of Water Channels

Channel Type and Description	**Value**
Smooth Concrete	0.012-0.013
Unfinished Concrete	0.013-0.016
Earthen, smooth, no weeds	0.02
Firm gravel	0.02
Earthen, some stones & weeds	0.025
Earthen, unmaintained, winding natural streams	0.035
Mountain streams	0.04-0.05

(g) **Velocity Weight Coefficient.** Recommended values of Velocity Weight Coefficient depending on different types of channels are given in **Table7**.

Table 7: Velocity Weighted Coefficient Values

Channel Type	Value of α		
	Minimum	Average	Maximum
Regular Channels, Flumes, Spillways	1.1	1.15	1.2
Natural Streams	1.15	1.3	1.5

(2) **Stream Flow Data/ Flood Levels.** Flood level is one of the most important input in hydraulic models. They should be calculated using historical stream flow data.

(3) **Modeling Results Processing**

(a) Results of hydraulic modeling should include Velocity, Hydraulic Depth, Flow Area and Stream Power.

(b) Based on the results extracted from hydraulic modeling inundation maps should be prepared. These results should be processed for obtaining floodplain delineation.

(c) GIS layers should be created on the TIN and hydraulic modeling results for inundation mapping.

(d) Using this TIN the floodplain polygon should be created. This polygon should be obtained through intersection of water surface and terrain surface.

(e) The water surface grid should then be subtracted from the terrain. In subtracted output, the areas with the positive results should be identified as the flood area and negative values should be taken as the dry area.

(f) All the positive values in the surface grid should then be converted into a polygon.

(g) The Depth grid should then be clipped with bounding polygon and areas outside the river hydraulic model.

(h) From this depth grid the Floodplain polygon should be generated. All the results extracted from the given methodology should be calibrated by cross examination with Modeled flood extents and with actual historic flood extents.

(i) Flow chart of Methodology for Flood Hazard Assessment in given in **Figure 8**.

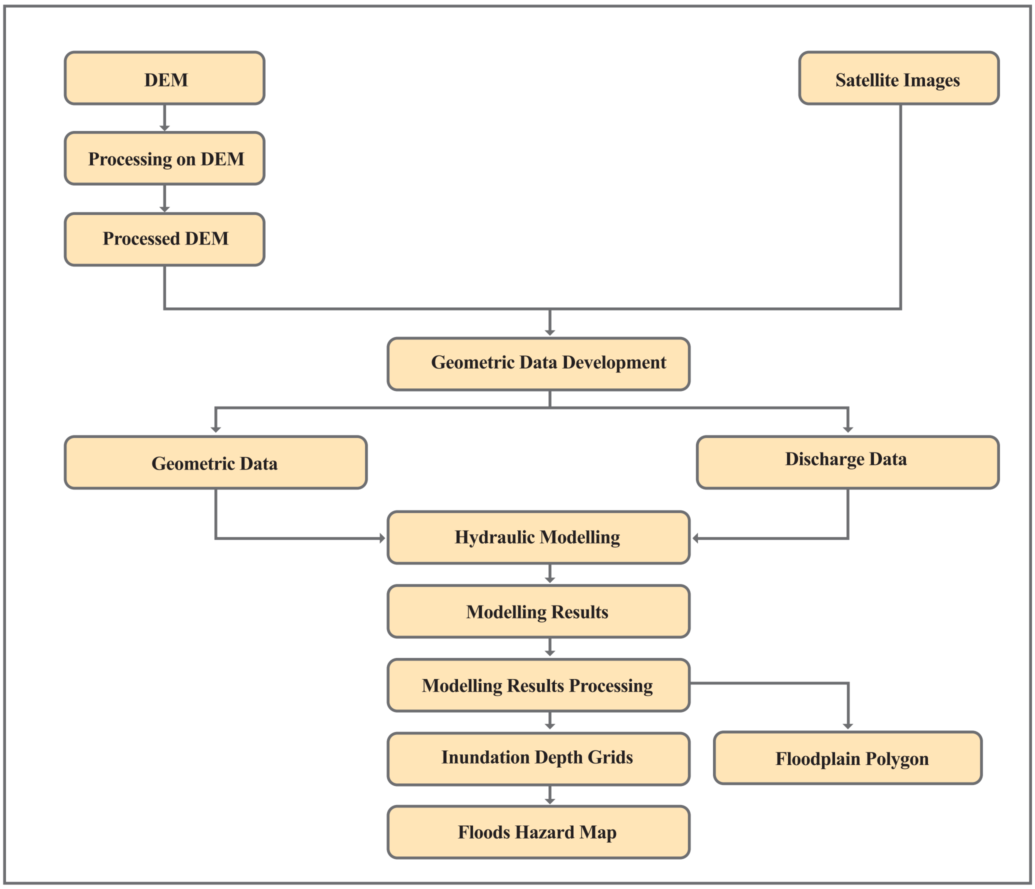


Figure8: Flood Hazard Assessment Methodology Flow Chart

(4) **Hazard Mapping**. The final product should be presented in the form of Hazard map using Depth Grid. After classification, the modified inundation depth grids should be overlaid with the satellite image and base map of the study area. Subsequently, Flood Hazard map for 10, 25, 50 and 100 years return period should be generated. The flood Hazard maps should then be used to estimate the severity of flood hazards and its likely impact on element at risk in a given area.

(5) **Hazard Severity Score**. Flood Hazard Severity should be scaled as per **Table 8.**

Table 8: Flood Hazard Severity Scale

Flood Water Depth	Scale	Severity
0-3 feet	1	**Low**
3.1- 6 feet	2	**Medium**
6.1- 9 feet	3	**High**
9.1-49 feet	4	**Very High**

b. **Required Tools/ Parameters for Flood Hazard Assessment**

(1) **Data Parameters**

(a) Elevation (DEM)
(b) Rivers & Streams Geometry (Stream Center Line, Bank Lines, Cross Sections)
(c) Land Use/ Land Cover
(d) Flood Level (River Discharge Data)
(e) Bridges, Levees and Embankments
(f) Sewerage System
(g) Underground tunnels, subways and parking lots
(h) Precipitation
(i) Solar Radiation
(j) Soil Features
(k) Flood Protection Infrastructures
(l) Hydraulic Structures
(m) Irrigation System Maps
(n) Satellite Imagery and Products
(o) Solar Radiation
(p) Historical Flood Catalogues
(q) Historical Flood Extents

(2) **Data Sources**

(a) Pakistan Meteorological Department (PMD)
(b) Water and Power Development Authority (WAPDA)
(c) Provincial Soil Survey Departments
(d) National Highway Authority (NHA)

(e) Irrigation Departments

(f) Federal Flood Commission (FFC)

(g) Space and Upper Atmosphere Research Commission (SUPARCO)

(h) Pakistan Council of Research in Water Resources (PCRWR)

(i) Small Dams Organization

(j) National Agriculture Research Centre (NARC) / Pakistan Agriculture Research Centre (PARC)

(k) Communication and Works (C&W) Departments

(l) FATA- Irrigation & Hydel Power Department

(3) **Model Selection**

(a) **Hydraulic Models**

i. HEC-RAS (Hydrologic Engineering Center-River Analysis System)

ii. MIKE Flood

iii. SOBEK

iv. Flood Modeler

v. TUFLOW

vi. MIKE Urban

vii. SWMM

(b) **Hydrologic Models**

i. HEC-HMS (Hydrologic Engineering Center- Hydrologic Modeling System)

ii. UBC-WM (University of British Colombia Watershed Model)

iii. MIKE SHE

iv. SRM (Snowmelt Runoff Model)

v. VIC (Variable Infiltration Capacity)

vi. IFAS (Integrated Flood Analysis System)

(4) **Model Inputs Preparation**. Inputs should be prepared as required and used in the selected model. Different climatic scenarios must be incorporated in model execution where required for future forecasting.

c. **Final Outputs.** Once the test run results are approved by NDMA, the outputs should be generated for 10, 25, 50 and 100 years return periods. Climate Change Scenarios to be considered for extreme events simulations. The final outputs must include the following elements for specified return periods:-

(1) Flood Extent

(2) Flood Depth

(3) Flood Duration/ Water Session Period/ Water poundage

(4) Flood Velocity

(5) Element at Risk vs. Flood Hazard Consequence Matrix

(6) Flood Impact on Element at Risk Classification

7. **<u>Landslide Hazard Assessment Methodology</u>**

a. **<u>General Guiding Steps</u>**

(1) The primary information required for landslide hazard assessment should cover four main categories i.e.

(a) Landslide inventory data

(b) Triggering factors

(c) Environmental factors

(d) Elements at risk

(2) Landslides inventory data should be utilized to identify the previous landslide activities occurred in a specific location.

(3) For hazard assessment of landslide susceptibility, the foremost step is the identification of the triggering factors or causative parameters. Triggering factors are the cause of occurrence of these events such as heavy rainfall, weathering, land degeneration, deforestation, and wrong land use plans.

(4) Different landslide causative parameters such as Slope, Aspect, Lithology, Geomorphology, Rainfall, hydro-meteorological parameters like distance from stream network, distance from faults and thrusts, land cover, normalized difference vegetation index (NDVI), Topographic Wetness Index (TWI), Plan Curvature, Stream Power Index (SPI), major land covers and distance from road network should be used for landslide hazard analysis.

(5) Field measurements are vital for determining soil depth and slope and other hydrological parameters and therefore must be incorporated in the assessment.

(6) Qualitative landslide hazard assessment should include spatial coverage (probability that a specific area will be hit by landslide), temporal aspect, size or volume of the event along with run-out probability (that the event will reach certain point downslope).

(7) For quantitative landslide assessment, a probabilistic statistical approach should be applied on the bivariate – statistical weight of evidence (W.O.E) method. The commended Weight Calculations for chosen parameter classes are given in **Table 9**, however assigned weightages can vary from terrain to terrain therefore Geological Survey of Pakistan should also be consulted before carrying out analysis.

Table 9: Weight Calculations for Different Landslide Parameter Classes

Parameter	Class	Weight Assigned
Lithology	Panjal Volcanics	-0.724
	Panjal Metasediments	1.027
	Lockhart and Patala Formation (Undivided)	1.219
	Abbottabad Formation (Quartzite Unit)	-0.005
	Lockhart Limestone	1.342
	Muzaffarabad Formation	1.942
	Murree Formation	0.393
	Mansehra orthogneiss	-0.561
	Salkhala Formation	0.225
	Patala Formation	1.361
	Terrace Deposits	-1.325
	Abbottabad Formation (Undivided)	0.850
	Tanawal Formation	-1.427
Land Cover	Open Areas	1.449
	Agricultural Land	-1.588
	Agricultural Land with Scattered Houses	-1.216
	Open Forest	-0.682
	Thick Forest	-1.248
	Water	-0.491
	Settlement	-0.208
NDVI	No Vegetation	1.953
	Sparse Vegetation	2.150
	Middle Vegetation	-0.100
	Dense Vegetation	-1.670
Slope (°)	0-10	-1.309
	10-15	-0.689

	15-20	-0.466
	20-25	-0.501
	25-30	-0.265
	30-40	0.213
	40-50	0.637
	>50	1.350
Geomorphology	Planar	-0.248
	Pit	-0.063
	Channel	0.472
	Pass	-0.632
	Ridge	-0.575
	Peak	0.061
Distance from First Order Streams (meter)	0-150	2.180
	150-300	1.735
	>300	-0.193
Distance from Second Order Streams (meter)	0-75	0.3421
	75-150	0.2957
	>150	-0.2744

b. **<u>Required Tools/ Parameters for Landslide Hazard Assessment</u>**

(1) **<u>Data Parameters</u>**

(a) Digital elevation model (DEM) of high resolution should be used for the study.

(b) The DEM should be used to produce depression less DEM for extracting different landslide conditioning parameters like slope, aspect, drainage network, topographic wetness index, stream power index and plan curvature for the study area.

(c) Satellite imageries (remote sensing dataset) with low cloud cover must be employed in the study for enhanced land cover (water bodies, built up area, forest and barren land) classification in study area.

(d) Lithology and faults should be considered the most relevant factors that affect the rock strengths and soil permeability thereby controlling the susceptibility to land sliding. Lithology map and faults map can be obtained from Geological Survey of Pakistan. Road network and settlement distribution should also be incorporated in the study.

(e) Rainfall data to be collected from Pakistan Meteorological Department.

(f) Spatial distribution of precipitation must be produced using interpolation techniques.

(2) **Data Sources**

(a) Geological Survey of Pakistan (GSP)

(b) National Centre of Excellence in Geology (NCEG), Peshawar

(c) Pakistan Meteorological Department (PMD)

(d) Provincial Soil Survey Department

(e) Space and Upper Atmosphere Research Commission (SUPARCO)

(f) National Engineering Services Pakistan (Pvt.) Limited (NESPAK)

(g) Communication and Works (C&W) Departments

(h) National Highway Authority (NHA)

(3) **Model Selection.** List of favorable models for landslide hazard assessment is given below:-

(a) GIS Weighted Overlay Analysis

(b) ALICE BRGM

(c) MTD (Gruber, 2007)

(d) MSF (Huggel et al., 2003)

(e) SINMAP (Pack et al., 2005)

(f) SHALSTAB (Dietrich and Montgomery, 1998)

(g) RAMMS (Avalanche, Debris Flow, Rock-fall)

c. **Final Outputs**. The final output must include following outputs

(1) Landslide Hazard Maps

(2) Landslide Micro Zonation Maps

(3) Historical Landslide Inventory

(4) Probabilistic Landslide Intensity Inventory (i.e. likely volume of displaced material, velocity of movement and triggering factors)

8. Cyclone Hazard Assessment Methodology

a. General Guiding Steps

(1) **Cyclone Modeling.** The cyclone is characterized based on its pressure and wind field which is acting as a drag force on the water body through a wind shear stress.

(a) To simulate the wind fields over the study area, numerical simulation model for analyzing wind speed and probabilistic approach should be used. For this following data related to wind field over the domain of interest should be used:-

i. Radius of maximum winds

ii. Maximum wind speed

iii. Pressure drop

iv. Cyclone track speed and direction

(b) For pressure field following parameters should be used:-

i. Central pressure

ii. Neutral pressure

(c) With the above inputs, the model should generate the possible ground wind field with hourly frequency of outputs for each return period.

(d) The generated results should be validated with historical cyclone track data and observed wind data obtained from reliable ground weather stations.

(e) While generating modeling outputs of worst case scenarios, an increase of 10 to 20 % in tropical cyclone intensities should be considered for a rise in sea surface temperature of 2^0C to 4^0C relative to the current threshold temperature as recommended by IPCC.

(f) The cyclone hazard map displaying the spatial distribution of the wind speed should be developed for prescribed return periods as per classification given in **Table 10**.

Table 10: Tropical Cyclone Intensity Scale and Hazard Severity Index

Tropical Cyclone Intensity Scale & Hazard Severity Index		
Category	**Sustained Winds (3-min average)**	**Hazard Severity Index**
Super Cyclonic Storm	>222 km/h	Very High
Very Severe Cyclonic Storm	118–221 km/h	
Severe Cyclonic Storm	88–117 km/h	High
Cyclonic Storm	62–87 km/h	Medium
Deep Depression	52–61 km/h	Low
Depression	≤51 km/h	Very Low

(2) **Storm Surge Modeling.** The output from cyclone model, i.e. wind and pressure fields should be used as input for the storm surge hydrodynamic/tidal model.

(a) To calibrate storm surge model, wind friction factor of 0.0026 (Dube et al., 1985) should be used as a guidance for the calibration.

(b) Simulation results (surge heights) and Digital Elevation Model of coastal area should be used to prepare the hazard maps using GIS technology.

(c) Maximum inundation depth maps for cyclones of various return periods should be generated based on storm surges model results for demarcating hazardous zones. The flow chart is shown in **Figure 9**.

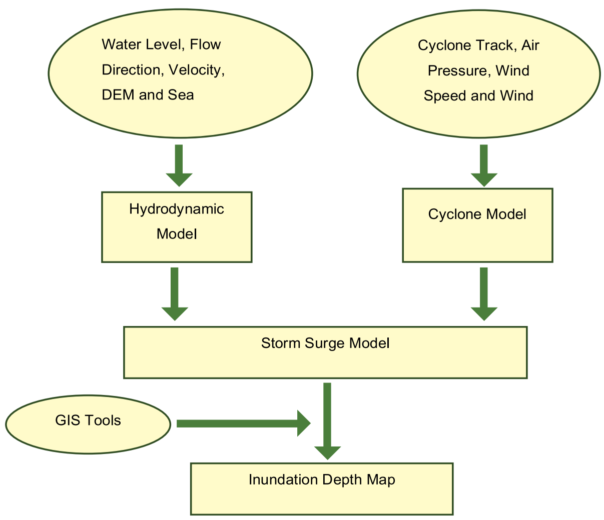


Figure 9: Flow Chart to Produce Inundation Depth Map

b. **Required Tools/ Parameters for Cyclone Hazard Assessment**

(1) **Data Parameters**

(a) Historical Wind Maximum Radius

(b) Wind Speed, Direction and Pressure

(c) Precipitation

(d) Sea Surface Temperature

(e) Elevation

(f) Coastal Bathymetric Data

(g) Cyclone Tracks

(h) Cyclone Inventory

(2) **Data Sources**

(a) Tropical Cyclone Warning Center, Pakistan Meteorological Department (PMD)

(b) Space and Upper Atmosphere Research Commission (SUPARCO)

(c) Global Change Impact Studies Centre (GCISC)

(3) **Model Selection**. List of favorable models for Cyclone hazard assessment is given below:-

(a) SLOSH (Sea, Lake, and Overland Surges from Hurricanes)

(b) P-Surge (Probabilistic Hurricane Storm Surge)

(c) WAVEWATCH III (for modeling of waves)

(d) Tropical Cyclone Risk Model (TCRM)

(e) Advanced CIRCulation Model (ADCIRC)

(f) ERN-HURRICANE

(g) Advance Research WRF (ARW) Modeling System

c. **Final Output**. The final output of cyclone hazard assessment must include cyclone hazard map of 10, 50, 100 and 1000 years of return period. The final product must include:-

(1) Cyclone Tracks

(2) Cyclone Hazard Maps

(3) Cyclone Storm Surge Intensity Maps

(4) Cyclone Consequences Matrix

9. Drought Hazard Assessment Methodology

a. General Guiding Steps

(1) Droughts can be characterized in terms of their severity, location, duration and timing. They can arise from a range of hydro-meteorological processes that suppress precipitation and/or limit surface or ground water availability, creating conditions that are significantly drier than normal or otherwise limiting moisture availability to a potentially damaging extent. The indices provide options for identifying the severity, location, duration, onset and cessation of such conditions.

(2) List of indices and indicators (both mandatory and optional) to be used for mapping drought severity is given in **Table 11**.

Table 11: Indicators and Indices for Drought Hazard Assessment

Indices/ Indicators	Input Parameters	Characteristics	Mandatory / Optional
Meteorological Based			
Aridity Anomaly Index (AAI)	P, T, PET, ET	A real-time drought index in which the water balance is considered. The Aridity Index (AI) is computed for weekly or bi-weekly period. For each period, the actual aridity for the period is compared with the normal aridity for that period. Negative values indicate a surplus of moisture while positive values indicate moisture stress.	**Optional**
Deciles	P	By using the entire period of record of precipitation data for a location, the frequency and distribution of precipitation is ranked. The first decile is composed of the rainfall amounts having lowest 10 percent of the values followed by the median and a wet scale. Daily, weekly, monthly, seasonal and annual values are considered in the methodology.	**Optional**
Keetch-Byram Drought Index (KBDI)	P, T	The KBDI is the net effect of evapotranspiration and precipitation in producing a moisture deficiency in the upper layers of the soil and also	**Mandatory**

		gives an indication of how much precipitation is needed for saturation of the soil and eliminating drought stress.	
Standardized Precipitation Index (SPI)	P	The SPI uses historical precipitation records to develop a probability of precipitation that can be computed at various timescales, from one month to 48 months or more.	**Mandatory**
Drought Reconnaissance Index (DRI)	P, T	The standardized DRI value is similar in nature to the SPI and can be compared to it directly. The DRI is more representative than the SPI, as it considers the full water balance instead of precipitation alone.	**Optional**
Hydro-Thermal Coefficient of Selyaninov **(HTC)**	T, P	This index uses temperature and precipitation values and is sensitive to dry conditions specific to the climate regime being monitored.	**Optional**
NOAA Drought Index (NDI)	P	This drought index is a precipitation-based index in which the actual precipitation measured is compared with normal values during the growing season. Mean precipitation for each week is calculated and a running eight-week average of measured average precipitation is summed and compared. If the actual precipitation is greater than 60 percent of the normal precipitation for the eight-week period, then the current week is assumed to have little or no water stress. If stress is detected, it remains until the actual precipitation is at 60 percent or more of normal.	**Mandatory**
Palmer Drought Severity Index (PDSI)	P, T, AWC	PDSI takes into account moisture received (precipitation) as well as moisture stored in the soil, accounting for the potential loss of moisture due to temperature influences.	**Optional**
Standardized Precipitation Evapo-transpiration Index (SPEI)	P, T	SPEI uses the basis of the SPI but includes a temperature component, allowing the index to account for the effect of temperature on drought	**Mandatory**

		development through a basic water balance calculation.	
Soil Moisture Based			
Soil Moisture Anomaly (SMA)	P, T, AWC	SMA is intended to reflect the degree of dryness or saturation of the soil compared with normal conditions and to show how soil moisture stress influences crop production.	**Mandatory**
Soil Moisture Deficit Index (SMDI)	Mod	The SMDI is a weekly soil moisture product calculated at four different soil depths, including the total soil column, at 0.61, 1.23 and 1.83 metres (2, 4 and 6 feet), respectively, and can be used as indicator of short-term drought.	**Optional**
Soil Water Storage (SWS)	AWC, RD, ST, SWD	The SWS identifies the amount of available moisture within a plant's root zone. This depends on the type of plant and the type of soil. Precipitation and irrigation both affect the results associated with the SWS.	**Mandatory**
Hydrology Based			
Palmer Hydrological Drought Severity Index (PHDI)	P, T, AWC	PHDI is based on the original PDSI and is modified to take into account longer-term dryness that will affect water storage, streamflow and groundwater. The PHDI has the ability to calculate when a drought will end based on precipitation needed by using a ratio of moisture received to moisture required to end a drought	**Mandatory**
Standardized Reservoir Supply Index (SRSI)	RD	Similar to the SPI in that monthly data are used to compute a probability distribution function of reservoir storage data to provide information on water supply for a region or basin with a range of -3 (extremely dry) to +3 (extremely wet).	**Mandatory for Irrigated Area**
Standardized Stream Flow Index (SSFI)	SF	SSFI was developed using monthly stream flow values and the methods of normalization associated with the SPI. It can be calculated for both observed and forecasted data, providing a perspective on high/ low flow periods associated with drought and flood.	**Mandatory for Irrigated Area**

Standardized Water-Level Index (SWI)	GW	As a hydrology-based drought indicator, the SWI uses data from wells to investigate the impact of drought on groundwater recharge. Results can be interpolated between points.	**Mandatory for Barani and Urban Area**
Surface Water Supply Index (SWSI)	P, RD, SF, S	SWSI takes into account the work done by Palmer with the PDSI but adds additional information including water supply data (snow accumulation, snowmelt and runoff, and reservoir data). It is calculated at the basin level. The SWSI identifies the approximate frequency of mild, moderate and extreme drought events.	**Mandatory for upper catchment**
Remote Sensing Based			
Normalized Difference Vegetation Index (NDVI)	Sat	NDVI measures greenness and vigour of vegetation over a 7-day period as a way of reducing cloud contamination and can identify drought-related stress to vegetation.	**Mandatory**
Temperature Condition Index (TCI)	Sat	TCI is used to determine stress on vegetation caused by temperatures and excessive wetness. Conditions are estimated relative to the maximum and minimum temperatures and modified to reflect different vegetation responses to temperature.	**Mandatory**
Vegetation Condition Index (VCI)	Sat	VCI is used to identify drought situations and determine the onset, especially in areas where the drought episode is localized and ill defined. The VCI focuses on the impact of drought on vegetation and can provide information on the onset, duration and severity of drought by noting vegetation changes and comparing them with historical values.	**Mandatory**
Vegetation Drought Response Index (VegDri)	Sat, P, T, AWC, LC, ER	VegDRI was developed as a drought index that was intended to monitor drought-induced vegetation stress by using a combination of remote sensing, climate-based indicators and other biophysical information and land use data.	**Optional**

Vegetation Health Index (VHI)	Sat	VHI was one of the first attempts to monitor and identify drought-related agricultural impacts using remotely sensed data. Advanced Very High Resolution Radiometer (AVHRR) data in the visible, infrared and near infrared channels are all used in the VHI to identify and classify stress to vegetation due to drought.	**Mandatory**
Normalized Difference Water Index (NDWI) and Land Surface Water Index (LSWI)	Sat	NDWI is very similar to the NDVI methodology but uses the near-infrared channel to monitor the water content of the vegetation canopy. Changes in the vegetation canopy are used to identify periods of drought stress.	**Optional**

Table 12: Input Parameters for various Indicators of Drought Hazard Assessment

Input Parameters	**Description**
AWC	Available Water Content
CC	Crop Coefficients
ER	Eco Regions
ET	Evapotranspiration
GW	Groundwater
LC/LU	Land Cover/Land Use
P	Precipitation
PET	Potential Evapotranspiration
Rad	Solar Radiation
RD	Reservoir
S	Snowpack
Sat	Satellite
SF	Stream Flow
ST	Soil Type
SWD	Soil Water Deficit
T	Temperature
Td	Dew Point Temperature
W	Wind Data

(3) Based on the recommended indices/indicators, Model for Drought Hazard Assessment given in **Figure 10** should be followed to extract final consolidated Hazard Index defining severity level from extreme to no drought events.

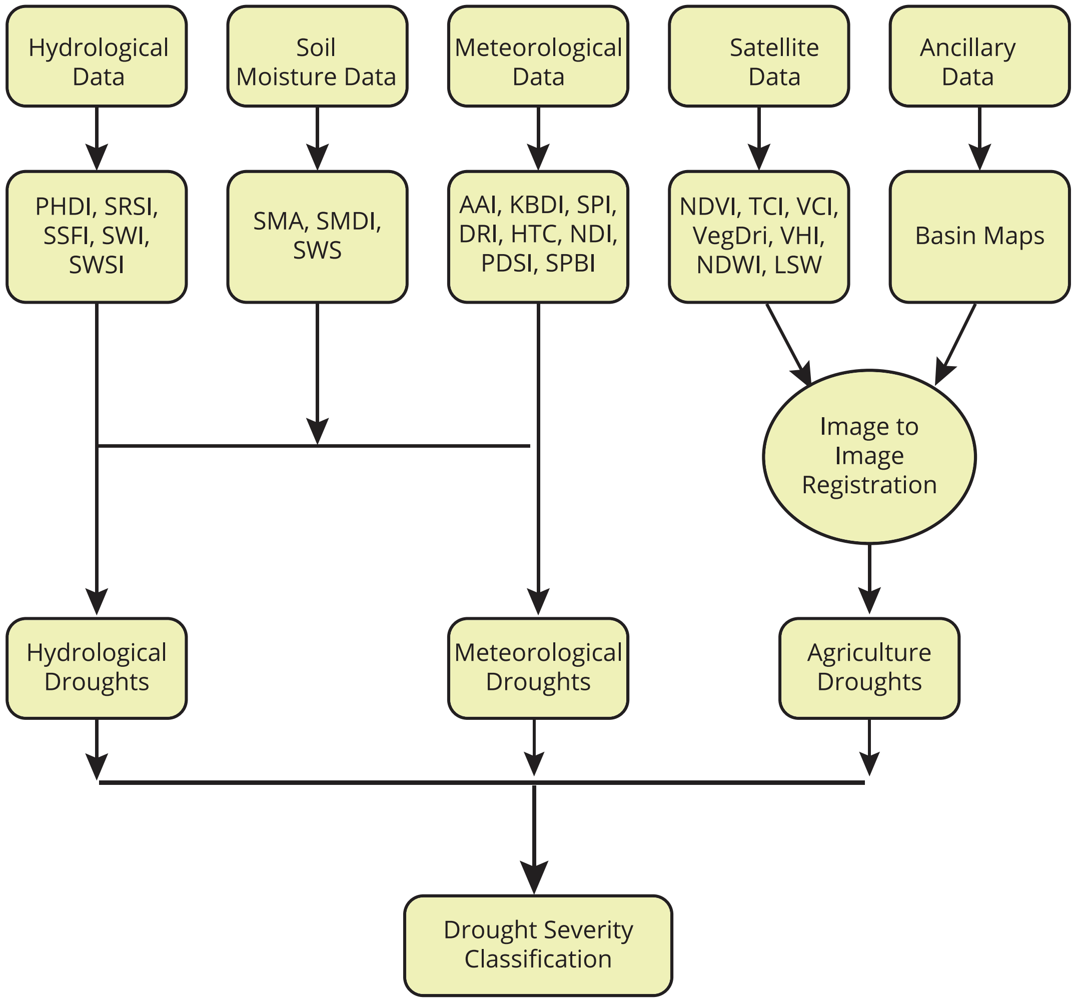


Figure 10: Drought Hazard Assessment Methodology[3]

(4) All indices should be computed for each UC of study area and drought intensity class should be assigned for each index. Likewise drought classes should be for UCs for all indices. Finally, under each UC, all indices/indicators should be consolidated on statistical weight assignment method.

[3] *K. Chandrasekar, M. V. R. Sesha Sa, P. S. Roy, V. Jayaraman and R. Krishnamoorthy (2009) Identification of Agricultural Drought Vulnerable Areas of Tamil Na du, India Using Gis-Based Multi Criteria Analysis. Asian Journal of Environment and Disaster Management Vol. 1, No. 1 (2009) 40–61*

(5) For identifying the Meteorological Droughts climatic/meteorological factors[4] specified in **Table 13** should be considered in the assessment:-

Table 13: Climatic Factors and its Criteria with Class Value and Weights

Criteria	Class	Class Value	Weights
Normal Rainfall	< 500 mm	5	**9**
	500 – 750 mm	4	
	750 – 1000 mm	3	
	1000 – 1250 mm	2	
	>1250mm	1	
Aridity Zone (P/PET)	Hyper arid (<0.05)	5	**5**
	Arid (0.05–0.2)	4	
	Semi-arid (0.21–0.50)	3	
	Dry Humid(0.51–0.65)	2	
	Humid/Cold >0.65	1	
Evaporation (mm)	>2500	5	**2**
	2000–2500	4	
	1500–2000	3	
	1000–1500	2	
	<1000	1	

(6) The edaphic factors of soil should be taken in account in the assessment. These factors help in determining water holding capacity of soils on which growth of vegetation depends. Different classes of soil with their weights and capacities are listed in **Table 14**

Table 14: Edaphic Factors and its Criteria with Class Value and Weights

Criteria	Class	Class Value	Weights
Soil Type	Lateritic Soil	5	**5**
	Coastal Sandy Soil, Red Gravely Soil and Laterite Soil	4	
	Red Sandy Soil	3	
	Young & Coastal Alluvial, Mixed Red and Black Soil	2	

[4] *http://www.dmcsee.org/uploads/file/70_drought_indices_a_ceglar.pdf*

	Deltaic & Coastal Alluvial Soil	1	
Water Holding Capacity	<80mm/m	4	**6**
	80–120 mm/m	3	
	120–170 mm/m	2	
	>=170 mm/m	1	
Soil Depth	0–25 cm	5	**5**
	25–50 cm	4	
	50–75 cm	3	
	75–100 cm	2	
	>100 cm	1	
Slope	0–3%	5	**2**
	4–6%	4	
	7–15%	3	
	16–33%	2	
	>33%	1	
Hydrogeology Ground Water Potential	<1lps	5	**3**
	1–5 lps	4	
	5–10 lps	3	
	10–25 lps	2	
	>25 lps	1	

(7) Biotic factors that should be taken into consideration for studying the agricultural droughts in the study area are given in **Table 15**. Biotic factors represent the living components of an ecosystem. They are normally sorted into three groups: producers or autotrophs, consumers or heterotrophs, and decomposers or detritivores.

Table 15: Biotic Factors and its Criteria with Class Value and Weights

Criteria	Class	Class Value	Weights
Gross Irrigated Area to Gross Sown Area	80 – 100 %	1	**6**
	60 – 80 %	2	
	40 – 60 %	3	
	20 – 40 %	4	
	0 – 20 %	5	
Net Sown Area	48 – 60 %	1	**5**
	36 – 48 %	2	

	24 – 36 %	3	
	12 – 24 %	4	
	0 – 12 %	5	
Frequency @85% of max	> 16	1	**9**
	13 – 16	2	
	9 – 12	3	
	5 – 8	4	
	0 – 4	5	
NDVI Elasticity	80 %	1	**8**
	61 – 80 %	2	
	41 – 60 %	3	
	21 – 40 %	4	
	0 - 20 %	5	
NDVI CV	0 – 5	1	**7**
	5 – 10	2	
	10 - 15	3	
	15 – 20	4	
	>20	5	

(8) The mapping of "*Social Indicators Affecting Drought*" with "*Severity of Drought*" should be performed based on criteria as depicted in **Table 16** below.

Table 16: Social Factors and its Criteria with Cass Value and Weights

Criteria	Class	Class Value	Weights
Rural Population Density	0 – 100	1	3
	101 – 200	2	
	201 – 300	3	
	301 – 400	4	
	>400	5	
SC/ST Population Density	0 – 35	1	4
	36 – 70	2	
	71 – 105	3	
	106 – 140	4	
	>140	5	
Main Agriculture Labours Population Density	0 – 20	1	5
	20 – 40	2	
	41 – 60	3	
	61 – 80	4	
	>80	5	

Marginal Worker Population Density	0 – 15	1	5
	16 – 30	2	
	31 – 45	3	
	46 – 60	4	
	>60	5	

(9) Drought Hazard Severity should be scaled as per **Table 17**.

Table 17: Drought Hazard Severity Scale

Severity	Scale
No Hazard	**0**
Mild	**1**
Moderate	**2**
Severe	**3**
Extreme	**4**

b. **Required Tools/ Parameters for Drought Hazard Assessment**

(1) **Data Parameters**

(a) Satellite Imagery

(b) Meteorological Data

(c) Ground Water Table Depth

(d) River & Stream Discharge

(e) Soil Moisture

(f) Agriculture Statistics

(g) Land-Cover

(h) Reservoir Storage and Supply Data

(i) Evapotranspiration Data

(j) Solar Radiation

(k) Soil Data

(2) **Data Sources**

(a) Pakistan Meteorological Department (PMD)

(b) Space and Upper Atmosphere Research Commission (SUPARCO)

(c) Global Change Impact Studies Center (GCISC)

(d) Water and Power Development Authority (WAPDA)

(e) Pakistan Council of Research in Water Resources (PCRWR)

(f) Provincial Irrigation Department

(g) Agriculture Statistics, Pakistan Bureau of Statistics (PBS)

(h) Provincial Agriculture Department

(i) Provincial Soil Survey Department

(3) **Model Selection**. Required Indicators, Indices and Models.

c. **Final Outputs**. Once the test run results are approved, the outputs should be generated for different return periods. The final outputs should include following outputs for the selected return periods:-

(1) Drought Hazard Maps

(2) Indicators/ Indices Data

(3) Drought Severity Maps

(4) Drought Duration Matrix

(5) Drought Spatial Extent

(6) Drought Consequence Matrix of Element at Risk

10. Tsunami Hazard Assessment Methodology

a. General Guiding Steps

(1) Data Preparation

(a) For Primary data both topographic and bathymetric data of high resolution pertinent to study area should be used.

(b) The fault plane parameters corresponding to seismic events with prescribed recurrence periods i.e. of 50, 100, 475, 1000 and 2500 years should be investigated in association with potential tsunami generation. In the context Makran seduction zone is the only zone having history of generating tsunami in coastal areas of the Country.

(c) High resolution DEM should be used in order to generate accurate topographic data. It is important to note that accuracy of Tsunami inundation modeling depends on a large extent on the resolution of topographic data used.

(d) Historical records pertaining to water levels due to past tsunami events should also be sought for better understanding of tsunami pattern in the study area.

(2) Tsunami Modeling

(a) Due to unavailability of consistent historical data, probabilistic approach is recommended to be used for delineation of seismic scenarios for tsunami simulation in this document.

(b) Probable tsunamigenic seismic events corresponding to prescribed recurrence periods i.e. of 50, 100, 475, 1000 and 2500 should be delineated for the Makran subduction zone which is the only zone with history of generating tsunami in coastal area of Pakistan.

(c) Tsunami model simulations must incorporate the simultaneous rapture of both the western and eastern segments of the Makran zone.

(d) For Tsunami inundation modeling following seismic event data parameters should be used:-

i. Depth of the fault plane
ii. Length of the fault
iii. Seismic moment
iv. Width of the fault plane
v. Strike angle
vi. Dip angle
vii. Rake angle
viii. Slip

(e) The model employed in the study should be validated by comparing the computed water surface levels due to historical tsunami event with available tsunami heights off Pakistan. Only a few field observations of maximum water levels due to the tsunami in 1945 are available off the coast of Pakistan. These include the tsunami wave heights of about 4-5 m in Pasni and about 1.5-2 m in Karachi. Therefore, the computed maximum water level should be compared with these two available tsunami heights for validation.

(3) **Tsunami Hazard Maps.** Tsunami Hazard Maps depicting the probable spatial distribution of the depth of inundation at Mean High Water Spring (MHWS) for prescribed return periods should be prepared. The flow depths in these maps should be classified as according to **Table 18**.

Table 18: Classification of Tsunami Inundation Depths

Classification of Tsunami Inundation Depths	
Depth of Inundation (meter)	**Hazard Severity Index**
0	**No Hazard**
0.2	**Very Low**
0.2-0.5	**Low**
0.5-1.5	**Medium**
1.5-2.5	**High**
>2.5	**Very High**

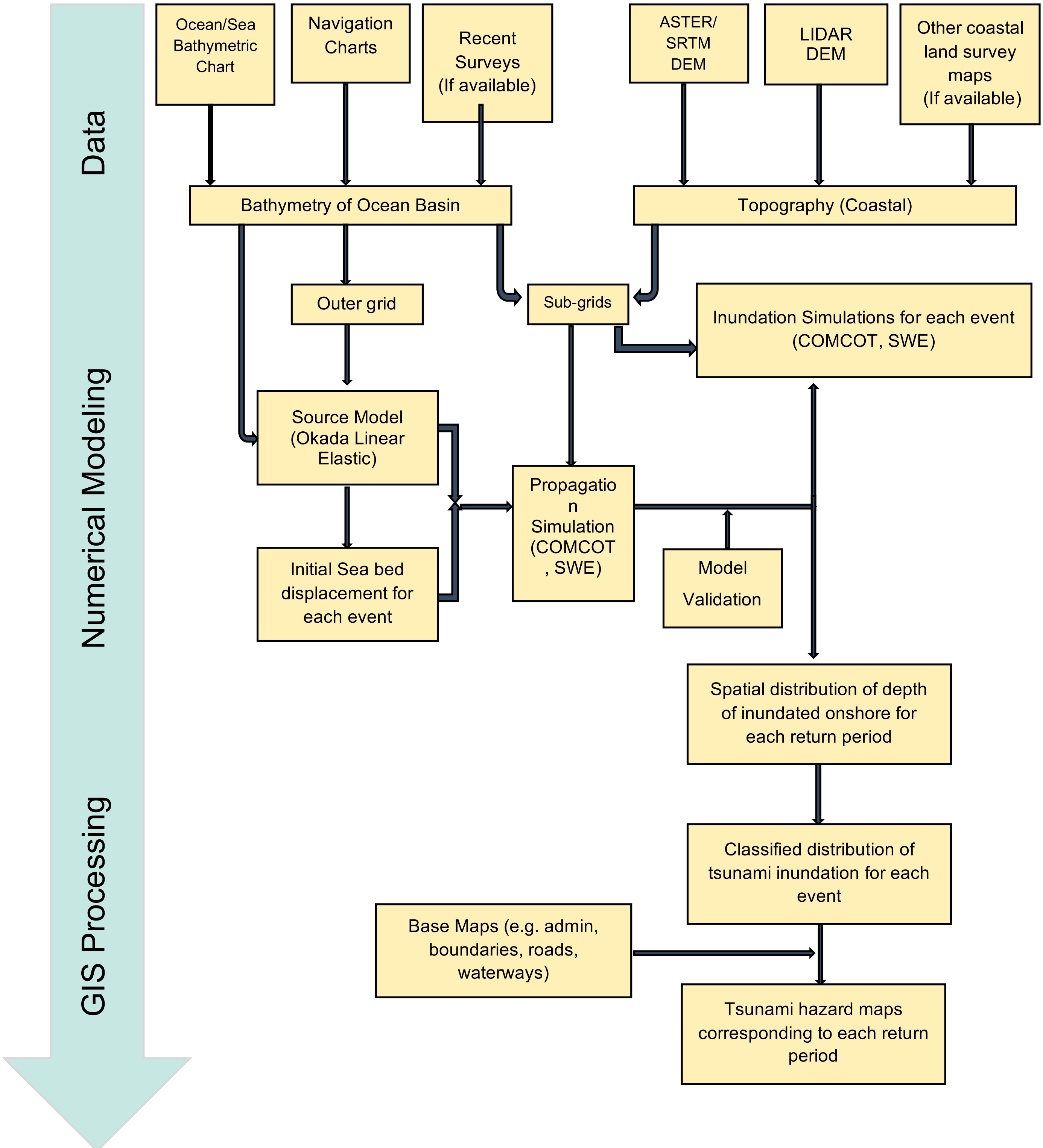


Figure 11: Tsunami Hazard Analysis Methodology

b. **Required Tools/ Parameters for Tsunami Hazard Assessment**

(1) **Data Parameters**

(a) Underwater Earthquakes Magnitude and Depth.

(b) Seismic Source Geometry (length and width of the fault).

(c) Elevation

(d) Earthquake Catalogue

(e) Geological Data

(f) Sea Bathymetric Data

(g) Land Cover Data

(2) **Data Sources**

(a) Geological Survey of Pakistan (GSP)

(b) Pakistan Meteorological Department

(c) Space and Upper Atmosphere Research Commission (SUPARCO)

(d) National Institute of Oceanography (NIO)

(3) **Model Selection**. List of recommended models for tsunami hazard assessment are presented below:-

(a) COMCOT (Cornell Multi-grid Coupled Tsunami Model)

(b) COMMIT (Community Model Interface for Tsunami)

(c) Okada

c. **Final Outputs**. Once the test run results are approved the outputs should be generated for seismic events of 50, 100, 475, 1000 and 2500 return periods. The final outputs should include:-

(1) Hazard Maps

(2) Peak Ground Acceleration (PGA) Maps

(3) Deaggregation (Magnitude, Distance)

(4) Inundation Maps (velocity, depth, wave height)

11. Element at Risk Quantification and Mapping

a. The Elements at Risk, susceptible to be adversely effected, due to hazard should be linked to physical, economic, social and environmental vulnerability of the area of interest.

b. Elements at risk should be considered in the following dimensions as identified in **Table 19**.

Table 19: Dimension of Elements at Risk

Physical Elements	**Life Lines**
Buildings, Urban Land Use, Construction Types, Building Height, Building Age, Covered Area, Monitory Value, Building Use, Monuments and Cultural Heritage	Water Supply Lines, Electricity Lines, Gas Lines, Telecommunication Lines, Communication Towers, Sewerage Lines, Grains/Food Storage
Essential Facilities	**Population**
Emergency Shelters, Schools, Hospitals, Police Stations, Rescue Offices, Humanitarian Relief Warehouses	Density, Area Distribution, Age Distribution, Gender Distribution, Physical Disability, Income Distribution
Transportation Facilities	**Socio-Economic Aspects**
Roads, Railways, Bridges, Metro, Public Transportation Systems, Airports, Sea Ports	Dimensions Of Population, Governance, Community Organization, Government Support, Socio-Economic Levels, Livelihood, Cultural Heritage And Traditions
Economic Activities	**Environmental Elements**
Spatial Distribution Of Economic Activities, Dependency, Redundancy, Unemployment, GDP	Ecosystems, Protected Areas, Natural Parks, Forests, Wetlands, Aquifers, Biodiversity
Critical Infrastructure	**Agriculture**
Nuclear Power Plants, Hydro Power Plants, Grid Stations, Oil& Gas Fields, Petroleum & Gas Storage Facilities & Pipelines, Chemical & Fertilizer Storage Points , Major Industries, Oil Refineries, Communication Towers	Crops production (Rabbi and Kharif), Livestock, Fertilizer Consumption, Farm Machinery, Irrigation, Tube Wells

12. Exposure Assessment

a. The interaction of element at risk and hazard defines the exposure.

b. To quantify the level of exposure three possible values should be assigned to each indicator selected for exposure on scaling index i.e. low 1, medium 2 and high 3. A zero (0) score should be assigned if an indicator is not applicable to the hazard type. Another aspect, which needs to be considered, is the manner and degree each hazard tends to affect the elements at risk given the same exposure.

c. Each assigned indicator has a different meaning for a specific hazard. Thus, a hazard specific weight should be applied individually to every indicator i.e. low 1, medium 2 and high 3. A zero (0) score should be assigned if an indicator is not applicable to the hazard type.

d. The Exposure Score should be described in terms of **Low to Extremely High** with the help of the Score-Scaling Table (**Table 20**) given below.

Table 20: Exposure Scoring Scale

Class	Score
Extremely High	76-100
High	51-75
Medium	26-50
Low	1-25
No to Negligible	0

13. Vulnerability Assessment

a. Vulnerability is the condition determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards[5].

b. The quantification of vulnerability is also supported by the Hyogo Framework for Action, which stresses the need for the development of vulnerability indicators. The impacts of disasters on physical, social and agricultural conditions must be examined

[5] *UNISDR Terminologies on Disaster Risk Reduction 2009*

through such indicators[6]. Important tools required for Vulnerability Assessment are given in **Annex G**.

c. The Vulnerability Score should be described in terms of **low to extremely high** with the help of the score-scaling as given in **Table 21**.

Table 21: Vulnerability Score Table

Class	Score
Extremely High	76-100
High	51-75
Medium	26-50
Low	1-25
No to Negligible	0

d. Vulnerability Assessment should be undertaken by taking following three main areas into consideration:-

(1) **Physical Vulnerability Assessment**

(a) **Analysis Procedures for Earthquake Hazard.** For fragility analysis of buildings the structures should be classified into engineered and non-engineered constructions. Each category should be assessed for classification of their vulnerability against each hazard.

i. **Engineered Structures**. The engineered structured should be analyzed using finite element based software and numerical analysis, which should be calibrated for the considered structures by conducting laboratory experiments on building constituent materials (brick units, mortar, brick assemblages, brick panels and brick walls for masonry structures and concrete cylinders, reinforcing steel bars, structural beam-column members for reinforced concrete structures) to define input for design and analysis software such as ETABS – structure design software and SeismoStruct – structure assessment software.

6 UN/ISDR. 2004. Living with Risk

ii. **Non-Engineered Structures**. The numerical analysis of non-engineered buildings, based on the material properties alone, are not reliable due to the complexity of the non-engineered building in modeling and the complex behavior of these buildings under earthquake induced dynamic excitations. The buildings falling in this category have shown in-plane cracking, out-of-plane deflection and delamination of materials during shaking, which are complex to model numerically. Therefore, a fully dynamic shake table tests, using seismic simulator (1.5m x 1.5m), on reduced 1/3rd scaled model should be conducted to evaluate the seismic performance of non-engineered buildings and retrieve the lateral force-deformation capacity of equivalent SDOF system for further fragility analysis using engineering analysis tools.

iii. **Structural Fragility Analysis**

aa. Calculate Fragility of each structure type using Method for Fragility Functions Derivation (NDRM) for structural Reliability analysis for probabilistic and nonlinear dynamic approach, respecting all sources of uncertainties, for the fragility analysis of structures.

bb. For this purpose and to understand the seismic behavior of structures over the full range of seismic demand and most importantly to develop the full capacity of the system subjected to ground shaking, Incremental Dynamic Analysis (IDA) technique. The scope of the structural analysis is to quantify ground motions with different level of probability, exceeding a target performance of structures in order to develop structural fragility functions.

cc. Then apply Incremental Dynamic Analysis (IDA), which is a computational analysis method for structures to estimate more thoroughly the structure performance under dynamic seismic loading i.e. acceleration time histories representing strong ground shaking. IDA technique involves subjecting a structural mathematical model to a suite of ground motion records which should be scaled to multiple levels of increasing intensity in order to produce curves of response parameters versus intensity level of input excitations. The execution agency should have to consider the inter-storey drift as the response quantity for damage measure in structures.

dd. The capacity-demand convolution can be performed using classical reliability approach and first-order-reliability-method (FORM) approximation.

(b) **Analysis Procedures for Flood Hazard**

i. Structural flood vulnerability can be best accessed using empirical procedure based on the site observations from the past flood events. From literature review, the physical vulnerability can be considered to include the following elements at risk:

aa. Structural types of building

cc. Building contents

cc. Outside properties of building

ii. The structure damageability is governed by the water depth and the water flowing velocity.

iii. **Flood Fragility Functions Derivation**. Consider different types of buildings present in study area, for example Adobe Masonry, Brick Masonry, Block Masonry and Concrete Structures with infill (Brick Masonry and Block Masonry)to derive fragility based on historical damages w.r.t. floods.

(c) **Vulnerability Scoring and Mapping**

i. Additionally, analyzing the fragility functions, vulnerability scoring of each building typologies obtained corresponding to the damageability of building stock. The vulnerability score should be derived herein refers to the demand parameter (e.g. shaking severity for earthquake hazard and water depth for flood hazard) that has 50 percent chance to cause damage to the building. The vulnerability scoring should be qualitative index that, for a given hazard, can be used to quantify the relative vulnerability of building typologies in a given area and to develop the vulnerability map for that area.

ii. Further, following Vulnerability Score, calculated by NDMA, can also be used for calculating Physical Vulnerability, if the implementation organization lacks skill set required to carry out engineering structure analysis.

Table 22: Building Vulnerability Scoring for Floods and Earthquakes Based on Engineering Structure

Sr.	Building Types	Vulnerability Scoring	
		Flood	**Earthquake**
aa.	Reinforced Concrete	2.5	3.09
bb.	Stone Masonry	5.4	5.56
cc.	Mud/Adobe Masonry	7.14	7.14
dd.	Brick Masonry	3.66	3.79
ee.	Wood/Bamboo Traditional	4.82	2.50
ff.	Block Masonry	4.24	5.00
gg.	Others undefined	5	6.25

Table 23: Building Vulnerability Scoring for Floods and Earthquakes Based on Building Type

Sr.	Building Types	Vulnerability Scoring	
		Flood	**Earthquake**
aa.	Katcha	6.5	7
bb.	Semi-Pacca	5.0	6
cc.	Pacca	2.5	3

iii. Final composite vulnerability should be calculated according to building types (as per latest housing survey available) present in the area and their associated vulnerability score given in above tables.

(2) **Social Vulnerability Assessment**

(a) For Social Vulnerability an approach known as Social Vulnerability Index (SoVI) Model is recommended to be employed in the assessment. The SoVI model is composed of following steps:-

i. Identification and collection of relevant variables from a variety of locally available sources.

ii. Statistical analysis for data exploration and calculation of factors driving the social vulnerability.

iii. Standardization of factors to allow for comparisons.

iv. Weighting and aggregation of variables and groups of variables.

v. SoVI Calculation.

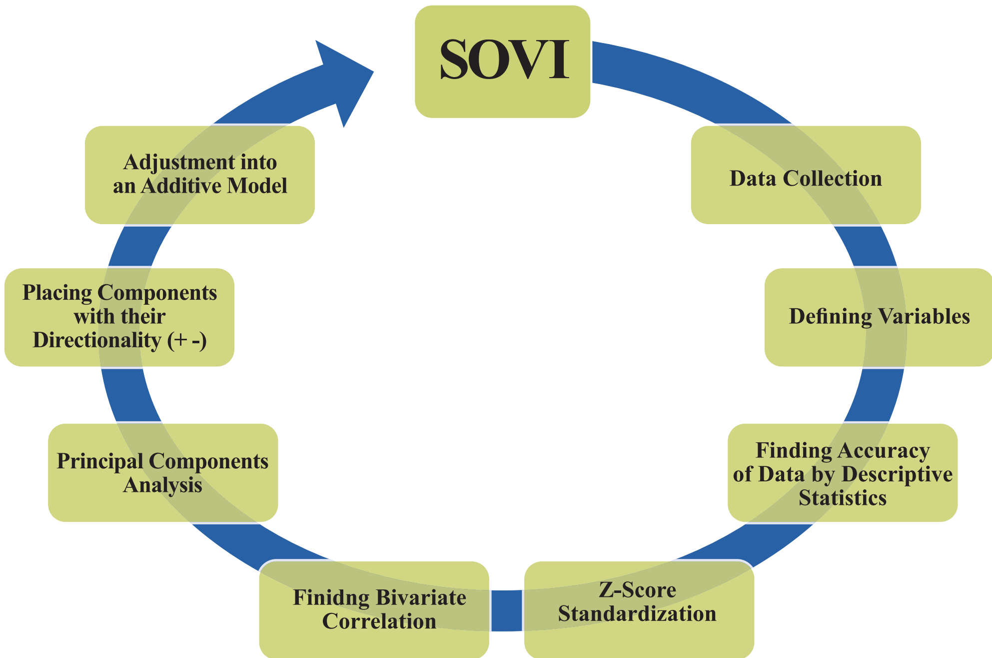


Figure 12: Steps Involved in Computing SoVI

(b) In SoVI approach, set of relevant indicators, variables or indices should be used for capturing the social vulnerability against impending hazards in the study area.

(c) List of relevant variables, in context of Pakistan, is given in **Table 24**.

Table 24: National Relevant Variables and Description

Variable Names	Variables Description	Data Source
NOSCL	A population that has ever attended School	Multiple Indicator Cluster Survey
PRIMSC	Percentage distribution of population that has completed Primary or Higher Level Education	
ENRLPR	Net enrolment rate in government primary schools (age 5-9)	
ENRMA	Net enrolment rate at the Matric level (age 14- 15)	
GBPEF	Government boy primary educational facility within 2 km	
GGEF	Government girls primary educational facility within 2 km	
ADLLIT	Adult literacy-population 15 years and older	
DIARR	Treatment of diarrhea in children under 5 years	
IMMUN	The percentage of children aged 12-23 months that have been immunized	
WTTI	Pregnant women that received a tetanus toxoid injection	
VAS	Vitamin A supplementation (under 5 years)	
CbyladyHW	Care provided by Lady Health Worker (LHW)	
PATHF	Physical access to health facilities within half an hour's distance	
PNCONSL	POST-NATAL CONSULTATIONS (Govt. Hospital /BHU)	
FERTILITY	Fertility Rate	
CHDISABL	Child disability (2-9) years	
TENURE	Percent distribution of households by housing tenure (own)	
ROOMS	Percentage distribution of households by number of rooms	

	(2-4)	
ELECTRIC	The percent distribution of households by electricity used for lighting	
PPUNIT	Average household size	
TAPWATER	Percentage distribution of household from source of tap drinking water	
WWDISPOSAL	Proper disposal of waste water	
PERCEPTION	The percent distribution of households by the perception of the economic situation of the household compared to the year before the survey (below poverty line)	
Exposures	Percentage of population exposure with TV	Pakistan Media
Exposure N	Percentage of population exposure with Radio	
Exposure R	Percentage of population exposure to Newspaper	
SATISFACTION	The percent distribution of households satisfaction by facilities & police service	Pakistan Bureau of Statistics
QOLD	% population age 65 and above	Multiple Indicator Cluster Survey
QMID	% population age 15-64	
Fpop	Female population	Census Data of Pakistan
Rpop	Rural Population	
Upop	Urban population	
QKIDS	% population age <15	Multiple Indicator Cluster Survey
GROWTH	Average Annual growth rate	Multiple Indicator Cluster Survey
UNEMPLOYED	Unemployment rate	
STDNTLABOR	Laborer students	
QAGRI	% population employed in agriculture	
CHLDLABOR	Child Labor	
LBROUTSIDE	Family member working outside village/town	
REMITT	Receiving remittances within Pakistan	
SOCBENIF	Social benefits receiving pensions	

(d) All data or variables used in the Model should then be used as input to Z-scores and be placed into a correlation analysis to remove potential redundancies in variables data.

(e) Data with very high correlations >= 0.90 should be removed however in some circumstances data with high correlation may be included in the social vulnerability index depending upon its high theoretical association with the social vulnerability concept.

(f) The variables selected for the Analysis should be taken as input to the Principal Components Analysis (PCA), to reduce the number of variables into a smaller set of common factors as a subsequent step.

(g) Each component should be subjectively categorized based upon the known contribution of its variables to the social vulnerability of study area.

(h) All variables that contribute to a particular factor should have distinct weighting.

(i) For a given factor, the variables with significant factor loadings (i.e. Correlation Coefficients) usually greater than 0.50 and less than -0.50, should be selected to define the factor. To ensure that the sign of the loadings corresponds with their known influences on vulnerability, the factors must be scaled for making adjustments to their directionality.

(j) A positive directionality must be assigned to all factors known to increase vulnerability. A negative directionality should be assigned to those factors known to decrease vulnerability. All components should be taken as input to an additive model where the component loadings have to be summed and mapped.

(k) Following nine Directional Factors should be used in additive model in order to calculate social vulnerability of study area.

Table 25: Nine Composite Factors for Social Vulnerability Assessment

Factor	Component
1	Age, Education, Health Outcome, Socioeconomic Status
2	Rural Farm Populations
3	Information Access
4	Children with Disabilities
5	Social Benefits
6	Infant safety
7	Low Income Laborers
8	Poverty/Need for External Income Source
9	Preventative Health Measures

(1) To obtain a final composite score of social vulnerability, the factors should be added to obtain the aggravating factor i.e. the Social Vulnerability Index of the Study Area.

$$\textbf{SoVI Score} = \left[\textbf{Factor 1} + \textbf{Factor 2} + \textbf{Factor 3} + \textbf{Factor 4} + \textbf{Factor 5} + \textbf{Factor 6} + \textbf{Factor 7} + \textbf{Factor 8} + \textbf{Factor 9} \right]$$

(3) **<u>Vulnerability Assessment for Agriculture and Food Security</u>**

(a) Agriculture & Food Insecurity should be described in terms of 'stressors' which effectively undermine household and livelihood strategies. These stressors must include sudden shocks (e.g. floods, droughts, earthquake, unemployment, death and price increases) and also gradual changes (e.g. changes in service delivery, land degradation, social and economic marginalization, erosion of assets and the changing nature of the world food situation).

(b) In order to assist those communities which are most exposed to multiple stressors, it is necessary to determine which households are currently food-insecure and which are vulnerable to food insecurity.

(c) The Study should focus on the exposed agriculture land to impending hazards and the relative frequency of each hazard in the study area.

Furthermore It should further be translated to food insecurity by the following relation of the variables, while providing population dependent on agriculture:-

$$\textbf{Food Insecurity} = \left[\text{Hazard} \times \text{Agriculture Exposure} \times \text{Hazard Frequency} \times \text{Percentage Population} \right]$$

(d) The ranking be categorized into Scoring Scale ranging from **1 to 5**, for which the 5 carries highest value (Extremely High Food Insecure) and 1 is the least food insecure or food efficient.

Table 26: Agriculture & Food Insecurity Vulnerability Score Table

Class	Scoring Scale
Extremely High Food Insecure	**5**
High Food Insecure	**4**
Medium Food Insecure	**3**
Low Food Insecure	**2**
Least Food Insecure or Food Efficient	**1**

14. **Capacity Assessment (Coping and Adaptive).** Capacity of a community is categorized as "Coping & Adaptive Capacity". The coping capacity refers to the "ability of people, organizations, and systems, using available skills and resources, to face and manage adverse conditions, emergencies, or disasters and adaptive capacity which refers to the ability of a system or individual to adapt to climate change, but it can also be used in the context of disaster risk . For collection of information on strengths, attributes and resources available within the study area and to systematically analyze it, the coping capacity is characterized as capacity to anticipate risk and avoid being affected, capacity to respond, capacity to recover and the adaptive capacity is characterized as capacity to reduce the disaster risks. However, relationship between vulnerability and capacity has to be considered which can be described in two ways (1) Vulnerability is the result of a lack of capacity (2) Vulnerability is the opposite of capacity, increased capacity means less vulnerability, and high vulnerability means fewer capacities. Important tools required for Capacity assessment are given in **Annex H**.

15. Risk Calculation

a. After calculating individual values for all the factor components i.e. hazard consequences, exposure, vulnerability, and capacity, the final risk score for each individual hazard (all return periods) should be calculated using the equation:-

Risk = (Hazard x Exposure x Vulnerability) / Capacity

b. The Risk values of Risk would vary from 0 –No Risk to 300 –Extremely High Risk. The Risk Score should be described in terms of **Extremely High, "High to Very High", "Moderate to High", "Low to Moderate"** and **"No to Very Low"** with the help of the Score Scaling Table (**Table 27**) given below.

Table 27: Risk Scoring Scale

Risk State	Risk Score
Extremely High	250-300
High to Very High	200-249
Moderate to High	100-199
Low to Moderate	50-99
No to very Low	0-49

16. Risk Treatment & DRR Programming

a. The purpose of Risk Treatment and DRR Programming (as described in National DRR Policy 2013)is to advocate an approach to disaster management that focuses on reducing risks – the probability of losing one's life or health, assets and livelihoods.

b. Risk Treatments and DRR Programming should be strictly based upon MHVRA study's findings and results based on the nature and degree of vulnerability and risk along with prioritization rationale.

c. DRR Programming should be based upon both short-term and long-term remedial measures, and should clearly delineate measures for prevention and mitigation paradigms.

d. DRR Programing should involve local level actors in the study area to produce more effective and sustainable results. It should involve Community Level Training and Awareness to better cope with hazardous events. Local level DRR Programing should focus on strengthening of organization/capacity building and preparation of community level DRR Plans.

e. On basis of gaps identified in the study area, DRR interventions aligned with National DRR Policy 2013 and NDMP 2012-2022 should be proposed covering following broad parameters:-

(1) Strengthening community participation and resilience
(2) Strengthening the resilience of vulnerable groups
(3) Compatibility with local customs and norms
(4) Clearly defined division of roles and responsibilities between different layers of government
(5) Promoting inter-organizational partnerships
(6) Transparency and accountability in all DRR intervention
(7) Strengthening Early warning capacity against multiple hazards
(8) Enhancing multiple communication dissemination system for alerts and evacuations order
(9) Strengthening awareness program on disaster risk reduction of study area
(10) Implementation and dissemination of community based disaster risk reduction activities
(11) Mainstreaming DRR into development activities
(12) Implementation of structural and nonstructural measures to increase resilience of study area to multi impending disasters

17. <u>Advocacy of MHVRA Results & Findings</u>

a. Training and advocacy of MHVRA findings should involve orientation about importance of MHVRA intervention in prevention & mitigation, preparedness, vulnerability reduction, hazard mitigation and emergency response management.

b. Training on the utilization of MHVRA tools and results should be provided to multiple sectors including government or non-government organization, development ministries at provincial and national levels, staff of district, provincial and national DM authorities, staff of technical agencies, national or international stakeholders i.e. Federal, Provincial and District agencies and United Nations' agencies and most importantly communities.

c. The study should build the capacities of all relevant stakeholders in proper utilization of MHVRA findings and result and its associated tools.

d. This module should build awareness on utilization of MHVRA tools in preparation of effective emergency response systems, deployment of demand driven early warning systems and optimal deployment of rescue &relief facilities.

e. Training should cover the role of MHVRA study in effective long-term land use planning and integration of disaster risk reduction into National and local development projects and mainstreaming DRR into development processes through precise risk calculations of any impending hazard in a specific area.

f. Orientation should encompass the following modules:-

(1) Use of GIS and Remote Sensing in MHVRA study

(2) Orientation on hazard modeling tools

(3) Geo-Spatial Techniques for Exposure, Vulnerability, Capacity and Risk Assessment in context to MHVRA

(4) MHVRA as decision making tool for both structural and non-structural mitigation measures

(5) MHVRA for prompt emergency response management

(6) MHVRA for disaster relief and early recovery planning

(7) MHVRA for Damage and Needs Assessment (DNA) for effective rehabilitation and reconstruction

(8) MHVRA for post disaster relief, recovery and reconstruction

(9) MHVRA as planning tool for camp site selection and management

18. **<u>Cost Benefit / Effective Analysis (CBA/CEA) of Proposed DRR Interventions</u>**.

For Cost Benefit/Effectiveness Analysis (CBA/CEA) of the proposed mitigation measures and Disaster Risk Reduction (DRR) interventions, a phase-wise approach should be carried out involving following steps:-

a. **<u>Desk Review</u>**. Desk review should be performed to collect requisite information concerning similar work carried out in past.

b. **<u>Inception Meeting with Relevant Stakeholders</u>**. In order to assess findings and proposed DRR interventions, an inception meeting should be undertaken with both key government officials of selected districts and district-level community stakeholders for incorporation of feedback and input on emerging issues and concerns of local people.

c. **Identification of Risk Management Measures and Associated Costs**. In order to perfectly control particularities of individual district and differences in disaster magnitudes, the study should compare impact of disaster in a community with DRR to the hypothetical impact of this same disaster in this same community had it not had the DRR programming.

d. **Analysis of the Benefits & Effectiveness of Risk Management**. The study should analyze the benefits of Risk Management measures by comparing realized impacts without DRR programming to hypothetical impacts of the same disaster in that where there had there been DRR with percentage reduction in losses.

e. **Calculation of Economic Efficiency.** The study should compare costs and benefits under a common economic efficiency decision criterion to assess whether benefits exceed costs. Internal Rate of Return (IRR) criterion calculates the interest rate internally, which represents the return on investments in the given project. A project is rated desirable if this IRR surpasses the average return of public capital determined beforehand.

19. Uploading MHVRA Results into MHVRA Repository

a. Final products should be integrated and stored in MHVRA central repository.

b. All products should be provided in prescribed format for ensuring their portability to MHVRA Repository.

c. Entity must ensure data compatibility during stages of data collection, preparation, conversion and analysis.

d. All the exported maps and assessment raw data (hazard, risk, exposure, vulnerability and risk) should follow a prescribed folder structure (**Annex I**).

e. Original source files of all the geographic data used in the study should be stored in the MHVRA Repository.

f. All the spatial data related to MHVRA study i.e. original source file of all maps and hazard layers to be stored in the MHVRA Repository in the prescribed format (**Annex J**).

g. Documentary evidence of all information collected from primary and secondary sources should be provided to NDMA.

20. **Publication of Final Results.** Final publication of study should include:-

a. Consolidated Technical Report of study districts

b. Atlas of each study district, which should include:-

(1) General Maps

(2) Hazard Maps

(3) Vulnerability/Exposure Maps

(4) Coping Capacity Maps

(5) Risk Maps

(6) DRR Plan

(7) Geospatial data for MHVRA repository

ANNEXURES

Annex A

To NDMA Policy Guidelines
For Conduct of MHVRA

MHVRA- POLICY DOMAIN & ITS RELATIONSHIP WITH SECTORIAL OBJECTIVES

REFERENCE POLICY DOCUMENTS	LINKAGES WITH SECTORIAL OBJECTIVES
National Climate Change Policy, 2012	**Policy Measures** **4.7 Disaster Preparedness** a. Allocate adequate financial and other resource in order to implement "National Disaster Risk Management Framework" formulated by NDMA. b. Strengthen early warning systems and develop communities' evacuation plans for vulnerable coastal and other areas against cyclones and sea storms. c. Ensure that the elderly, children, disabled, and women get particular priority in evacuation strategies. d. Set up an appropriate mechanism to monitor the development of glacial lakes and develop evacuation strategies in case of Glacial Lake Outburst Floods (GLOF) for vulnerable areas. e. Undertake risk mapping for possible avalanches and landslides in vulnerable mountain areas and take precautionary measures accordingly. f. Undertake GIS mapping of all existing irrigation infrastructure especially flood embankments for efficient monitoring and flood management. g. Enhance capacities to address the impact of floods, flash floods, droughts and so on by strengthening the relevant agencies. h. Undertake hydrological modeling and flood plain mapping/zoning of the Indus River system against climate change scenarios to estimate various projected flood levels. i. Ensure that infrastructure, including telecommunication, power, utilities, and transport are resilient to the impact of climate change, particularly to extreme weather events. **5.4 Town Planning** a. Undertake hazard mapping and zoning of areas before construction;

National Disaster Management Plan (NDMP) 2012-2022	**Section 4.5;** **Intervention-3:** **"Establishment of National Hazard and Vulnerability Assessment"** a. **Strategy-1**. Conduct detailed multi–hazard vulnerability and risk analysis/assessments at the national level. b. **Strategy-2**. Conduct detailed multi–hazard vulnerability and risk analysis/assessments at local levels. c. **Strategy-3**. Conduct research and studies on the impact of climate change on glaciers and ice caps. **Intervention-4:** **"Establish Multi Hazard Early Warning System"** a. **Strategy-2**. Prepare hazard maps at local scale in targeted location.
National DRR Policy 2013	a. **Policy Principles** **2.3.1** The country's DRM system will conduct a multi-hazard approach. **2.3.2** DRR interventions will be based upon vulnerability and risk analysis. b. **Policy Interventions** **3.1.1** Risk or vulnerability atlas and index at national level. **3.1.2** Local/ district level risk assessments. **3.2.2** Promoting "risk conscious" and resilient development and integrate DRR into development planning (micro-level projects).
Sendai Framework for Disaster Risk Reduction (SFDs)2015-2030	**Priorities for actions** a. **Priority 1.** Understanding disaster risk. b. **Priority 2.** Strengthening disaster risk governance to manage disaster risk. c. **Priority 3.** Investing in disaster risk reduction for resilience. d. **Priority4.** Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction.
Sustainable Development Goals 2016-2030	a. **Goal 1.** **<u>End poverty in all its forms everywhere</u>** **Target 1.5.** By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters. b. **Goal 2.** **<u>End hunger, achieve food security and improved nutrition and promote sustainable agriculture</u>**

	Target 2.1. By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round. **Target 2.4.** By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality. c. **Goal 11. <u>Make cities and human settlements inclusive, safe, resilient and sustainable</u>** **Target 11.1.** By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums 11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons **Target 11.3.** By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries **Target 11.4.** Strengthen efforts to protect and safeguard the world's cultural and natural heritage 11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations **Target 11.6.** By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management **Target 11.b.** By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015–2030, holistic disaster risk management at all levels.

	d. **Goal 13. Take urgent action to combat climate change and its impacts*** **Target 13.1.** Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries **Target 13.2.** Integrate climate change measures into national policies, strategies and planning **Target 13.3.** Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning. e. **Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss** **Target 15.3.** By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world
Pakistan Vision 2025	**Pillar 1. Putting People First: Developing Human and Social Capital** **Target. Inclusion of Vulnerable Segments** **Pillar 2. Achieving Sustained, Indigenous and Inclusive Growth** **Target. Strategic Initiatives;** a. Urban Development and Smart Cities **Pillar 3. Energy, Water & Food Security** **Target.** Combating Climate Change a. Key target goals for responding to climate change are; b. Design water, food and energy security policies and plans of the country with specific reference to the profound challenges posed by climate change.

Annex B

To NDMA Policy Guidelines
For Conduct of MHVRA

IMPLEMENTATION ROADMAP OF NDMP (2015-2030)

PHASE - 1 (2016-2018)

Sr.	NDMP Rank	Province	District
1	1(a)	Sindh	Karachi Central
2	1(b)	Sindh	Karachi South
3	1(c)	Sindh	Karachi East
4	1(d)	Sindh	Karachi West
5	1(e)	Sindh	Karachi Malir
6	1(f)	Sindh	Karachi Korangi
7	2	AJ&K	Hattian
8	3	AJ&K	Muzaffarabad
9	7	Khyber Pakhtunkhawa	Nowshera
10	4	Khyber Pakhtunkhawa	Charsadda
11	6	Khyber Pakhtunkhawa	Sawat
12	12(a)	Khyber Pakhtunkhawa	Mansehra
13	12(b)	Khyber Pakhtunkhawa	Tor Gharh
14	23	AJ&K	Neelum
15	19	Punjab	Rawalpindi
16	18	Sindh	Badin
17	16	Sindh	Dadu
18	13	Sindh	Hyderabad
19	14(a)	Sindh	Thatta
20	14(b)	Sindh	Sujawal
21	28(a)	Balochistan	Jaffarabad
22	26	Khyber Pakhtunkhawa	Peshawar
23	36	Balochistan	Nasirabad
24	47	Khyber Pakhtunkhawa	D. I. Khan
25	45	Punjab	Rahim Yar Khan
26	38	Sindh	Kashmore
27	51	Balochistan	Quetta
28	64	Capital Territory	Islamabad
29	59	Punjab	Mianwali
30	58	Punjab	Muzaffargarh
31	53	Sindh	Ghotki
32	72	Punjab	Sialkot
33	68	Sindh	Tharparkar
34	79	Punjab	D. G. Khan
35	81	Punjab	Rajanpur
36	97	Punjab	Lahore
37	103	Khyber Pakhtunkhawa	Chitral
38	121	Gilgit-Baltistan	Gilgit
39	28(b)	Balochistan	Sohbatpur
Total Districts: 39			

PHASE - 2 (2019-2022)

Sr.	NDMP Rank	Province	District
1	11	AJ&K	Bagh
2	5	Khyber Pakhtunkhawa	Shangla
3	24	AJ&K	Kotli
4	22	Balochistan	Bolan
5	21	FATA	Bajaur Agency
6	20	Khyber Pakhtunkhawa	Buner
7	17	Sindh	Qamber and Shahdadkot
8	15	Sindh	Tando Muhammad Khan
9	27	FATA	Mohmand Agency
10	25	Sindh	TandoAllahyar
11	35	FATA	Khyber Agency
12	34	Khyber Pakhtunkhawa	Abbottabad
13	33	Khyber Pakhtunkhawa	Bannu
14	32	Khyber Pakhtunkhawa	Swabi
15	31	Khyber Pakhtunkhawa	Upper Dir
16	30(a)	Punjab	Sheikhupura
17	29	Sindh	Matiari
18	50	Khyber Pakhtunkhawa	Lower Dir
19	46	Punjab	Multan
20	43	Sindh	NaushahroFeroze
21	42	Sindh	Shaheed Benazirabad
22	66	Balochistan	JhalMagsi
23	65	FATA	Orakzai Agency
24	63	Khyber Pakhtunkhawa	Malakand
25	55	Punjab	Gujranwala
26	52	Sindh	Khairpur
27	54	Sindh	Sukkur
28	78	Balochistan	Loralai
29	70	Punjab	Faisalabad
30	75	Punjab	Jhang
31	74	Punjab	Narowal
32	77(a)	Balochistan	Sibi
33	77(b)	Balochistan	Lehri
34	90	Balochistan	Kech
35	89	Balochistan	KillaSaifullah
36	87	Punjab	Jhelum
37	83	Punjab	Leiah
38	99	Khyber Pakhtunkhawa	Kohat
39	93	Punjab	Chiniot
40	96	Punjab	MandiBahauddin
41	107	Balochistan	Awaran
42	105	Balochistan	Kalat
43	106	Balochistan	Pishin
44	116	Balochistan	Killa Abdullah
45	111	Gilgit-Baltistan	Diamir

46	110(a)	Gilgit-Baltistan	Hunza
47	110(b)	Gilgit-Baltistan	Nagar
48	101	Punjab	Bahawalpur
49	127	Balochistan	Gwadar
50	128	Balochistan	Lasbela
51	123	Gilgit-Baltistan	Ghanche
52	120(a)	Gilgit-Baltistan	Skardu
53	120(b)	Gilgit-Baltistan	Kharmung
54	120(c)	Gilgit-Baltistan	Shigar
55	138	Balochistan	Panjgur
56	137	Balochistan	Zhob
57	143	Balochistan	Sherani
58	129	Balochistan	Ziarat
59	30(b)	Punjab	Nankanasab
Total Districts: 59			

PHASE - 3 (2023-2030)

Sr.	NDMP Rank	Province	District
1	10	AJ&K	Haveli
2	9	AJ&K	Poonch
3	8	AJ&K	Sudhnoti
4	49	Khyber Pakhtunkhawa	Mardan
5	37	AJ&K	Mirpur
6	48	Khyber Pakhtunkhawa	Batagram
7	40	Sindh	Jacobabad
8	39	Sindh	Jamshoro
9	44	Sindh	Mirpur Khas
10	41	Sindh	Shikarpur
11	67	AJ&K	Bhimber
12	62	Khyber Pakhtunkhawa	Hangu
13	61	Khyber Pakhtunkhawa	Haripur
14	60	Punjab	Gujrat
15	56	Punjab	Okara
16	76	Khyber Pakhtunkhawa	Tank
17	73	Punjab	Sahiwal
18	71	Punjab	Toba Tek Singh
19	69	Sindh	Larkana
20	86	Punjab	Kasur
21	85	Punjab	Khanewal
22	84	Punjab	Khushab
23	82	Punjab	Lodhran
24	80	Punjab	Sargodha
25	100	FATA	South Waziristan Agency
26	98(a)	Khyber Pakhtunkhawa	Kohistan (Upper)
27	98(b)	Khyber Pakhtunkhawa	Kohistan (Lower)
28	95	Punjab	Pakpattan

29	94	Punjab	Vehari
30	92	Sindh	Sanghar
31	91	Sindh	Umerkot
32	101	Punjab	Bahawalnagar
33	102	Punjab	Hafizabad
34	114	Balochistan	Barkhan
35	113	Balochistan	Harnai
36	117	Balochistan	Khuzdar
37	115	Balochistan	Mastung
38	109	Khyber Pakhtunkhawa	LakkiMarwat
39	124	FATA	FR Bannu
40	126	FATA	Kurrum Agency
41	125	FATA	North Waziristan Agency
42	122	Gilgit-Baltistan	Ghizer
43	119	Punjab	Attock
44	118	Punjab	Chakwal
45	133	Balochistan	Kohlu
46	132	Gilgit-Baltistan	Astore
47	131	Khyber Pakhtunkhawa	Karak
48	130	Punjab	Bhakkar
49	135	Balochistan	Chagai
50	140	Balochistan	Kharan
51	139	Balochistan	Nushki
52	136	Balochistan	Washuk
53	142	Balochistan	DeraBugti
54	144	Balochistan	Musakhel
55	134	FATA	FR Tank
56	141	FATA	FR LakiMarwat
57	88	FATA	FR Peshawar
58	112	FATA	FR Kohat
59	104	FATA	FR D.I Khan
Districts 59			

Annex C

To NDMA Policy Guidelines
For Conduct of MHVRA

NON-DISCLOSURE AGREEMENT

This Agreement is made by and between PMU, NDMA, government of Pakistan and ________________________, whose principal mailing address is ____________________________ ("Recipient").

1. **Definition of Confidentiality**. As used in this Agreement, "Confidential Information" refers to any information which has commercial value and is either (i) technical information, including geospatial data types/formats or (ii) non-technical information relating to NDMA's products, including reports, plans and any other information which is the property of Pakistani public in the domain of NDMA.

2. **Nondisclosure and Nonuse Obligations.** Recipient will maintain in confidence and will not disclose, disseminate or use any Confidential Information belonging to NDMA and National Working Group on MHVRA, whether or not in written form. Recipient agrees that Recipient shall treat all Confidential Information of NDMA with at least the same degree of care as Recipient accords its own confidential information. Recipient further represents that Recipient exercises at least reasonable care to protect its own confidential information. If Recipient is not an individual, Recipient agrees that Recipient shall disclose Confidential Information only to those of its employees who need to know such information, and certifies that such employees have previously signed a copy of this Agreement.

3. **Survival.** This Agreement shall govern all communications between the parties. Recipient understands that its obligations under Paragraph 2 ("Nondisclosure and Nonuse Obligations") shall survive the termination of any other relationship between the parties. Upon termination of any relationship between the parties, Recipient will promptly deliver to NDMA, without retaining any copies, all documents and other materials furnished to Recipient by NDMA.

4. **Governing Law.** This Agreement shall be governed in all respects by the laws of the Islamic Republic of Pakistan and by the laws of the constituents units of it; as such laws are applied to agreements entered into and to be performed entirely within Pakistan between Pakistani residents.

5. **Injunctive Relief.** The parties agreed that the disclosing party will suffer irreparable injury if its confidential information is made public, release to a third party, or otherwise disclosed in breach of this agreement and that the disclosing party shall be entitled to obtain injunctive relief against a threatened breach or continuation of any such breach and, in the event of such breach, an award of actual and exemplary damages from any court of competent jurisdiction.

6. **Entire Agreement.** This Agreement constitutes the entire agreement with respect to the Confidential Information disclosed herein and supersedes all prior or contemporaneous oral or written agreements concerning such Confidential Information. This Agreement may only be changed by mutual agreement of authorized representatives of the parties in writing.

IN WITNESS WHEREOF, the parties have executed this Agreement as of the date first written below.

NDMA	**RECIPIENT ORGANIZATION**
Signature_____________________________	Signature______________________________
Name_________________________________	Name_________________________________
Designation___________________________	Designation____________________________
CNIC/Passport_______________________	CNIC/Passport__________________________
Dated________________________________	Dated_________________________________

WITNESS NO. 1	**WITNESS NO. 2**
Signature______________________________	Signature______________________________
Name_________________________________	Name_________________________________
Designation____________________________	Designation_____________________________
CNIC/Passport__________________________	CNIC/Passport___________________________
Dated_________________________________	Dated__________________________________

Annex D

To NDMA Policy Guidelines
For Conduct of MHVRA

DATA REQUEST FORM

Request No: ___________ Date: ____________________

Name of Requesting Agency: ____

Project Name: ____

Project Background: ____

____

____

_______________ (additional details to be enclosed)

Type of Organization (i.e. Gov, Private, UN, NGO):________________________________

Official Website: ____

Focal Person: ____

Designation: ____

CNIC/ Passport Number: ____

Email Address: ____

Telephone/ Mobile No: ____

Sr.	Data Required	Purpose	Type/ Format	Possible Sources	Remarks	Attributes (In case of GIS data)

Signature: __________________________

Countersigned by Head of Department of Requesting Agency: ______________________

Annex E

To NDMA Policy Guidelines
For Conduct of MHVRA

DATA GAP ANALYSIS

DATA GAP ANALYSIS TEMPLATE								
Sr.	Data Specification	Data Category	Data Format	Temporal Status (Time Series)	Geographical Extent (Scale Series)	Recommendation		Recommended Source
						Essential	Desirable	

Organization: ____________________________

Name: __________________________________

Designation: _____________________________

Signature: _______________________________

CNIC/Passport: __________________________

Dated: ____________________________________

Annex F

To NDMA Policy Guidelines
For Conduct of MHVRA

RECURRENCE INTERVAL OR RETURN PERIOD

Return Period is an estimate of the likelihood of an event, such as a flood or discharge and earthquake to occur. When events are random or quasi-random, it is helpful to represent their frequency as an average time between past events. Once a return period of a hazard is known then through hazard modeling tools, intensity of hazard can be assess for better mitigation, preparedness and DRR initiatives.

Recurrence intervals occur in a variety of geophysical, climatological and hydro-meteorological events including:

a. Maximum Flood Flow frequency
b. Earthquake hazard
c. Cyclone frequency
d. Severe weather and storms

Example for calculating flood return period is explained in proceeding para, same approach can be used for other Natural Hazards as well.

Method for Calculation:

a. Annual Maximum flood flows for the gauging station is required. All the values need to be instantaneous values (not mean flow).
b. Flow values are sorted from largest to smallest according to their rank among the available data.
c. Recurrence Interval (T) is calculated according to the following formula.

$$T = \frac{n+1}{m}$$

Where: T = recurrence interval

n = total number of years (water years in case of floods) of record available

m = rank / magnitude

d. Plot recurrence interval on X-axis (logarithmic) against flood size in Cubic feet per second (cfs) or cubic meters per second (cms) on Y-axis.
e. Fit a trend line to the data, disregarding any outliers in the data.
f. Read the return period or flood size value for a particular flood size or return period from the graph.
g. Annual exceedance probability (AEP) is calculated by reciprocating the return period and is expressed in terms of percentage.

***Note*: For Hydro-Meteorological and climatological Hazards, margin of exceedance of 10% due to possible impacts of climate change for extreme events should also be taken in account.**

Annex G

To NDMA Policy Guidelines
For Conduct of MHVRA

VULNERABILITY ASSESSMENT TOOLS

For vulnerability assessment following participatory tools should be used for data collection and verifications.

Tool	Description	Limitations	Solutions
Information Collection Tools			
Historical Profile	This tool aims at highlighting trends and key points in the history of the community. It helps local people to gain insights into past hazards and changes in hazards' nature, intensity and behavior and at the same time make people more aware of these changes.	When researching historical profiles, there are usually more available data in urban than in rural areas. However, while conducting surveys, interviews or group discussions, it will be difficult to identify the right group to target due to the greater mobility of urban populations.	Research should be based mainly on secondary data, verified by local people through in-depth interviews with the longest-term dwellers.
Mapping	Creation of maps such as hazard maps, risk maps or resource maps could be a useful tool in determining the spatial distribution of certain aspects of the surroundings.	Though information and data in urban areas (administrative maps, topographic maps, and detailed construction plan) are more available, detailed mapping tools still encounter difficulties when applied in urban areas.	Specialized people engage for assessment with good skills.

Seasonal Calendar	Seasonal calendars are usually associated with livelihood activities and crop planting schedules in rural areas.	This tool has been applied in rural areas only, and is based on crop schedules	Develop tools for urban area
Transect Walk	A systematic walk with key-informants through the community to look at the layout of the community to produce a cross-sectional diagram.	Due to high density and complexity of urban infrastructure, it is difficult to produce the transect diagram.	Using urban plans and GIS,
Direct Observation	The purpose of this tool is to better understand the landscape of the area, especially to collect information and pictures that are difficult to acquire from documents or group discussions.	Similar to the transect walk, a limitation in urban areas is that it is difficult to have an overview of the area by observation from a single direction	Study the urban plan, NESPAK reports on infrastructure
Venn Diagram	A Venn diagram shows key organizations, groups and individuals in a community, the nature of their relationships and level of importance, to identify organizations, their role/ importance and perceptions.	The difficulty in analysis using Venn diagrams is in how to identify roles of the political or social organizations of interest, because the amount and complexity of information in urban areas makes it difficult to collect and analyze.	Improving this tool to assess agents in the urban areas, clarifying roles and linkages between organizations and individuals
Focus Group Discussions	Focus group discussions with NGOs and INGOs, working in study area, to collect both general and specific information, analyze issues, vulnerabilities, capacities and	It is difficult to verify information provided and to identify groups because the selection and classification of groups are not the same as for rural areas.	Working closely with leaders of residential areas

Interviews	Interview provides detailed information, or to confirm unclear information collected from related group discussions or documents.	First, it is difficult to meet with the targeted interviewees in urban areas due to the nature of their work and lifestyles. Consumption habits of urban people might also prevent the development of effective adaptive measures.	Raising public awareness while doing assessment; Working closely with leaders of residential areas.
Information Analysis Tools			
Strengths Weaknesses Opportunities and Threats (SWOT) Analysis	This tool can also be used to collect general and basic information about the strengths, weaknesses, opportunities and threats to the local community	This tool is based mainly on available secondary data and therefore faces similar challenges to those faced with secondary data reviews.	Improving capacity of assessment staff

Annex H

To NDMA Policy Guidelines
For Conduct of MHVRA

CAPACITY ASSESSMENT TOOLS
Union Council Level

District: ___________________________ **Tehsil/Taluka:** ______________________________

Union Council: _____________________ **Village/Moza/Deh:** ___________________

UC Level Capacity Assessment Performa	
Sub- Indicator	**Score- Answer Yes/No and Write Number Where Asked**
No. of community social & religious organizations working on disaster awareness	
No. of external actors i.e. NGOs and INGOs working on disaster awareness	
Early warning systems, time of warning (in **hours)**	
No. of villages covered out reach of early warning system	
No. of literate adults	
No. of households (HH) having access to electronic media, TV, radio & internet	
UC Level Capacity to Respond	
Sub- Indicator	**Score/Yes/No**
Emergency Response Plan exists	
Evacuation Plan exists	
Early warning available before disaster (in hours)	
No. of villages - out reach of early warning	
No. of community emergency response teams with team size	
No. of PRCS volunteers/ teams	
No. of female community emergency response teams	
No. of religious/welfare organization networks working on emergency	
No. of external actors i.e. I/NGOs working on emergency response	
Is Pak Army involved in emergency Response in past?	
No. of health facilities (all categories)	
No. of Evacuation Centers/ schools used as evacuation centers	
No. of displaced pop last year floods	
Risk transfer mechanism such as insurance and loans exists	

UC Level Capacity to Recover	
Area of irrigable land under influence of hazard i.e. drought/ flood	
No. of households - HH dependent on agriculture as source of earning	
No. of HH dependent on industry as source of earning	
No. of HH dependent on trade as source of earning	
No. of HH receiving assistance from Baitul-Maal / BISP	
No. of HH that received any zakat/donation during the last year	
No. of casualties in natural disasters (last 2 years)	
No. of houses destroyed in disasters (last two years)	
No. of population using safely managed drinking-water services	
No. of population using safely managed sanitation services	
UC Level Capacity for Disaster Risk Reduction	
Hazard Vulnerability & Capacity Assessment – How many HVCA conducted in union council (last 2 years)	
Emergency Response & Evacuation Plan (community level). If yes when was it last reviewed and cover which hazards?	
No. of Community Evacuation Centers with their capacity and location	
No of DRR awareness raising and capacity building activities at school level (last 2 years)	
No of DRR awareness raising and capacity building activities at community level (last 2 years)	
No of UC level drills and simulations involving all stakeholder for response (last 2 years)	
No of trainings on Awareness of Hazard-Resistant Building Codes in community (last 2 years)	
No of trainings on awareness of safe land use planning i.e. construction in flood prone area and construction in area lying on fault line	
No of trainings on awareness on use of drought resistant seeds and practices (last 2 years)	
No. of warehouses for emergency storage at UC level	

Responder Details:

Name: ______________________________

Designation: _________________________

Contact Number: ____________________

Information Collected by:

Name: ______________________________

Designation: _________________________

Signature: ___________________________

Information Collection Date: __________

District Civil Defense

Information Required for Capacity Assessment

District: ___________________________ **Tehsil/Taluka:** ________________________

Union Council: ____________________ **Village/Moza/Deh:** ____________________

Sr.	Indicators	Response
1	Rescue1122 capacity (i.e. staff, equipment, vehicles, centers)	
2	No. of Civil Defense posts	
3	No. of community level Response Teams	
4	No. of Pakistan Red Crescent Society volunteers/teams and their capacity	
5	No. of community religious/welfare organizations working on emergency response	
6	No. of external actors i.e. I/NGOs working on emergency response	
7	Early warning available before disaster (in hours)	
8	No. of community social & religious organizations working on emergency awareness	
9	No. of external actors i.e. I/NGOs working on awareness	
10	Early warning system coverage (No. of villages)	

Responder Details:

Name: ______________________________

Designation: _________________________

Contact Number: ____________________

Information Collected by:

Name: ______________________________

Designation: _________________________

Signature: ___________________________

Information Collection Date: __________

District Rescue 1122

Information Required for Capacity Assessment

District: ________________ ***(Please write name of all Tehsils and UCs and add additional sheets)***

Sr.	Indicators	Tehsil/UC	Response
1	No of Rescue 1122 stations		
2	No of civil defense posts		
3	No of community level response teams		
4	No of PRCS volunteers / teams		
5	No of community religious/welfare networks / organization networks working on emergency response		
6	No of external actors i.e. I/NGOs working on emergency response		
7	Early warning available before disaster (in hours)		
8	No of community social & religious organizations working on emergency awareness of disasters		
9	No of external actors i.e. I/NGOs working on disasters awareness		
10	Early warning system coverage (No. of villages)		
11	No of Rescue workers		
12	No of ambulances		
13	No of boats with motors (OBM)		
14	No of rescue vehicles		
15	No of HAZMAT Teams		

Responder Details:

Name: ______________________________

Designation: _________________________

Contact Number: ____________________

Information Collected by:

Name: ______________________________

Designation: _________________________

Signature: ___________________________

Information Collection Date: __________

DCO Office Information

Required for Capacity Assessment

District: ________________ *(Please write name of all Tehsils and UCs and add additional sheets)*

Sr.	Indicators	Tehsil/UC	Response
1	No of community social & religious organizations working on disaster awareness		
2	No of external actors i.e. I/NGOs working on disaster awareness		
3	No of community / religious/welfare organization networks working on emergency response		
4	No of external actors i.e. I/NGOs working on emergency response		
5	No of civil defense posts		
6	No of community level response teams		
7	No of PRCS volunteers/ teams		
8	No of Rescue 1122 stations		
9	No of ambulances		
10	No of Evacuation Centers/ schools used		
11	No of males age 15-55 years		
12	No of females 15 -55 years		
13	No of children below 15 years		
14	No of population above 55 years		
15	No of population below poverty line		
16	No of HH registered in BISP		
17	Irrigable land under influence of hazard i.e. drought/Flood		
18	No of population below poverty line		
19	No of unemployed population 15-55 yrs.		
20	Per Capita Income (in PKR)		

Responder Details:

Name: ______________________________

Designation: _________________________

Contact Number: _____________________

Information Collected by:

Name: ______________________________

Designation: _________________________

Signature: ___________________________

Information Collection Date: __________

District Education Department

Information Required for Capacity Assessment

District: ________________ *(Please write name of all Tehsils and UCs and add additional sheets)*

Sr.	Indicators	Tehsil/UC	Response
1	No of schools (all categories)		
2	Literacy rate males		
3	Literacy rate females		
4	No. of schools used as evacuation centers		
5	No. of Emergency Response & Evacuation Planning training in union council schools (in last 2 years)		
6	No of awareness raising and capacity building activities at school level (in last 2 years)		
7	No of school having hazard-resistant building		
8	No of schools in flood prone areas (please attach list of schools)		

Responder Details:

Name: ______________________________

Designation: _________________________

Contact Number: _____________________

Information Collected by:

Name: ______________________________

Designation: _________________________

Signature: ___________________________

Information Collection Date: __________

District Health Information
Required for Capacity Assessment

District: ________________ *(Please write name of all Tehsils and UCs and add additional sheets)*

Sr.	Indicators	Tehsil/UC	Response
1	Budget allocated for health 2014-15 (% of provincial budget)		
2	Per capita health spending of district		
3	Adult mortality rate		
	Infant mortality rate		
4	Mortality rate children under 5 years		
5	Maternal mortality ratio		
6	No. of children under five years (stunted)		
7	No. of population using safely managed drinking-water services		
8	No. of population using safely managed sanitation services		
9	Average No. in last 5 years TB prevalence rate		
10	Average No. last 5 years Malaria parasite prevalence		
11	No of Disease Early Warning System (DEWS) alerts (last 2 years)		
12	No. of Doctors/Physicians		
13	No. of Paramedic staff		
14	No of tested safe drinking water sources at union council level		
15	No of households visited by Lady Health Worker (LHW) last year		
16	No of health facilities all categories		
17	No of ambulances		
18	No of LHWs		
19	No of health facilities in flood zone/ area		
20	Incidence of Waterborne and Hygiene-related disease in last two years		
21	Provisions for emergency response funds/ budget?		
22	No of tested water sources in district?		

Responder Details:

Name: ______________________________

Designation: _________________________

Contact Number: ____________________

Information Collected by:

Name: ______________________________

Designation: _________________________

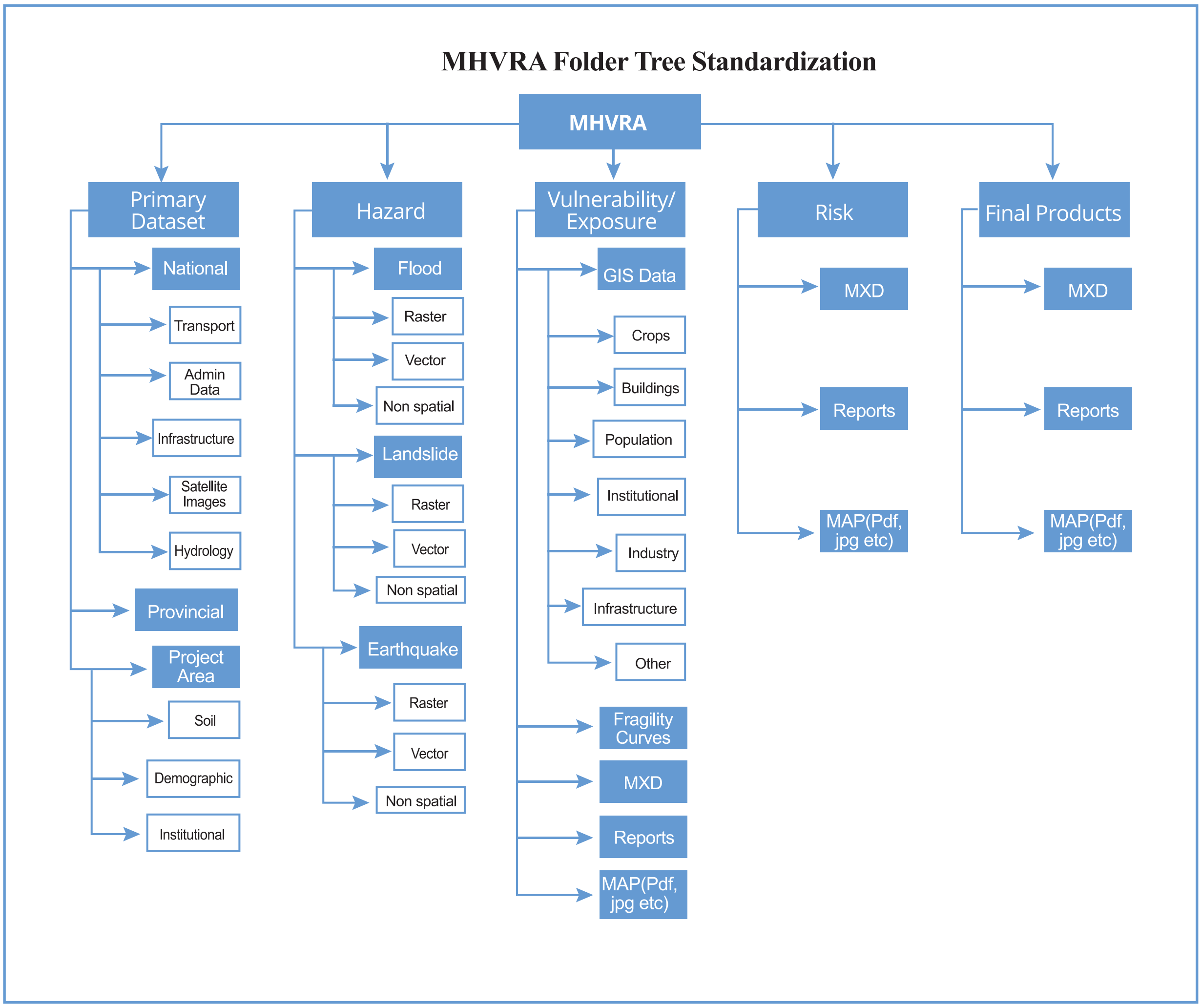
Signature: ___________________________

Information Collection Date: __________

Annex I

To NDMA Policy Guidelines
For Conduct of MHVRA

DATABASE STRUCTURE (FOLDER TREE AND GEO-DATABASE)



Annex J

To NDMA Policy Guidelines
For Conduct of MHVRA

GEOSPATIAL METADATA STANDARDIZATION FOR MHVRA

Metadata Fields	Description
Title	Name of the dataset
Data Type	Raster/Vector/Paper Maps/Mxds
Theme	Elevation/Infrastructure/Population/Land Use etc.
Data Level	Provincial/District/Tehsil/Union Councils
Acquisition Purpose	Explain intended data usage
Data Source	Developing organization of a specific dataset e.g. SoP
Data Provider	Handing over body e.g. Operations wing NDMA, UNDP, etc.
Date Of Production	Date at which a specific data is produced
Date Of Acquisition	Date at which a specific data is acquired
Spatial Extents	Latitudes/Longitudes/Coordinate System/Projection (if any)
Scale	Scale at which data has been prepared
Field Description	One liner explanation of the data fields
Other Data	

National Disaster Management Authority
Prime Minister's Office Premises, 2nd Floor, Sector G-5/1
Constitution Avenue, Islamabad - Pakistan
Website: www.ndma.gov.pk