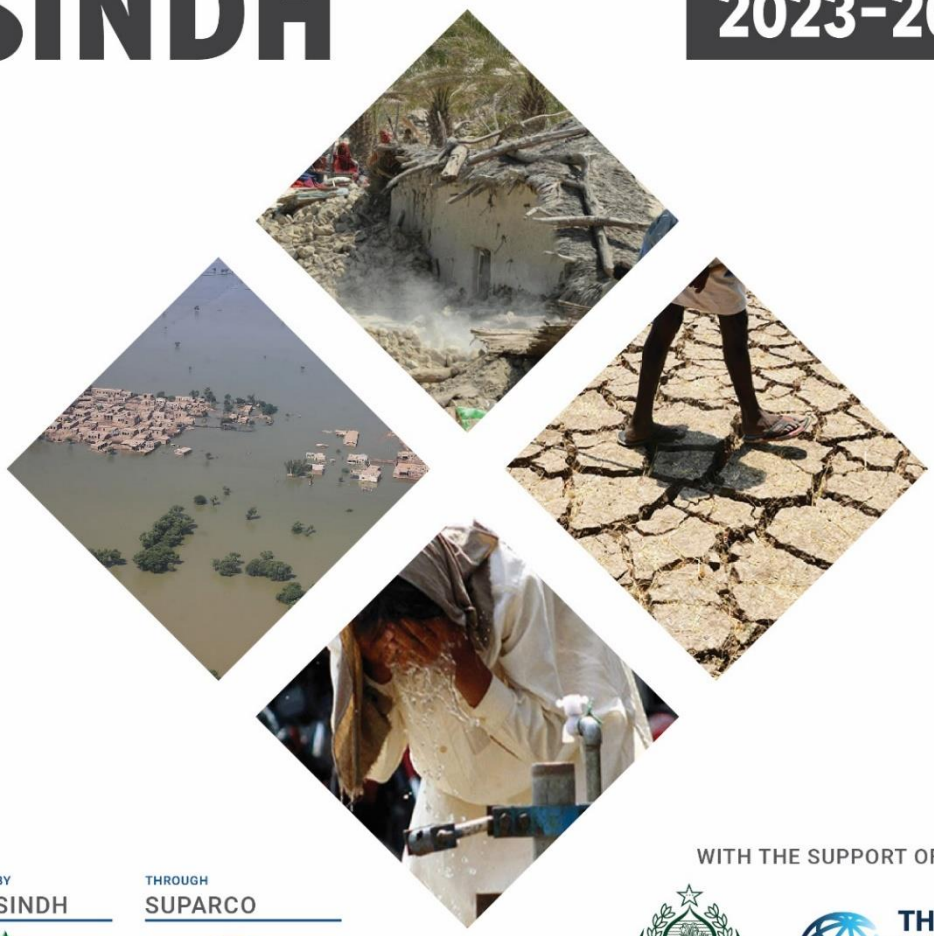
MHVRA

INFORMED DISASTER MANAGEMENT PLAN

SINDH

2023-2032



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PDMA SINDH

THROUGH
SUPARCO

WITH THE SUPPORT OF
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Executive Summary

The frequency of natural disasters has been on the rise in recent years, a trend that is expected to continue due to the increasing impact of climate change, urbanization, population growth, and the destruction of natural habitats. These events not only pose a significant risk to human safety and well-being, but also have the potential to cripple economies, particularly in developing countries. While it is impossible to completely eliminate the threat of natural disasters, timely preparedness can help to mitigate the impact of these events on communities and economies.

Effective disaster risk management is a holistic and integrated approach that involves coordinating the efforts of all relevant agencies. This includes not only emergency response organizations, but also government agencies, Non-Governmental Organizations (NGOs), and the private sector. Timely dissemination of information through various media channels, including radio, television, cell phones, and the internet, can be crucial in executing rescue, response, and rehabilitation efforts.

To better understand and mitigate the risk of natural disasters in the region, the Provincial Disaster Management Authority (PDMA) of Sindh has undertaken several initiatives, including conducting a Multi-Hazard Vulnerability Risk Assessment (MHVRA) and establishing an inventory management system.

The Provincial Disaster Management Plan 2023-2032 is a comprehensive guide for all relevant institutions to follow in the event of an emergency. It is developed by the Provincial Disaster Management Authority Sindh and SUPARCO to help concerned departments to reduce vulnerabilities and risks against natural disasters in the region. The plan outlines the strategies, policies, and measures that should be taken to prepare for, respond to, and recover from natural disasters.

The importance of the Provincial Disaster Management Plan lies in its ability to coordinate the efforts of all relevant agencies, including emergency response organizations, government agencies, NGOs, and the private sector. By having a clear and comprehensive plan in place, these agencies can work together effectively to respond to natural disasters and minimize their impact on communities and economies.

The plan also outlines the roles and responsibilities of each agency, as well as the communication channels that should be used to ensure timely and effective response to emergencies. In addition, the plan includes guidelines for risk assessment, emergency preparedness, and recovery efforts, as well

as details on the resources and equipment that will be needed to respond to disasters in a comprehensive action plan.

Overall, the Provincial Disaster Management Plan 2023-2032 is a crucial tool for authorities to reduce vulnerabilities and risks against natural disasters in the region. By carefully reviewing and utilizing the plan, they can effectively respond to any disaster and minimize its impact on communities and economies.

Preface

The Provincial Disaster Management Plan (PDMP) is a milestone in the history of the Disaster Management System (DRM) in Sindh. The rapid change in global climate has given rise to many disasters that pose a severe threat to human life, property and infrastructure. Disasters like floods, earthquakes, tsunamis, droughts, heatwave and cyclones with storm surges are some prominent manifestations of climate change phenomenon.

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

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

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

The Provincial Disaster Management Authority (PDMA) Sindh, was constituted under the NDM Act (National Disaster Management Act) in 2010, PDMA specializes in mitigation, preparedness and an organized response to a disaster. The most important role of PDMA lies in providing a platform for all provincial departments to come together and strategize management and response to disasters and calamities. PDMA also acts as the coordinating authority, which articulates the coordination mechanism between key provincial departments including Rescue 1122, Civil Defense, District Governments and Police for immediate rescue and rehabilitation operations. In case of a disaster, PDMA not only oversees search, rescue and evacuation of the affected people, but also takes concrete measures to provide immediate relief, early recovery and long-term rehabilitation to them. In case of emergencies, the PDMA works closely with District Governments to organize initial and subsequent assessment of disaster affected areas, and determine the course of action to ensure long-term rehabilitation of the affected population.

Multi-Hazard Vulnerability Risk Assessment (MHVRA) project was conceptualized by PDMA Sindh to revolutionize the disaster management in Sindh Province. The project was funded by World Bank and executed by SUPARCO. This evidence-based Disaster Management Plan (DMP) is thus based on MHVRA and resultant database. Such databases are also an integral part of the implementation of disaster risk reduction and disaster risk management strategies. The MHVRA study of the province has been conducted successfully using high-resolution satellite imagery and its products like digital elevation models, historical disaster datasets, hydro-meteorological data, pertinent socio-economic data, and various other essential datasets. The hazard, vulnerability, and risk maps at Union Council (UC) level have been prepared and compiled as atlases and a compressive Disaster Management Information System (DMIS) is also developed and deployed for effective monitoring and response to natural hazards. Using disaster risk information obtained through MHVRA, the disaster management plans of the districts are prepared and being presented to disaster management practitioners, executors, and prominent stakeholders. Before the MHVRA study, the district-level disaster and contingency plans were prepared using conventional methods and human knowledge. In contrast, the MHVRA based disaster management plans are realistic, based on modern techniques and multiple data sources, therefore, are more authentic and reliable for planning and management of disasters in the province.

The disaster management plans are based on MHVRA study carried out to understand the hazard vulnerability and risk at UC levels. The multi-criteria approach used in this disaster management plan offers comprehensive understanding of vulnerable communities at UC levels, while offering

concerned authorities with viable and best practices to minimize the hazard impacts to the communities.

Provincial disaster management plan is prepared for 10 years from 2023-2032 and will be revised after 10 years on updating of the MHVRA study. The disaster management plan of Sindh Province is comprehensive and covers guidelines on the complete spectrum of disaster management and standard operating procedures to efficiently cope with disasters and emergencies in the district.

The disaster management plan is duly approved by Provincial Disaster Management Board and demands its proactive implementation in true letter and spirit. The proactive implementation of the plan will ensure reduced disaster losses and damages in the province.

List of Basic Terms

Acceptable risk	The level of loss a society or community considers it can live with and for which it does not need to invest in mitigation
Biological hazard	Biological vectors, micro-organisms, toxins and bioactive substances, which may cause the loss of life or injury, social and economic disruption or environmental degradation.
Capacity	Capacity may include physical, institutional, social or economic means as well as skilled personnel or collective attributes such as leadership and management. Capacity may also be described as capability.
Capacity building	Efforts aimed to develop human skills or societal infrastructure within a community or organization needed to reduce the level of risk. In extended understanding, capacity building also includes development of institutional, financial, political and other resources, at different levels of the society.
Climate change	The climate of a place or region changed over an extended period (typically decades or longer) that is statistically significant in measurements of either the mean temperature or variability of the climate for that region.
Coping capacity	The means by which people or organizations use available resources and abilities to face a disaster. In general, this involves managing resources, both in normal times as well as during crises or adverse conditions.
Disaster	A serious disruption of the functioning of a community or society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources. It results from the combination of hazards, conditions of vulnerability and insufficient capacity to reduce the potential negative consequences of risk.

Disaster risk management (DRM)	The comprehensive approach to reduce the adverse impacts of a disaster. DRM encompasses all actions taken before, during, and after the disasters. It includes activities on mitigation, preparedness, emergency response, recovery, rehabilitation, and reconstruction.
Disaster risk reduction / disaster reduction	The measures aimed to minimize vulnerabilities and disaster risks throughout a society, to avoid (prevention) or to limit (mitigation and preparedness) the adverse impacts of hazards, within the broad context of sustainable development.
Early warning	The provision of timely and effective information, through identified institutions, to communities and individuals so that they could take action to reduce their risks and prepare for effective responses.
Emergency management	The management and deployment of resources for dealing with all aspects of emergencies, in particularly preparedness, response and rehabilitation
Forecast	Estimate of the occurrence of a future event (UNESCO, WMO). This term is used with different meanings in different disciplines.
Geological hazard	Natural earth processes that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. For example, earthquakes, tsunamis, volcanic activity and emissions, landslides, rockslides, rock falls or avalanches, surface collapses, expansive soils and debris or mud flows.
Hazard	Potentially damaging physical event or phenomenon that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Hazards can include natural (geological, hydro-meteorological and biological) or human induced processes (environmental degradation and technological hazards). Hazards can be single, sequential or combined in their origin and

	effects. Each hazard is characterized by its location, intensity, frequency and probability.
Hazard analysis	Identification, studies and monitoring of any hazard to determine its potential, origin, characteristics and behavior.
Land-Use planning	Branch of physical and socio-economic planning that determines the means and assesses the values or limitations of various options in which land is to be utilized, with the corresponding effects on different segments of the population or interests of a community taken into account in resulting decisions. Land-use planning can help to mitigate disasters and reduce risks by discouraging high-density settlements and construction of key installations in hazard-prone areas, control of population density and expansion.
Landhis	Remote Monitoring Check-Post
Natural hazards	Natural processes or phenomena occurring on the earth that may constitute a damaging event. Natural hazards can be classified by origin namely: geological, hydro-meteorological or biological. Hazardous events can vary in magnitude or intensity, frequency, duration, area of extent, speed of onset, spatial dispersion and temporal spacing.
Preparedness	Activities and measures taken in advance to ensure effective response to the impact of hazards, including the issuance of timely and effective early warnings and the temporary evacuation of people and livestock from threatened locations.
Prevention	Activities to ensure complete avoidance of the adverse impact of hazards.
Public awareness	The processes of informing the general population, increasing levels of consciousness about risks and how people can reduce their exposure to hazards. This is particularly important for public officials in fulfilling their responsibilities to save lives and property in the event of a disaster.

Recovery	Decisions and actions taken after a disaster with a view to restoring or improving the pre-disaster living conditions of the stricken community, while encouraging and facilitating necessary adjustments to reduce disaster risk.
Relief / Response	The provision of assistance during or immediately after a disaster to meet the life preservation and basic subsistence needs of those people affected. It can be of an immediate, short-term, or protracted duration.
Resilience / Resilient	The capacity of a community, society or organization potentially exposed to hazards to adapt, by resisting or changing in order to maintain an acceptable level of functioning. Resilience can be increased by learning from past disasters for better future protection and to improve risk reduction measures.
Retrofitting (or upgrading)	Reinforcement of existing buildings and structures to become more resistant and resilient to the forces of natural hazards.
Risk	The chances of losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between hazards and vulnerable social conditions. Risk is expressed as Risk = Hazards x Vulnerability. Some experts also include the concept of exposure to refer to the physical aspects of vulnerability.
Risk assessment /analysis	A methodology to determine the nature and extent of risk by analyzing potential hazards and evaluating existing vulnerability that could pose a potential threat to people, property, livelihoods and the environment.
Structural / Non-structural measures	Structural measures refer to any physical construction to reduce or avoid possible impacts of hazards, which include engineering measures and construction of hazard-resistant and protective structures and infrastructure. Non-structural measures refer to policies, awareness, knowledge development, public commitment, and methods and operating practices, including participatory mechanisms and the provision of information, which can reduce risk and related impacts.

Sustainable development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: the concept of "needs," in particular the essential needs of the world's poor, to which overriding priority should be given, and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and the future needs.
Technological hazards	Danger originating from technological or industrial accidents, infrastructure failures or certain human activities, which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Some examples: industrial pollution, nuclear activities and radioactivity, toxic wastes, dam failures; transport, explosions, fires and spills.
Vulnerability	The conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community or society to the impact of hazards.

Introduction

Disaster is defined as “a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses or impacts and which exceed the ability of the affected community or society to cope using its own resources.” Disasters arise from the combination of natural hazards, conditions of vulnerability, and insufficient capacity or measures to reduce or cope with the potential negative consequences.

Recently, climate-related disasters have prominently affected many people, particularly the lives of the poor. Events such as droughts, floods, and cyclones are often terrible experiences for those affected; they cause significant loss of life, destroy countless livelihoods, and devastate millions of people. In the coming decades, climate change is expected to exacerbate the risks of disasters. More frequent and intense storms and floods, and long-lasting droughts can erode existing community coping capacity to prepare, respond and rebuild after successive hazard events.

The other adverse impacts of climate change, for example on public health, ecosystems, food security, migration and on the situation of especially vulnerable groups such as children, the elderly and women, will increase the vulnerability of communities to natural hazards of all types. Any increase in disasters, whether large or small, will threaten development gains and hinder the implementation of the Sendai Framework for Disaster Risk Reduction (SFDRR) Targets and Sustainable Development Goals (SDGs). Countries like Pakistan, that are already of humanitarian concern and has populations that are highly vulnerable will face even greater risk owing to the impact of climate change.

As per the declaration of National Disaster Management Act 2010, the provinces are required to develop disaster management plans to effectively cope with disasters and emergencies. The objective of disaster management plan is to adopt a proactive approach in managing disaster risk by building capacity and strengthening institutional mechanisms. The plan is aimed to provide direction and guidelines to authorities and other stakeholders, and to layout the standard operating procedures to be followed in the complete cycle of disaster management.

Multi-Hazard Vulnerability and Risk Assessment (MHVRA) is integral for proactive risk management, hence under Sindh Resilience Project (PDMA Component), MHVRA has been conducted at the UC level for Sindh Province. MHVRA is a multi-disciplinary process involving the quantification of the frequency and intensity of possible hazard(s), the assessment of the elements that can be destroyed or damaged from possible disasters, and the degree of the damage each element can sustain when affected by certain disasters of various intensities. The assessment of hazard, exposure, vulnerability and capacity

leads to the risk assessment, which indicates the anticipated damages in case of a possible disaster. Disaster risk assessment is normally the first step in planning for disaster management activities. It provides an evidence-based estimation of the risk so that effective risk reduction measures can be employed appropriately and cost-effectively.

The development of MHVRA informed disaster management plan is based on diversified information sources including satellite imagery, Digital Elevation Model (DEM), and pertinent information collected from concerned departments. To maximize relevance, applicability and impacts of MHVRA informed disaster management plan are developed for following return period against each disaster;

- Cyclone and Storm Surge (100 years return period)
- Drought (50 years return period)
- Earthquake (95 years return period)
- Flood (50 years return period)
- Heatwave (50 years return period)
- Tsunami (9.0 M)

The outcomes for MHVRA study are depicted in atlas including; landuse /landcover, critical infrastructure, hazard, exposure, vulnerability, and risk maps of cyclone and storm surge, drought, earthquake, flood, heatwave, and tsunami at UC level.

The MHVRA Informed Disaster Management Plan is a significant step towards disaster resilient Sindh because the foundation of disaster management plan is laid on realistic disaster risk identification and efficient need-based disaster preparedness and response measures. UC-level multi-disaster risk identification will not only enable active and effective disaster preparedness but also help in disaster risk reduction at the grass-root level. In addition, the plan is intended to strengthen the district disaster management system and provide guidance on pre-disaster preparedness, coordinated response and recovery through implementable agenda.

Overview of Sindh Province

Geography

The Province of Sindh is located in the southeastern part of the country. Its gross geographical area is 140,914 sq. km which is 18% of the country. The geographical area is 14.0 million hectares, of which almost 8.0 million are cultivable. The remaining area is unavailable for cultivation, mainly in the northern hills of the Khirthar Range, the eastern desert of Thar and Achharo Thar, and the riverine area. Sindh's 60% land area is arid. Annual average precipitation is between 128.80 mm/yr.; however, the province has recently seen abnormal and heavy rain with densities ranging between 550 to 1600 mm, respectively. The mighty River Indus flows in the middle of the province. There are seasonal streams which become active in the monsoon season, they emanate from the Khirthar hill range from west of province, which fallout in River Indus and Arabian Sea. The boundaries of Sindh are touched by Arabian Sea in south, India in east and Punjab in north and Balochistan in west.

The province took its name from River Sindh (as per the Greeks). Predominantly, it is an agricultural and pastoral economy. Lately, natural resources have been found like petrol, gas, coal, granite and cut stone, etc. These are being exploited, which contributes substantially to the national produce. The province also has various industries, including textile, chemical, cement, steel, and others. Most industries are located in Karachi, Kotri/ Hyderabad, and Sukkur. There are two modern seaports: Karachi Port and Bin Qasim Port, both of which are situated in Karachi and serve the entire country, including Afghanistan.

Geology

The geology of Sindh is divisible in three main regions, the mountain ranges of Khirthar, Pab containing a chain of minor hills in the west and the Thar Desert and part of Indian Platform in east where the main exposure is of Karoonjhar Mountains, which is famous for Nagar Parkar Granite. In the north Sindh is enquired by rocks of Laki range extending to Suleiman range and its southern most part is encircled by the Arabian Sea. The rocks exposed in this area belong to upper Cretaceous which are recent in age. The sub-surface rocks are about 20,000 feet thick and belong to Cretaceous and Pre-Cretaceous periods. Mostly the rocks are of sedimentary origin of clastic and non-clastic nature and belong to marine, partly marine and fluviatile depositional environments.

Basin wise Sindh lies in the lower Indus Basin and its main tectonic features are the platform and fore deep areas. Thick sequences of Pab sandstone of Upper Cretaceous, Ranikot Group (Khadro, Bara, Lakhra) of Palaeocene, Laki, Tiyon, and Khirthar of Eocene age, Nari Formation of Oligocene, Gaj

Formation of Lower to Middle Miocene, Manchar of Upper Miocene to Pliocene, Dada Conglomerate of Pleistocene are present in various areas of Sindh. Limestone and sandstones are the most dominant sedimentary rocks in the area. Structurally Sindh contains gently folded anticlinal features trending in north-south direction.

Demography

Sindh has the second highest Human Development Index out of all of Pakistan's provinces at 0.51. The 2017 Census of Pakistan indicated a population of 47,854,510 persons. According to 2017 census, urban population in Sindh is 51.89% and rural is 48.10% of the total province population. According to the Economic Survey figures, the literacy rate in Sindh for the year 2018 was 62.2%. The male literacy rate in the province in 67%, whereas, the female literacy rate is 44%.

Society

The society is cosmopolitan and the languages spoken besides Sindhi are Urdu, Punjabi, Pashto, Siraiki, Balochi, Brahui, Rajasthani, and Gujarati.

Sindh's population is predominantly Muslim. The province of Sindh is also home to nearly all of Pakistan's Hindus, numbering roughly 2.0 million, although most Sindhi Hindus migrated to India at the time of the partition. Smaller groups of Christians, Paresis or Zoroastrians, Ahmadis, and a few members of the Jewish community can also be found in the province.

Economy

As of the rest of Pakistan, the economy of Sindh is predominantly agricultural and depends almost entirely on artificial irrigation. The principal source of water is the Indus River, on which three irrigation barrages have been built, Guddu Barrage on the Punjab border; the Sukkur Barrage in Sukkur and the Kotri Barrage at Jamshoro is the farthest at south.

Sindh's principal crops are wheat, rice, cotton, oilseeds, sugarcane, vegetables and fruits. Sheep, cattle, camels, and poultry are raised, and there is a healthy fishing industry as well. Manufacturing industries are concentrated in Karachi, Hyderabad, Nooriabad, Kotri and Sukkur. They produce textile products, cement, cardboard, chemicals, electric power supplies, rail-road equipment, machinery and other metal products.

Administrative System

Sindh province is administratively governed through 6 divisions namely Karachi, Hyderabad, Mirpurkhas, Shaheed Benazirabad, Sukkur and Larkana. The 6 divisions, headed by Commissioners are further sub-divided into 30 districts which are governed by Deputy Commissioners. Karachi being a metropolitan city cum division is parallelly administered through Karachi Metropolitan Corporation (KMC) followed by its sub-categorization into District Municipal Corporations (DMCs). There are 142 Talukas with 954 union councils across Sindh. Total settlements in Sindh including Karachi as per DMIS is 49,348 (named and unnamed settlements).

Hazards, Vulnerabilities and Disaster Risks Profile of Sindh

Disaster Risk Profile of Sindh Province

The Province of Sindh is the second most populous province of Pakistan with approximately 21.26% of the country's total population. It has an area of 54,407 sq. miles (140,914 sq. km) and a population exceeding 47 million. It consists of 30 administrative districts and 6 administrative divisions.

This unique geographical juxtaposition has made the province of Sindh vulnerable to most kinds of disasters, with river flood and hill torrents frequently occurring since 2010. Sindh faces floods in varying intensity almost every year. There have also been examples of cyclones and earthquakes in the province but their frequency has been quite low, with most of the Sindh being relatively safe with regard to vulnerability to earthquakes. Sindh's geographic location and climatic conditions make it more vulnerable to monsoon floods and droughts. The effects of climate change and associated variability in the monsoons means that the occurrence and intensity of floods have significantly increased in the last decade. The effect of climate change has also resulted in increasing instances of extended heatwaves in the urban centers, as well as, increased frequency of cyclones. Table-1 highlights the Moderate to high risk profile of Sindh Province for natural disasters.

Floods

The topography of Sindh Province is almost flat and located at the bottom of Indus basin. The surplus water of Indus River and its tributaries including monsoon has to pass through Sindh. Hill torrents which emanate from Balochistan are also adding up to the pressure on both accounts, till its outfall in the Arabian Sea. The River Indus in Sindh is dangerous, because it flows at ridge. In case of breach the out flowing water cannot be drained back into the river at any point. The Indus River is also popular for changing its course.

High floods since the creation of modern irrigation network in 1932 are being monitored. The River Indus is contained by flood protection embankments, which are 1400 miles long, so as, to protect irrigation network emanating from three barrages having 12.8 million acres of command area. Besides, there is a large network of surface drainage and 6000 public tube wells, roads and railways network, cities / towns, rural settlements etc. The high floods occurred during 1942, 1956, 1957, 1958, 1973, 1975, 1976, 1979, 1992, 1994, 1995, 2003, 2005, 2007, 2010, 2011, 2012 and 2022.

Cyclone and Storm Surge

The coastal districts have also been adversely affected by cyclones and resulting storm surge. The three coastal districts - Karachi, Thatta and Badin, are highly vulnerable to cyclone emergency. The

districts of Thatta and Badin have been badly affected on several occasions. Cyclones not only wiped out the human settlements and resulted in the huge losses of human and animal lives, but they also destroyed and damaged fishing boats, therefore badly affecting the livelihood of the majority of residents of these two districts.

Historically, the tropical cyclones formed over the Arabian Sea made landfall at the coastal areas of Sindh. Major cyclones during the last 100 years which hit Sindh were in May 1902, June 1926, June 1964, November 1993, June 1998, May 1999 and June 2007 (Cyclone– 02A). The Cyclone Yemen in 1999 hit three coastal districts of Sindh, where 244 loss of life, 40177 animals perished, villages affected to 1449, houses damaged to 29873, population affected 0.5 million was reported. Damaged infrastructure included, 16 Health facilities, 334 Educational institutions and 208 km of roads. Loss in financial terms was about Rs. 3.231 billion. Keti Bunder town was wiped out four times in recent history. The cyclones of 2010 (PHET) and 2011(KIELA) also emerged during few years back, out of which PHET caused significant damages in district Thatta. The 1998 Gujrat cyclone resulted in inundation of 100's of villages along the coastline due to resulting storm surge.

Tsunami

The Sindh province can be a recipient of a tsunami disaster. A tsunami disaster occurred in November 1945 at Makran coast in Balochistan Province. It produced sea waves of 12-15 m height that killed about 4,000 people. Although Karachi was away from the epicenter, but still it experienced 6 feet high sea waves which affected harbor facilities.

The effects of tsunami of December, 2004 due to Sumatra earthquake were also felt along the Pakistan coastline. Abnormal rise in water detected by tide gauge station at Keti Bander area created panic in the coastal population including Karachi.

Drought

Sindh geographically can be divided into four zones namely eastern desert, western hilly / mountainous area, coastal area in the south and irrigated agriculture area in the middle. Its 60% area is arid receiving rainfall on average of 5 inches during monsoon and very little in December and January. The people living in arid areas depend upon the scanty rainfall raising livestock and planting millet crops. The failure of rainfall and global climatic effects reduce the water supplies in Indus River System (IRS). Sindh being at the end of the system usually takes the brink. Besides, two-third of ground water is brackish and 80% agricultural land is affected by water logging and salinity.

Traditionally, people living in arid area usually move to canal commanded areas in case of drought, however, the record low flow in the river Indus from 1998-2002 created havoc in the entire province. Historically, Sindh faced the worst drought situation during 1871, 1881, 1899, 1931, 1942 and 1999. The last one persisted till the year 2002. Around 1.4 million people, 5.6 million cattle head and 12.5 million acres cropped area were affected. The ground water depleted to 30-40 feet, and the quality of life became poor. As a result, malnutrition and diseases erupted. The cultivated area reduced in 1998 from 3.415 million acres to 2.611 million acres. The most affected was wheat area 22% and rice almost 35%, which created food scarcity all over Sindh, except for a couple of districts. There was tremendous drop out (about 27%) in schools, due to drought situation.

During the year 2012 also the drought situation was severe, but late monsoon rains saved the area from devastation, even than about 15% population of Thar district moved to barrage command area with their livestock in search of livelihood.

Earthquake

Sindh province is prone to earthquakes due to its location along geological tectonic lines. This line runs under Karachi and through the Khirthar Hills and Thar Desert, and has caused earthquakes in the past. The 2001 earthquake affected the Tharparkar and Badin districts and resulted in the deaths of 12 people, the injury of 115 people, and the full or partial damage of over 44,000 houses and 1,400 public sector buildings. The financial loss was estimated to be around Rs. 2.4 billion. 5.5 M earthquake jolts were recorded in Karachi on 16th July, 2013, due to an earthquake in Iran.

Heatwave

Sindh province in Pakistan experiences heatwaves during the summer months, with temperatures reaching as high as 50 ^{o}C (122 ^{o}F). These heatwaves can last for several days and can be extremely dangerous, as they can cause heat stroke, dehydration, and other heat-related illnesses. The province's hot and arid climate, coupled with its high population density, makes it particularly vulnerable to the effects of heatwaves. In addition to the health impacts on individuals, heatwaves in Sindh province can also have significant economic and societal impacts. The high temperatures can damage crops, leading to reduced yields and food shortages. Heatwaves can also disrupt daily life and activities, as people may be forced to stay indoors during the hottest part of the day. This can impact businesses and lead to economic losses. Furthermore, the heatwaves can also increase the demand for electricity, putting a strain on the power grid and leading to blackouts.

Table 1: Moderate to high risk profile of Sindh

S#	District	Riverine Flood	Met Drought	Agr. Drought	Tsunami	Cyclone	Heatwave	Earthquake	Storm Surge
1	Badin		√	√	√		√		√
2	Dadu	√	√	√			√		
3	Ghotki	√	√	√			√		
4	Hyderabad	√	√	√			√		
5	Jacobabad		√	√			√		
6	Jamshoro	√	√	√			√		
7	Kambar Shahdadkot		√	√			√		
8	Karachi Central		√				√		
9	Karachi East		√	√	√		√		
10	Karachi Korangi		√	√	√		√		√
11	Karachi Malir		√	√	√		√		√
12	Karachi South		√		√		√		√
13	Karachi West		√	√	√		√		√
14	Kashmore	√	√	√			√		
15	Khairpur	√	√	√			√		
16	Larkana	√	√	√			√		
17	Matiari	√	√	√			√		
18	Mirpurkhas		√	√			√		
19	NowsheroFeroz	√	√	√			√		
20	Sanghar		√	√			√		
21	Shaheed Benazirabad	√	√	√			√		
22	Shikarpur	√	√	√			√		
23	Sujawal	√	√	√	√		√		√
24	Sukkur	√	√	√			√		
25	Tando Allah Yaar		√	√			√		
26	Tando Muhammad Khan	√	√	√			√		
27	Tharparkar		√	√	√		√		√

S#	District	Riverine Flood	Met Drought	Agr. Drought	Tsunami	Cyclone	Heatwave	Earthquake	Storm Surge
28	Thatta	√	√	√	√	√	√		√
29	Umerkot		√	√			√		

Disaster Risk Reduction Strategies and Initiatives of PDMA Sindh

PDMA Sindh was established after promulgation of National Disaster Management Act 2010. As per its mandate (Table 2) and keeping in view the global disaster risk reduction activities, PDMA Sindh has taken several disaster risk reduction initiatives. The authority has adopted different strategies to understand and manage disaster risks, as well as, strengthening disaster risk governance. By investing in disaster risk reduction for resilience and enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction, PDMA Sindh intends to minimize impacts of disaster by effective planning, and preparedness.

Table 2: PDMA Sindh's Mandate

Policy	• Formulate the provincial disaster management policy obtaining the approval of the Provincial Commission • Coordinate and monitor the implementation of the National Policy, National Plan and Provincial Plan
Risk Mitigation	• Examine the vulnerability of different parts of the province to different disasters and specify prevention of mitigation measures
Disaster Management Plans	• Lay down guidelines to be followed for preparation of disaster management plans by the Provincial Department and District Authorities
Preparedness	• Evaluate preparedness at all governmental or non-governmental levels to respond to disasters and enhance preparedness.

	• Examine the construction in the area and if it is in the opinion that the standards laid down have not been followed it may direct the same to secure compliance of such standards • Ensure that communication systems are in order and disaster management drills are being carried out regularly, and performance of such other functions as may be assigned to it by the National or Provincial Authority
Disaster Response	• Coordinate response in the event of disaster • Give directions to any Provincial Department or authority regarding actions to be taken in response to disaster • Provide indispensable technical assistance or give advice to the District Authority and Local Authorities for conveying out their functions effectively
Community Based DRM	• Promote general education, awareness and community training relating to the actions to be taken in response to disaster.
Fiscal Management	• Advice the Provincial Government regarding all financial matters in relation to disaster management

Types of Disasters and their Management

Flood Management

Characteristics of Flood Vulnerability of Sindh

Riverine floods, although, are characterized by heavy water flow but generally give enough cushion to authorities to vacate vulnerable and endangered areas as experienced in 2022. However, contrary to this, hill torrents, are of less intensity, but create significant dent to lives and properties of people because their occurrence is sudden and water flows with gravitational pull. The western districts of the Province face the risk of flash floods originating in the western mountain ranges. Districts such as, Dadu, Kambar Shahdadkot and others are vulnerable to flash floods due to heavy rains as experienced in recent 2022 floods in the province. At least 801 people lost their lives, including 160 children. More than 14 million people in the province were badly affected, of which only 377,000 are living in camps right now. Previously, the 2010 flood effected nearly 23 districts in the province, including Kashmore, Ghotki, Shikarpur, Sukkur, Larkana and Khairpur among others. The flood effected over one million people and submerged nearly 2,000 villages.

SOPs for Flood Management in Sindh

Preparedness
1. Recording of daily river discharge at barrages in Sindh, and regular dissemination among stakeholders. 2. In case of high discharge, dissemination of warnings and alerts to masses living in flood plain. 3. Identification and inspection of vulnerable embankments likely to be affected due to flooding during pre-monsoon season, as per “Bund Manual” of irrigation department. 4. Inspection and readiness of flood fighting equipment available with district government departments prior to flooding season. 5. Classify and map bunds based on their origin (Mud, Brick, Stone, Concrete, Boulder, etc.) 6. Readiness of flood camps in high riverine flood and breaching risk areas. 7. Maintenance and strengthening of identified weak embankments. 8. Awareness and motivation campaigns on construction of flood resilient buildings and infrastructures.

9. Regular awareness campaigns on flood precautions and safe evacuations using various media platform.

10. Inclusion and implementation of Disaster Risk Reduction (DRR) measures in development projects at planning stage for building flood resilient infrastructure.

11. Conduct of satellite imagery based study for identification of vulnerable embankments before each monsoon and flooding period.

12. Collection and management of contact information of area/village influential for alert and warning dissemination.

13. Readiness of community-based volunteers and other related organizations / NGOs.

14. Regular community-based flood fighting trainings through government departments or any other appropriate platforms.

15. Installation of digital flood level gauges along embankments and dissemination of real-time flow level measurements to concerned authorities.

16. Installation of surveillance cameras at safe places for consistent monitoring of structural integrity of vulnerable embankments.

Response

1. Mobilization of rescue services, relevant NGOs, scouts and volunteers.

2. Evacuation of people and livestock to shelters/camps.

3. Camp management as per standard practices.

4. Relief distribution.

5. Precautionary measures for communicable diseases.

6. Activation of mobile health and education services for flood affectees.

7. Arrangements for early recovery including flood de-watering and early restoration of communication and essential services.

Recovery and Rehabilitation
1. Damage assessment of flood affected areas. 2. Conduct post flood repairs or refurbishment of embankments/barrages/canals 3. Resettlement of population on build back better basis. 4. Complete restoration of communication and essential services.

Flood Hazard Severity in Sindh

Flood Risk Severity in Sindh

Action Plan for Flood Hazard Management

Action	Timelines	Responsibility
Letter to irrigation department for identification of vulnerable embankments and disaster mitigation measures	April-May	PDMA
Inspection, maintenance and ensure readiness of flood fighting equipment available with PDMA	May-June	PDMA
Inspection, maintenance and ensure readiness of flood fighting equipment available with line departments	May-June	Local Government, Irrigation, and other relevant functionaries
Letter to concerned departments for removal of congestions in water ways	May-June	PDMA
Conduct pre monsoon meetings/conference with concerned departments	June-July	PDMA
Organization and conduct of pre monsoon meetings headed by DDMA and chalking out of monsoon contingency and action plans	June-July	PDMA to write letter to concerned departments and organize such meetings through online or other feasible mechanism

Interaction and close liaison with PMD on weather forecast	June-July	PDMA
Dissemination of severe weather alerts to concerned DDMA and likely population to be affected	Based on forecast	PDMA
Daily monitoring of discharge data and flood inundation levels	During flooding	Sindh Irrigation Department
Deployment of man and material resources and soaking, inspection and monitoring of flood protecting infrastructure	Pre and during flooding	Sindh Irrigation Department

Flood Risk Management Projects

Given the increased risk of floods across the Sindh province, following projects are recommended to be undertaken by PDMA in consultation with various authorities and departments to better prepare for flood hazard and risk management:

1. **Geomorphological study of flood plain and river course modelling**

Geomorphological mapping of the fluvial landforms and sediments that developed on large lowland floodplains are the 'historical framework' in which present-day fluvial processes operate, and represents an active and dynamic control on the modern floods. In this regard, flood plain study is recommended for identification of bottlenecks, including elevated islands (Annex – A) impeding the flow of (super) flood water, and Indus River course modeling (historic and predictive) for simulating catchment processes and river flow, etc.

2. **Conduct feasibility study for Indus River training and straightening**

River training measures, like bell bunds, confine the river flow within the embankments, while dredging makes the river deeper so it can hold more water. Straightening the river removes the meanders and increase the velocity of the water to pass through an area. This stop a backlog of water and reduces the risk of flooding. Detailed concept is given in Annex-B.

3. **Installation of river/flood flow digital gauges at suitable locations for real time monitoring of water level, water discharge rates, wave height and flow speed**

Digital water gauges may be installed to collect water flow characteristics. Digital water gauge is an electronic device, which uses an advance processor chip as a controller, records the water flow characteristics through measuring electrodes and transmit it using wired/wireless communication channel after digital processing.

4. **Monitoring of vulnerable bunds using IP Camera systems and Drones for surveillance during floods**

Image camera sensors and drones have relatively low procurement cost, portability, high efficiency, durability, minimum maintenance and low power consumption. Camera networks can effectively be used at remote 'Landhis' (monitoring check post) for real-time monitoring of flood level.

5. **Capacity building of vulnerable communities**

Create Community Based Disaster Risk Management (CBDRM) associations and equip them with training and equipment for early response, including rope rescue, sand bags, bamboo and others.

6. **Develop emergency operation center**

Establish and equip emergency operation center with modern tools and techniques for management and operation activities in pre, during and post disaster events.

7. **Establish a database of resources and equipment for emergency response in relevant agencies**

Create a well-maintained data repository for all available resources with operational status, quantity, location, and maintenance authority in districts. This will help in getting the right resources, to the right place, at the right time.

Drought Management

Drought occurs in circumstances arising due to temporary reduction in water availability below the normal or expected level for a specified period. A drought is an extended period of months or years when a region notes a deficiency in its water supply. Generally, this occurs when a region receives below average precipitation consistently. Drought risk characterization is therefore, paramount to assessing food vulnerability and ensuring livelihoods in communities.

Climate of Sindh

Sindh is characterized by a semitropical climate, with hot summers from May to August and cold winters from December to January. During the summer, the temperature can frequently rise above 46 °C, while in the winter it can fall below 2 °C.

The average annual total precipitation in Sindh is about 150-180 millimeters, with more than 70% of it occurring during the monsoon season from July to August. This scarcity of water is compensated by the inundation of the Indus River twice a year, due to the spring and summer melting of the Himalayan snow and by precipitation. However, these natural patterns have been somewhat modified by the construction of dams and barrages on the Indus River.

Historical Catalogue for Sindh Droughts

Sindh province of Pakistan has confronted with shortage of rainfall especially on eastern side in its Thar Desert. From time to time, the Indus Basin have been hit by the droughts and associated famines. From 19th to 1st half of 20th century, famines typically occurred after every 7 to 8 years. 1871, 1881, 1899, 1931, 1947, and 1998 were declared the worst drought years in Sindh province. Table 3 lists the historical drought of Sindh.

Thar Desert

Desert area of Thar is the most drought prone region in Sindh Province. Thar Desert presents an undulating surface, with high and low sand dunes separated by sandy plains and low barren hills, or bhakars, which rise abruptly from the surrounding plains. The dunes are in continual motion and take on varying shapes and sizes. Older dunes, however, are in a semi-stabilized or stabilized condition, and many rise to a height of almost 500 feet (150 metres) above the surrounding areas. Several playas (saline lake beds), locally known as dhands, are scattered throughout the region. The soils consist of several main groups—desert soils, red desertic soils, sierozems (brownish gray soils),

the red and yellow soils of the foothills, the saline soils of the depressions, and the lithosols (shallow weathered soils) and regosols (soft loose soils) found in the hills.

All these soils are predominantly coarse-textured, well-drained, and calcareous (calcium-bearing). A thick accumulation of lime often occurs at varying depths. The soils are generally infertile and, because of severe wind erosion, are overblown with sand.

The grasses form the main natural resources of the desert. They provide nutritive pasturage as well as medicines used locally by the inhabitants. Alkaloids, used for making medicine and oils for making soap are also extracted. There are five major breeds of cattle in the Thar. Among those the Tharparkar breed is the highest yielder of milk, and the Kankre breed is good both as a beast of

Table 3: Historical Catalogue of Sindh Province

Timeline	Severity	Affected Areas	Affected Human Population	Human losses	Affected Livestock	Livestock losses
1998 – 2002	Extreme	Sindh, Balochistan	3.3 million	NA	30 million	2 million
2013 – 2016	Severe	Nara, Achhro Thar and Thar, Kohistan and the Kachho region	-	1366		-
2018 – 2019	Severe	Tharparkar, Umerkot, Dadu, Thatta, Sanghar, Kambar Shadadkot, Jamshoro and Badin	184,244	-		-

Source: Center for Strategic and Contemporary Research

burden and as a milk producer. Sheep are bred for both medium-fine and rough wool. Camels are commonly used for transport as well as for plowing the land and other agricultural purposes. Crops like wheat and cotton are grown in selected regions where water is available.

As, water is scarce, the seasonal rainwater collected in tanks and reservoirs is used for drinking and domestic purposes. Most groundwater cannot be utilized, because it lies deep underground and is often saline. Good aquifers have been detected in the central part of the desert. Apart from wells and tanks, canals are the main sources of water in the desert.

Due to inadequate and erratic rain patterns, the Thar Desert, in south-eastern Pakistan's Sindh province, is a drought-prone region. As a result of the periodic and prolonged dry spells, the Thar has seen years of below-average crop production and losses of cattle, which have exacerbated the already dire food insecurity and malnutrition situation in the area. Limited access to clean water and proper sanitation has also compromised health conditions of the affected households.

SOPs for Drought Management in Sindh

Preparedness
1. Implement Drought Early Warning System (EWS) at provincial/district level to get clear indications of the impending drought and its consequences, e.g. forecast of impending drought conditions related to changing weather conditions linked to El Nino or La Nina events. 2. Implementation of water supply and demand management and encouragement of efficient irrigation systems in agriculture. 3. Research and promote drought resistant agriculture crops. 4. Resilience and improvement of adaptive capacity of farmers. 5. Monitoring of temperature, precipitation, potential evapotranspiration, soil moisture, stream flow, groundwater levels, lakes, and reservoirs for drought forecasting. 6. Control ground water extraction from upper and lower aquifers to be within the sustainable yield limits. 7. Desalination of sea water and reuse of treated waste water.
Response
1. Assess data about the nature of drought conditions and their impact. 2. Provision and installation of solar water pumps for availability of clean drinking water. 3. Public information campaign for water management and conservation.
Recovery and Rehabilitation
1. Cash and in-kind support to farmers for next cropping. 2. Awareness and encouragement of farmers on best irrigation practices and water conservation.

Agricultural Drought Hazard Severity in Sindh

Meteorological Drought Hazard Severity in Sindh

Agricultural Drought Risk Severity in Sindh

Meteorological Drought Risk Severity in Sindh

Action Plan for Drought Hazard Management

Action	Timelines	Responsibility
Interaction with PMD for forecasting and monitoring of drought	Based on forecast	PDMA
Dissemination of forecast to concerned DDMA and local community	Based on forecast	PDMA
Mobilization of NGOs, INGOs and individuals for stocking of food and life support items to prevent and mitigate famine conditions depending upon severity and spell of drought	During drought period	PDMA and DDMA

Drought Risk Management Projects

Drought is one of the most frequently occurring natural disaster in Sindh Province, which effects the poorest segment of society the most. Thereby, the most viable approach for authorities to relieve masses from drought hazard is to undertake poverty elevation measures that can help to overcome drought hazard by providing communities with the resources and support they need to better prepare for and cope with drought implications. Poverty elevation measures such as job training programs and microfinance can help individuals and families to diversify their livelihoods and become more resilient to the impacts of drought. Such poverty elevation initiatives can also help to improve overall health and well-being, which can make communities more resilient to the effects of drought.

Given the increased risk of drought across the Sindh province, following projects are recommended to be undertaken by PDMA in consultation with various authorities and departments to better prepare for disaster hazard and risk management:

1. **Conduct feasibility study for identification of suitable sites for rainwater harvesting and aquifer recharge in the province.**

The rainwater harvesting sites should be identified by using geospatial technologies and ancillary data, which can be used as clean water aquifers by communities, which in turn can use it for drinking, and irrigation purposes.

Potential rainwater harvesting sites may be identified by using Analytical Hierarchy Process (AHP) and spatial analyst tool, with multiple thematic layers (rain data, population, digital elevation model, soil type, etc.)

In order to encourage rain-water harvesting in Tharparkar and other desert districts the construction of tankas (underground storage tanks) be supported by financial means in terms of soft loans/aids. This soft loan scheme maybe continued until 1 to 2 tankas are constructed in each small village.

Installation of waste water recycle plants using Soil Aquifer Treatment (SAT) techniques near major cities of Tharparkar such as Mithi and Deplo may be carried out. The treated water may be utilized for agricultural purposes.

2. **Provision of internet facilities throughout drought prone districts**

It is recommended to connect Thar and other districts population with the world through internet. Skillful labor can be produced by arranging short training courses and providing computer and internet facilities, so that they can earn money online and generate a reliable income, independent of the weather conditions. It will increase their food buying capacity and reduce poverty in region.

3. **Establishment of Solar Energy Park**

To increase the income/employment situation in the area appropriate /feasible development projects such as installation of Solar Energy Park can boost economic situation of the area. Multiple solar energy parks can be established at suitable locations after conducting a feasibility study.

4. **Building infrastructure to promote tourism**

Thar culture is very rich and attractive, it can be exploited for boosting tourism and improving lives of the local Thar community. Sports activities such as desert safari, camping, desert jeep rallies etc. may be promoted.

Initiatives may be started to promote tourism by building infrastructure such as big/enterprise scale farmhouses; educating the masses; and promoting the Thar culture through media campaigns.

5. Establishment of camel dairy production plants

Establishment of camel farming and processing plants for manufacturing of camel dairy products for export purposes.

6. Establishment of local grain storage warehouses

Establishment of local storage of wheat/grains warehouses in rain-fed areas, keeping in view the El-nino period. Quantitative assessment should be carried out for goods storage keeping in view the requirement of goods during consecutive seven years with less rain.

7. Establishment of ambulance and health facilities

Since, remoteness is an issue in addition to Tharparkar's vast landscape and spread out population, efficient and well distributed ambulance services are required in Thar so that drought effected/mal-nutrient patients from remote areas/villages can be reached to major hospitals in main cities of the district/province.

Moreover, it is suggested to initiate an air-ambulance service in Nagarparkar due to its remoteness and dense population.

Other than malnutrition, major health care facilities required are in terms of gynecologist and treatment of snake or insect's bites.

A selected female from a cluster of villages (5-10 villages) in Thar can be sponsored by Govt./NGOs/INGOs to get medical education/professional courses in major cities of Sindh. These females after getting trainings/education can serve as doctor/lady health workers in their villages.

8. Improve mechanism for declaration of drought

One indicator described in Calamities Act for the declaration of drought is the total rainfall in monsoon season. However besides overall rain falls count the spread of rain (i.e. the number of rains spread over a total period of monsoon) in full monsoon season need to be accounted.

It is suggested to use geospatial technology to monitor and assess the cultivated area, type of crop and crop in stress, so that timely distress period can be calculated.

9. Improve grain distribution mechanism during drought

Wheat distribution is the most favored exercise by the government aimed for disaster relief. Tons of wheat bags are distributed every time in case of droughts as well as other calamities like Riverine Floods or displacement.

However, for fair distribution and to avoid its theft, it is suggested to place video cameras on distribution points/centers. Also, stock count technologies like RFID/barcode scanning may be used to ensure transparency in storing and distribution of grain sacks to the deserving people. Temporarily vehicle tracking device can also be installed on goods distribution trucks for their monitoring.

10. Rain through cloud seedling

Cloud seeding is a weather modification technique aimed at enhancing precipitation from clouds. A program may be initiated under which cloud seeding may be done during monsoon or western disturbance system at Tharparkar region. This program will greatly help in mitigating the effects of drought in the region.

Earthquake Management

Out of all the natural hazards counted, Earthquake is one of the most severe hazards which can neither be predicted nor be controlled. Pakistan is situated in a highly seismically active region which has experienced many disastrous earthquakes during historical times. The last 100 years alone include the 1945 Makran coast earthquake with M 8.0, the Mach earthquake in August 1931, M 7.3, the Quetta earthquake in 1935, M 7.4, the Pattan earthquake in 1974, M 6.0, and the recent disastrous Muzaffarabad earthquake in October 2005, M 7.6, which has shaken the entire nation in many ways. Many active faults exist in Northern and Southern areas of Pakistan and more than half of the total population are living in earthquake prone areas.

It is globally realized that poorly-constructed buildings and houses are the main reason for the large number of victims due to earthquakes. In recent years several destructive earthquakes occurred in the world, with significant social and academic impact. The observation of strong motion and aftershock sequences as well as the investigation of the destruction from these earthquakes, provide the disciplines of seismology and earthquake engineering with informative and valuable data, experiences, lessons, and raise a number of important scientific problems.

Earthquakes, unlike many other natural hazards, have the potential to cause catastrophic losses. Although Sindh has a low earthquake risk, a major earthquake could still occur under a heavily developed and populated area, especially in Karachi. The impact of such an earthquake could have widespread consequences and thereby, it is important to recognize the potential for such catastrophic impacts.

Geology of Sindh

The geology of Sindh is divisible in three main regions, the mountain ranges of Kirthar, Pab containing a chain of minor hills in the west and in east it is covered by the Thar Desert and part of Indian Platform where the main exposure is of Karoonjhar Mountains, which is famous for Nagar Parkar Granite. In the north Sindh is enquired by rocks of Laki range extending to Suleiman range and its southern most part is encircled by the Arabian Sea.

The latest earthquake that affected Sindh desert area was recorded in the year 2001 in Tharparkar district and the bordering Badin District was also badly affected. Due to this earthquake 12 people lost their lives, 115 persons were injured, 1989 houses were fully damaged, 43643 houses partially damaged and 1406 public sector buildings got damaged. Loss in financial terms was recorded around Rs. 2.4 billion.

A geological tectonic line runs under Karachi through Kirthar Hills / Mountains to north-west of Sindh and Thar desert, which may cause a major earthquake in the future.

SOPs for Earthquake Management in Sindh

Preparedness
1. Identifying and inventorying weak buildings/structures especially in urban settings of the district and situations demanding action by concerned departments. 2. Preparation of landuse plans, town plans and implementation of building codes in new residential schemes, schools, public and private offices. 3. Implementation of DRR measures in public infrastructure development schemes. 4. Establishment of search and rescue infrastructure and services which can be mobilized as first responder in post-earthquake situation. 5. Mobilize NGOs, INGOs, community development organizations and volunteers, and conduct earthquake safety awareness campaigns and drills especially in main urban settings. 6. Availability of necessary material and equipment required for establishing temporary shelters with life support facilities i.e. mobile medical camps, schools, power supply, water and sanitation etc. 7. Availability of alternative communication system in case if usual communication means are disturbed by earthquake. 8. Preparation of medical emergency plan to manage mass casualties in case of any major earthquake event.
Response
1. Obtain firsthand information on intensity of earthquake and damages; prioritize areas for search and rescue operation.

2. Mobilize community-based volunteers, scouts and other trained personnel to hard hit areas to assess situation and help victims.
3. Establish emergency camps / shelters with necessary life support facilities.
4. Establish medical camps for provision of first aid and possible medical assistance to injured.
5. Evacuate people from damaged houses to safe places and shelters.
6. Provide security in affected areas and maintain law and order situation to prevent incidents of thefts and stampede.
7. Arrange and conduct aerial / drone survey of the affected areas.
8. Establish information and help desks for facilitation of affectees.
9. Restore essential services like power, water supply and telecommunication of critical infrastructure like hospitals, control rooms, etc. on priority basis.

Recovery and Rehabilitation

1. Detailed damage and need assessment for recovery and rehabilitation.
2. Rehabilitation on build back better principle.

Earthquake Hazard Severity in Sindh

Earthquake Risk Severity in Sindh

Action Plan for Earthquake Hazard Management

Action	Timelines	Responsibility
Mobilization of man and material resources for rescue and recovery	Post disaster	PDMA and DDMA
Mobilization of NGO, INGO, volunteer groups, scouts and armed services for rescue and recovery	Post disaster	PDMA and DDMA
Coordination and establishment of relief camps, mobile medical camps, life support facilities and provision of relief to affectees	Post disaster	PDMA and DDMA
Coordination and mobilization of rescue teams to search and rescue life in collapsed structures	Post disaster	PDMA and DDMA
Coordination with National Disaster Management Authority (NDMA) for seeking assistance from international agencies (depending on severity of events and damages/losses)	Post disaster	PDMA
Coordination and mobilization of resources on Build Back Better principles	Post disaster	PDMA

Earthquake Risk Management Projects

While the risk of geophysical hazards is low in the province, recommended projects may be undertaken to avoid losses in case of jolts, especially in densely populated urban areas.

1. Ensure implementation of building codes and standards

Prepare policy and SOP to ensure new buildings are constructed as per the seismic codes and standard of the area.

2. Identification and retrofitting of weak existing structures and unsafe buildings

Coordinate with local community regarding unsafe buildings (schools, hospitals and government offices) and regularly conduct building safety surveys to check structural integrity of buildings against the seismic risk and take necessary retrofitting measures to strengthen weak structures.

Create database of vulnerable and unsafe buildings and take retrofitting measures to strengthen the structure of such buildings.

3. Preparation of rescue and rehabilitation plan

Coordinate with line departments to create a comprehensive plan with clearly defined roles and responsibilities of first responding departments, as well as, correspond with rescue agencies/NGOs for their role in an event of earthquake. The plan should also detail the rescue equipment available with concerned departments.

Heatwave Management

Heatwave is a result of joint phenomenon which occurs on sea and terrestrial areas / near coastal belt. Heatwave take place when low pressure develops on the ocean for long time and high pressure develops simultaneously on terrestrial areas. This phenomenon, if remains for long time, will keep sky clear with hot days. Normally, the temperature rises and remains above normal continuously causing sustained heatwave. Heatwave rises temperature up to 5°C for prolonged period, causing cut off in breeze. This high pressure and clear skies make air warmer and stagnant over the region for many days.

Considerable deforestation and rapid urbanization has also contributed to the severity of the heat by generating Urban Heat Island Effect. Trees and vegetation lower surface and air temperatures by providing shade and through evapotranspiration. Shaded surfaces, for example, are significantly cooler than the temperatures of un-shaded materials. During 2015, Karachi faced a severe heat wave which caused several casualties.

Heatwave in Karachi

Usually in summer season, Karachi displays high temperature during daytime. The gigantic city's historic maximum temperature data profile for the month of May and June reveals very high maximum temperature on May 09, 1938 i.e. 47.8 ^{o}C and 47 ^{o}C on June 18, 1979.

The severity and persistence of Karachi heatwave in June 2015 was a rare occurrence for the dwellers of this metropolitan; hosting more than 20 million people of diverse socio-economic status. The causes were combination of the environmental, meteorological and demographic phenomena. Most of the causalities did not occur due to high temperatures rather extended exposure to sun, no ventilation in housing, dehydration due to fasting, prolonged power outages and discontinuity of water supplies were responsible for such elevated death toll.

SOPs for Heatwave Management

Preparedness
1. Consistent future development strategy: Tree plantation, restoration of natural ecosystem, construction of environment friendly and well planned residential societies, offices, infrastructure and human dwellings. 2. Monitoring for hot weather alerts through local and international sources and issuance of timely Hot Day Advisories, and Hot Day Warnings. 3. Upgradation of major public health care facilities with necessary equipment and medicines to treat heatstroke patients. 4. Heatstroke awareness campaigns and wide public coverage through media, social media, SMS, NGOs and social welfare organizations. 5. Arrangements for uninterrupted supply of electricity and water in vulnerable areas.
Response
1. Mobilization of NGOs, social welfare organization and volunteers for arranging heatstroke facilitation camps and distribution of fresh drinking water in affected areas. 2. Local radio FM broadcasts to disseminate heatstroke safety and precautions. 3. Mobilize medical teams for first-aid and other medical emergency support in affected area. 4. Record keeping of heatwave patients and fatalities.
Recovery and Rehabilitation
1. Post event review of heatwave plan and modifications if required.

Heatwave Hazard Severity in Sindh

Heatwave Risk Severity in Sindh

Action Plan for Heatwave Management

Action	Timelines	Responsibility
Interaction with PMD for forecasting and monitoring of heatwave	Based on forecast	PDMA
Dissemination of forecast to concerned DDMA and local community	Based on forecast	PDMA
Mobilization of NGOs, INGOs and individuals for arrangement of heat stroke and medical camps within affected areas	During disturbance period	PDMA and DDMA

Cyclone Management

Cyclones have caused large-scale damage to the coastal areas in Pakistan. The coastal belt of Pakistan, especially in Sindh Province, is highly vulnerable to tropical cyclones and associated storm surges. The coastal belt is mostly low-lying; therefore, storm surges extend several kilometers inland damaging standing crops and converting the agricultural land into gully lands for a long time. The climate change has led to an increase in frequency, intensity and changes in tracks of storms. During the period 1971-2001, about 14 cyclones were recorded along the coastline of Sindh.

Cyclones in Sindh

Coastal districts of the province are prone to cyclone hazard due to geographical setting. Recently, Cyclone Yemyin hit the coastal area of Pakistan in 2007 and killed at least 213 people in Karachi from rains and winds that might have been associated with an outer band of the cyclone, packing at least 70 mph winds that lashed at the city. The cyclone affected at least 10 districts in Balochistan and 4 districts in Sindh, affecting the lives of at least 1.5 million people. At least 2 million people were indirectly affected by the cyclone from power outages and water shortages. More than 2 million livestock, worth over Rs 4 billion, were killed by the cyclone. Property losses from the storm were estimated at Rs 24 billion.

More recently, Cyclone Phet brought extremely heavy rainfall in 2010 over the coastal areas of Balochistan (Gwadar 370 mm, Jiwani 208 mm, Pasni 139 mm) accompanied by very strong winds gusting to 120 km/hour. On 6 June 2010, rain started in Karachi with 35 mph winds under the influence of the cyclone disrupting the city's railways and electrical transmission systems. At least 15 people were killed, mostly by electrocution, and dozens were injured. Cyclone Phet has also left thousands of people homeless in Sindh and Balochistan. The storm moved about 50 km past Karachi and made landfall between the coastlines of Thatta and Badin, causing heavy rains in the area.

SOPs for Cyclone Hazard Management

Preparedness
1. Identify community based DRR measures and inclusion of disaster prone communities in disaster risk management. 2. Establishment of multipurpose permanent shelters with all life support facilities to facilitate safe evacuation of people and livestock. 3. DRR mainstreaming in development planning. 4. Strengthening of cyclone detection, forecasting and warning dissemination centers. 5. Launching a series of public awareness campaign throughout the coastal areas by various means including radio, TV and other media. 6. Training of local administration in warning dissemination and evacuation techniques. 7. Mobilization of NGOs and community based organizations for awareness on construction of houses, billboards, roof tops, and boundary walls, keeping in view effects of high winds. 8. Review/Update emergency response plans and disaster recovery plans. 9. Stocking of key equipment and supplies to carry out immediate response activities including evacuation, shelters, medical camps, water and sanitation, power supply, alternate communication means etc. 10. Design, practice and implementation of evacuation plans with emphasis on self-reliance. 11. Cleaning of water channel, drainage and sewerage before cyclone season of Arabian Sea. 12. Readiness of de-watering machines before start of monsoon and cyclone season. 13. Ensure availability of real-time cyclone hazard map depicting the probable track and landfall impact on PDMA website

Response
1. Issue early reliable warning through siren or other relevant means to reduce the severity of the cyclone related disasters and save valuable human lives. 2. Establish communications with isolated fishermen / coastal communities for furnishing cyclone early warning. 3. Identify, involve and mobilize local NGOs which can assist in community awareness and mobilization for response. 4. Identify and mobilize volunteers' / volunteer organizations which can assist various facets of response like provision of emergency healthcare and relief items. 5. Initiate preliminary damage assessment and run search and rescue operations. 6. Provision of immediate relief including provision of food and portable water to affectees. 7. Deployment of emergency medical support. 8. Provide emergency health care to the affected population, in order to cover risk of spread of epidemic diseases like acute watery diarrhea, typhoid fever, malaria and measles, relapsing of fever and acute respiratory illness.
Recovery and Rehabilitation
1. Assess damage to buildings across the impacted areas to gather information about the extent and severity of damage. 2. Rehabilitation on build back better principle.

Cyclone Hazard Severity in Sindh

Cyclone Risk Severity in Sindh

Storm Surge Hazard Severity in Sindh

Storm Surge Risk Severity in Sindh

Action Plan for Cyclone Risk Management

Action	Timelines	Responsibility
Interaction with PMD for forecasting and monitoring of cyclone and likely landfall	Based on forecast	PDMA
Dissemination of forecast to concerned DDMA and local community	Based on forecast	PDMA
Evacuation of population likely to be affected to safe places	Before forecasted landfall	PDMA and DDMA
Temporary shelter and camp management for affected population and livestock	Before forecasted landfall	PDMA and DDMA
Arrangement of initial relief for affectees	During disturbance period	PDMA and DDMA
Recovery and resettlement of population to native places	Post disaster	PDMA and DDMA

Cyclone Risk Management Projects

Given the increased risk of cyclones across the coastal belt of Sindh province, following projects are recommended to be undertaken by PDMA in consultation with various authorities and departments to better prepare for disaster hazard and risk management:

1. **Establishment of cyclone early warning detection and dissemination system using Common Alert Protocol (CAP)**

A single emergency alert using Common Alert Protocol (CAP) can trigger a variety of public warning systems, increasing the likelihood that people receive the alert by one or more communication

pathways. The CAP is capable to disseminate rich multimedia such as photographs, maps, streaming video and audio. An early warning system based on CAP may be established at suitable location.

2. Construction of coastal dikes along major public facilities against cyclones and storm surges

Dikes can provide a high degree of protection against flooding in low-lying coastal areas. Important public infrastructure like schools, hospitals and shelter places should be secured by constructing protection dikes with a slope. The sloped dike forces the wave to break when the water becomes shallow, and therefore reduces the energy of the wave.

3. Establishment of a meteorological radar system along coastal areas

Update and expand meteorological radar stations across the coastal belt as part of early warning system to detect precipitation particles in the atmosphere and send real-time notifications for any in-coming cyclone / heavy precipitation.

4. Construction of permanent multi-purpose Cyclone shelters

Multi-Purpose Shelters are meant to provide refuge to vulnerable populations at the time of a cyclonic storm and otherwise to be used as community centers etc. The Multi-Purpose Cyclone Shelters will act as a safe shelter for people living in a cyclone threatened region or meant for those who fail to evacuate due to various reasons. The number of Multi-Purpose Shelters should be proportionate to the population size with due examination of its safety and sustainability aspects.

5. Preparation of cyclone response and evacuation plan

Collaborate with community leaders to create community evacuation plans, including evacuation zones and routes. Identify and prepare shelter locations above sea level and conduct emergency evacuation trainings to ensure readiness of communities.

6. Conduct of District Level Mock Exercise (DLME)

Develop a calendar for mock exercises to assess the preparedness, review the District Disaster Management Plans, Standard Operating Procedures and to evaluate the readiness of various departments against any disaster or emergency.

7. Development of insurance policy for financial risk management

Collaborate with Provincial Govt. and Private Partners to devise a disaster insurance policy for vulnerable communities. Disaster insurance provides a means of covering losses incurred through disasters and catastrophic events and reducing financial impact on individuals and communities. Financial liquidity provided by insurance helps mitigate disasters' effects on food security, health and livelihood assets.

Tsunami Management

Due to the tectonic setting in the Arabian Sea, where the Arabian plate subducts beneath the Eurasian plate, large earthquakes have occurred historically along the Arabian coast. It should be noted that not all of the large earthquakes generated tsunamis. Besides earthquakes, tsunamis can be generated by volcanic activity. A historical study of tsunamis in the Arabian Sea indicates that there remain uncertainties about tsunamis that have affected Pakistan.

The Makran subduction zone is located 70 km from the Pakistan coast. Large earthquakes have historically occurred along the Makran subduction zone, though not all of them have generated a tsunami. It is reported that the 1945 Tsunami hit the coast in less than 20 minutes. Distant tsunamis have not affected Pakistan so far. The 2004 Indian Ocean Tsunami did not reach Pakistan, as Pakistan is located behind the Indian subcontinent where the tsunami originated.

Tsunami Hazard in Sindh

The Sindh province can be a recipient of a tsunami disaster. A tsunami disaster occurred in November 1945 at Makran coast in Balochistan Province. It produced sea waves of 12-15 m height that killed about 4,000 people. Although Karachi was away from the epicenter, but still it experienced 6 feet high sea waves which affected harbor facilities.

The effects of tsunami of December, 2004 were also felt along the Pakistan coastline. Abnormal rise in water detected by tide gauge station at Keti Bander area created panic in the coastal population including Karachi.

SOPs for Tsunami Hazard Management

Preparedness
1. Strengthening of tsunami detection, forecasting and warning dissemination centers. 2. Conduct feasibility study for deployment of tsunami early warning systems along coastal belt of Sindh. 3. Launching a series of public awareness campaign through NGOs and community development organizations. 4. Training of local administration in warning dissemination and evacuation techniques.

5. Preservation of mangroves and coastal forests along the coastline.
6. Development of a network of local knowledge centers (rural/urban) along the coastlines to provide necessary training and emergency communication during crisis time.
7. Design, practice and implement evacuation plans and shelter sites with emphasis on self-reliance.
8. Identify buildings and places that could, in the event of a Tsunami, be used as relief centers or camps and make arrangements for water supply and sanitation in such buildings or places.
9. Protect hazardous material storage facility located in tsunami prone area.

Response

1. Coordination with Pakistan Meteorological Department as nodal agency for earthquake and tsunami detection service and dissemination of alerts and warnings through dedicated tsunami warning systems in coastal belt.
2. Immediate evacuation of nearest coastal belt population to safe sides emphasizing population living near coastal creeks.
3. Arrangement for alternate communication links like satellite phones, HF/ VHF communication, VSAT, etc.
4. Establishment of shelters with all necessary life support facilities.
5. Mobilize and deploy resources e.g. search and rescue and medical teams in the Tsunami affected areas.
6. Supply food, drinking water and medical supplies to the affected population.
7. Assess hygiene of affected area and prevent the spread of disease.

Recovery and Rehabilitation

1. Reconstruction of essential infrastructure, such as access to roads, water supply, sanitation, waste water treatment and solid waste disposal.

2. Enhance the ability of the natural system to act as a bio-shield to protect people and their livelihoods by conserving, managing and restoring wetlands, mangroves, spawning areas, seagrass beds and coral reefs.

3. Conduct post-Tsunami damage assessment analysis to provide a clear, and concise picture of post disaster situation, to identify damage caused to different sectors and to develop strategies for rehabilitation, reconstruction and recovery on build back better principle.

Tsunami Hazard Severity in Sindh

Tsunami Risk Severity in Sindh

Action Plan for Tsunami Hazard Management

Action	Timelines	Responsibility
Conservation and afforestation of Mangroves	Pre-disaster	PDMA and DDMA
Mobilization of man and material resources for rescue and recovery	Post disaster	PDMA and DDMA
Mobilization of NGO, INGO, volunteer groups, scouts and armed services for rescue and recovery	Post disaster	PDMA and DDMA
Coordination and establishment of relief camps, mobile medical camps, life support facilities and provision of relief to affectees	Post disaster	PDMA and DDMA
Coordination and mobilization of rescue teams to search and rescue life in collapsed structures	Post disaster	PDMA and DDMA
Coordination with National Disaster Management Authority (NDMA) for seeking assistance from international agencies (depending on severity of events and damages/losses)	Post disaster	PDMA
Coordination and mobilization of resources on Build Back Better principles	Post disaster	PDMA

Tsunami Risk Management Projects

Given the increased abrupt nature of Tsunami and availability of small-window for response, following projects are recommended to be undertaken by PDMA in consultation with various authorities and departments to better prepare for tsunami hazard and risk management:

1. **Installation of tidal gauges along the coast**

Install digital tide gauges as part of the early warning system, to continuously record the height of the surrounding water level and send real-time notifications to monitoring centers.

2. **Construction of coastal dikes along major public facilities against tsunamis and storm surges**

Dikes can provide a high degree of protection against flooding in low-lying coastal areas. Important public infrastructure like schools, hospitals and shelter places should be secured by constructing protection dikes with a slope. The sloped dike forces the wave to break when the water becomes shallow, and therefore reduces the energy of the wave.

3. **Establishment of Tsunami early warning detection and dissemination system using Common Alert Protocol (CAP)**

A single emergency alert using Common Alert Protocol (CAP) can trigger a variety of public warning systems, increasing the likelihood that people receive the alert by one or more communication pathways. The CAP is capable to disseminate rich multimedia such as photographs, maps, streaming video and audio. An early warning system based on CAP may be established at suitable location.

4. **Construction of permanent multipurpose Tsunami shelters**

Multi-Purpose Shelters are meant to provide refuge to vulnerable populations at the time of a cyclonic storm and otherwise to be used as community centers etc. The Multi-Purpose Cyclone Shelters act as a safe shelter for people living in a cyclone threatened region or meant for those who fail to evacuate due to various reasons. The number of Multi-Purpose Shelters should be proportionate to the population size with due examination of its safety and sustainability aspects.

5. Preparation of cyclone response and evacuation plan

Collaborate with community leaders to create community evacuation plans, including evacuation zones and routes. Identify and prepare shelter locations above sea level and conduct emergency evacuation trainings to ensure readiness of communities.

6. Conduct of District Level Mock Exercise (DLME)

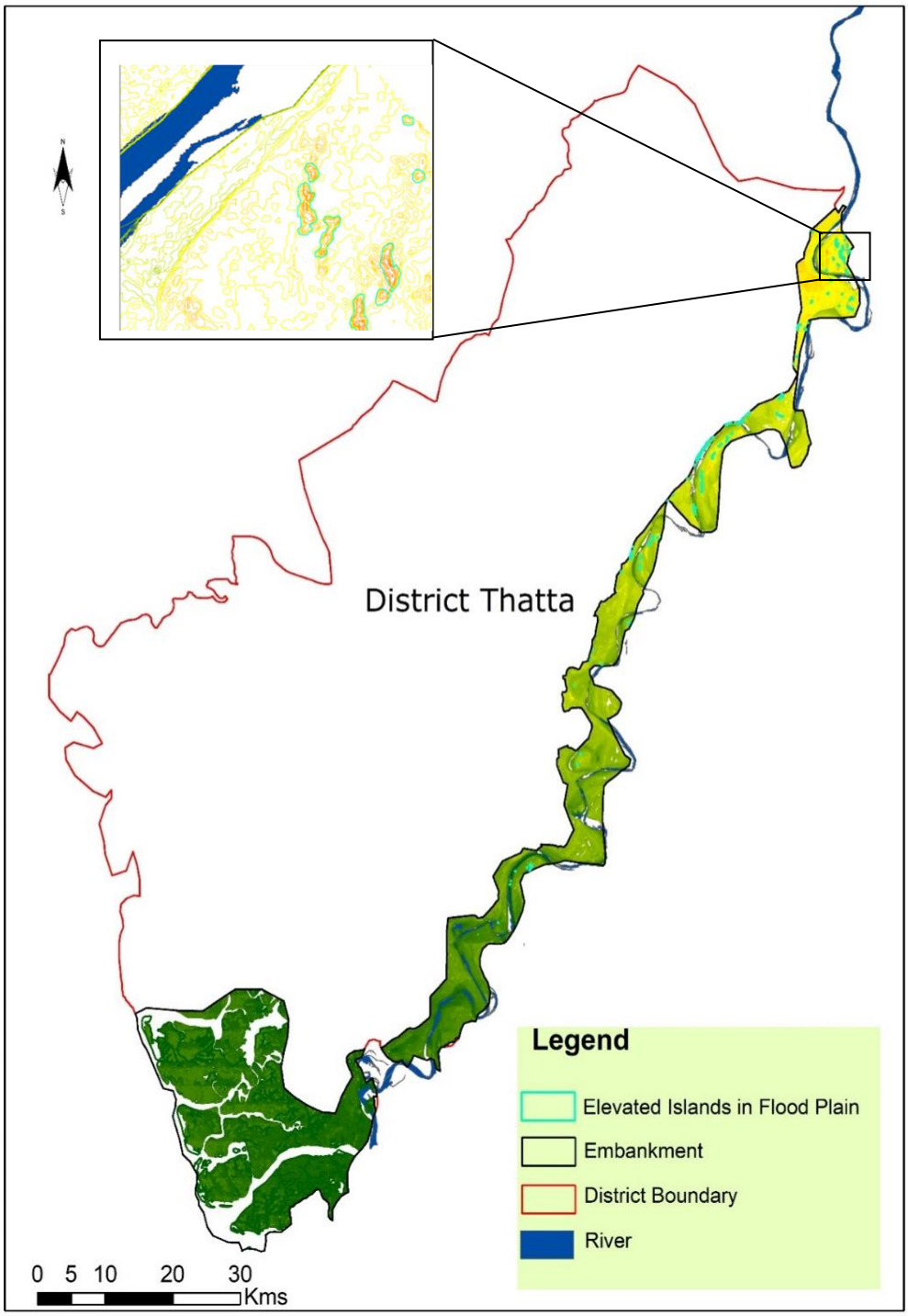
Develop a calendar for mock exercises to assess the preparedness, review the District Disaster Management Plans, Standard Operating Procedures and to evaluate the readiness of various departments to any disaster or emergency.

7. Development of insurance policy for financial risk management

Collaborate with Provincial Govt. and Private Partners to devise a disaster insurance policy for vulnerable communities. Disaster insurance provides a means of covering losses incurred through disasters and catastrophic events and reducing financial impact on individuals and communities. Financial liquidity provided by insurance helps mitigate disasters' effects on food security, health and livelihood assets.

Elevated Islands within Embankments in Sindh Province

Total 838 elevated islands have been identified within the embankments in Sindh Province, with a cumulative area of approximately 4,365 acres. These elevated islands obstruct the river flow and may be demolished/removed to reinstate the normal river flow within the flood plain.



River Training and Straightening

Settled areas along the River Indus are relatively safe from riverine flooding since, in the past, there have been rare occasions of the river out-bursting its protective embankments. However, breaches in river embankments may put at risk a large population in the settled areas across various districts.

Embankment breach due to Normal River flow meandering

A river meanders on flat terrain that reduces the flow speed of the water, allowing the river to curve or meander. The bends in the meandering river migrate back and forth within the flood plain. A differentiation in flow speeds within a meandering river channel produces areas of erosion and deposition. Within the Indus Flood Plain, the meandering river periodically comes very close to the embankments and starts eroding them, thereby making them vulnerable to flood (low to very high flood).

Loop bunds are constructed to mitigate erosion of main bunds due to river meandering; however, it's a repetitive task and doesn't offer a permanent solution. It is, thereby, recommended to straighten the river path inside the flood plain away from both sides of the main bunds so as to minimize the vulnerability of embankment breaching and subsequent flooding in settled areas of Sindh. The figure below illustrates the concept of river training and straightening.