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Review of National Multi-Hazard Early Warning System Plan of Pakistan in context with Sendai Framework for Disaster Risk Reduction

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Abstract

Pakistan has undergone multiple geological and climate-related disasters in recent years. This includes the devastating 2005 Kashmir earthquake, and yearly countrywide flooding since 2010 till present. The recurrence of such disasters has led to the establishment of national and provincial disaster management institutions, which worked towards the formulation of national disaster management plan. As a result, Pakistan's National Disaster Management Plan (NDMP) was approved in 2012. This paper provides a review of Pakistan's National Multi-Hazard Early Warning System Plan (NMH-EWS-P) that is part of the overall NDMP, approved prior to the introduction of the 2015-2030 Sendai Framework for Disaster Risk Reduction (SFDRR). The research identifies various aspects of the national plan, which require amendments in the light of the Sendai Framework. The implementation of the NMH-EWS-P is reviewed by the case study of the province of Punjab, where the Punjab Disaster Management Authority (PDMA) is responsible for the implementation of the national plan at provincial level. With the analysis of Early Warning Systems against natural disasters, as implemented by the PDMA, the gaps and shortcomings of the prevailing practice are identified. Furthermore, this research also aims to propose practical solutions and recommendations for improvement, and better alignment of the prevailing Early Warning System with that of the Sendai Framework.

Peer-review under responsibility of the scientific committee of the 7th International Conference on Building Resilience.

Keywords: National Multi-Hazard Early Warning System , Pakistan , Sendai Framework for Disaster Risk Reduction, Implementation

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1. Introduction

According to International Disaster Database [1], there is an increasing global trend in the number of reported disasters, affected population and estimated damages. The main causes of increases in disaster risks are attributed to various factors influencing the human settlement which include increasing population, land use issues, uneven economic and urban development, climate change, disaster related policies, weak governance and limited endogenous capacities [2,3]. Nevertheless, if vulnerabilities and the coping capacity of communities are suitably addressed, the occurrence of "natural disasters" can be controlled [4]. This requires improved and coordinated monitoring of risk, reliable information, scientific predictions and an overall integrated early warning system [5]. The objective of this research is to study various aspects of multi-hazard early warning system to counter natural disasters as deemed necessary for the practical implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR). The case of one of most populous and disaster prone developing countries i.e. Pakistan is considered where the responsibility to prepare for and respond to disasters has been decentralized on a provincial level. For this study, Pakistan's largest, most industrialized and developed province of Punjab [6] is selected. The prevailing Early Warning System (EWS) in the province, as implemented by the Provincial Disaster Management Authority (PDMA), is analysed and compared with the contemporary state of the art practices in the world. This study aims at identifying the scientific, social, technological and institutional gaps in the implementation of EWS in the province and proposes practical solutions and recommendations for improvement, and better alignment of the prevailing system with that of the Sendai Framework.

Research methodology is presented in section 2 and standard literature review covers section 3. In section 4, the case of Pakistan and Punjab is discussed from disaster risk management and multi-hazard EWS viewpoint. Lastly, section 5 comprises of the key findings of the investigation, conclusions and recommendations for improvement in the existing EWS of Punjab.

2. Methodology

This research is conducted by reviewing online documents, reports and subject-relevant literature. Categorically, two types of documents are reviewed. First, the published draft of the Sendai Framework and peer reviewed research papers by international academics and practitioners. Second, official documents published by the government of Pakistan, which are publically available. The former of these documents sets the foundation of this research, by establishing a standard with which the publications, policies and frameworks developed by the government institutions are compared and analyzed. Since the focus of this research is to establish the functionality of government institutions with reference to EWS against natural disasters, the study of publication by official institutions is crucial to gain insight into prevailing institutional mechanisms. The process of studying two distinguished set of documents exposes gaps and deficiencies in the prevailing early warning system practiced in Punjab, Pakistan. Also, the author's experience of working with several government and non-government institutions has provided valuable insight of the existing system. Overall, this study aids in revealing how some components of the early warning system are overly emphasized, while others are left unattended. Based on the findings of this research, suggestions and recommendations are proposed in order to cover up the gaps in existing scenario and to align the prevailing EWS with that of the Sendai Framework.

3. Literature Review

One of the seven targets of the Sendai Framework is to "substantially increase the availability of an access to multi-hazard early warning system and disaster risk information to the people by 2030"[7]. Both in the pre 2015 Hyogo framework for Action (HFA) and post 2015 SFDRR, an early warning system (EWS) is conceived be a complex, multidimensional tool, focusing multi-hazard phenomenon with sound scientific basis, supported by institutional and technological instruments and encompassing people's centred approach [7]. EWSs are considered to be effective if these are designed to be "people-centred: understood, accessible, timely, and tied to response actions"[8,9]. For this reason, EWSs should be "end-to-end: from the hazard assessment to the response" [10]. In this way, the people's centred early warning system creates links between scientific observations of hazards, communication science, and social science and management science. The potentially affected communities, local

governments, national governments, international bodies, non-government organizations, private sectors, scientific communities and academia, all are stakeholders, constituting an effective people's centered EWS.

The main components of people's centered EWS, as mentioned in table -1, include risk knowledge, monitoring and warning service, dissemination and communication, and response capacity. These components should be supplemented by effective governance and institutional arrangements, such as robust legal and regulatory arrangements, long term political commitment, local decision-making and participation, administrative and resource capacities as well as by vertical and horizontal communication channels between various stakeholders. Similarly, the aspects of climate change adaptation, multi-hazard approaches, consideration for gender inclusion, and cultural diversity are essential for a practical EWS. This has also been explicitly advocated in SFDRR.

Table 1 : Four Elements of People Centered Early Warning System. Adapted from [8,9,12,13]

General Elements of Early Warning System	**1. Risk Knowledge**	**2. Monitoring and Warning Service**	**3. Dissemination and communication**	**4. Response Capacity**
Technical Specialties required	Scientific Research; Historical databases; Hazard, Vulnerability and Risk Assessments; Local knowledge; Information storage and accessibility	Forecasts and nowcasts system based on observational data and monitoring system, numerical weather prediction, conceptual models and situational awareness; Establishment of warning system; Institutional, legal and operational arrangements	Institutionalization of organizational and decision making processes; Effective communication management regarding warning presentation, communication means and effectiveness of communication	Community response capacity assessment and strengthening; Social science and emergency management coving public perception, public education, establishment of disaster preparedness and response planning
Key Outcomes to Strengthen Disaster Risk Governance according to SFDRR	Taking into account the risk of small and large-scale, frequent and infrequent, sudden and slow-onset disasters, caused by natural or environmental, technological and biological hazards.	The development of quality standards and operational guides on standard operating procedures that link early warning systems and hazard monitoring processes to the response agencies and vulnerable groups	The development of innovative technology and communication systems that provide low-cost early warning systems and emergency communication mechanisms.	To cultivate people's centered approach i.e. enhancing community response capability by ensuring that preparedness and contingency plans are consistently reviewed, updated and linked to warning systems so that timely and appropriate action can be taken by people in advance of, during and after the event

4. National Disaster Management System of Pakistan

The national disaster management system of Pakistan is backed by National Disaster Management (NDM) Act 2010 [14]. This act provides necessary legislative support for the establishment of three-tier disaster risk management system at national, provincial and district level in the country. Consequently, the National Disaster Management Authority (NDMA), Provincial Disaster Management Authorities (PDMAs) and District Disaster Management Authorities (DDMAs) were established. Figure 1 shows an institutional model for disaster management in Pakistan. Though horizontal communication may take place between national and provincial departments, after the 18th amendment in the country's constitution in 2010, provincial governments are the primary responsible bodies for preparedness, response, relief and mitigation of disaster impacts within their respective provinces.

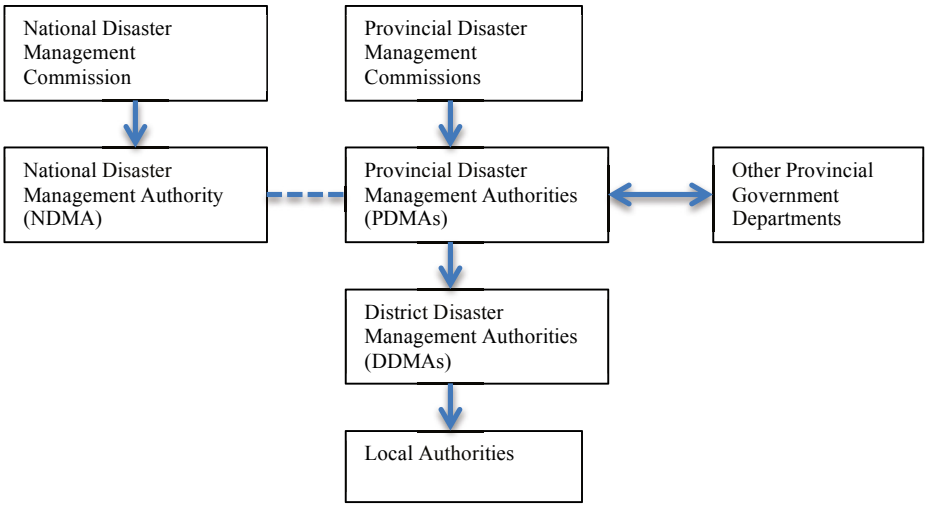

Figure-1: Institutional Model for Disaster Risk Management in Pakistan. Adapted from [20]

Based on National Disaster Management Act 2010, a comprehensive National Disaster Management Plan (NDMP) was formulated in 2012 [15]. Various segments of NDMP include the Main Plan, Human Resource Development Plan, National Multi-Hazard Early Warning System Plan, and Instructor's Guidelines on Community based Disaster Management.

4.1. National Multi-Hazard Early Warning System Plan

The National Multi-Hazard Early Warning System Plan (NMH-EWS-P) is part of NDMP [16] and the main focus of present research. It aims at mainstreaming disaster risk reduction strategies and ex-ante disaster risk management, as opposed to the country's existing ex-post emergency and relief mechanism.

- *Duration:* The duration of implementation of NMH-EWS-P is set to be 10 years, starting in 2012 till 2022, subject to interim evaluation in 2016. The implementation of NMH-EWS-P is divided into three broad time bound categories; short to medium term plans of span 2-3 years, long term plans of span 6-7 years, and super long term plans to be executed throughout the 10 years of planned life of project. After 18th amendment in the country's constitutions, provinces are responsible for preparedness, response, relief and mitigation of disaster impacts.
- *Communication Route:* According to NMH-EWS-P, the basic early warning communication route is that the government agencies responsible for monitoring disasters-related-data should broadcast warnings and alerts directly to the susceptible districts as well as to the media and other government agencies. For example, in the case of a potential hydro-metrological event, the Pakistan Metrological Department (PMD) would issue a warning to DDMAs of vulnerable districts. At the same time, a warning would be transmitted to the media and other government agencies including PDMAs and NDMA. The DDMAs would inform the community via verbal and telephonic medium, and electronic media. Announcement of potential threat would also be broadcasted through loudspeaker of a mosque or a siren. All possible means of communication should be utilized. The main modes include phone (call and short messaging service), Fax, Siren, Media (radio/television), Internet by Virtual Private Network (VPN) and Public Address Systems by DDMAs, Civil Defence, Police and Fire Brigade etc.
- *Strategies:* NMH-EWS-P is based on four strategies as outlined in table -2. The scope and allocated budget pertinent to each strategy is also mentioned in table-2. Major focus is on the first strategy of strengthening weather forecasting and early warning system, which is technology and equipment extensive. About 90% of the total project budget is allocated for this strategy.

Table-2: Strategies for National Multi-Hazard Early Warning System with scope and budget. Adapted from [16]

Strategy No.	Strategy Description	Duration Category	Scope	Budget (Million USD)
1	Strengthen weather forecasting and early warning system	Short to medium, long and super long term plans	• Replacement/rehabilitation of existing radars and installation of new metrological radars; • Expansion of Automatic Weather Stations Network; Establishment of: • Forecast and Warning system for Riverine flood, flash flood, Glacial lake outburst flood (GLOF); • Observational Networks for rainfall and water level; • Tide monitoring network; • Seismic Intensity monitoring reporting system; • Landslide and Avalanche Early Warning System; • Upper air observational system	168.5
2	Prepare hazard maps at local scale in targeted locations	Long and super long term plans	• Development of hazard maps for riverine floods, flash floods, GLOF and snow melt, and earthquakes • Tsunami simulation and hazard maps	5.7
3	Strengthen early warning dissemination systems	Short to medium and long term plans	Establishment of: • Communication system between Pakistan Metrological Department (PMD) and NDMA; • Communication system between various disaster management authorities i.e NDMA, PDMAs and DDMAs • National Early Warning System for Health Emergency, Preparedness and Response	3.1
4	Develop capacity of early warning and evacuation systems	Long term and recurring activates throughout project life	• Establishment of weather forecast guidance system • Launch of educational program of Metro-Hydrology for PMD Staff • Enhancement of community understanding of early warning system by conducting trainings and drills	11.2

- *National Disaster Management Plan Implementation Road Map:* In 2015, NDMA launched NDMP Implementation Road Map, in which the implementation time frame of the project was modified to 2016-2030, as opposed to the previous proposed time frame of 2012-2022 [17]. The execution sequence of the project was altered from the categories mentioned in table-2, to three phases of priority wise districts. Some progress is achieved in facilitating PMD for upgrading early warning system as per the scope mentioned in table-2 and was reflected in the 2015 annual report issued by the NDMA [17]. However, the detailed work plan of NDMP Implementation Road Map is not available on NDMA official website and the overall scope, breakup of activities, progress milestones and the extent of deviations from the original NDMP cannot be determined.
- *Current State of NMH*-EWS-P: At national level, several hazard specific early warning centers exist, such as Seismic and Tsunami Early Warning Centre, Tropical Cyclone Warning Centre, Flood Forecasting and Warning Centre, and Drought monitoring Centre. However, there is lack of effective coordination and liaison between various forecasting agencies and natural disasters warning issuance bodies [18].

4.2. Case Study: Multi-Hazard Early Warning System in the Province of Punjab:

Punjab is homeland to five rivers, namely Indus, Chenab, Jhelum, Sutlej and Ravi, complemented by an

extensive canal-based irrigation system [21]. This also makes the province highly susceptible to flood-related disasters. It is the most densely populated province in the country, consisting of 36 different administrative districts. Climate wise, the province exhibits two extremes, fairly cool hills in the north and a scorching desert in the south. In comparison with other provinces of Pakistan, Punjab is a rich agricultural region and the most industrialized and developed province in Pakistan [19].

- *Provincial Disaster Management Structure:* The provincial disaster management structure in Punjab is shown in figure-2. PDMA is the main coordinating authority to strategize preparedness and response to disasters after consultation with all stakeholders at federal, provincial and district levels, as well as with international agencies.

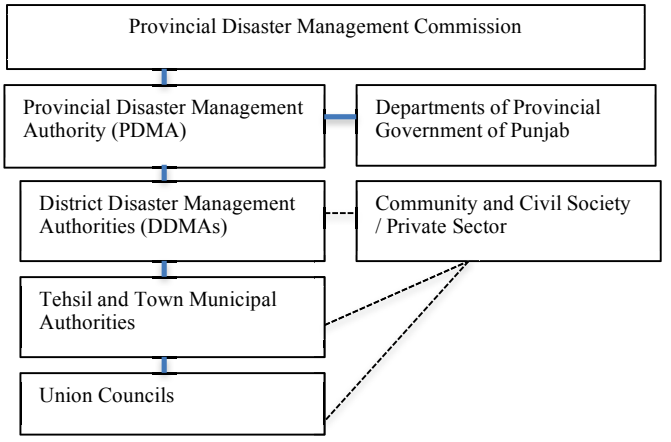

Figure-2: Provincial Disaster Management Structure. Adapted from PDMA Disaster Management Plan, 2008 [19]

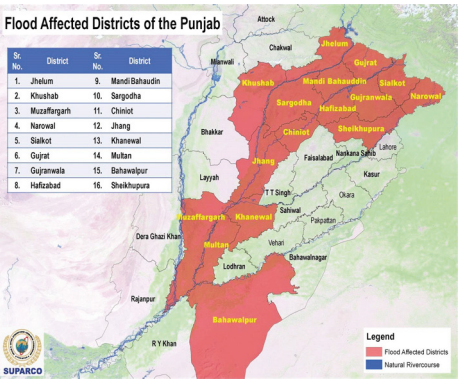

Figure -3: Province of Punjab showing 2014 flood affected districts. Source: SUPARCO

- *Natural Disasters in Punjab:* The province of Punjab is prone to numerous natural disasters such as floods, droughts and famines, landslides, forest fires and medium to low intensity earthquakes. Since 2010, the recurring and most damaging types of disasters are the riverine floods and flash floods. Figure - 3 shows geographical map of the Province of Punjab along with the network of rivers, highlighting the flood-affected districts during 2014 flooding. Between 2010 and 2016, the data regarding the damage sustained to life, livelihood and property was summarised in Provincial Disaster Response Plan 2016 [22]. The Plan showed that in 2010, the flooding was most damaging to the assets such as households , whereas in 2014, the flooding caused the highest number of deaths and impacted the largest number of districts in the province.

- *Multi-Hazard Early Warning System in Punjab:*

PDMAs were established in the aftermath of countrywide flooding in 2010 [23]. Less than a decade old, PDMA Punjab is a newly established institution and is constantly improving its role from responsive/reactive mode to anticipatory and proactive mode of disaster management. However, a great deal of work is required to establish multi-hazard early warning system in the province. The prevailing early warning system is limited to riverine flooding as shown in figure - 4. It is based on linear connections from observation through warning generation and transmittal to users. As mentioned earlier, the first source of flood-related early warning dissemination and information to local, provincial and federal decision-makers and to the general public is PMD. Within PMD, Flood Forecasting Division (FFD) and Flood Warning Centre (FWC) is established where the

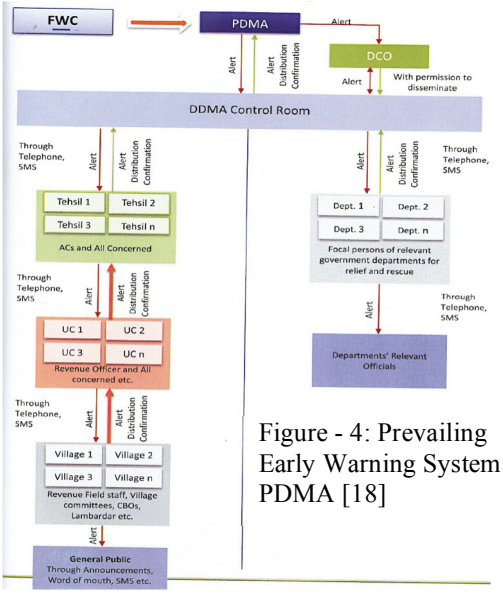

Figure - 4: Prevailing Early Warning System of PDMA [18]

former provides flood forecasting information to the latter. The information from FWC is then transmitted to government agencies including PDMA and to the general public through electronic media. Within PDMA, the warning is transmitted to DDMAs and further to tehsils and union councils through phone calls, SMS, and DDMA's wireless network. The general public receives early warnings through electronic media, as well as through public announcements in mosques, SMS, and in-person communication with local authorities. Word of mouth is also a means of communicating early warning. PDMA and DDMAs also coordinate and update other government agencies regarding the situation. For this reason, Command, Control and Communication Center (4C) is established at PDMA [22]. It receives early warning from disaster monitoring agencies and releases it to the public, media, ministries, humanitarian and rescue agencies. It also coordinates relief, rescue and rehabilitation work during and after the disaster. Moreover, a dedicated helpline has been setup by PDMA and there is an increasing trend of using social media platforms by government agencies for dissemination of early warning.

5. Discussion on Findings and Recommendations

In the light of SFDRR, the role of PDMA is concentrated within the third element of people's centred EWS as described in table-1 i.e. dissemination and communication. The second element i.e. monitoring and warning services is being carried out by separate government agencies and beyond the scope of PDMA. The first and last element of EWS i.e. risk knowledge and response capacity seem missing or not being acknowledged as essential parts of EWS. The people's centred approach is completely absent. Though access to information is available as shown in figure - 4, it is not being translated into useable and actionable advice. According to the ground realities during the course of this research, DDMAs are either not functional or being newly setup and there is no custodian of EWS at local level. The EWS is mostly based on technology, it is challenging to include individuals without access to electronic or social media. Also, in instances where technology fails, there is no alternative pre-designed plan.

The communication of early warning, as reflected in EWS line diagram of PDMA, is a one-way process and the interaction/ involvement of community is weak in the entire design of existing EWS. The linear paradigm of such model-based EWS and the inbuilt focus on the hazard rather than vulnerabilities, risks and response capacities [4] are obvious limitation of the present approach. The cross cutting aspects of EWS as described in section 3, including governance and institutional arrangements, multi-hazard approach, involvement of local communities, consideration of gender perspective and cultural diversity, are either drastically weak or altogether absent in the prevailing EWS of Punjab. The only hazard under consideration is flood, which undoubtedly is the most prominent hazard for the province. However there is an obvious lack of synergies between various hazard specific monitoring centres, and is hence a challenge for implementing the multi-hazard approach.

Considering the three-tier disaster management system of Pakistan, there is a lack of formal linkages between relevant ministries and departments, especially between the federal and provincial government institutions. Moreover, within the departments of the same tier, duplicated mandates exist, which require institutional development, backed by legal frameworks, in order to clarify roles and responsibilities, and enhance the productivity of government institutions before, during and after disasters.

The NMH-EWS-P of Pakistan, when compared with the guidelines of Sendai Framework, reveals that a lot of emphasis is given to the element of monitoring and warning services. Almost 90 % of project budgeted costs are devoted to this element, conceived as technology extensive and expensive, while other elements of people's centred EWS remain under emphasised.

The current situation of multi-hazard early warning system in Pakistan and in the province of Punjab can be improved if EWS is acknowledged as a complex interdisciplinary mechanism where technology is one feature and not the ultimate solution. The other essential dimensions of early warning system are institutional, legal and social. At the same time, continuous supply of energy is necessary to run the early warning system, especially during black outs and long term poor weather conditions. Sustainable early warning system requires a maintainable source of financing, continuous operation, and system maintenance by trained personnel. The most critical component of effective early warning system is demonstrated by appropriate response by the vulnerable and exposed population. This requires the provision of reliable and trustworthy information to the public, strong collaboration with potentially affected populations to rebuild their confidence over numerous disaster management actors and

facilitators such as responsible government authorities, non- government organizations, the private sector, and civil society organizations. Whilst there is a need to build formal communication structures between various stakeholders, it is also important to develop informal communication channels between people to people and people to government. Gender inclusive, culturally acceptable, sustainable and low cost community based early warning system should be introduced to provide creditable and actionable risk alerts. Moreover, indigenous practices should be encouraged and revived, which can provide workable solutions, even in instances of technological failures.

The monitoring of disasters is not in scope of PDMA and it has to relay on information from other government departments. Apart from establishing strong inter-departmental linkages and communication channels, public-private partnerships can be established, such as with international research institutions and agencies, to cover the information and technical deficiencies related to disaster monitoring. For instance, Global Flood Awareness System (GloFAS) can provide reliable information for highly unanticipated and devastating events, such as the 2010 floods in Pakistan, with a forecast horizon of one month [24]. Such partnerships can prove instrumental in elevating the productivity of government machinery and prevailing EWS in the country. Nevertheless, like any other country, the conscious efforts by political leadership and senior management of government institutions are required to materialise the proposed solutions and recommendations, necessary to bring improvements in the existing EWS.

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