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FROM PREPAREDNESS TO RESILIENCE: A QUALITATIVE-META-SYNTHESIS ON INTEGRATING GOVERNANCE, MEDIA, AND GEO-SPATIAL TECHNOLOGIES FOR EFFECTIVE DISASTER RISK REDUCTION IN PAKISTAN

Alina Ishrak[1], Nisfariza Binti Mohd Noor[1*], Sumera Batool[2], Aimee Binti Halim[1], Safiah Yusmah Binti Muhammad Yusoff[1]

[1]Department of Geography, Faculty of Arts and Social Sciences, Universiti Malaya, 50603, Kuala Lumpur, WP Kuala Lumpur, Malaysia

[2]Department of Mass Communication, Lahore College for Women University, Lahore, Pakistan

Email: nish@um.edu.my

ABSTRACT

Floods remain one of the most devastating and recurring climate-induced disasters in Pakistan, exposing the pervasive nature of risks alongside communication, technological, and governance challenges. This study explores how combining risk-informed governance, media, and geospatial technologies can strengthen resilience in flood-prone areas across the country. Using qualitative meta-analysis, it examines institutional frameworks, and the roles of geoscience and media, in shaping disaster preparedness, response, and long-term resilience with reference to the Sendai Framework. It highlights how geospatial technology supports the entire cycle from preparedness to resilience, while media plays a critical role in effective mobilization, communication, and awareness. The discussion situates floods within broader debates on risk knowledge, disaster risk governance, policy implementation mechanisms, fiscal policies for disaster risk reduction, and post-disaster "Build Back Better" initiatives. It emphasizes the importance of both technological and policy evolutions in mitigating escalating flood risks. Case studies of flood events, specifically the 2010 and 2022 floods in Pakistan, highlight uneven access to communication infrastructure, a lack of risk knowledge among communities, and limited capacity-building initiatives for both geospatial and media technologies, challenges that are deepened by existing socio-economic inequalities. By bridging perspectives from geography and media studies, the study argues that the effective integration of risk governance and modern technologies is essential for reducing vulnerabilities. The analysis offers policy frameworks to institutionalize geospatial technologies, strengthen governance mechanisms, and expand digital media infrastructure, all of which are critical to advancing inclusive and optimal flood resilience in Pakistan.

Keywords: *Disaster Resilience, Geo-spatial, Media, Build Back Better, Disaster Risk Reduction (DRR), SENDAI, Floods in Pakistan*

INTRODUCTION

Pakistan lies on the frontlines of climate change. Despite contributing less than 1% of global emissions (Adnan et al., 2024), it remains among the top 10 climate vulnerable countries on the Climate Rate Index (CRI) (Eckstein et al., 2018; UNDP, 2014). While hazardous flood events occur worldwide, their frequency and intensity can vary regionally (Abbass et al., 2022). Currently, riverine, flash and urban flooding are on the rise in Pakistan, especially due to

climate change. The disaster risks imposed by these events highlight the gaps in the conventional disaster management system (DMS), which remains focused on reactive rather than proactive approaches (Khan et al., 2022; Shaw, 2014b).

The 2010 and 2022 flood events in Pakistan, are considered the most calamitous in the nation's history. The super flood of 2010 was a clear warning of climate change, during the worst wave of flooding that year, 1985 lives were lost, 20 million people were affected, and the country faced a huge financial loss of $9.7 billion (Waseem & Rana, 2023; WFP, 2018). The 2020 floods impacted more than 2.4 million people (Patel, 2020). The monsoonal floods of 2022 took around 1700 people's lives, cost $14.9 billion in damages, and resulted in $16.3b in post-disaster recovery and reconstruction activities (WB, 2022). In the recent wave of flooding in June 2025, the monsoonal rains claimed the lives of 800 people across the country. Khyber Pakhtunkhwa (KPK) suffered the highest death toll, with 479 deaths due to flash floods and several cloudburst events (OCHA, 2025).

Existing research on flood disaster risk reduction (DRR) in Pakistan focuses on post-disaster damage assessments, alongside evaluations of governance, policy frameworks, institutional and local challenges (Danish et al., 2023; Hote & Koike, 2025; Shah et al., 2023; Wang et al., 2023). Numerous studies have offered technical solutions, such as implementation of effective Early warning systems (EWS), space-based technologies, and the impact of situational awareness on flood vulnerability (Jan et al., 2024; Mehboob & Maryam, 2025; Mukhtar, 2018). Moreover, studies have also evaluated the connection between developmental planning, DRR budgeting, investment, and lastly the socio-economic DRR-poverty nexus (Hote & Koike, 2025; Khan et al., 2024; Khan et al., 2022).

However, there remains a significant gap in investigating the integrated role of geospatial technology and media in DRR to improve DRR-policy. Thus, there is a clear need for a holistic and integrated approach to manage climate-inflicted disasters. This approach should be based on the priorities of the Sendai Framework, leveraging geospatial technology and media for improving DRR, resilient development and effective EWS within the country.

Global Practices in Implementation of Geospatial Technology and Media for DRR

Many new possibilities have emerged in disaster risk management (DRM) with the availability of multi-source satellite datasets, such as optical and synthetic aperture radar (SAR). High-resolution, all-weather, and real-time data provided by SAR are highly beneficial during floods (Hostache et al., 2018).

In recent years, remote-sensing data volumes have increased to the scale of exabytes-often referred to as big data. Therefore, to address the storage and processing related challenges, two main platforms are in use; cluster-based high-performance computing (HPC) systems and cloud-computing systems (Gorelick et al., 2017; Sedona et al., 2019). The low costs, along with efficient data storage and processing capabilities, have given cloud computing platforms a clear edge over HPC (Amani et al., 2020).

Nowadays, many companies are providing cloud computing services for remote sensing applications in DRM. Among the most popular are Amazon Web Services (AWS), Microsoft's Azure, and International Business Machines (IBM) cloud services (Ferreira et al., 2020; Lu et al., 2016; Lukacz, 2022). Google Earth Engine (GEE) hosted on Google Cloud Platform (GCP) is a free geospatial platform for academics, researchers and students (Kumar & Mutanga, 2018). It is compatible with different interfaces and software, which makes it a suitable choice for disaster risk assessment and profiling.

Globally, China, the United States of America (USA), Japan, and India are leading in the research for disaster management, based on Artificial Intelligence (AI), Machine Learning (ML) and Deep Learning (DL) (Aggarwal et al., 2024; Chen et al., 2024; DHS-FEMA, 2025; WBG, 2017). They are focused on developing better forecasting models (Xiang et al., 2024), data fusion techniques for prediction (Awasthi & Chinzvende, 2025), and producing high-quality results essential for emergency responders (Lo et al., 2015; Schumann et al., 2018).

Similar to many member states of the Asia Pacific Space Cooperation Organization (APSCO), Pakistan operates Low Earth Orbit (LEO) satellites and Geostationary Equatorial Orbit (GEO) satellites. It also has a National Space Policy (NSP); however, it still lacks indigenous launch capabilities (Mehboob & Maryam, 2025).

Media has emerged as a cornerstone of effective DRM, particularly in strengthening EWS, risk communication, and community resilience. This effectiveness is often rooted in the integration of multi-communication platforms, where traditional broadcast media is combined with digital and social media networks to maximize outreach across diverse populations (Houston et al., 2015). A primary example of this is seen in Japan's disaster communication framework, which relies heavily on a public broadcasting service. The system delivers real-time alerts during earthquakes and tsunamis, ensuring nationwide coverage (Shaw, 2014a).

Beyond one-way broadcasting, a shift toward the two-way communication system using social media platforms has proven equally vital, as demonstrated during Hurricane Sandy in the USA (Alexander, 2014; Merchant et al., 2011). Similarly, the Bangladesh Cyclone Preparedness Programme highlights how integrated approaches can dramatically reduce mortality rates. In this case, mobile-based alerts and community volunteers worked in tandem with local media institutions (Paul, 2009). Collectively, these practices demonstrate that the media's optimal role in DRM is realized when it operates inclusively with the government, fostering trust, transparency, and resilience.

Sendai Framework for Disaster Risk Reduction (SFDRR) (2015-2030)

The Hyogo Framework for Action (HFA) (2005-2015) was the starting point for introducing laws and policies to implement DRR (UNISDR, 2005). It acted as the primary instrument for creating resilience and advancing DRR. Later, the HFA was replaced by the Sendai Framework for Disaster Risk Reduction (SFDRR) (2015-2030) (UNDRR, 2015), with aims to both manage and reduce the risks associated with disasters. The SFDRR is considered to be more far-reaching and inclusive compared to the HFA. It focuses on social and health-related issues and emphasizes adopting a people's centric approach (Raftopoulos et al., 2024).

Moreover, the Sendai Framework emphasizes the media's role in building a culture of resilience through sustained awareness campaigns, disaster education, and advocacy for risk-sensitive development (UNDRR, 2015). However, effective implementation also requires bridging the digital divide by ensuring equitable access to communication infrastructure in vulnerable geographies. Pakistan, to a greater extent, has aligned its post-2015 legislative instruments and policy frameworks with the Sustainable Development Goals (SDGs), SFDRR, and the Paris Agreement (Danish et al., 2023).

All these frameworks rely on a shared foundation: building community resilience towards climate change and disaster risks. The main idea is to reduce systemic risks, promote sustainable development, and create a positive impact on the future of humanity (Flood et al., 2022).This study illustrates these principles through an enhanced framework for disaster risk governance (as shown in figure 1). In this conceptual model, media and geospatial technology play crucial roles as drivers across four major pillars: risk knowledge, governance, budgeting,

and resilient development. The model aligns with the Sendai Framework to facilitate the cycle of disaster risk resilience, covering mitigation, preparedness, response, and recovery, by incorporating these technical and communication drivers.

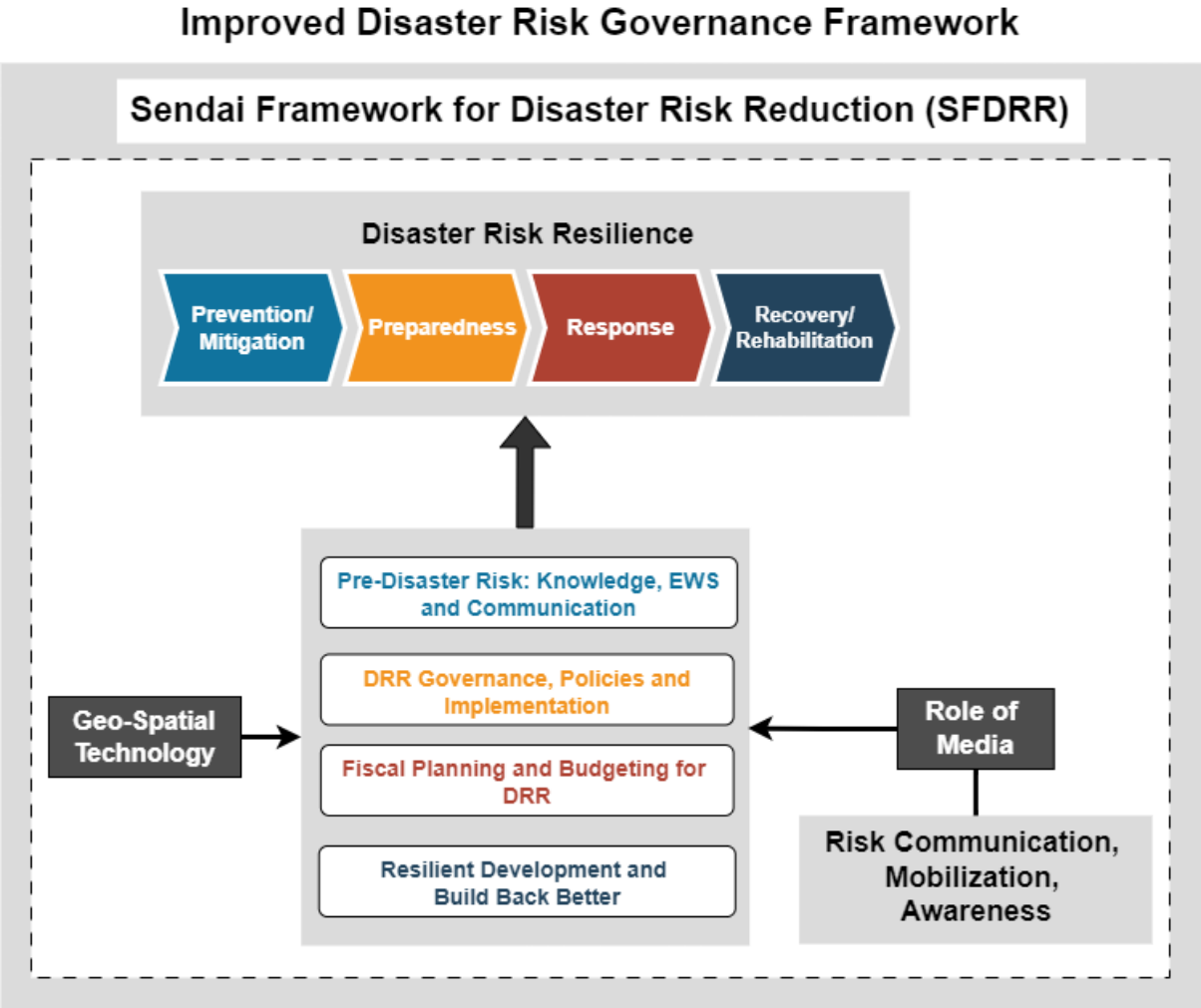

Figure 1: Conceptual model for the research study

Disaster Management System of Pakistan

Following the 2005 earthquake, the government of Pakistan revised its policies, which had largely been based on a reactive approach. In 2006, the National Disaster Management Ordinance (NDMO) was promulgated and later endorsed as the National Disaster Management Act (NDM Act) of 2010 (Ali & Iqbal, 2021). As a result of the Act, a three-tiered DMS was established. The main objectives of the DMS were effective preparedness, response, recovery, and rehabilitation, all under the DRR framework. The National Disaster Management Authority (NDMA), Provincial Disaster Management Authority (PDMA), and District Disaster Management Authority (DDMA) were the primary components of the DMS. All three tiers were backed by legislative support from the NDM Act of 2010 (Azhar, 2022; NDMA, 2023) (as shown in figure 2).

In 2010, the 18th Amendment to the constitution led to the decentralization of PDMAs from the NDMA. The amendment granted provincial governments both financial and legislative authority and removed federal regulations over relief responsibilities (Mukhtar, 2018). In 2012, the National Disaster Management Plan (NDMP) was formulated under the NDM-Act 2010 (NDMA, 2012). Since EWS(s) have always been central to the DMS, the National Multi-

Hazard-Early Warning System-Plan (NMH-EWS-P) was made part of the NDMP that same year and later revised in 2016 (GOP-MoCC, 2012). In 2025, the NDMP was reviewed and updated as the NDMP 2025, following the expiration of the previous plan in 2024 (NDMA, 2024, 2025). The key goals of the plan were to prioritize integrated institutional and community empowerment, capacity building, and increasing the capacity of the state to mitigate future disasters.

Pakistan's national space agency, the Space and Upper Atmosphere Research Commission (SUPARCO), has been operating since 1961 (Mehboob & Maryam, 2025). In 2013, SUPARCO launched a digital watch portal known as the Space Application Centre For Response In Emergency And Disaster (SACRED) (SUPARCO, 2025). SACRED provides space-based information, real-time data, reports, and images, to both the NDMA and the PDMA. It helps evaluate the extent of natural disasters and damage to human lives, property, and infrastructure (ESCAP, 2020), as seen during the floods of 2010, 2014, and 2015. The technical support provided by SACRED to the NDMA is important for achieving long-term agendas, such as, the NDMP, the Sendai Framework, the Paris Climate Change Agreement (COP21) and the SDGs 2015-30.

The National DRR policy recognizes the importance of managing DRR knowledge and research. As a result, the Disaster Response Centre (DRC)-a hub for disaster-related information was established. The main purpose was to provide information to institutions, print and electronic media, professionals, and scholars for research and other purposes (NDMA, 2013a). Media acts as a bridge for communication and the transmission of information between state organizations, and locals. However, varied concerns have arisen regarding the mainstream media's role in disaster management (Rashid & Shah, 2025).

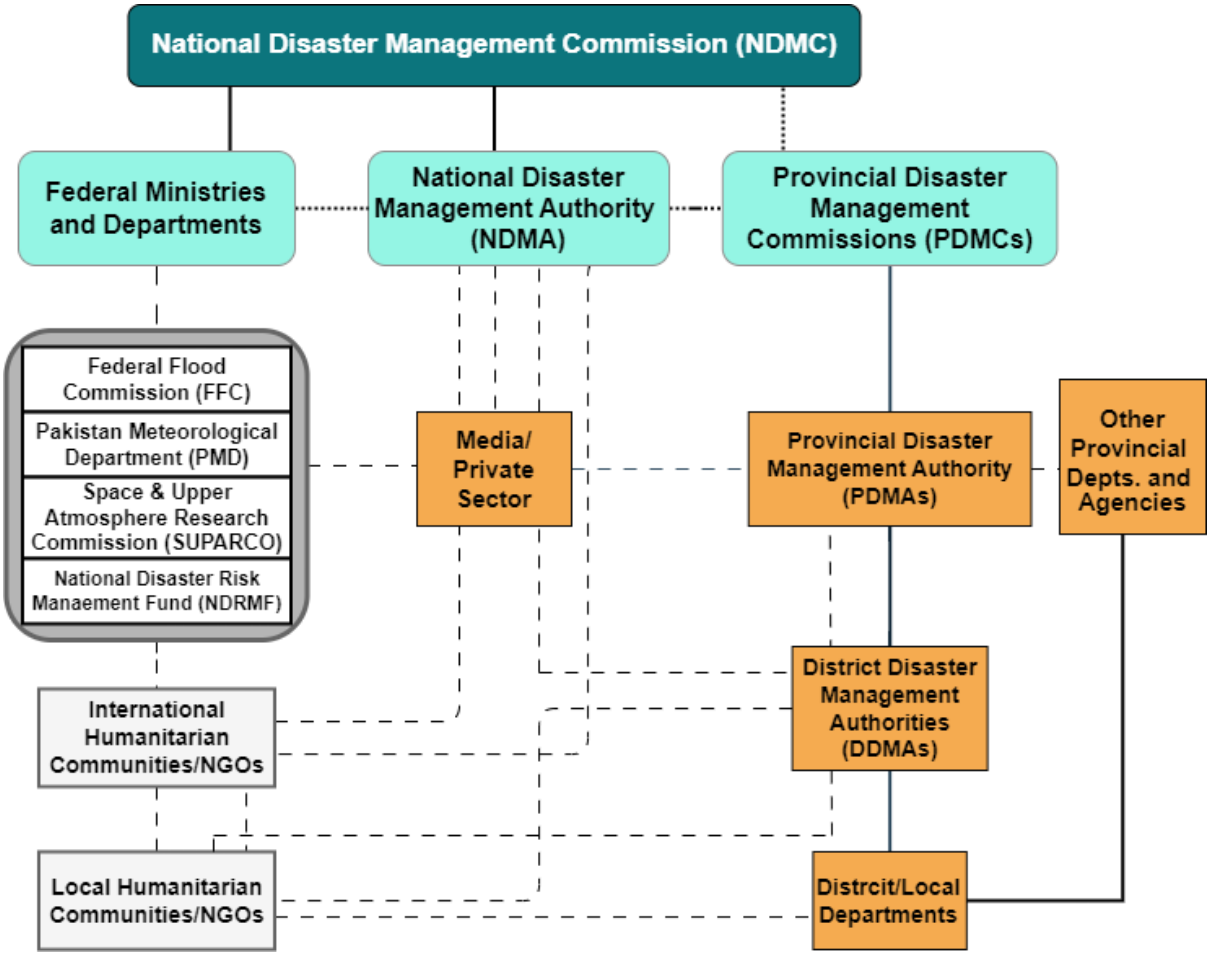

Figure 2: Organogram of Pakistan's Disaster Management System

METHODOLOGY

Research Design

For this research study, a theory-driven qualitative meta-synthesis was conducted, following the approach outlined by Hoon (2013). This method, often described as a meta-study or a qualitative meta-synthesis of case studies (Hoon, 2013), involved the systematic extraction, analysis and synthesis of evidence from existing flood related case studies in Pakistan . The study utilized qualitative case studies focusing on risk governance, geospatial technology and media, particularly concerning flood events in Pakistan from 2010 to 2025. A robust systematic screening, coding and meta-synthesis of case studies resulted in directly addressing the two-primary research questions (RQs):

i. How can the integration of geo-spatial technology and media can reduce flood risks?
ii. How does the integration of geo-spatial technology and media improve flood Risk Governance?

At the end, the outcomes of all qualitative case-studies were connected to develop new, theory-informed insights, aligned with the Sendai Framework priorities. The study followed a combined deductive-inductive approach: initially, the four priorities of Sendai Framework were established as priori themes. Subsequently, the inductive method generated additional themes and sub-themes from the evidence found within each case study (Eisenhardt & Graebner, 2007; Shah & Corley, 2006).

Searching and Screening

To establish the search boundaries, a set of keywords was defined based on the research questions. This search was conducted exclusively on Google Scholar, restricted to English-language articles, published between 2010 and 2025. Furthermore, key concepts such as, risk governance and Sendai were only assessed in reference to flood events in Pakistan. During the query-based analysis in Google Scholar, an iterative keyword-refinement approach from Habersang and Reihlen (2025) was utilized to continuously improve the search string.

After an extensive process of query refinement 68 articles were downloaded from Google Scholar. Next, the articles were further filtered based on their titles, strictly adhering to the exclusion and inclusion criteria. The title screening phase resulted in the exclusion of 49 articles, narrowing the selection down to 19. During the final phase of abstract screening, the article count was further reduced to 10. Some of the articles were also excluded because of their type, more specifically book chapters (as shown in figure 3). This final set of 10 articles was considered adequate, as they provided thorough thematic saturation within the specified scope (risk governance, geospatial technology, and media), while retaining the depth essential for a strong, theory-based qualitative meta-synthesis.

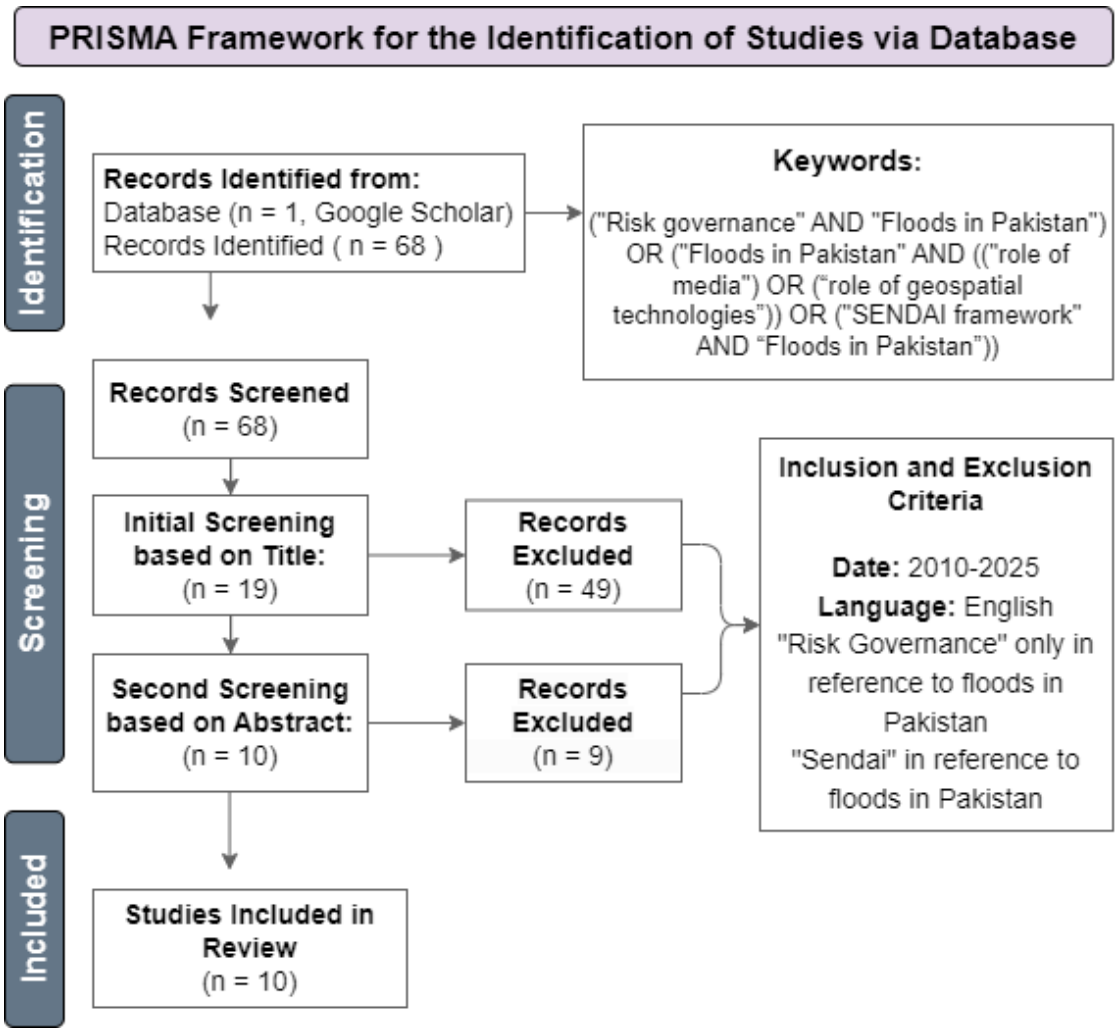

Figure 3: An illustration of PRISMA framework for literature search and screening.

Code-sheet Preparation

All ten studies were treated as pilot studies to inductively obtain themes from their abstracts. Following this, a preliminary code sheet was developed by systematically the reading abstracts, results, discussion, and conclusion sections of all ten case studies. This code sheet was structured around a priori Sendai categories, themes, and their corresponding sub-themes. During the subsequent analysis, these inductive themes were deemed validated and finalized upon reaching thematic saturation. Specifically, when new themes or sub-themes ceased to emerge after reviewing the key sections of all ten pilot studies (Saunders et al., 2018).

Data Extraction

All ten articles were read in full and coded using Microsoft Word and Excel. The excerpts and memos taken from all articles were noted in an Excel sheet and used to inductively generate sub-themes within each priority. Audit trails and memos ensured alignment between the new sub-themes and the priorities of the Sendai Framework (as shown in figure 4).

Synthesis and Theory Development

The final stage involved a detailed comparison and the identification of contextual elements, mechanisms, and concepts across all ten case studies concerning the 2010 and 2022 flood events in Pakistan. This synthesis resulted in the formulation of an evidence-based conceptual model that explains the integrated role of geospatial technology and media in improving flood risk governance and reducing flood risks within the Sendai Framework priorities.

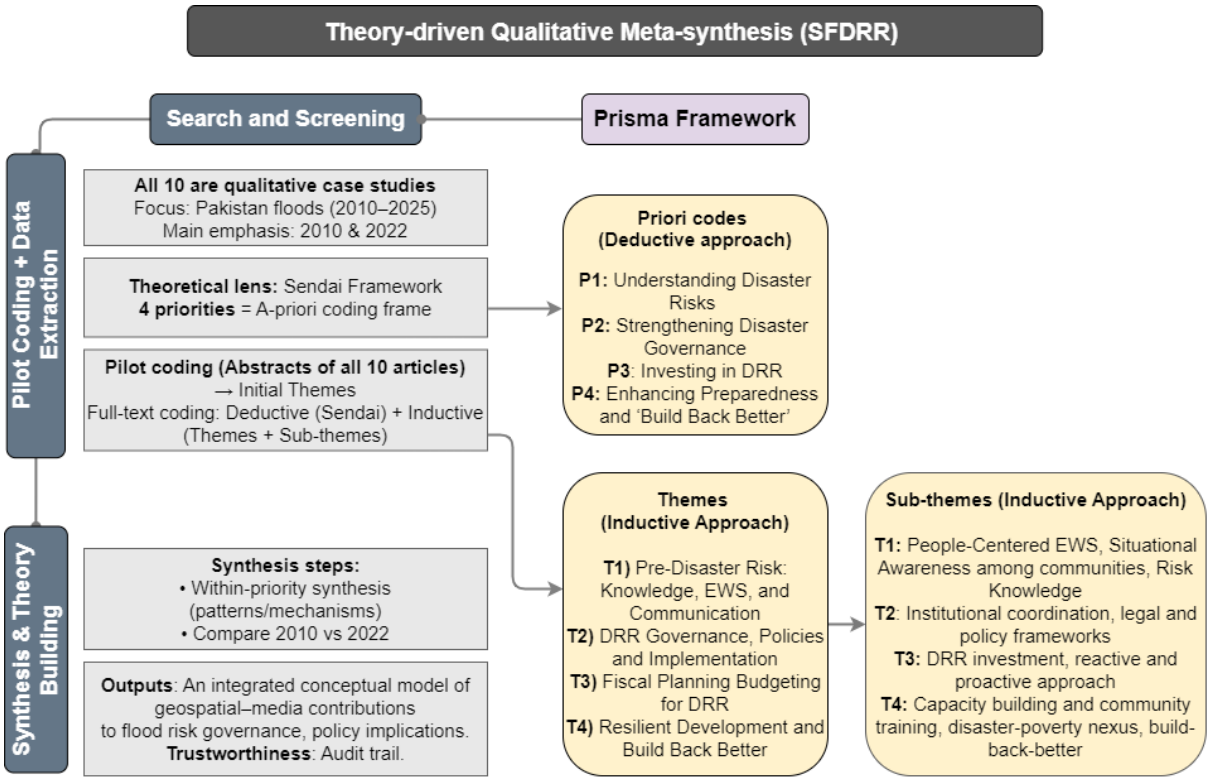

Figure 4: Methodological framework showing the process of qualitative meta-synthesis of case studies, for developing an evidence based conceptual model

FINDINGS AND CRITICAL ANALYSIS

Priority-1 of Sendai in Reference to DRR in Pakistan

Importance of Risk Knowledge and the Evolution of EWS

Priority-1 of Sendai Framework emphasizes leveraging risk knowledge for disaster preparedness, mitigation, and prevention, as well as for effective response to disaster risks (UNDRR, 2015). Consistent with this theory, Hussain et al. (2023) have listed some important risk-management measures like, raising situational awareness, constructing hazard-adapted buildings, taking risk precautions, and developing EWS. Moreover, evacuation planning and well-articulated evacuation routes are also critical for risk preparedness and management (Tsai & Chang, 2023).

An EWS is an important aspect of risk communication and perception. In 2012, the NMH-EWS-P for Pakistan was formulated through NDMP-2012 (GOP-MoCC, 2012). While Mustafa et al. (2015) argued that an effective EWS should be people-centered and gender-sensitive, recent research has broadened the scope. It has been suggested that a joint-integration of ML, Geographic Information System (GIS), big-data analytics, and cultural-sensitivity into a DMS can enhance predictive abilities. These systems promote greater community resilience and provide better disaster response by fusing cutting-edge technology with human factors (Hussain et al., 2023; Muñoz et al., 2021).

Media's Role, Institutional Shortcomings and People-Centric Approach

Current practices of risk communication in Pakistan fall behind the principles of Sendai's Priority-1. The mega-floods of 2022 in South Punjab revealed the severity of gender-based discrimination. Women were impeded from accessing risk knowledge due to cultural obstacles, a biased educational system, and social marginalization (Aleha et al., 2024; Mustafa et al., 2015). According to Mukhtar (2018), Pakistan's EWS is highly technological and forecasting-oriented, yet lacks a people-centered approach. Two-way communication is missing, especially at the local and district levels. This is mainly due to failed coordination among institutions, exacerbated by weak internet access and a limited social media presence. All these factors diminish the aptness and reliability of the linear EWS model. The lack of operational integration between community tools, space-based data, ground sensors, and centralized decision-making highlights the need for investment in an interoperable data system (Mehboob & Maryam, 2025).

The lack of in public-awareness during flood disasters has raised serious concerns regarding disaster management authorities in Pakistan (Jan et al., 2024). In remote rural areas, limited resources and access to trustworthy information contribute to vulnerability, making community-resilience initiatives more difficult to deliver (Dhiman et al., 2019). With increasing flood disasters, the timely and high-quality delivery of knowledge has become extremely important, requiring specialized skills, professional training, and planning. Information Communication Technologies (ICTs) can play a crucial role in fixing these systemic flaws. ICTs can help close the gap between the government and marginalized communities by integrating mobile networks, satellite data, mapping tools, and real-time communication (Alexander, 2015; Shah et al., 2023). Although media can play a significant role in disseminating early warnings and educating diverse communities through knowledge sharing, and communication, its usage remains inconsistent (Rashid & Shah, 2025). During the 2022 floods, a notable gap was identified in the media's role in disaster preparedness, a time when it should have been central to community awareness campaigns (Rashid & Shah, 2025).

Importance of Situational Awareness and the Lack of Geospatial Technology

According to Jan et al. (2024), situational awareness is a vital component of flood hazard knowledge and is essential for reducing vulnerability. To facilitate this, the high resolution of SAR makes it exceptionally useful for emergency planning and disaster management activities by providing accurate flood-extent maps (Adjovu et al., 2023). Moreover, remote sensing-based flood modelling techniques enhance this awareness by generating early warnings and directing evacuation plans (Liu et al., 2023). Countries like Vietnam have established community-based disaster management (CBDM) programs, by integrating technical data into local frameworks. These programs enable local committees to create and implement context-specific evacuation plans. The core focus is to close the gap between general risk awareness and targeted local action (ASEAN, 2024).

Nonetheless, flood studies in Pakistan expose persistent gaps in risk management. For instance, during the 2010 floods in Nowshera, locals were aware of flood-related risks in general; however, they lacked location-specific knowledge, community preparedness, and defined evacuation routes. Riverine communities were left extremely susceptible to disaster risk due to this lack of localized information (Jan et al., 2024).

In terms of technology, Haq et al. (2010), recommended the fusion of optical data with SAR while mapping 2010 flood events. However, Pakistan lacks indigenous SAR and heavily relies on three functioning optical satellites (PRSS-1, PakTES-1A, and PRSC-EO1). Due to this, Pakistan lacks all-weather imaging capabilities during cloudy monsoon conditions and resorts to foreign data, such as the European Sentinel-1 or commercial providers (Mehboob & Maryam, 2025).

Priority-2 of Sendai in Reference to DRR in Pakistan

Current DRR Policies and Institutional Framework

Priority-2 of Sendai Framework highlights the strengthening of disaster governance at national and local scales. It suggests that clear directional planning, institutional coordination, participation of stakeholders, and policy implementation mechanisms are essential for DRR (UNDRR, 2015). Climate change is a widely acknowledged factor contributing to intense hazards (Trenberth et al., 2015). Accordingly, it has been recommended to integrate climate change adaptation (CCA) into policy frameworks for long-term disaster-risk resilience (Shah et al., 2023).

In Pakistan, the national DRR policy was formulated by the NDMA in 2013 (NDMA, 2013b). CCA is essential for effective EWS (Mukhtar, 2018), mitigating flood vulnerability (Jan et al., 2024), enhancing community resilience (Khan et al., 2022), and implementing developmental and non-developmental measures (Khan et al., 2024). Responding to these needs, the Ministry of Climate Change (MoCC) of Pakistan updated the national climate change policy (NCCP) in 2021, integrating CCA into national development (MOCC, 2021). Furthermore, in 2023, a National Adaptation Plan (NAP) was formulated to outline the strategy for climate resilient development and risk reduction (MOCC, 2023). The 18th Amendment to the Constitution also serves as a landmark reform, as it was adopted to facilitate federal-provincial and inter-provincial coordination (Syeda Dua Raza, 2025; UNDP, 2021).

Pakistan has well-established comprehensive space laws and policies, particularly, the National Space Policy of Pakistan (NSPP), 2024 (SUPARCO, 2024). SUPARCO serves as a Regional Support Office (RSO) for UN-SPIDER (Iqbal et al., 2014). In developing countries, the integration of ICTs in governance signifies effective e-governance, as it reflects transparency and accountability (Banerjee et al., 2020; Novita et al., 2021). Furthermore, the Pakistan NDM-

Act 2010 (Articles 16-2 J, 20-2 K), the National DRR-Policy 2013, and the NDMP 2024 emphasize the use of ICTs to strengthen early warning capacity and improve resilience through preparedness (NDMA, 2010, 2012, 2013b, 2024). The DRC-hub developed by the NDMA, manages disaster-related information. It provides data to organizations, the media, students, and researchers for research and development (R&D) purposes (NDMA, 2013a). Both the NDMA and PDMA also use social media platforms, specifically Facebook and X (formally known as Twitter), to provide timely updates and warnings to their users (Azhar, 2022).

Inadequate DRR Governance Implementation Mechanisms

Despite existing policies and institutional frameworks, recurring flood risks and damage clearly reflect the gaps in the current DMS. These policy implementation flaws mainly arise from a disjointed, top-down governance structure. Factors such as fragmented institutional responsibilities, a lack of resources, weak data infrastructure, inefficient disaster planning, and the failure to identify community concerns-compounded by a shortage of government expertise, a lack of collaboration with international agencies, ineffective implementation mechanisms, the digital divide, and a lack of ICT mainstreaming within the domain of DRR, are all the probable causes of DRR-policy failures in Pakistan (Anis & Ashfaq, 2023; Cheema, 2022; Jan et al., 2024; Mayer, 2019; Shah et al., 2023; Tariq & Van De Giesen, 2012; Tufail & Ainuddin).

In many Southeast Asian countries, governments formally support the use of geospatial data as the fundamental layer for planning, which requires cross-agency data sharing and standardization. This practice has also helped in establishing an effective coordination among government agencies (ESCAP, 2022). In Pakistan, a major limitation in the governance system that prevents risk reduction initiatives is that the system remains reactive rather than proactive. Overall, the flood management system in Pakistan works on an ad hoc manner rather than proactively (Manzoor et al., 2022; Mustafa et al., 2015; Rana et al., 2021). While studying the resilience of media during the 2022 floods in Pakistan, Rashid and Shah (2025), found that reporting by the media peaks during flood crises and declines in the pre and post-disaster phases. They later proposed the need for development-oriented journalism to educate the public about preparedness, prevention, and sustainable management practices.

Failures in Media Integration and Multi-Level Coordination

The absence of coherent inter-governmental collaboration is the primary barrier to DRR governance. Communication and coordination remain the weakest among the three tiers of government (UNDP, 2021). In Pakistan, the federal government often devises future developmental plans without integrating local and provincial authorities (Ahmad & Anjum, 2012). Similar lack of coordination has been observed at the district and sub-district levels (Rana et al., 2017). During the floods of 2010 and 2022, the local officials assigned by the DDMAs were not readily prepared for effective emergency planning and response (Ateeb & Zia, 2023; Khushik et al., 2015). A high level of institutional incompetency was observed across governmental departments, such as irrigation, rescue 1122, the Pakistan meteorological department (PMD), and communication and network departments (Jan & Muhammad, 2020). These enduring problems clearly indicate inadequate vertical and horizontal integration at both the policy and execution levels. On the other hand, the neighbouring Bangladesh, has effectively closed this vertical gap, by emphasizing community empowerment and fortifying its institutional framework. They created a more inclusive system by incorporating local insights into national DRR planning (UNDRR, 2025). In Pakistan, these shortcomings have damaged the reputation of local and government officials in front of rural communities (Mian, 2014). Although a single integrated system exists for all district-level developmental goals,

however, execution varies from region to region due to shifting government priorities (Shah et al., 2023).

Media acts as a vital conduit between institutions and communities. It plays a crucial role in the governance and policy implementation of DRR policies. Communication systems are essential for institutions to effectively coordinate crisis response, post-disaster recovery, and pre-disaster preparedness (Alexander, 2014; Houston et al., 2015). Combining digital and geospatial communication technologies improves situational awareness in real time, allowing for more flexible implementation strategies and evidence-based policy decisions (Meier, 2015). In Pakistan, the absence of systematic media integration in DRR governance exacerbates inequitable disaster response, public mistrust, and fragmented communication.

Priority-3 of Sendai in Reference to DRR in Pakistan

Global Investment Challenges and Fiscal Planning for DRR

Priority-3 of Sendai Framework suggests that investing in DRR for developmental, administrative, technological, research, and risk communication sectors is essential for building financial resilience to disaster management. Such investments should also be made in human mobility, capacity building, health, and social safety (UNDRR, 2015). Limited financial resources also mean low resilience (Jan & Muhammad, 2020), and poverty reduction can significantly minimize the aftermath of floods among risk-prone communities (Hote & Koike, 2025). Therefore, DRR investment should address disaster risk-poverty nexus at the community level, and provide educational support to poor households for vulnerability reduction (Nakamura & Kawasaki, 2022; Okuda & Kawasaki, 2022).

Two main issues that have been observed with the SFDRR are the lack of tangible commitment to financial aid for developing countries, and the lack of recognition of CCA as an overlapping theme within DRR (UNDRR, 2023). These two prerequisites are of particular importance in developing countries like Pakistan for combating climate induced disasters. Globally, while there has been a rise in political commitments, DRR strategies, and the implementation of EWS, however, a significant gap persists in terms of investment (Raftopoulos et al., 2024).

Need to Invest in Communication-Based Solutions and Geospatial Technology

The inadequate performance of SUPARCO over the last five decades, is mainly due to resource limitations and a lack of steady funding (Abdullah, 2021). These financial constraints have led to shortages in technical capabilities, insufficient tools to access satellite-derived products, a lack of community training initiatives, and a weak open data infrastructure (Wang et al., 2024; Zakaria & Nasir, 2019). However, a positive development occurred during the 2024-2025 budget, when SUPARCO was allocated significant funding to “develop space technology capabilities” for climate-related disasters, (24NewsHD, 2024).

The Integrated Flood Analysis System and multi-hazard vulnerability assessment developed by SUPARCO provide daily inundation maps and flood risk maps, while also assessing damage using remote sensing inputs (Mukhtar, 2018). Moreover, a web-based Disaster Watch portal has made the information accessible to the NDMA, and PDMA especially during emergency situations (SUPARCO(DisasterWatch), 2025). The National Catastrophic Model of Pakistan (NatCat) created by SUPARCO, provides coarse risk assessment, and monetary loss estimation at a sub-district level. This model incorporates datasets such as historical satellite data, climate change projections, and socio-economic exposure (Farooq, 2022; SUPARCO, 2025). Recently, the NDMA launched a new National Emergencies Operation Centre (NEOC) that gathers real-

time feeds and sophisticated analytics to predict disasters up to three months in advance (NDMA(NEOC), 2025). Regardless of these developments, there is still a lack of collaboration, a multisectoral fusion approach, and political inertia towards integrating space science into DRR planning (Mehboob & Maryam, 2025).

A huge population of Pakistan has access to mobile phones, the internet, and social media. Almost 93.15% of the population are active mobile phone users, and 11.75% own a laptop or computer (PBS, 2021). Furthermore, 193 million Pakistanis have subscribed to various mobile networks (NDMA, 2024), and at the beginning of 2024, approximately 111 million internet users, and 71.70 million social media users were reported (Datareportal, 2023). These estimates suggest that mobile-based solution can enhance existing EW-ICTs, given the limited financial resources to invest in telemetry stations, weather radars, and automatic weather stations (Jan et al., 2025). Most of the current Pakistan-based disaster risk apps are static and do not support two-way source of communication from citizens.

In 2018, a citizen portal app was launched by the government of Pakistan to empower citizens to report and file queries and complaints directly to the government departments. In terms of disasters, the app enabled local people to file complaints about delayed compensation for relief and cash packages (PDMA, 2018). However, there was still no mechanism to share early warnings or any other disaster-related information. In contrast, the Philippines has effectively improved its EWS by using ICTs and social media to enable quick, two-way communication between local communities and national agencies (CFDS, 2018).

Institutional Restraints and Reactive Fiscal Approaches

Many studies have strongly advocated for adopting a proactive fiscal approach in pre- and post-disaster development, specifically through allocating funds toward preventive measures in reducing disaster impacts (Izumi & Shaw, 2014; Olu et al., 2016; Righi et al., 2021; Shamkhi & Ebraheem, 2020; Srividhya et al., 2020; Verma, 2012). From 2013 until 2019, a rise in funding from the government and donor agencies for pre-disaster interventions was observed in KPK (Khan et al., 2022). This contrasts with the 2010 floods, where most of the spending directed toward recovery from damages (Molnar, 2020; WB, 2022).

Although, in Pakistan a rise in proactive fiscal investment has been observed in Pakistan, however, institutional constraints, vague DRR policies, and ambiguity in the allocation of resources continue to obstruct long-term resilience (Khan et al., 2022). For example, Central American countries have started tackling this issue through regional cooperation. They formed a shared commitment between DRR authorities and Ministries of Finance to create a detailed DRR financing plan that encourages robust public investment (UNDRR & CEPREDENAC, 2025). According to Khan et al. (2024); Mustafa et al. (2015), a rise in disaster risks is also tied to limited funding for community-led DRR initiatives, capacity building programs for locals, and unequal funding allocation during recovery. To achieve better provincial disaster governance, there is a dire need for establishing an inter-departmental task force on DRR and the provision of sector-specific investment.

Priority-4 of Sendai in Reference to DRR in Pakistan

Post-Disaster Land Use Planning and Build Back Better

Priority-4 of Sendai Framework stresses DRR-focused recovery and developmental measures. It advises preparing for all disaster phases well ahead of time to improve national and community resilience (UNDRR, 2015). According to the UNDRR (2017), basic risk

management practices can make a nation or a community resilient. While views on resilience differ, the most important pointers are the knowledge and understanding of risks, proper damage assessment, and awareness of risk-prone areas. Additionally, early interventions, such as ensuring structural integrity, resilient, land use planning, capacity-building, along with proper drainage systems, and key stakeholder participation, are vital for evaluating the degree of resilience (Aleha et al., 2024; Jan & Muhammad, 2020)

Build-Back-Better (BBB) is a comprehensive and holistic method for post disaster developmental and non-developmental measures (Mannakkara et al., 2018). In developing countries, improper land use planning is mainly due to financial limitations, poverty, informal settlements, fuzzy land tenure, and controversial land owner-ship (UFCOP, 2017). In Pakistan, knowledge regarding BBB and land-use planning is in its nascent stages. For instance, during the 2010 flood event in Nowshera, it was discovered that 88% of commercial and residential infrastructure in KPK was prone to flood risks due to poor neighbourhoods, rapid population growth, and a lack of public awareness (Jan et al., 2024). Furthermore, a lack of funding and mismanagement have halted the basic flood defence structures to be build, such as walls, spur bunds, and embankments across all rivers in Pakistan (Abbasi, 2025). GIS-based proper spatial planning can play a significant role in long-term recovery and resilience by identifying better land suitability sites. Similarly, Unmanned Aerial Vehicles (UAVs) can aid in planning and restoration through aerial surveys and 3D mapping of affected regions (Der Sarkissian et al., 2022; Wu et al., 2024).

It has been found that the concept of BBB has been limited to physical development and reconstruction, often overlooking social aspects (Shuvo et al., 2022). The World Bank report on the 2022 floods in Pakistan, put an emphasis on medium and long-term initiatives for sector-based disaster resilience. This includes using climate change adaptive housing designs, building community-based solutions, promoting active community involvement, and developing policy structures aimed at cultivating resilience (WB, 2022). Many developing countries are actively integrating this sectoral resilience. For instance, Tonga is strengthening the ability of village water committees to safeguard vital freshwater resources, while Bhutan has integrated resilience measures into its national-five-year strategic plan (UNDRR, 2024).

Lack of Geospatial Technology and Community Involvement in DRR System

In developmental planning, flood resilience goes beyond preventing risks. It includes vulnerability reduction and inculcating preparedness strategies to efficiently respond and adapt to future floods (Norizan et al., 2021). The active participation of locals through citizen science for risk awareness, post-disaster relief campaigns, damage assessment, and restoration can play a significant role in DRR (Tidball et al., 2012; Ottinger,2022, Ahmed, 2024, thesis).

While geospatial technologies, such as remote sensing, GIS, and Global Navigation Satellite Systems (GNSS) facilitate in risk mapping, designing evacuation plans, and strategizing resource allocation (Aggarwal et al., 2024), developing countries like Pakistan still fall behind in adopting these tools. The 2020 monsoonal floods showed that, despite timely rescue missions initiated by the provincial governments, the lack of GIS-based , multitemporal field data resulted in delayed damage assessment (ReliefWeb, 2020; Sajjad et al., 2023).

According to Mukhtar (2018), proper training and emergency drills might have better prepared locals for managing risks, and responding to early warnings during the 2010 floods. Furthermore, the government should launch programs related to hydrometeorology for agencies such as the PMD, increase institutional capacity, enhance local capabilities for DRR,

update EWS, and work for post disaster management and societal restoration (Buriro & un nisa Jatoi, 2025; Danish et al., 2023; Mukhtar, 2018).

Crisis During Recovery Phase and Socio-Economic Vulnerability

Rural areas in Pakistan account for a large portion of country's vulnerable households. The majority of the economic shocks caused by flooding are felt by these impoverished individuals, primarily as a result of limited income and coping mechanisms, low-cost housing, and poorly planned infrastructure (Hote & Koike, 2025; UNDRR, 2019). The inability of poor families to recover from disasters is exacerbated by their limited social and economic capacity, further driving the cycle of disaster-poverty nexus (Hallegatte et al., 2020; Hamidi et al., 2020; Hote & Koike, 2025).

For example, the 2022 floods in Pakistan caused a 7% loss in GDP and pushed 9 million people into poverty (UN, 2023). Local and provincial institutions should provide financial assistance, building materials, and temporary employment to local communities for effective recovery and rehabilitation (Shah et al., 2019). In Pakistan, the institutional constraints, minimal post-disaster initiatives, and unequal resource allocation by local representatives have created mistrust among local communities toward recovery efforts (Shah et al., 2023).

DISCUSSION AND CONCLUSIONS

Flood events are becoming more frequent and intense, which calls for a more proactive, integrated, and resilient approach. This study has reviewed literature on policy implementation and technology usage for DRR in Pakistan through the lens of the Sendai Framework, accompanied by regional comparisons. the meta-synthesis provides several theoretical implications that can improve and challenge traditional DRR approaches.

Sendai's Priorities and their Theoretical Implications

The qualitative meta-synthesis helps to analyze challenges faced by Pakistan in understanding risk knowledge. The analysis calls for strengthening the theoretical application of Sendai's Priority-1, within developing nations. In theory, understanding risk is often regarded as a technical data collection task. However, this study demonstrates that risk knowledge remains incomplete without the socio-technical integration of geospatial data and inclusive communication. In the case study of Nowshera, the inability to translate high-technology forecasting into local action strongly challenges the "linear information to action" theory. Therefore, combining satellite data with institutional practices, and substituting top-down approaches with two-way, gender, and culturally sensitive feedback mechanisms can make Sendai's Priority-1 theoretically reliable. This indicates that a nation's capacity for effective DRR is defined by its connectivity between technical EWS infrastructure, culture-specific situational awareness, and institutional coordination.

The analysis calls for a fundamental improvement in risk governance theory, shifting the emphasis from static institutional frameworks to dynamic operational integration. Following Priority-2 of the Sendai Framework, present policy-frameworks have created DRR-based governmental structures. However, across all the three tiers of organizations; NDMA, PDMA and DDMA, operational and conceptual fragmentation has been identified as a critical failure point.

Effective disaster risk governance should go beyond a structural checklist to a more collaborative communication model involving locals, media and government authorities. The

research highlights that e-governance cannot guarantee transparency without media integration, a challenge exacerbated by the digital divide. To bridge this gap, the study suggests a multisectoral fusion approach. This model views geospatial data as a foundational policy-layer that necessitates data standardization across agencies while empowering local communities. This evolution marks a scholarly shift from a state-centric model to an integrated network model, where national policy relies on local expertise and sustained development-oriented communication via media channels.

Priority-3 of Sendai necessitates a change from reactive spending to more proactive fiscal strategy. It emphasizes interdepartmental coordination and pre-disaster mitigation. Moreover, it promotes sector-specific investments that close the gap between high-level technological assets and localized, long-term resilience projects. Priority-4 of Sendai Framework emphasizes the implementation of BBB during the recovery and preparedness phases. However, in Pakistan, the concept of BBB is still mostly limited to physical reconstruction, ignoring the crucial requirement for social resilience and institutional capacity. This limits the capacity to address the disaster-poverty nexus. In order to break the cycle of vulnerability, recovery models should incorporate risk-informed public financing and dedicated livelihood support into the post-disaster recovery phase. This would directly lead to the effective implementation of BBB within the theory of poverty alleviation.

FUTURE RESEARCH DIRECTIONS AND RECOMMENDATIONS

Although this study provides a thorough analysis of Pakistan's DMS, it also identifies a number of new research directions. Future research should focus on local solutions rather than high-level policy analysis. For example, researchers could investigate how local schools can serve as disaster education hubs. Furthermore, community-led mapping initiatives are greatly needed. These initiatives can make evacuation routes both technically accurate and user-friendly, as they integrate satellite imagery with the firsthand accounts of local residents.

However, the potential biases in this qualitative meta-synthesis must also be acknowledged. This study is susceptible to publication bias, as it is based on existing scholarly articles and government reports. As noted in previous studies, major flood events are reported more frequently compared to small-scale, effective preventive measures. Additionally, there is a likelihood of research bias, as the study strongly relies on the Sendai Framework, potentially neglecting other principles and concepts. Lastly, language and geographical biases are likely to be present. As the review concentrated on English-language databases, it might have overlooked important traditional knowledge shared in local languages that is not found in major journals.

Based on the finding and analysis, the following recommendations are made to mitigate disaster risks and improve DRR policy:

i. The combination of big data and GIS can improve monitoring, EWS, response and recovery capabilities. Integrating different big data types, such as remote sensing (Bai et al., 2021), social media (Huang et al., 2018), and ML-based flood risk assessment (Mojaddadi et al., 2017), can enable timely disaster warnings. Together, these technologies can enhance the promptness and precision of emergency responses, which can considerably reduce flood-related damage.
ii. Achieving vertical coherence in risk communication at the national, provincial, and local levels, requires formal media integration. This entails using electronic and social media along with GIS to raise situational awareness and disseminate risk warnings. Creating a multi-hazard disaster risk communication framework that reflects the ASEAN model is

crucial to delivering messaging that is understandable, consistent, and culturally relevant (ASEAN, 2024). In order to deliver true and up-to-date information, community volunteers should be trained to use citizen science initiatives like open-data portals. Media journalists should also be trained to use these portals for public awareness campaigns (Goodchild, 2007; Parajuli, 2020).

iii. The state's DMS should adopt a bottom-up approach. In order to accomplish this, the district-level DDMA's resources and capacity must be greatly enhanced. Furthermore, fully functional DDMAs should be established with the authority to oversee emergency responses and implement high-level policies. Fostering cooperation between local institutions and rural communities is important for rebuilding the reputation of local institutions within those communities.

iv. Data pertaining to the distribution of resources to local authorities must be placed in the public domain and subject to third-party scrutiny. Additionally, to support bottom-up communication, public service media channels and strategic social media engagement must be used methodically. Public needs, requests, and complaints should be proactively forwarded to the appropriate authorities through this mechanism. This transparency would also strengthen the media's role in serving the general public (WMO, 2015).

v. Despite provincial autonomy in the budgeting system for DRR, the lack of coordination and the unavailability of DRR-related budget data make it difficult for policymakers to consider investing in DRR (Asgary et al., 2012). An economic analysis using GIS is necessary to ascertain whether current DRR programs are successfully reducing risks and losses.

vi. Rural flooding has become recurrent in many rural regions of the country. However, the government still lacks an inclusive rural development plan at both the federal and provincial levels. It is crucial to address the multidimensional facets of rural risks by combining DRR interventions with socioeconomics, and infrastructure development. Furthermore, to reduce the multi-faceted poverty brought on by floods, especially in rural regions, policy must place a high priority on human capital investments, especially education, skill development, and healthcare.

vii. As suggested by the SFDRR, the BBB principle should be prioritized during recovery and rehabilitation. This should be achieved by building flood-resilient infrastructure in areas that have been severely impacted in the past, using GIS-based land use planning (Der Sarkissian et al., 2022). Additionally, in flood-prone areas, a geospatial approach must be utilized to rebuild and increase micro, small and medium business (LEHAN, 2022). Other initiatives include comprehensive flood risk assessments, capacity building, resilient agriculture practices, and the establishment of a flood research center (Jan et al., 2024).

viii. It is essential to incorporate CCA into comprehensive flood control policies. Pakistan is highly vulnerable to flood risks, due to its monsoon climate (Ullah et al., 2021), and limited resources (Khan et al., 2019). Therefore, all national and provincial public investment decisions should incorporate climate and disaster risk screening. To guarantee adherence to resilience standards, every significant infrastructure project must undergo a thorough risk assessment, following the examples of Bhutan and Madagascar (UNDRR, 2024).

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