Pakistan's Flood Management Strategies: A Critical Review of Disaster Preparedness, Response, and Risk Mitigation

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Abstract: Pakistan has been challenged by recurring floods due to its critical climatic location, causing widespread damage affecting both lives, agriculture, local infrastructure and public health. In relation to it, the policies in the sector of pre and post disaster management in Pakistan still need improvements; e.g. the floods of 2010 and 2022 in Sindh, Pakistan, the large-scaled crisis exposed major loopholes and lacking in the disaster management system. This study critically reviews the flood management and its effectiveness in Pakistan. The aim of the review is to evaluate and review Pakistan's flood management strategies, assess disaster management and its effectiveness in minimizing the risks, and analyze responses to the current trends. It covers the areas in flood management such as pre- and post-disaster management and public health reforms for a detailed understanding. Based on the review it highlights important areas for improvement in the policy and government sectors that deal directly with local interventions to improve public health, increase flood resilience, and identify areas that need attention for future preparedness and immediate response. Further, the recommendations and implications have been given at the end for review, such as; initiatives to improve early warning system, trainings and education for locals and relevant community members, the need of nationwide campaign, filling the gap between government agencies and non-government organizations, building barriers, and so on. the steps could be taken to improve and prevent/minimize the intensity of destruction for future.

Keywords: Flood Management, pre- and post-disaster management, Health & hygiene, Public Administration.

1. Introduction

The catastrophe like floods in 2010 and 2022 in region of Sindh, Pakistan shows how evident natural disasters are in Pakistan and its high vulnerability to the natural crisis. These events affected millions in different ways, including; the destruction of infrastructure, major displacements from rural to urban areas, affecting the health of the population regardless of age and damaging the lands and livestock. while people faced the flood, the major damages were caused by lack of pre-disaster management where Deforestation, poor planning, and insufficient drainage system further intensified the damages.

Despite the present National and provincial disaster management frameworks, Pakistan struggles with flood preparedness and response. It has major been observed to have weak early warning system & delayed emergency relief that keeps the lives on stake. additionally, the gap of coordination between government and humanitarian agencies obstructs disaster mitigation efforts. While in the crisis the lack of WaSh (clean water, sanitation, and hygiene) services and health risks further add to the damages.

Natural disasters that have occurred in Pakistan so far include the yearly tropical storms and coastal rains, the ongoing melting of glaciers, and the eruption of glacial lakes, which cause flooding in Pakistan's northern and southern areas. In addition, millions of people in the Punjab and Sindh regions are at risk of dying each year due to the growing frequency of heat waves and the threat of riverine

floods. The UN stated that the current floods in the Sindh region in 2022 affected 33 million people, resulting in 5.9 million people being displaced, 9.4 million land being destroyed, and 1.1 million livestock being killed, directly illustrating the severity of these damages caused by natural disasters (Eckstein et al., 2021; United Nations Office for the Coordination of Humanitarian Affairs, 2022). Pakistan geographical location and climate conditions are highly observed to be prone to floods, especially in the monsoon season like the floods of 2022 were the most devastating in the history of Pakistan , affecting the approximately the one third of region especially Sindh and Balochistan. according to the world bank report , It resulted into damages and losses exceeding the 30 billion USD where the damages exceeded 14.9 billion and economic reached up to 15.2 billion. the floods did not only affect the population during the crisis but also the post-disaster, needing the authorities to provide clean water, sanitation, and healthcare services. The World Health Organization reported in August 2022 that the stagnant flood waters were leading to health threats and risks to further spread of diseases like malaria, dengue, fever, and cholera.

Even though the National Disaster Management Authority was structured under the act of Disaster Management 2010 the challenges kept recurring, the floods of 2022 highlighted the need to evaluate the existing management, policies, and their execution to reduce the gaps and improve the system to prevent any further damages in future or preparedness for any climatic disaster.

The present situation of frequencies and flood events in Pakistan calls for a critical evaluation the effectiveness of the current system and existing management strategies. the aim of this study is to evaluate and review Pakistan's flood management strategies, assess disaster management effectiveness in minimizing risks, and analyze response to the current trends.

2. Significance of the Study

This study highlights the areas to be improved in Pakistan by assessing the weaknesses in pre and post-disaster management system, identifying gaps, highlighting the importance of WasH areas in health risk management, and providing insights on present preparedness and response. It also addresses key public health challenges for improvement. The government or policy makers along with the authorities who work in the above-mentioned sector could use the study for a wider cause and reduce the key challenges to support the public health and hygiene that comes under threat under crisis. Policy makers could utilize it to modify or reform the policy frameworks.

3. Floods in Pakistan

Globally, there has been a noticeable shift in the climate throughout time. According to Ajani and van der Geest (2021), severe weather, frequent occurrences of excessive rainfall & floods, cloudbursts, along downpours may have been witnessed in urban as well as rural regions over the past few years. One major environmental risk that puts infrastructure & human lives as well as their hygiene issues at serious danger is flooding. Floods are dangerous hydro meteorological phenomena that have the potential to cause catastrophic occurrences in many parts of the world. Changes in the climate, population increase, & growing cities are making metropolitan regions increasingly vulnerable to devastating thunderstorms, flash floods, & sewage malfunctions (Hassan et al., 2024).

According to Ferdowsi et al. (2024), the two biggest effects of the changing climate on residential water distribution systems are catastrophic flooding & water scarcity. Between fourteen & twenty million people died in Pakistan's disastrous floods in 2010 & 2011, which also damaged over a million houses followed by 436 healthcare institutions, resulting in several health & hygiene problems (World Food Programme, 2023). Arshed et al. (2023) state that Pakistan is situated in a danger zone for adverse weather therefore is susceptible to many floods that may result in substantial harm throughout different regions of the country. Tens of thousands of fields of arable land were inundated by the most severe flash flood in Pakistan's history, which happened between mid-June & August 2022 (NASA Earth Observatory, 2022). The UNO characterized the span ending in August as an exceptional climate disaster, with this flash flood receiving almost two times the volume of rain compared to the 30-year norm. The rural economy, encompassing agriculture, livestock, seed reserves, animal husbandry, agricultural products, hygiene & health, alongside forestry, has been significantly impacted by flash floods (Ruidas et al., 2022). Storms & the appearance of strong rainfall during monsoons are the primary causes of land slide & severe flooding in Pakistan (Bowen et al., 2021). Pakistan's irregular topography

& robust precipitation patterns during the monsoon season render it susceptible to flooding (Sajjad et al., 2019). Throughout the boundaries of Sindh Province, floods typically occur in July & August, which are commonly known as the monsoon season. As of the assessment of National Disaster Management Authority (NDMA), nearly one third of those affected have been harmed by the floods through mid-June 2022. Following the seventeenth of October in 2022, the Pakistani government designated 85 districts as "calamity-hit" (Brath et al., 2002). Pakistan's Sindh province suffers several difficulties that lead to great pain for people, disruption of their livelihoods, severe damage to infrastructures & problems with their health and hygiene.

However, the yearly monsoon season feeds the disintegration of the Himalayan glaciers, which in turn greatly increases the water flow of the Indus River (Chai & Wu, 2023). The river's limit may be exceeded by such meltwaters & intense monsoon rains, resulting in barrier breaks & extensive flooding throughout the area of floods. The land's capacity for retaining water is diminished by unchecked deforestation across the Indus River's reservoir regions, which increases precipitation from the surface & causes floods downstream (Chai & Wu, 2023).

3.1. Pre Disaster Management in Pakistan

Climate change has led to a considerable rise in the occurrence & severity of water-based catastrophes, which include hurricanes, storms, & floods (Rana et al., 2021). Because socio-ecological systems are becoming more vulnerable, these issues have created serious risks to societies. Ineffective management of these circumstances will result in several further serious emergencies, such as problems with food (food supply & food hygiene), outbreaks of illness, as well as poverty as a result of a lack of resources to deal with these emergency situations (Pardana et al., 2022). In these situations, disaster management officials should prioritize managing risks & prevention. Thus, in contrast to widely used catastrophe response techniques, early warning systems (EWS) are successful in managing risks & prevention (Rana et al., 2021). The prevalence & severity of floods has increased as an outcome of the concerning state of catastrophic climate conditions. Pakistan has seen devastating earthquakes, floods, & rainy seasons that have severely damaged infrastructure, crops, animals, as well as human life (Majeed, 2023). According to research by the Federal Flood Commission (FFC), Pakistan has seen no less than 28 super fluid floods throughout its founding. The deadly effects associated with these terrible floods were mostly caused by the absence of an effective disaster management system (Anees, 2022).

Post-flood situations in Sindh must be predicted using a diverse methodology. For this procedure, hydrological modeling is essential. Hydrological models may estimate prospective flood eventualities depending on climatic circumstances by combining previous data on rainfall, the flow of rivers, & earlier flood occurrences (Haji Seyed et al., 2021). Such models are able to get further improvement by including information on the trends in deforestation, adjustments to land use, & possible shifts in melting glacier quantities caused by changing climates (Hamidi et al., 2022). Predicting the maximum intensity and duration, alongside the start time of rainfall is essential for accurate forecasting, which cannot be done in the absence of appropriate models. Integrated flood risk frameworks have been created for Sindh using modern predictive modeling approaches. For the purpose of improving forecast accuracy, information from multiple locations, including photos from satellites & hydrological data, has been included. Furthermore, locally owned adjustment techniques have been emphasizing programs that improve the ability to adapt along with endurance (Khan et al., 2017). Finding susceptible locations & charting zones that are susceptible to floods have both benefited greatly from hydrological modeling. As found by Ullah et al. (2023), who studied community members chosen from districts, the community bemoaned the absence of appropriate early warning systems, pointing to situations in which poor communication caused mayhem during emergencies. Additionally, the community members voiced discontent with government agencies' performance in responding to disasters & early warning systems (EWS), pointing out that authorities frequently offered little assistance amid emergencies.

3.2. Post-disaster management in Pakistan

Government organizations in Pakistan have frequently overlooked the significance of comprehending early warning systems & social preparation in favor of post disaster management & society restoration (Ullah et al., 2023). Nonetheless, reducing the effects of catastrophes requires a strong sense of public concern & readiness. Supervision & administration of disaster preparedness & recovery operations are carried out at the National Operations Center (NEOC), which is the primary governing and command structure. At the province level, it acts as the main hub for coordinating post disaster management & recovery efforts. It is difficult for Sindh Province's current EWS to adequately emphasize risk understanding. To gather & examine crisis-related data, it makes use of tools for example the Disaster

Management Information System (DMIS), Multi-Hazard Vulnerability & Risk Assessments (MHVRA), & risk analysis. UNICEF's emergency WASH strategy emphasizes crisis & natural catastrophe preparation. Measures related to water, sanitation, & hygiene are essential for individuals to survive during humanitarian disasters as well. Further the post risk management also needs to take actions in WaSH area, according to the study by Alareqi et al. (2024), WaSH actions are seen as crucial humanitarian responses during emergencies, particularly when it comes to stopping the spread of illness. Prompt WASH delivery in emergencies may reduce infestations & the overall cost of illness & mortality linked to natural or human-caused catastrophes from increasing. During crises, occurrences of diarrheal illnesses, such as cholera and dysentery, are frequent. Polluted water (at origin & when in use), a shortage of water (volume), inadequate sanitary availability or usage, an absence of soap & washing up supplies, & polluted food have all been recognized as potential triggers for dissemination in post-response case analyses & epidemic studies (Al-Hamawi et al., 2025). In post-emergency situations, WASH services may assist impacted populations in the long run. In addition to offering instant assistance, these services strengthen WASH services' endurance, especially during prolonged crises, allowing them to more effectively handle as well as adjust to emerging disruptions (Krishnan, 2019).

3.3. Health and hygiene issues

The physiological, social, demographic, & economic facets of human existence are all impacted by natural disasters. Even though the effects on health are consistent throughout disasters, the severity of each effect (such as death, sickness, etc.) varies depending on the nature, the degree of disaster, & people's susceptibility (Diaz-Sarachaga and Jato-Espino 2020). According to Schultz (2024), in comparison with actively employed individuals, youth & elderly citizens (those over 65 & fewer than 18) are particularly vulnerable to the hygiene issues associated with natural catastrophes like floods. Similarly, Menne et al. (2013) contend that newborns' underdeveloped immune systems, restricted movement, & lack of motor skills make them prone to infections. According to Raza et al. (2023), areas impacted by flooding provide perfect conditions for diseases to flourish, particularly malaria mosquitoes, which can transmit health and hygiene issues.

Weather-related emergencies are becoming more common & severe in Pakistan. These occurrences affect infrastructure, towns, and ecological systems, & cause human displacement (Saeed et al., 2024). The nation is vulnerable to several natural disasters, including landslides, seismic waves, hurricanes, floods, and tropical cyclones. With regret, the hardest-hit populations tend to be underprivileged. They are particularly susceptible to disaster especially the effects of climate change because of their dependency on relatively scarce commodities including water, cattle, & agricultural production (Aziz et al., 2024). In Sindh, floods have disastrous ecological & financial implications. Communities are uprooted, occupations are disturbed & vital grounds including bridges, roadways, & transportation systems are harmed by these occurrences. Floods may additionally enhance the danger of illnesses caused by water by contaminating water supplies. It is anticipated that the recent floods will have a major effect on Pakistan's economic health (Aziz et al., 2024).

World Bank (2022) reports that nearly fifty percent of the nation was hit by the 2022 floods, which also damaged 13% of the country's healthcare facilities. This led to a disruption in the provision of health services at all levels, from the fundamental level (Rural Medical Centers & Critical Health Centers) to the second level (District Headquarters, Tehsil Headquarters, & Civil Hospitals). Over one-fifth of the services that were impacted suffered destruction. The existing alarmingly high rate of poverty has significantly risen. Approximately 4 million children do not have a source of health care, and 650,000 pregnant women are having difficulty accessing maternity treatments. The prevalence of infectious illnesses including dengue, pneumonia, severe diarrhea, & influenza is significantly rising in Pakistan. Because of the limited availability of facilities like vaccinations, regular medical treatment, consisting of persistent illness medication, health care for mothers & children, & the possibility of increased needful medical expenses, disruptions in the provision of wellness programs will exacerbate health disparities for the underprivileged & impoverished.

Cholera, digestive disorders, dengue virus, sickness, polio, as well as skin illnesses were all spread by the current floods (WHO EMRO, 2022). Before the floods, Sindh, Balochistan, & Punjab had previously identified 290 verified instances of cholera (Disease Outbreak News, 2022). Diarrheal illnesses are now so common that they cause 40% of the total fatalities in disaster areas & shelters where a variety of hygienic problems arise from overpopulation & water contamination from toxic chemicals & feces (Al Jazeera, 2022).

4. Summary

In Pakistan's Sindh province, floods constitute a frequent natural disaster that endangers residents, infrastructure, & the economic system as a whole. Numerous researches have looked into different methods for predicting floods in Sindh. Tragic effects are caused by floods everywhere. Global warming has significantly raised the occurrence & intensity of flooding. The 2010 megafloods & the 2022 seasonal floods, which affected several million people, were two of the greatest devastating flood storms to hit Pakistan in the past century. Despite having a very small environmental impact, Pakistan is severely impacted by warming temperatures (United Nations, 2010). As per the Greenwatch global climate risk index, Pakistan is the fifth most impacted country & most susceptible to climate-based disasters. In the nation, floods—whether downstream or flash have become a common occurrence. Nationwide floods are becoming more frequent, and severe, & lasting longer each year (Ali et al., 2022). As a result, floods are becoming increasingly frequent. Exposure (infrastructural, societal, financial, organizational, or psychological components) is quickly growing as a result of diminishing capacity & growing sensitivity.

5. Recommendation/Implications for Flood Management in Pakistan

Based on the above critical review, the following recommendations are made for different authorities to step forward for flood management and post disaster management in Pakistan:

- The management needs to improve the early warning systems e.g. meteorological forecasting and improvising the community-based alert system
- There is a need to construct flood barriers and an efficient drainage system
- The government needs to introduce large-scale reforestation projects in the flood-prone areas
- Need for preparing nationwide campaign against the disaster to prepare the population and educate the communities on risk mitigation and strategies to cope with the crisis
- For better forecasting and decision making upgrade the disaster management system with real-time data
- To ensure smooth communication on the ground during the disaster, create clear protocols for both national and provincial bodies.
- Use advance tools to asses the risk and create proactive policies
- Initiatives are needed to improve the rural livelihood by introducing climate-smart agriculture with community training programs, and financial assistance for farmers
- Initiatives are needed to improve the coordination between locals, authorities, and Natural disaster management authorities
- Preparedness for local health improvement system is required to provide access to flood-stricken areas with water, sanitation, and medical services
- Initiatives are needed to fill gap between the government agencies and international or private organizations efficient results
- The government needs to take initiatives to develop and adopt multi-layered flood risk management approach that should include the understanding of land usage, knowledge of deforestation areas and glacial melt patterns to increase the preparedness
- Ensure the medical supplies are available and infrastructure is developed to address the needs beforehand for vulnerable population such as infants and children, pregnant women, elderly persons
- Ensure the long-term health care planning and resources are taken into light while planning for preparedness.

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