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A Comprehensive Review on Flood Disaster and Mitigation Measures in Context of Nepal

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Abstract:

Floods are one of the most devasting and frequent natural disasters in Nepal, causing significant loss of life, property, and livelihoods annually. This comprehensive review synthesizes existing research to provide a holistic understanding of flood disasters and mitigation strategies within the Nepali context. It examines the key drivers of floods, including intense monsoon rainfall, fragile Himalayan geomorphology, glacial lake outburst floods (GLOFs), and human induced factors such as deforestation, land use change, and unplanned urbanization. The paper then systematically reviews the current and proposed mitigation measures. This includes both structure measures like embankments, river training works, and gabion walls, as well as non-structural and community-centric approaches. A major focus is placed on the evolution and effectiveness of disaster risk reduction (DRR) policies, particularly the shift from a response-centric to a proactive risk reduction framework. The role of technological advancements, such as GIS and remote sensing for hazard mapping and early warning systems (EWS), is critically assessed, alongside the importance of community-based EWS in saving lives. Furthermore, the review explores the challenges and opportunities in trans boundary cooperation with neighbouring countries like India and china, which is crucial for managing shared river basins. By identifying gaps in policy implementation, research, and institutional capacity, this review aims to provide valuable insights for policymakers, researchers, and practitioners to enhance Nepal's flood resilience and contribute to sustainable development in a highly vulnerable and dynamic environment.

Keywords: *Flood disaster, Mitigation Measures, Climate change, Himalayan Geomorphology, Early Warning Systems (EWS), Monsoon, Glacial Lake Outburst Flood (GLOF), Vulnerability Assessment, Policy and Governance, Structural and Non-structural Measures*

1.0 Introduction:

Nepal is a landlocked country with a diverse geography ranging from the high Himalayas to the flat Terai plains which are highly vulnerable to a range of natural hazards. Among these, floods are the most frequent and destructive, causing immense annual damage to lives, livelihoods, and infrastructure(Dewan,2015).The country's unique hydro-geological setting, characterized by steep slopes and a powerful monsoon season, makes it a 'hotspot' for flood-related disasters. While past efforts have focused on a top-down, engineering-centric

approach, recent research and policy have begun to shift towards decentralized, community-driven strategies. This review paper synthesizes the current understanding of flood dynamics and risk reduction in Nepal, with a specific focus on the effectiveness of diverse mitigation measures.

2.0 Statement of the Problem:

Nepal's steep topography and fragile geological structures combine with heavy monsoon rainfall from June to September, make the country highly susceptible to flash floods and landslides. The overwhelming river system during monsoon season creates huge disaster in low-lying Terai region which should not be underestimated. These floods affect disproportionately to vulnerable population destroying their homes, crops, and livestock leading to food insecurity, displacement and rise in waterborne diseases. The destruction of various infrastructures like roads and bridges hampers rescue and relief efforts, isolating the communities. Basically, flood in Nepal cause immense damage to agriculture which is a key aspect of Nepal's economy. Unplanned urbanization poorly coordinated and designed infrastructure project and lack of a proactive, coordinated approach to disaster management are major problem to be addressed for obtaining sustainable solution regarding to flood disaster in context of Nepal.

3.0 Objectives:

- To analyse the primary causes and types of floods in Nepal.
- To assess the socio- economic and environmental impact of flood disasters.
- To review and evaluate existing flood mitigation and management strategies.
- To identify research gaps and propose future recommendations for effective flood risk reduction.

4.0 Literature Review:

Nepal's unique and challenging geography, characterized by the rugged Himalayas, the hilly middle region, and the low-lying Terai plains, makes it highly susceptible to a range of water-induced disasters, with floods being a major recurring threat. Monsoon-driven river flooding, flash floods in steep terrains, and glacial lake outburst floods(GLOFs) are the primary types of flood disasters that plague the country(Sharma et al.,2023).Historical data underscores the severity of this issue, with thousands of flood events, deaths, and significant economic losses recorded over the past several decades(Shrestha, Rai,& Marasini,2020;Reliefweb,2017).The impacts are particularly devasting for marginalized and impoverished communities, who often live in the most vulnerable areas and face immense challenges in recovery(UN Spider, n. d.).

Basically, a lot of factors are liable in contributing this type of huge disaster in Nepal. The primary cause is the intense, seasonal monsoon rainfall, which leads to river overflow the banks and causes a huge inundation especially in Terai region. Beside this other factors mostly, pertaining to such catastrophic disaster are geographical and environmental factors, anthropogenic factors, climate change respectively. Nepal possesses young and fragile Himalayan Geology which in combination with erotic monsoon leads to soil erosion and landslides. This in turn block rivers and trigger flash floods (Basnet& Singh,n.d.). Likewise,

deforestation is also equally liable in supporting this vulnerable aspect in upstream due reducing land ability to absorb water (Sudmeier-Rieux et al.,n.d.).

In addition to geographical and environmental factors, human factors also cannot be neglected regarding to this natural hazard issue. Unplanned urbanization, settlement near river, poorly design infrastructure, hydropower projects basically play a vital role to immense obstruction to natural drainage which worsen the impact of flooding (Delalay et al., 2020; UN Spider, n.d.). Likewise, in many recent researches it has been observed that the rainfall pattern is changing due to climate change which leads to more frequent and intense rainfall activities. This in turn causes to increase in flood frequency leading to severe floods, landslides and GLOFs (ICIMOD, n.d,; ReliefWeb,2024)

4.0 Flood Mitigation and Management Measures:

From very beginning, flood management in Nepal has been dominated by a "structural" or "engineering'' measures especially a large scale embankment. But with passage of time this has been criticized by the local community for not effectively addressing the issues. (UN Spider,n.d.).

Now, it requires more comprehensive, multi-faceted approach that combine structural and non-structural measures including community for effective solution of concern problem.

4.1 Structural and Engineering Measures:

These measures include the following assessment:

- River training and Embankment works
- Early warning System(EWS)
- Hydrological Modelling
- Use of Geospatial Technologies.

Whatever traditional methods may be implemented for mitigating flood hazard but these days modern studies is being gaining popularity with utilization of advanced technologies like remote sensing(RS),Geographic Information System(GIS) and hydrological models(e.g., HEC-RAS) for flood hazard mapping, risk assessment and floodplain analysis (Shrestha et al.,2022;Adhikari,2013;DPNET Nepal, n.d.).These tools basically assist in identifying vulnerable areas and land use planning. (Khanal, shrestha, & Ghimire,2007)

4.2 Non-Structural and Community-Based Measures:

These measures include the following assessment:

- Community-Based Flood Risk Management(CB-FRM)
- Land-Use Planning and Zoning
- Social Protection and cash Transfers
- Policy and good Governance.

Empowering local community and building resilience is mostly used approach (Sharma, 2021).integrating local knowledge and practices, forming disaster management committees

and providing training regarding to search, rescue and first aid.Forest Action Nepal are essential parameters for community based flood risk management(CB-FRM).Beside this restricting settlements and development by implementing better regulation and institutional framework is one of the major fundamental aspect to address this issue. Nepal Red Cross Society's pilot projects has shown that post-disaster assistance especially multi-purpose cash transfer seems to be helpful for affected household in recovery.(ReliefWeb,n.d.).Whatever discussed of all good policy and governance are required to meet the objectives.

Probably, Nepal possesses good policy but due to fragmentation there is no clarity in roles and responsibilities between provincial and local governments (Oxford Policy Management,n.d.) .This affect vulnerable community in long run which sounds bitter.

5.0 Research Gaps and Future Directions:

Though there are sever studies on flood hazard issues but still they have to be explored due to gaps in literature on flood management aspect in Nepal which can be pinpointed as:

- Marginalized group must be focussed such as migrant household which often have lower resilience scores.(Sharma et al.,2023)
- Various advance technology such as remote sensing (RS), geographical information system (GIS) must be integrated in ground reality in between community.
- Urbanization area and hydropower project must be especially focussed regarding complex interplay between climate change, land-use change and flood risk potential.
- There must be a systematic evaluation regarding to policy framework, current legislative and institutional as well as community resilience.

6.0 Conclusion:

To ensure effective planning and implementation regarding to flood risk and its mitigation measure following things are noteworthy for attaining optimal solution.

- Non-structural measures must be supported.
- Integrate both structural and non-structural measures efficiently and effectively.
- More investment must be done in research and technology.
- Trans-boundary cooperation must be promoted.
- Support local governments and communities to lead and manage their own disaster risk reduction efforts.

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