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Mainstreaming ecosystem-based approaches into disaster risk reduction policies: a comparative study of Nepal, India, and Bangladesh

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ABSTRACT

Humanity faces a rising number of challenging disasters due to their increasing unpredictability and scale. While large-scale engineering solutions have been the mainstream approach, there is a growing acknowledgment that ecosystem-based disaster risk reduction (Eco-DRR) is a suitable approach in the long term due to its cost-effectiveness, social equity, and environmental sustainability. Governments worldwide are integrating Eco-DRR into policies and legislation. Here, we review the extent of integration of Eco-DRR into DRR policies and legislation in Nepal, India, and Bangladesh using content analysis based on five criteria: acknowledgment, inclusion, weighting, resources, and reflexivity. While Eco-DRR principles are acknowledged and included in the national policies of these three countries, they are not prioritized as compared to competing alternatives due to limited integration tools. Resource allocation is directed towards prevention and relief mitigation, with limited emphasis on research and capacity building, which are crucial for strengthening Eco-DRR. Notably, policy aspirations still need to be realized in legislative action. Strengthening Eco-DRR requires enhanced integration, capacity-building, and robust institutions to boost resilience.

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1. Introduction

The world has been experiencing various disasters for centuries such as floods, landslides, droughts, hurricanes, earthquakes, tsunamis, etc., resulting in a wide range of impacts, at varying scales and extents (GDAR 2021; IFRC 2020; IPCC,

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2014; Rosselló, Becken, and Santana-Gallego 2020). Disasters are not a new phenomenon, but their extent and severity depend on the level of preparedness to mitigate and cope with them (Coppola 2015). Data show that the total number of disasters in 2021—compared to the average over the last 30 years (1991-2020)—has increased by 13% resulting in an 82% rise in direct economic loss in the last three decades (GDAR 2021), affecting billions of people worldwide (Pathirage et al. 2015). Mead (2022) reports more than two million deaths between 1971 and 2019 from 11,000 climate and weather-related disasters, such as floods, landslides, droughts, tsunamis, etc. Several countries in Asia and Africa, in particular, are disproportionately affected by multiple disasters (GDAR 2021; Guha-Sapir, Vos, and Below 2011).

South Asia, a home for 1.8 billion people, is highly vulnerable to disasters due to a combination of factors, including its location in a seismically active region (Amarnath, Amarasinghe, and Alahacoon 2021; GDAR 2021), geologically fragile mountainous landscape (Wester et al. 2019), extremely high altitudinal gradient and climatic variability (Zhang et al. 2017), high population density (Dewan 2015; Mall et al. 2019), and widespread poverty (World Bank 2012). The region experiences diverse disasters, ranging from avalanches and earthquakes to glacial lake outburst floods (GLOF) in the Himalayas to the North, droughts and floods in the plains, and cyclones that originate in the Bay of Bengal and the Arabian Sea in the South (Dewan 2015; Wester et al. 2019). This region is the center for the highest population density and economic disparity (Wester et al. 2019), which, in combination with a lack of effective risk management practices, has resulted in an enhanced risk to people and physical assets (Kafle 2017, Dewan 2015).

Nepal, India, and Bangladesh share similar geological formations and river basins (Shrestha and Ghate 2016, Zhang et al. 2017), and have comparable cultural, environmental, political, historical, and economic characteristics (Poudel et al. 2024). These countries lack adequate early warning systems, disaster response plans, and emergency preparedness measures, which put a large proportion of people at high risk from disasters (Mall et al. 2019; World Bank 2012). Here, natural hazards related to rivers are often cascading in nature (Kafle 2017; Wester et al. 2019) and transcend across national boundaries (World Bank 2012). Sediment deposition, river channel shift, and erosion/floods are common along Himalayan rivers in these countries. A large population in these countries relies on agriculture as a primary means of survival, and many people in rural areas face several socio-economic challenges, including poverty, malnutrition, poor access to health care and drinking water, and limited access to development services (UNDP 2013). These challenges contribute to significant loss of life and property during disasters (Mathbor 2007; Rebotier, Pigeon, and Glantz 2021).

2. Ecosystem-based approach in disaster risk reduction (DRR)

While it is generally accepted that disasters are events that are largely beyond human control (Comfort et al. 1999), various approaches have been implemented to reduce their risks (UNDRR 2022). The common approaches include activities aimed at reducing the vulnerability of communities to disasters while increasing their resilience in the face of hazards (Lamont 2019; UNDRR 2022). Two most common DRR

approaches include structural and nonstructural measures. Structural measures involve physical interventions such as constructing hazard-resistant infrastructure (UNDRR 2015; UNISDR 2019), while nonstructural measures involve nonphysical approaches like early warning systems, disaster preparedness plans, and public education programs (Estrella, Saalismaa, and Renaud 2013; Faivre et al. 2018). Structural measures are often expensive, demand specialized expertise and resources, and may cause negative social (e.g. displacement, disregard of local concern and knowledge, etc.) and environmental impacts (e.g. loss of habitat, ecosystem services). There have been calls to shift towards a more balanced use of structural and nonstructural measures with a focus on ecosystem and community since the 1960s (Li and Eddleman 2002; Renaud et al. 2016; Moos et al. 2018).

Eco-DRR is considered sustainable since it is a holistic approach that focuses on preventing disasters rather than simply reacting to them after they occur (Gupta and Nair 2012; IUCN 2020). Eco-DRR is a branch of the broader concept of nature-based solutions (NbS), which involves using ecosystem-based approaches to address climate change and disaster-related challenges, including the restoration and maintenance of ecosystems and biodiversity (IUCN 2020). Ecosystems are often degraded by natural hazards like floods and soil erosion, but restoring healthy and functional ecosystems offers natural shields against common natural hazards while also sustaining human livelihoods by providing essential goods such as food, fiber, medicine, and construction materials (Dorren and Moos 2022; Gupta and Nair 2012; IUCN 2020). However, structural measures are still preferred over nature-based approaches (Moos et al. 2018) in Nepal, India, and Bangladesh due to their perceived effectiveness and faster implementation (IUCN 2020; Satake, McLean, and Alcántara-Ayala 2018).

3. Integration of Eco-DRR in the policy documents

Over the past three decades, the global approach to disaster risk reduction (DRR) has evolved significantly (Lamont 2019; Mannan, Haque, and Sarker 2021). In the face of growing climate-induced disasters, policymakers and practitioners explore several disaster governance approaches to mitigate disaster impacts. This is particularly crucial in the least-developed countries where limited resources pose a major challenge to effectively implement risk reduction strategies. The strategies have evolved with the guidance of international policy forums and organizations such as the Global Network of Civil Society Organizations for Disaster Risk Reduction, the United Nations Development Programme - Bureau for Crisis Prevention and Recovery, and the United Nations Office for Disaster Risk Reduction (Vij et al. 2020). Eco-DRR emerged as a competing strategy for mitigating disaster risks after the 2004 Indian Ocean tsunami which provided an example of how ecosystem services buffer the risk of disasters. Recent global agreements, such as the Sustainable Development Goals, Sendai Framework (UNDRR 2015), UNFCCC/Paris Agreement (UNFCC 2015), Ramsar Convention, and CBD's Decision XII/20 (CBD 2014) acknowledge the vital role of ecosystems and natural infrastructure in achieving sustainable development and disaster risk reduction (Faivre et al. 2018; Whelchel et al. 2018). This recognition has resulted in growing interest

worldwide in using ecosystem-based approaches for building resilience to disasters (Onuma and Tsuge 2018). Such approaches typically involve the use of natural infrastructure, including "green-grey" solutions (an integration of nature based approach and engineered infrastructure such as dams or dikes), as part of ecosystem-based strategies for DRR (Renaud, Sudmeier-Rieux, and Estrella 2013; Whelchel et al. 2018).

While previous studies have shown that the ecosystem-based approach is cost-effective (Sudmeier-Rieux et al. 2021) and scientifically validated (Ruangpan et al. 2020), there is limited understanding of the extent of its integration into national policies (Faivre et al. 2018; Ogra et al. 2021) in Nepal, India, and Bangladesh (Bhardwaj and Gupta 2021; Paudel et al. 2023; Poudel, Mishra, and Shaw 2021; Shaw, Islam, and Mallick 2013). This study aims to fill this gap by assessing the extent of integration of Eco-DRR into policy documents in these three countries.

4. Methodology

4.1. The conceptual framework for assessing the integration of Eco-DRR to DRR

We used a conceptual framework based on the key criteria developed by Mickwitz et al. (2009) and extended it by incorporating additional criteria proposed by Niedertscheider, Haas, and Görg (2018) and Runhaar, Driessen, and Uittenbroek (2014) (Figure 1).

We included five criteria for assessing the integration of Eco-DRR policies. The first criterion, "acknowledgment," denotes an explicit acknowledgment of Eco-DRR as one of the strategies of disaster management. It involves searching Eco-DRR in the introductory sections of policy documents (e.g. introduction, rationale, background) (Table 1). This section usually focuses on the "need assessment" of the policy in question and may contain a brief overview of historical milestones and future directions. The "inclusion" criterion refers to the integration of Eco-DRR principles in the policy. As disaster risk reduction involves diverse mitigation strategies, ranging from hard engineering to nature-based measures, the explicit mention of these principles reinforces a strong priority for integration. Eco-DRR includes sustainable management, conservation, and restoration of ecosystems to reduce disaster risk to achieve sustainable and resilient development (Estrella, Saalismaa, and Renaud 2013; Gupta and Nair 2012; IUCN 2020). The "weightage" criterion involves prioritizing ecosystem-based DRR relative to other alternatives. It is based on the argument that the issues should take priority in situations where contradictions between different policy objectives emerge (Lafferty and Hovden 2003). Additionally, the "resources" criterion signifies that a well-planned policy should come with commitments, often with financial and technical resources (Table 1).

There may be considerable uncertainties in the policies, which may have been known during their development or might have evolved due to changes in circumstances. The "reflexivity" criterion is a feedback mechanism to avoid unintended outcomes and ensure that lessons are learned and better integrated into forthcoming refinements (Edwards, Ranson, and Strain 2002).

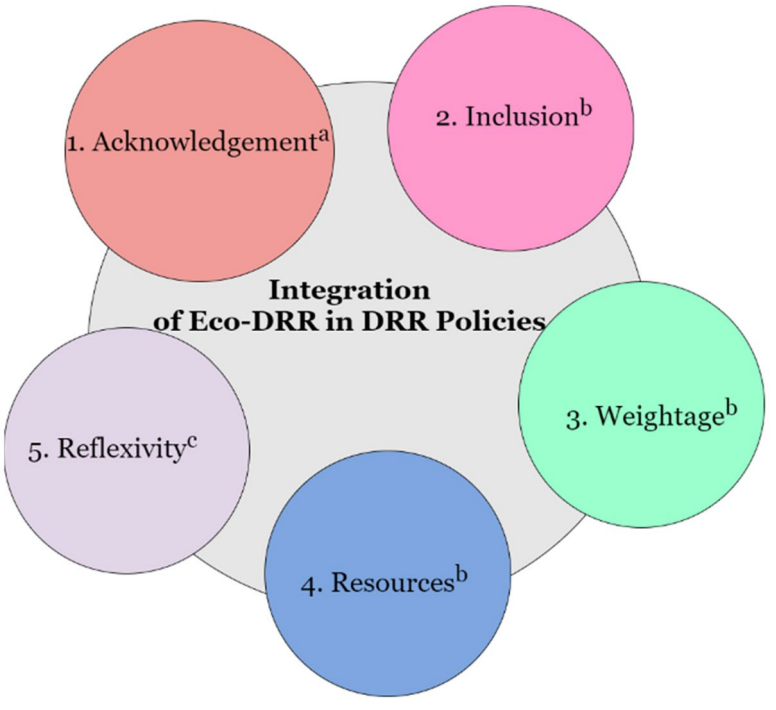

Figure 1. A Conceptual framework for assessing the integration of Eco-DRR in policy documents of Nepal, India, and Bangladesh. [a]Our additional criteria, [b]Mickwitz et al. (2009), [c]Runhaar, Driessen, and Uittenbroek (2014).

4.2. Data sources

We reviewed the latest policy and legal documents (e.g. strategy, plans, and legislations) at the federal level related to disaster management, mitigation, and risk reduction to gauge the extent to which ecosystem-based approaches have been integrated into them. The documents from Nepal included National Policy for Disaster Risk Reduction 2018 (MoHA 2018a), Disaster Risk Reduction National Strategic Plan of Action 2018-2030 (MoHA 2018b) and Disaster Risk Reduction and Management Act 2017 (GoN 2017). The DRR-related policy and legal documents from India included the National Policy on Disaster Management 2009 (NDMA 2009), the National Disaster Management Plan 2019 (NDMA 2019), and The Disaster Management Act 2005 (GoI 2005). The documents from Bangladesh included in the National Plan for Disaster Management 2021-2025 (MoDMR 2020) and the Disaster Management Act 2012 (MoDMR 2012). These most recent documents ensure the inclusion of the latest advancements in disaster risk reduction strategies and frameworks in the respective countries.

4.3. Data collection and analysis

We reviewed eight documents with a focus on the integration of Eco-DRR. First, we read each policy document carefully, using the guidelines provided in Table 1. We then extracted relevant information, ensuring that the question of the

Table 1. Assessment grid for integration of Eco-DRR in DRR policies.

1 Priority

1.1 Acknowledgement

Are Eco-DRR issues stated as a part of policy background?

Inclusion of either one of the following keywords in policy background: "ecosystem" "ecosystem restoration", "maintenance of ecosystem", "biodiversity conservation", "green infrastructure", "ecosystem services", "ecosystem-based adaptation"

1.2 Inclusion

Are Eco-DRR principles explained in the policy documents?

Conservation, restoration, and sustainable use and management of land, wetlands, ocean, and other natural resources strengthen our capacity to manage the risk of disaster and climate management.

- Restoration of the ecosystems
- Maintaining biodiversity and natural habitats
- Strengthening the sustainable use and management of ecosystems

1.3 Weighing

Does the policy give a higher priority to ecosystem-based adaptation compared to other measures?

The focus is on the relative priority given to ecosystem restoration, ecosystem services, ecosystem-based adaptation, and sustainable management, wherever applicable while acknowledging the interdependency between human well-being, ecosystems, and changing risk patterns.

1.4 Resources

Are adequate financial and human resources for the implementation of ecosystem-based approaches to disaster risk reduction ensured/guaranteed?

- Emergency fund
- Disaster Management Fund
- Budgetary arrangement
- Human resources

1.5 Reflexivity

Is learning over time encouraged based on reporting and valuation of policy measures?

- Documentation and reporting mechanism of program activities.
- Feedback mechanisms
- Refinement of knowledge
- Research integration

corresponding criteria was answered appropriately. The information was then categorized as "Yes (++)," "to some extent (+)," and "No (-)" to indicate the extent to which each policy document fulfills our assessment grid (Table 1) for the integration of Eco-DRR into DRR policies.

5. Results and synthesis

5.1. Overall integration

Our results show that Eco-DRR is acknowledged and included in the national disaster risk reduction policies of Nepal, India, and Bangladesh. However, there are marked differences in the level of integration among countries and between policies and legislations (Table 2). The results show three major patterns. First, Eco-DRR is acknowledged in the policy documents, suggesting the realization of ecological aspects in disaster management. Second, the priority of the ecosystem approach over competing alternatives (e.g. grey solutions), is not explicit in all countries. Third, policies are better integrated with the principle of Eco-DRR as compared to laws. A better integration of Eco-DRR in policies could be attributed to the fact that they can adapt more readily to changing circumstances and emerging knowledge. In contrast, laws are often more rigid and can take considerable time and effort to amend or update.

Table 2. Integration of Eco-DRR principles in DRR policies and acts in Nepal, India, and Bangladesh.

	Nepal		India		Bangladesh	
Criteria	Policy	Law	Policy	Law	Policy	Law
Acknowledgment	+	−	++	−	+	−
Inclusion	++	−	++	−	+	−
Weightage	−	−	++	−	++	−
Resources	+	−	+	+	+	+
Reflexivity	+	−	++	−	−	−

6. Integrating ecosystem-based adaptation in disaster risk reduction policies

We found that the DRR policies of Nepal, India, and Bangladesh acknowledged the need for Eco-DRR, but there are considerable differences. Nepal's DRR policy calls for the best utilization of local resources and knowledge. It aims to increase community resilience by "…implementing disaster risk reduction and management activities in a balanced way" [15] (MoHA 2018a). Bangladesh's DRR strategy discusses damage caused by cyclones and storm surges on the ecosystem, particularly on the Sunderbans (MoDMR 2020). The Sundarbans hold particular importance in Bangladesh. It harbors a large contiguous mangrove forest that supports exceptional biodiversity and ecosystem services (Aziz and Paul 2015). These services not only directly support the livelihoods of millions of people but also act as a shelter belt, protecting them from storms, cyclones, tidal surges, sea water seepage, and intrusion (Islam 2019).

While the background section of policy documents is just snippets, the core inclusion is reflected in the vision and proposed actions. Bangladesh's strategy calls for the preservation of ecosystem functions to reduce risks and is explicit about the need for integration of nature-based solutions in DRR plans, "mainstreaming disaster management into national and local strategies through incorporating nature-based solutions" [42] (MoDMR 2020). Such plans need to incorporate the nature-based solution by providing specific pathways for mainstreaming it, depending local context and situation. The policy adopts a broader perspective, focusing on climate change in the DRR approach (Mannan, Haque, and Sarker 2021; MoDMR 2020).

India's DRR policies are very explicit in terms of narratives on the potential benefits of ecosystem conservation and restoration. The Indian disaster strategy states, "restoration of ecological balance in Himalayan regions […] shelters will be eco-friendly and in consonance with local culture" [30] (NDMA. 2009). The policy refers to the Sendai Framework and calls for ecosystem-based approaches to reduce the underlying risk factors and mitigate future disaster impacts.

Eco-DRR sounds appealing to DRR professionals, ecologists, and policymakers as an alternative to the structural approach (e.g. grey solution) due to the presumed benefits of the low cost of development, operation and maintenance, availability of other provisioning ecosystem services and community ownership (NDMA. 2009; 2019). The same is true for Nepal and Bangladesh where large physical structures requiring huge investments are neither always feasible nor preferable as the countries are confronting poverty and other development priorities (Bhardwaj and Gupta 2021; Moos et al. 2018; Poudel, Mishra, and Shaw 2021). However, Eco-DRR projects in these countries are limited, focusing primarily on climate change-induced risk (Poudel, Mishra, and Shaw 2021), afforestation (Bhardwaj and Gupta 2021), and mangrove

restoration (Kayum, Shimatani, and Minagawa 2022). Projects addressing resilient infrastructure and urban environments are notably scarce (Mukherjee et al. 2022).

Eco-DRR projects need to take account of multifaceted aspects, ranging from social, and cultural to technological aspects tailored to the intervention sites (Dorren and Moos 2022; Paudel et al. 2023). This is an important aspect for the localization of solutions based on the ecosystem and risk of hazards in question (Gupta and Nair 2012; Renaud, Sudmeier-Rieux, and Estrella 2013). Such aspects are discussed in the policies of these countries. Bangladesh calls for integrating nature-based solutions into national and local DRR strategies.

India's strategies recognize ecosystems as socio-ecological systems and their conservation as a means of disaster risk reduction. Such an explicit acknowledgment, inclusion, and weightage suggest a heightened understanding of ecological sustainability (Bhardwaj and Gupta 2021; MDNA 2019). Such policy priority is not mirrored in the national legislation (Table 2) and there are several reasons for this. First, national policies mirror the global policy landscape, and national strategies in all three countries are developed after the Sendai Framework (Das 2012; Mannan, Haque, and Sarker 2021; Nepal, Khanal, and Sharma 2018; UNDRR 2015). The international policy significantly influences national policies through several pathways, including financial assistance with conditions, economic integration, responses to global challenges, and participation in multilateral forums. The 2015 UN World Conference on Disaster Risk Reduction and its associated Sendai Framework for Disaster Risk Reduction 2015–2030 provided an important appeal to consider the ecosystem approach in DRR plans (Dorren and Moos 2022; Faivre et al. 2018). One of the key impetuses for growing integration in policies could be due to wake-up calls from the global academic and research community to take proactive and preventive measures to deal with environmental change such as climate change, land use change, and biodiversity degradation (Mouzam 2020; Renaud, Sudmeier-Rieux, and Estrella 2013; UNDRR 2015; UNFCC 2015; Wester et al. 2019). Policy formation involves academia and decision-makers and is relatively fast and straightforward (Comfort et al. 1999; Hoffmann and Blecha 2020), whereas acts/regulations take a long time due to procedural requirements to get approval from the legislators (Ogra et al. 2021, Comfort et al. 1999).

Despite acknowledgement and inclusion of Eco-DRR in the national policy of Nepal, it is not prioritized over other alternatives as shown by null results on weightage criteria. This may be due to several factors working together. First, Eco-DRR is a relatively new area, and the pathways for mainstreaming ecosystem-based approaches into DRR plans are not well established (Cohen-Shacham et al. 2016; Upreti 2006). Second, the use of Eco-DRR is contingent upon the type of hazards, their scales, and the ecological characteristics of the region (Cohen-Shacham et al. 2016), including the underlying social-ecological mechanisms (Chaudhary et al. 2021). Such information is not readily available, and both ecologists and DRR professionals need practical training, including guidelines and protocols (Estrella et al. 2016; Gupta and Nair 2012).

The lack of resources is one of the main barriers to the successful implementation of Eco-DRR. The provisions for the establishment of funds at the federal, provincial, and local levels are included in national DRR policies in Nepal, India, and Bangladesh. Nepal's policy proposes the allocation of a minimum of 5% of the annual budget

to disaster risk reduction activities. Bangladesh's policy focuses on preparedness and makes arrangements for early purchases of materials. Human resources, notably technical experts, are very important (Onuma and Tsuge 2018). Nepal's DRR policy articulates, "human resources will be developed for the Climate and Disaster Risk Assessment by conducting training" [111] (MoHA 2018b) and Bangladesh's policy emphasizes research on climate risk. There is a need for a strong and explicit priority for capacity building and research related to Eco-DRR. The gap in knowledge, expertise, and skill makes it nearly impossible to implement Eco-DRR in a large infrastructure (Le Dé 2017; Ogra et al. 2021; Triyanti and Chu 2018). A study from the Western Ghats in India corroborated this assertion, showing that major barriers to integrating Eco-DRR stemmed from ambiguity regarding how ecosystems buffer the risks of disasters and the poor integration of projects with the Eco-DRR principle (Krishnanunni 2022). Nepal and Bangladesh are not exception, where limited resource to planning, implementation, and monitoring of Eco-DRR is a major challenge for its integration (Ahmed et al. 2016).

Periodic learning and documentation are important aspects of policy for regular refinement. India's NDMP asserts that it is a "dynamic document" that will be periodically improved to align with emerging global best practices and knowledge in disaster management (Table 3). However, the policy is silent about the feedback mechanism. Nepal's policy states that lessons learned from the Gorkha Earthquake of 2015 have been used to reformulate policies (see Table 3) and remains silent about future learning and integration processes. Evidence-based learning allows policymakers, practitioners, and communities to make informed decisions about DRR strategies and interventions. This requires research findings based on empirical data on various aspects of Eco-DRR and their integration into policy and practice.

7. Key challenges in integrating Eco-DRR policies in Nepal, India, and Bangladesh

Since Eco-DRR is an emerging and multifaceted approach, there is a need for a well-founded plan based on a multidisciplinary research and implementation framework—mostly legal and policy—to effectively implement it in disaster management (Dorren and Moos 2022). As discussed in the earlier section, policy commitments are neither reflected in the allocation of resources for research and human resources, etc. nor are legal instruments explicit for Eco-DRR integration. Legal instruments are the most straightforward integration tool as they create mandatory requirements. Such instruments are already in practice in similar environmental policy implementation (Das 2012; Nepal, Khanal, and Sharma 2018; Shaw 2012). For example, legal instruments can provide institutional mechanism and establish standards and guidelines for implementing Eco-DRR specific criteria in the infrastructure projects. India and Bangladesh have also put a greater emphasis on market-based approaches to disaster risk reduction, such as insurance and risk financing (Botzen, Deschenes, and Sanders 2019; Das 2012; Islam et al. 2021). A recent study from India explored the possibilities and challenges of introducing proactive disaster risk financing for enhancing disaster resilience at the national and sub-national levels. The study, based on respondent surveys, suggested that there is a strong demand for both ex-ante

Table 3. Eco-DRR in policy and the act of Nepal, Bangladesh, and India. The figure in parenthesis indicates the page number of the corresponding documents.

Type	Nepal
	1. Acknowledgement
Policy	1.1 The use of […] local characteristics and optimum utilization of local means, natural resources, knowledge, and skills is addressed [18] (MoHA 2018a)
	1.2 The mission of this policy is to substantially reduce the disaster risk and losses in environmental assets of persons, communities and nations and to increase their resiliency by implementing disaster risk reduction and management activities in a balanced way [15] (MoHA 2018a)
	2. Inclusion
Policy	2.1 Establish Eco Disaster Risk Reduction and Management Fund from Federal to Local and community level [132] (MoHA 2018b)
	3. Resources
Policy	3.1 Disaster management funds will be established at federal, provincial and local levels as per the law to mobilize the resources. [31] (MoHA 2018a)
	3.2 The federal, provincial, and local governments will allocate necessary budgets for disaster risk reduction and management programs to implement this policy. [36] (MoHA 2018a)
	3.3 Budget for the projects/programs on disaster risk reduction and management in sectoral Ministries and Departments". [191] (MoHA 2018b)
	3.4 Establish Eco Disaster Risk Reduction and Management Fund from Federal to Local and Community level. [132] (MoHA 2018b)
	3.5 Human resources will be developed for the Climate and Disaster Risk Assessment by conducting training". [111] (MoHA 2018b)
	3.6 Make a provision to allocate a minimum of 5% of the annual budget by all sectoral agencies for disaster Risk reduction. [130] (MoHA 2018b)
	3.7 Prime Minister Disaster Relief Fund Operation Regulations 2006. [33] (MoHA 2018b)
	4. Reflexivity
Policy	4.1 Taking into account the lessons learned and experiences gained from the implementation of the National Strategy for Disaster Risk Management 2009, the learnings and experiences of the Gorkha earthquake 2015 and recent other disastersfor reducing the existing disaster risks and preventing of new potential risks, this National Disaster Risk Reduction Policy 2018 has been prepared to build a safer, adaptive, and resilience nation from disaster risks [15] (MoHA 2018a)
	4.2 This strategic action plan takes into account the experiences gained from the implementation of the National Strategy for Disaster Risk Management 2009, experiences and lessons learned from recent major disasters including the Gorkha earthquake, and initiatives on Climate Change Adaptation and Sustainable Development Goals. [41] (MoHA 2018b)
	India
	1. Acknowledgement
Policy	1.1 Ecosystems are socio-ecological systems and managing ecosystem services is highly relevant for the purposes of disaster risk reduction [87] (NDMA. 2019)
	1.2 Promote the implementation of integrated and inclusive economic, structural, legal, social, health, cultural, educational, environmental, technological, political and institutional measures to prevent and reduce hazard exposure and vulnerabilities to disaster [44] (NDMA. 2019)
	2. Inclusion
Policy	2.1 Ecosystems of forests, islands, coastal areas, rivers; and the agricultural, urban, and industrial environment are also to be considered for restoration of ecological balances and sustainable development. Zonal regulations must ensure the preservation of natural habitats. [30] (NDMA 2009)
	1.2 Restoration of ecological balance in Himalayan regions and raising coastal shelter belt plantations in DM plans. The design of such shelters will be eco-friendly and in consonance with local culture. [30] (NDMA 2009)

(*Continued*)

Table 3. Continued.

Plan	1.3 Implementation of ecosystem-based approaches regarding shared resources, such as within river basins, mountainous regions, and coastlines [45] (NDMA 2019)
	1.4 Ecosystem rehabilitation or restoration entails a wide array of activities, including post-disaster clean-up, e.g. altering an oil spill, as well as replanting forests or mangroves. Restoring ecosystems following natural and human-made disasters can work to reduce the underlying risk factors and mitigate future disaster impacts [……] [88] (NDMA 2019)
	1.5 Healthy ecosystems not only play an important role in supporting recovery and reconstruction after a disaster but also in reducing future disaster risk. Yet at the same time, disasters also pose significant risks to the ecosystems and could pose threats to the populations of endangered species, disrupt wildlife conservation, or ecologically important habitats. The agreements on Sendai Framework, [….] bring disaster risk management and environmental professionals closer. It is important to also pay some attention to the environment, ecologically important areas, and wildlife conservation areas/ protected areas even though the approach to DRR will have to be quite different [….] [85] (NDMA 2019)
	1.6 It has, at its core, the integration of the economic, social, and environmental dimensions of sustainable development. [39] (NDMA 2019)
	1.7 Protected areas, ecosystems restoration and natural resource management that do not incorporate disaster risk reduction objectives represent a missed opportunity. [. .] Two key areas of environmental management for disaster risk reduction are: Environmental Monitoring and Assessment, Protected Area Management, and Ecosystem Rehabilitation. [87] (NDMA 2019)
	1.8 The following challenges of DRR have been discussed in some detail: a) Climate Change Risks b) Livestock c) Environment and Wildlife d) Cultural heritage sites, their precincts, and museums. [34] (NDMA 2019)
	3. Weightage
Policy	2.1 Environmental considerations and developmental efforts, need to go hand in hand for ensuring sustainability. Restoration of ecological balance in Himalayan regions and raising coastal shelter belt plantations need to be incorporated […]. Ecosystems of forests, islands, coastal areas, rivers; and the agricultural, […] also to be considered for restoration of ecological balances and sustainable development. Zonal regulations must ensure the preservation of natural habitats. [30] (NDMA 2009)
Plan	2.2 Implementation of ecosystem-based approaches regarding shared resources, such as within river basins, mountainous regions, and coastlines. [45] (NDMA 2019)
	2.3 Ecosystems are socio-ecological systems and managing ecosystem services is highly relevant for the purposes of disaster risk reduction. [87] (NDMA 2019)
	2.4 Protected areas, ecosystems restoration and natural resource management that do not incorporate disaster risk reduction objectives represent a missed opportunity. Failures to identify the mutual benefits of environmental management, risk reduction, and climate change adaptation are lost opportunities to protect lives and promote human well-being [87] (NDMA 2019)
	4. Resources
Policy	3.1 A National Disaster Response Fund may be constituted as mandated in the Act. The necessary budgetary allocations will be made as part of the Five-year and Annual Plans. [22] (NDMA 2009)
	3.2 National Calamity Contingency Fund (NCCF). [24] (NDMA 2009)
Policy	3.4 Besides the funds which are available through public funded schemes, efforts have also been made by the center to mobilize the resources from external funding agencies for vulnerability assessment, capacity development, institutional strengthening of response mechanisms and mitigation measures etc. [35] (NDMA 2019)
	3.5 National and State Disaster Response Fund [346] (NDMA 2019)
	3.6 The primary mechanism for funding DRR-related schemes and projects in India is through Public Funded Schemes at the Central and State level [350] (NDMA 2019)
Law	3.3 National Disaster Response Fund for meeting any threatening disaster situation. [22] (GoI 2005)
	5. Reflexivity
Policy	National Disaster Management Plan (NDMP) is a "dynamic document" in the sense that it will be periodically improved keeping up with the emerging global best practices and knowledge base in disaster management [31] (NDMA 2019).

(*Continued*)

Table 3. Continued.

	Bangladesh
1. Acknowledgement	
Policy	1.1 In recent times a cyclone and storm surge has changed its direction and is moving toward to south-western direction and causing substantial damage to the assets and the ecosystem, the Sunderbans in particular. [8] (MoDMR 2020)
2. Inclusion	
Policy	2.1 Mapping and management into rural development planning and management of, inter alia, mountains, rivers, coastal floodplain areas, drylands, wetlands, and all other areas prone to droughts and flooding, including through the identification of areas that are safe for human settlement, and at the same time preserving ecosystem functions that help to reduce risks; [65] (MoDMR 2020)
3. Weightage	
Policy	3.1 Mainstreaming disaster management into national and local strategies through incorporating nature-based solutions, inclusivity, and better use of science and technology will help us reach our goal [42] (MoDMR 2020) 3.2 The Perspective Plans of the GoB (Vision 2021 and 2041) while progressing with the development efforts, also focus on the integration of environment and climate change considerations in the growth strategy [11] (MoDMR 2020)
4. Resources	
Policy	4.7 Risk reduction programme used the historical data and climatic risk from the study and research to protect the investment and in building resilience […] [32] (MoDMR 2020)
Law	4.1 … early purchase in pre-disaster period for one or more years altogether from the cabinet committee concern to economic affairs to ensure supply, delivery or use of necessary materials or resources in emergency basis during disaster or post disaster situation [13] (MoDMR 2012) 4.2 …the Government may form a fund and establish a central relief store and district relief store… [21] (MoDMR 2012) 4.3 Executing method of 'National Disaster Management Fund' and 'District Disaster Management Fund' Management Fund and District Disaster Management Fund should be determined by the rules: Provided that, until the rules are not formulated in this regard, execution of those funds and fund money may be spent according to government financial rules and regulations [27] (MoDMR 2012) 4.4 National Disaster Management Fund' and 'District Disaster Management Fund: a) Grant given by the government b) Grant given by a foreign government, organization, or any international organization with the approval of the government c) Grant given by any local authority d) Donation given by an elite person of local level e) Money received from any other legal source [20] (MoDMR 2012) 4.5 'National Disaster Management Fund' would be maintained under supervision of Disaster Management and Relief Division […] [20] (MoDMR 2012) 4.6 Building effective data management and sharing information system can help to reduce the digital divide at every disaster cycle and can contribute toward both social inclusion and building resilience to future disasters [19] (MoDMR 2012)

and ex-post disaster risk financing solutions such as mitigation funds, credit arrangements, and risk transfer instruments. The study concluded that such diversified solutions will not only safeguard human lives and assets but will also foster short- and long-term development in disaster-prone regions (Panwar, Sen, and Shaw 2022). This sector however needs to be developed carefully given ethical concerns that the private insurance might stand to gain by receiving aid money via public premium support and therefore it requires robust evidence, monitoring, and evaluation (Surminski, Architesh, and Lambert 2019).

All these countries have a designated body at national, state, and district/local levels, providing a multi-level institutional mechanism to plan and implement various activities for disaster management (Das 2012; Mannan, Haque, and Sarker 2021; Shaw 2012). The institutional mechanism requires clarity of formation, role, and responsibility, for achieving the expected target (Das 2012; Nepal, Khanal, and Sharma 2018). Bangladesh has established a framework for the execution of multi-agency disaster management initiatives conducted by both government and non-government entities (MoDMR, 2012; Shaw, Islam, and Mallick 2013). Nepal has undergone multiple disaster governance paradigms, with the Ministry of Home Affairs exerting great influence as a nodal agency, primarily focusing on response and recovery. Civil society organizations and donor agencies represent changing patterns based on their priorities and experiences. The DRM Act of Nepal provides multiple tiers of disaster governance at different levels of government, but there is a lack of coordination among them (Vij et al. 2020). The act considers public and private enterprises as important stakeholders and proposes to provide training on disaster management to the community (MoHA 2018a; Nepal, Khanal, and Sharma 2018). Such broad acknowledgment of multi-action is not well established in India (Ogra et al. 2021).

In recent years, India has developed a very strong response system to disasters in terms of deployment of the National Disaster Response Force (NDRF), rescue operations, and last-mile access but a formal incorporation of Eco-DRR is still awaited. In some cases, even if the local government has taken a step in the right direction, its implementation is not done properly or is not replicated at the national level. For example, the notification of river buffer zones on either side of the river by the Uttarakhand government is a good step to give room for rivers and control the impacts of floods, but there is hardly any sign of its implementation (pers. observation R. Sinha). In the alluvial regions of north Bihar, the embankments have proven to be ineffective for flood mitigation time and again, and while high sediment flux is known to be the primary reason for flood disasters in this region (Sinha et al. 2019), sediment management is yet to find a place in river management strategies (Sinha et al. 2023). The focus is still on the 'command & control' approach involving structural interventions such as embankments rather than Eco-DRR approaches like floodplain zonation, sediment management, and flood insurance. Bangladesh faces challenges stemming from poor governance, limited information, and inadequate funding mechanisms. In Nepal, Eco-DRR is not well established institutionally and technically similar to India and Bangladesh.

Ecosystems that are diverse and in good condition are more resilient to the effects of disasters (G20 Summit, 2023). However, effective Eco-DRR requires a careful

integration of both social and ecological aspects (Paudel et al. 2023). It is important to integrate the knowledge into policy interventions, which requires establishment of the science of Eco-DRR as ecosystem mechanism of risk reduction is site specific (Paudel, Dhakal, and Sharma 2024). The midterm review of Sendai Framework for Disaster Risk Reduction 2015–2030 advises reconsidering risk governance, increasing convergence between various policy processes, and closely examining the relationship between society, economy, and environment (G20 Summit, 2023). Thus, the key challenges are to make Eco-DRR policies actionable by providing (a) explicit priorities, (b) funding, (c) institutional mechanisms, and (d) other integration instruments. Such instruments may include a variety of tools, ranging from economic incentives—both positive and negative (e.g. tax rebates, subsidies, market-based instruments, etc.)—aimed at promoting specific actions in disaster-prone areas, protocols/certifications, and communication and dissemination strategies (e.g. training, awareness, capacity building, etc.) to make Eco-DRR a reality. Since South Asia is highly vulnerable to the impacts of climate change and is projected to face a worsening situation (Bhardwaj and Gupta 2021; Estrella, Saalismaa, and Renaud 2013), ecosystem-based adaptation should be given priority to minimize the risks of both climate change and disasters.

8. Conclusions

Eco-DRR is acknowledged and incorporated into the national DRR policies of Nepal, India, and Bangladesh. However, it needs to be explicitly prioritized in Nepal and Bangladesh. In all three countries, legal instruments lack explicit provisions for integrating Eco-DRR principles. While policies provide an overall guidance, the lack of explicit mandatory provisions and other integration tools (e.g. awareness, communication and capacity building) suggest a huge gap in translating policy aspirations into actions. This is because the effectiveness of Eco-DRR depends on the type and scale of hazards and the ecological and social characteristics of the area in question. There is a need for a holistic approach, with a clear institutional mechanism involving diverse stakeholders such as local communities, academia, DRR professionals and practitioners and policy makers. A multifaceted array of tools is needed encompassing economic (e.g. tax rebates or subsidies, funding, and market-based instruments) and communicative (e.g. awareness, networking), including mechanism for research and capacity building to better integration of Eco-DRR principles in disaster-prone areas.

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