Chapter 4
Ecosystem-Based Approaches and Policy Perspectives in Nepal

Shobha Poudel, Bhogendra Mishra, and Rajib Shaw

Abstract Mountain ecosystems are particularly vulnerable to climate change since increasing temperatures and disruptive precipitation patterns have led to floods, droughts and other natural disasters. Ecosystem-based approaches to disaster risk resilience (Eco-DRR) and Adaptation (EbA), is a nature-based method for climate change adaptation (CCA). That can reduce the vulnerability of the ecosystem to extreme events enhancing sustainability in various sectors, including but not limited to agriculture, forestry, energy and water. Similarly, by increasing the resilience of vulnerable communities, EbA helps countries to meet the goals of the Sendai Framework for Disaster Risk Reduction. This study reviewed the existing Eco-DRR/EbA approaches and its integration into policy and planning in Nepal. Literature suggests that EbA approaches (1) enhance community adaptive capacity or resilience, (2) help ecosystems to produce goods and services for local communities and (3) is financially and economically viable in Nepal. However, EbA is not in mainstream for CCA so far in the country. Existing policies, institutional and political obstacles are the major challenges for the effective implementation, despite EbA has a high potential in Nepal. Policymakers should bring it into the mainstream of development that could make significant progress in mitigating the climate impact at local, provincial and national scales.

Keywords Climate change · Ecosystem-based disaster risk resilience · Ecosystem-based adaptation · Policy · Nepal

S. Poudel (✉) · B. Mishra
Science Hub, Balaju, Nepal

Policy Research Institute, Kathmandu, Nepal

R. Shaw
Keio University, Fujisawa, Japan

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4.1 Introduction

The mountain ecosystem of Nepal is the source of various ecosystem goods and services such as clean water, mountainous food and habitat for the mountainous animal etc. (Poudel and Shaw 2016; Spehn et al. 2010). The mountain environment is fragile to change, which increases vulnerability in the region in the context of climate change (Houet et al. 2010; Poudel et al. 2020). The number of natural hazards such as landslides and floods are more frequent which cause considerable human and economic losses every year (Poudel and Shaw 2015, 2016). Natural and climatic factors, such as heterogeneous topography can induce such hazards. These hazards can claim a number of lives and enormous losses of resources every year (Table 4.1). Human interventions also exacerbated these natural risk factors. In addition to that climate-induced disasters are expected to increase in number and intensity in the future (Mishra 2011; Poudel et al. 2017; Poudel and Shaw 2016). To minimize the risk from these disasters, the disaster risk reduction (DRR) system in Nepal relies mainly on response and rehabilitation rather than preparedness and mitigation (Nepal et al. 2018). The climate change adaptation (CCA) measures are still not in the mainstream of development. Ecosystem-based measures for Disaster Risk Resilience (Eco-DRR) or adaptation (EbA) have not been widely planned and implemented albeit they have a high potential for mitigating potential risk. As well as it contributes to sustainable development because of their mutual benefits. Hence, ecosystems should be incorporated as a part of climate-compatible infrastructure. It should be treated as an integral part of facilities and equipment that played a vital role to make economic resilience with climate change and its induced disasters (Emerton et al. 2016).

EbA is one of the measures to adapt to the adverse effects of climate change and induced disasters by using biodiversity and ecosystem services. It aims to reduce vulnerability and improve the resilience of ecosystems and people considering the potential vulnerability under the climate change scenario (Mensah et al. 2011). The application of EbA spans through the diverse ecosystems, geography, sectors and stakeholders across the countries around the world (UNDP 2015). Forest conservation and sustainable management to prevent rainfall-induced disasters such as landslides with more intense rains; restoration of degraded wetlands to protect against increasing floods are examples of EBA measures. As well as sustainable management of grassland to protect against floods and soil erosion; and agroforestry can contribute against changing climate enables production (Secretariat of the Convention on Biological Diversity 2009).

Eco-DRR is a well accepted tool for the DRR in a sustainable way (Renaud et al. 2013). As Eco-DRR has a number of co-benefits over the conventional engineering-based solution, it is recognized as a no-regret strategy (Daigneault et al. 2016; Renaud et al. 2016). Andrade et al. (2011) suggested to take in account when implementing EbA: (i) increase multi-stakeholder engagement; (ii) incorporate flexible operational and management structures; (iii) operating at several geographical areas; (iv) increasing the co-benefits of development and conservation goals; (v) rely on the

Table 4.1 Damages and losses of disaster incidents in Nepal in 2018

Damage and losses of disaster incidents										
S. No.	Incident	No. of incidents	Death			Injured	Affected family	Houses destroyed		Estimated loss (NPR)
			Male	Female	Total			Partial	Complete	
1	Floods	418	128	55	183	61	16,196	14,424	286	60,944,400
2	Landslides	483	96	65	161	182	1083	149	328	191,662,000
3	Lightening	432	87	72	160	551	618	23	14	14,687,000
4	Fire	3973	74	76	150	557	6027	549	3234	6,422,638,013
5	Cold wave	48	26	22	48	0	48	0	0	–
6	High Altitude	45	37	4	41	6	46	0	0	–
7	Heavy Rainfall	342	8	22	30	84	538	193	252	89,415,160
8	Animal Terror	141	14	8	22	69	280	136	8	4,390,150
9	Wind storm	254	7	12	19	84	1527	763	301	51,447,998
10	Boat Capsize	10	9	7	16	9	27	0	0	–
11	Epidemic	22	11	4	15	1881	420	0	0	–
12	Snake Bite	18	7	7	14	5	18	0	0	–
13	Snow storm	2	10	0	10	0	10	0	0	–
14	Avalanche	1	1	0	1	0	1	0	0	–
15	Hailstone	3	0	0	0	0	127	2	0	457,000
16	Others	189	54	45	99	150	289	69	10	3,181,599
Total		6381	569	399	968	3639	27,255	16,308	4433	6,838,823,320

Source The Government of Nepal—Ministry of Home Affairs (MoHA) (2019)

best available evidence based on indigenous knowledge; (vi) enhancing the resilience of the most vulnerable people and (vii) ensure the active participation of socially excluded groups. Climate change is a cross-cutting issue and should be incorporated into different policy fronts. In this study, the integration of Ecosystem-based approaches within policies has been carried out especially in three areas: (1) Integration of international policies into ecosystems and natural resource management; (2) Analysis of National Adaptation Program of Action (NAPA) and national policies from the perspective of Ecosystem-based approaches (3) How water resource and forests sector have been integrated into the mainstream of development, climate change and sectoral policies in Nepal. There are several international policies that support Ecosystem-based approaches for climate change adaptation and disaster risk reduction.

4.2 Ecosystem-Based Approaches for Reducing Risks and Adapting to Climate Change

The main aim of EbA and Eco-DRR is the sustainable management, conservation and restoration of ecosystems to combat with consequences of climate change or to minimize the impacts of natural disasters (Munang et al. 2013; Renaud and Murti 2013). Both EbA and Eco-DRR intersect each other in making use of properly managed and well-functioning ecosystems, their goods and services, to support vulnerable communities to cope with the changing climate and natural disasters. These EbA and Eco-DRR incorporate the mixed approaches that connect naturally with scientific approaches (Van Bohemen 2012; UNEP 2015). Besides, they also have a common purpose to integrate multiple disciplines and multiple sectors. It seems Nepal had a proper balance of actions across sectors, where the forest sector (31%) covered most of the actions of EbA, agriculture covered 27% and water and biodiversity had (21%) (18%) respectively (Fig. 4.1; Table 4.2) (Ikkala 2011). Most of the actions in Nepal, Peru and Uganda on ecosystem-based approaches were under biodiversity conservation or under the natural resource management sectors of forests, agriculture and water. In Peru and Uganda, there were several actions in the tourism sector, related to wildlife and ecosystem conservation for tourism as another source of livelihood amid climate change whereas there was only one action in the energy sector in Nepal.

With the aim of providing benefits in poverty reduction and rural employment, as well as for climate change adaptation, community forest and multi-stakeholder and multi-actor participation in governance and management of forests have been promoted. Ecosystem-based approaches in the forest sector have taken into account of conservation, sustainable management, agroforestry and non-timber forest product (NTFP) management for adaptation. Forests and biodiversity come together in many plans and policies, which shows that many of the recognized forest adaptation approaches are ecosystem based. Additionally, several biodiversity conservation programs are concentrated particularly on forest ecosystems and its surroundings.

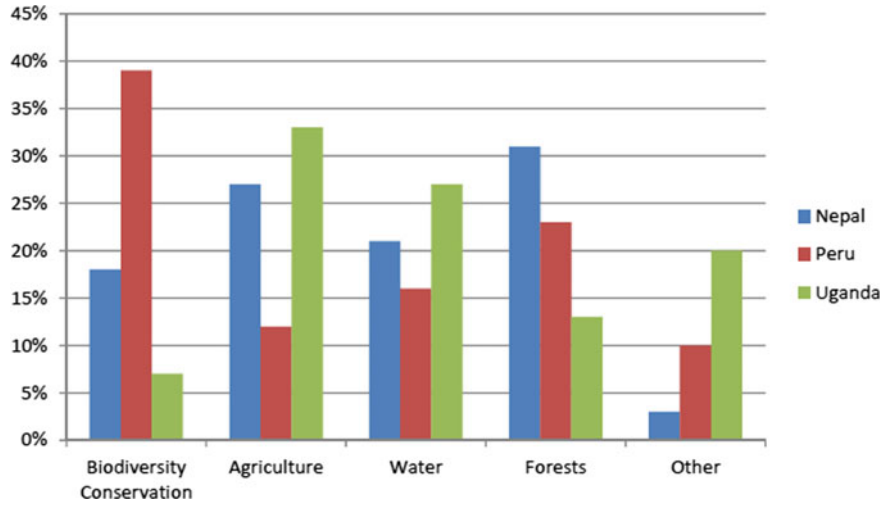

Fig. 4.1 Measures taken on ecosystem-based approaches to adaptation in different sectors in Nepal, Peru and Uganda. *Source* UNDP (2015)

Some examples are area increment of wetlands to minimize flood risks and forest restoration in the slopes to minimize the risk of landslides (Brink et al. 2016; Lange et al. 2019). Several researches prove the appropriateness and comparative advantages of Eco-DRR and EbA measures (Doswald and Estrella 2015; Renaud et al. 2016). Among them, some studies indicate that, besides their advantages in lower costs and sustainability, they can be the alternative sources of local livelihoods. As well as it plays an imperative role to minimize the risk of climate change impacts if they are well planned and focus on implementation (Daigneault et al. 2016; Renaud et al. 2013, 2016). Ecosystem-based approaches to adaptation and disaster risk reduction are interlinked in many cases; they can reduce vulnerability and enhance the resilience to both natural and human-induced disasters.

4.3 Integrating EbA and Eco-DRR into Planning and Policy

Ecosystem-based approaches to adaptation and disaster risk reduction are promoted by leading international development agencies. One of them is the Sustainable Development Goals (SDGs) adopted by the UN General Assembly. The SDGs associated to DRR are: developing cities for all that can integrate all the stakeholders, safe and resilient to disasters and sustainable (SDG 11), taking immediate action to cope with unprecedented disasters and minimize the adverse impacts (SDG 13). Similarly, protect and use of oceans, seas and marine resources in a sustainable way (SDG 14) and sustainably manage forests, combat desertification, reverse of degraded land and

Table 4.2 Examples of how three Eco-DRR projects in mountain countries of Nepal, Peru and Uganda integrated Community based-DRR goals and addressed four recommended principles

	Nepal	Peru	Uganda
Actions	Wetlands, pond, spring, forest restoration; women leased abandoned land to plant broom grass; gabion walls; roadside stabilization	Traditional water canal restored; land taken out of domestic grazing for vicuña grazing; wetland management; animal fibre production	Hydrological gravity flow schemes and reforestation; conservation agriculture; improved water retention; riverbank restoration
Benefits environment DRR	Water conservation; improve degraded land. Reduction of floods, fires, landslides, drought impacts	Grass and wetland restoration; vicuña (wildlife) conservation Decrease landslides, floods, fire risk, drought impacts	Water and soil conservation; forest loss reduction Reduction of floods, erosion, landslides, drought impacts
Principles governance	Strengthened institutional capacity for community management; used Panchase Protected Forest structure; worked with forest groups and women's groups. Informed Forest Management Plan	Strengthened water, pasture committees; formed new committees and plans; worked in No Yauyos Chochas Landscape protected area; contributed to the regional government's climate change strategy	Community water user groups formed Mt Elgon Conservation Forum brought together up/downstream actors for joint planning and decision making; worked with government extension
Capacity	Training promoted EbA; reduced water conflicts and diseases; enhanced incomes and employment	Capacity building for livestock and vicuña management; income from vicuña and tourism; value chain development increased	Increased income from crops; enhanced social capital; communities less reliant on food aid
Knowledge equity	Restored traditional water storage ponds Activities fit with women's schedules and workloads; included women in different castes	Restored a forgotten traditional water management model. Communication training focused on women, youth and elders, as under-represented groups	Farmer to farmer exchanges, peer to peer learning. Less time spent finding water and collecting firewood, especially for women

Source Klein et al. (2019)

reduce biodiversity loss (SDG 15). EbA and Eco-DRR can be promoted through effective incorporation into policy and practice in addition to the suggested goals related to sustainable development, poverty reduction and biodiversity conservation. This should be integrated into the policy cycle from policy planning to policy evaluation.

Top-down or bottom-up approaches are applied to integrate EbA and Eco-DRR most effectively. Meaningful participation of local people and indigenous communities, as well as practitioners, plays an imperative role in policymaking processes. Several countries have included EbA and Eco-DRR into their national plans and strategies. They have integrated EbA and Eco-DRR even in National Biodiversity Strategies and Action Plans (NBSAPs) under the CBD, disaster management plans, development policy and drought relief policy, NAPAs under the United Nations Framework Convention on Climate change (UNFCCC). NAPA under the UNFCCC supports the Least Developed Countries (LDCs) in prioritizing the tasks to cope with emerging climate change adaptation needs.

Many LDCs have identified the importance of ecosystems to support people to adapt to climate change in their spotlighted NAPA projects. Fifty-six percentage of high priority projects from NAPA had significant natural resource components (Reid et al. 2009). Some of the countries such as Cape Verde, Eritrea, Sudan, Solomon Islands and Vanuatu have NAPA projects that had a robust natural resource component, while each NAPA considered at least one project with a natural resource component. Pramova et al. 2010) identified the incorporation of EbA into the NAPAs and found that 68% of the NAPAs have mentioned the ecosystem services. It was estimated that around 42% of NAPA projects incorporated ecosystem restoration as an adaptation component Stucki and Smith (2011).

Climate change was not in mainstream development while formulating most sectoral policies. While looking into the climate change and sustainable water management policies in 9 countries, the biodiversity policies and to some extent water policies were not updated for many years. These policies were prepared before realizing the climate change impacts (Pittock 2011). Though most of the sectoral policies that did not consider the EbA are formulated two decades ago. Some recently formulated policies, including Nepal's Strategic Vision for Agricultural Research (NARC 2010) has not taken into account the EbA. A few Ecosystem-based approaches to adaptation-related activities are already being practised in Nepal. Forests and livelihoods project that is operationalized currently has mainstreamed adaptation. A new program on EbA in Mountain Ecosystems, supported by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), is being carried out in Nepal, Peru and Uganda (Fig. 4.1; Table 4.2). Several countries have been initiated and implementing activities on ecosystem-based approaches to adaptation. Some of them are related to prioritizing the NAPAs activities, however, it shows that these highly prioritized projects have not received the funding adequately. The NAPA highly prioritized project, integrated management of agriculture, water, forest and biodiversity sectors in Nepal has applied several ecosystem-based approaches to adaptation. Ecosystem-based approaches often come together with other approaches for adaptation for example integration of blue, green and grey infrastructure.

Institutional arrangements and structures play an imperative role to enhance coordination among the sectors. As the government body has coordinating powers over line ministries, it is better to lead the cross-sectoral issues like EbA and Eco-DRR. Capacity building of the local, provincial and federal governments should be mainstreamed for Eco-DRR/EbA activities. As well as for the effective implementation of Eco-DRR and EbA approaches, awareness among different stakeholders could be raised and technical skills need to be developed in Nepal.

4.4 Ecosystem-Based Approaches to DRR and Adaptation in the International Policy

The Rio Conventions have recognized the importance of ecosystems for adaptation. This type of platform provides policy guidance to the countries to get information on how to implement and promote action related to sustainable management, conservation and restoration of ecosystems that are practised at the international level (Lange et al. 2019). These types of conventions can also be opportunities for identifying and advancing the joint effort in the delivery of adaptation. The first set of decisions addresses the need for ecosystems to be adapted amid climate change, which is the objective of the UNFCCC as well. Incorporation of climate change in countries' strategic plan to managing ecosystems and maintain their resilience is mentioned in the CBD mandate. The UNCCD (2008–2018) aimed to enhance the resilience of impacted ecosystems to climate change. The emphasis of the second set of references is enabling people to adapt to the impacts of climate change from ecosystem management and the goods and services provided by it. The UNFCCC Cancun Adaptation Framework asks Parties to act on adaptation through sustainable management of natural resources while CBD defines Ecosystem-based Approaches to Adaptation. The UNEP/UNDP/IUCN partnership program on Ecosystem-Based Adaptation in Mountain Ecosystems funded by the German Government also emphasizes this kind of adaptation.

The two major global initiatives, the Sendai Framework for Disaster Risk Reduction and the Sustainable Development Goals (SDGs) acknowledge the EbA and Eco-DRR in 2015. It also shows the increasing importance as well as the benefits of EbA and Eco-DRR. The Sendai Framework for Disaster Risk Reduction was approved in Sendai, Japan, in March 2015 that replaced the Hyogo Framework for Action (UN 2015a). And In September 2015 Sustainable Development Goals has been adopted by the UN General Assembly (UN 2015b). A new consensus to address climate change was done in Paris in December (UNFCCC 2015). These agreements have recognized the importance of ecosystem and ecosystem services to climate change adaptation, mitigation, disaster risk reduction and sustainable development. The application of ecosystems for DRR, CCA and sustainable development has increased and ideas such as EbA, Eco-DRR, Nature-based Solutions, Green Infrastructures, Working with Nature etc. have come out or been advanced during the last

twenty years. This type of acknowledgement has eased the increased implementation of Eco-DRR/EbA projects. However, there is variation in the definition and concepts of ecosystem-based approaches (Renaud et al. 2016).

4.5 Ecosystem-Based Approaches to DRR and Adaptation in National Plans and Policies in Nepal

The significant role of ecosystems and ecosystem services for development has been emphasized in various sectoral policies without integrating it with adaptation. Some of the plans and policies such as the Agricultural Perspective Plan (1996), Conservation Strategy (1988), the Forest Sector Policy (2000), the Biodiversity Strategy (2002) and the Wetlands Policy (2003) in Nepal. All these policies emphasize the interrelation between ecosystems, biodiversity and human wellbeing, but do not integrate to climate change. The NBSAPs hardly recognize the relationship between biodiversity conservation, land degradation and desertification and adaptation. Nepal has already developed Local Adaptation Plans of Action (LAPAs) and NAPA, which provide a good opportunity for integrating ecosystem-based approaches to DRR and adaptation. And National Adaption Plan (NAP) formulation is ongoing. Several national and sectoral policies in the country do not integrate ecosystem-based approaches to adaptation.

4.5.1 National Adaptation Plan (NAP)

The NAP has been regarded as a pathway to identify the need for medium and long-term adaptation and to develop and implement strategies. This plan would build on the lesson learned from the NAPA process that was developed to address the short-term adaptation needs. Nepal has already pointed out that the NAP should take into account the vulnerable ecosystems and cross-sectoral approaches that should align with existing plans such as NAPA, National biodiversity strategies action plans (NBSAPs) while submitting its views on the NAP. The NAPs that is being developed under the UNFCCC framework could adopt the cross-sectoral, ecosystem-based approach for the CCA.

4.5.2 National Adaptation Program of Action (NAPA)

The National adaption program of action (NAPA) is developed through a comprehensive analysis of the climate change induced vulnerability and risk assessment. This includes development of a long list of adaptation options and identifies the

most promising one through a set of prescribed steps such as cost-benefit analysis among others. Some of them were ecosystem-based adaptions. In NAPA, four of such options included the ecosystem-based among nine. The adaptation options are often cross-sectoral, multi-stakeholders and multi-criteria process that is likely to be the ecosystem-based approaches. Therefore, the NAPA actions were selected based on a set of given criteria, which include potential to support the livelihood of rural part of the country and easy to implement. The focus was given to the cross-sectors approaches that could have mutual benefit in the range of sectors. The NAPA develop the project profile on community-based adaptation through integrated management with the ecosystem-based adaptation was the key that supports strengthening the local institutions and develop the early warning systems.

4.5.3 Nepal Climate Change Policy

Nepal Climate Change Policy aims to reduce the vulnerability to climate change enhancing the climate change adaptation capacity of local people to utilize the maximum products and services provided by natural resources and their efficient management (Climate Change Policy 2011). All three levels of government, federal, province and local should incorporate ecosystem-based approaches as important elements of climate change policy. National Development Plans also acknowledge the imperative role of ecosystems in supporting people to adapt to climate change. This indicates that ecosystem management and adaptation are taken as part of economic prosperity, poverty alleviation and sustainable development. Nepal has an integrated ecosystem-based approach to adaptation plans of water and forests. Overall national development is guided by these types of cross-sectoral documents, considering the ecosystem-based approaches as a mainstream development is significant. All countries should have built and structured the climate change and adaptation policies to complement one another to get the synergetic effect between priorities, objectives, visions and actions. The country's development plans are also lined up with the objectives around these approaches. The National Environmental Policies do not link adaptation and ecosystems. The National Environmental Policy of Nepal (1993) is too old and does not speak about climate change. Focus must be given at national level to take the advantage of adaptation in the nation's plan and implementation of commitments under all Rio Conventions.

4.5.4 National Strategy for Disaster Risk Management

In Nepal, disasters Management Strategies do not make interrelation between disaster risk management and ecosystems or adaptation. Nepal's National Strategy for Disaster Risk Management neither mentions adaptation, nor considers ecosystem management as a means to enhance resilience to disasters. On one hand, most of the

policies related to natural and environmental disaster risk reduction are formulated or derived from international discussions and frameworks. While new policies were also formulated aftermath of the disasters that occurred in the country, especially after the Nepal earthquake 2015. As a reaction to this event, the government of Nepal has formulated and amended several disaster risk reduction policies that establish responsibilities at the national, state and municipal level. Nepal recently established National disaster risk reduction and management authority (NDRRMA) in 2019. This legislation aimed to change disaster response from disaster risk prevention and mitigation in disaster risk management. However, risk professionals argue that this is the proper way; there is a big problem in the implementation of risk prevention and mitigation strategies. National authorities claim that this is mainly due to the lack of enough knowledge. Disaster practitioners are mainly trained for post-disaster responses like search and rescue; and relief. They are only trained on technical safeguarding, not in risk prevention and mitigation approaches. The political will and financial availability highly determine the effectiveness of the NDRRMA.

4.6 The Potential and Limitations of EbA and Eco-DRR

Several literatures depict that ecosystem-based approaches in Nepal have promising results, however, these kinds of measures are not taken into account. Consequently, it is bounded either in a specific location or in some piloting sites (Renaud et al. 2016; Ikkala 2011). Therefore, their full potential is not well explored how beneficial for resilience building and to reduce vulnerability. Nevertheless, Nepal government makes an effort for conservation and restoration of the forest sector at the national level. Specifically, with the implementation of the Mountain EbA program in the Panchase region of Nepal (Figs. 4.2 and 4.3). It shows that Mountain EbA has a direct contribution to minimize the disaster risk and climate change impacts. Additional information and concrete data on climate change impact and disaster risk could help to label these efforts as EbA and Eco-DRR measures.

A pilot project such as Panchase is also key to gaining experiences and makes a success story of EbA and Eco-DRR that can help to mainstream these measures on a national level. Nonetheless, to reduce the vulnerability and enhance the resilience of the landscape, a bunch of programs are needed which include but not limited to massive reforestation for regulating the regional climate and land restoration (Ikkala 2011; UNDP 2015). Forests can be used to protect from landslides and rockfalls and need to increase the buffer zone areas to reduce the loss from flooding.

While developing and designing the green or habitat corridors, wildlife protection should also be taken into consideration in a way that they simultaneously aligned with DRR activities. Nevertheless, this fosters a harmonious relationship between environmental planning authorities and disaster prevention.

Ecosystem-based measures that are still not recognized by the decision-makers is one of the major problems for its implementation. Difficulties in determination of cost and benefit ratio and assessing the effectiveness are major challenges in the short

Fig. 4.2 Wetland in Panchase area Nepal. *Source* Ikkala (2011)

Fig. 4.3 Village in Panchase area Nepal. *Source* Ikkala (2011)

run. Commitment of the local population is required as well as awareness-raising campaigns and environmental education should be conducted for the effective implementation of the ecosystem-based measures. These awareness campaigns should be conducted in a way that enhances community perception for better engagement (Lange et al. 2019).

There is not a proper monitoring and evaluation system and mechanism for the appropriate environmental impact assessment. In this regard, Panchase can be considered as one of the key pilot cases to upscale the EbA for the proper implementation and long-term monitoring and evaluation. Changes in land-use patterns sometimes may raise obstacles to manage floodplains areas, agricultural land and residential areas since floodplains are massively used for agriculture and settlements. Hence, shifting the residential areas and agricultural pocket areas to create retention areas may cost high and could generate major social and economic conflicts. Generally, EbA and Eco-DRR seem to be beneficial in the context of Nepal.

The ongoing CCA and DRR projects that are based on ecosystem-based services can contribute to make its widespread acceptance in the region.

4.7 Conclusion

EbA and Eco-DRR play imperative roles to reduce the vulnerability to climate change and its induced disasters for a country like Nepal. Therefore, ecosystem management, conservation and restoration should take into account to increase socio-ecological resilience and support people to adopt the EbA. Nepal has incorporated EbA and Eco-DRR into its climate change and adaptation policies. However, it is not enough to know the full potential of the EbA and Eco-DRR in the country's economic growth, poverty reduction and national development.

Ecosystem-based approaches to adaptation have not been well addressed in several natural resources management related policies even if they acknowledge the imperative role of ecosystem management for human wellbeing and development. The commitments made on all Rio conventions should be taken in high priority for the implementation and focus must also be given at the national level to take the benefits of adaptation in the planning. The existing NBSAPs and UNCCD NAPs also have not integrated adaptation. While formulating the environmental and sectoral policies climate change was not mainstreamed on the development agenda. On the other hand, these policies have not been updated for more than two decades. First of all, these policies need to be updated.

As discussed in the earlier section, several constructive developments have also taken place on the policy level. Several international agreements have highlighted the facts and mentioned the critical role of ecosystems for DRR and CCA. Sendai Framework for Disaster Risk Reduction (SFDRR) (UN 2015a) and Sustainable Development Goals (SDGs) have highlighted the role of ecosystems (UNFCCC 2015). Similarly, the Paris Agreement has also mentioned the environmental or ecosystem integrity (UNFCCC 2015). In the twelfth conference of the Parties in 2015, the Convention on Biological Diversity has also emphasized the importance of ecosystem-based solutions for CCA and DRR. Similarly, they have made a decision in the Ramsar Convention on Wetlands adopted resolution XII.13 on "wetlands and disaster risk reduction" (Renaud et al. 2016). Studies show that there is a possibility of interlink among major international agreements and Eco-DRR/CCA. The

importance of ecosystem-based solutions for DRR and CCA is increasing globally. Ecosystem-based approaches are important in every sector at the local unit for development and resources management. Therefore, it is crucial to develop as a component of mainstreaming in the local and sub-national level, which is responsible to plan and deliver the services in the field. Multi-stakeholders' engagement in planning and implementing EbA and Eco-DRR actions create the ownership among the different parties. These approaches can build on people's participation, cost-effective and easy to implement and can contribute significantly to local livelihoods.

Agriculture, water, forests and biodiversity conservation sectors have mainly integrated actions on ecosystem-based approaches to adaptation. Nevertheless, other sectors that focus on natural resource management, such as energy, health and tourism can also be benefited from ecosystem-based approaches to adaptation. And it is urgent to explore such opportunities. Hard infrastructure and institutional strengthening can also come together with ecosystem-based approaches to adaptation in many ways. Therefore, ecosystem-based approaches should be taken into account as part of broader, overall adaptation strategies. Research on ecosystem-based approaches to adaptation is highly recommended for future study. Ecosystem-based approaches should be linked with scientific cases to assess the vulnerability and climate change impact that support evidence-based decision making and action on the field level. Multi-stakeholder institutional arrangements are needed for better integrated, cross-sectoral policy formulation that is imperative to ensure the delivery of effective, sustainable solutions which enhance the resilience of both ecosystems and human being to climate change.

References

Andrade Á, Córdoba R, Dave R, Girot P, Herrera FB, Munroe R, Oglethorpe J, Paaby P, Pramova E, Watson E (2011) Draft principles and guidelines for integrating ecosystem-based approaches to adaptation in project and policy design: a discussion document. Turrialba, Costa Rica

Brink E, Aalders T, Ádám D, Feller R, Henselek Y, Hoffmann A, Ibe K, Matthey-Doret A, Meyer M, Negrut NL (2016) Cascades of green: a review of ecosystem-based adaptation in urban areas. Glob Environ Chang 36:111–123. https://doi.org/10.1016/j.gloenvcha.2015.11.003

Climate Change Policy (2011) Climate change policy Nepal

Daigneault A, Brown P, Gawith D (2016) Dredging versus hedging: comparing hard infrastructure to ecosystem-based adaptation to flooding. Ecol Econ 122:25–35. https://doi.org/10.1016/j.ecolecon.2015.11.023

Doswald N, Estrella M (2015) Promoting ecosystems for disaster risk reduction and climate change adaptation: opportunities for integration. United Nations Environment Programme, Geneva

Emerton L, Huxham M, Bournazel J, Kumara MP (2016) Valuing ecosystems as an economic part of climate-compatible development infrastructure in coastal zones of Kenya and Sri Lanka. In: Ecosystem-based disaster risk reduction and adaptation in practice. Springer, pp 23–43. https://doi.org/10.1007/978-3-319-43633-3_2

Houet T, Loveland TR, Hubert-Moy L, Gaucherel C, Napton D, Barnes CA, Sayler K (2010) Exploring subtle land use and land cover changes: a framework for future landscape studies. Landsc Ecol 25:249–266. https://doi.org/10.1007/s10980-009-9362-8

Ikkala N (2011) Ecosystem based approaches to adaptation in national policy: a case study from Nepal, Peru and Uganda

Klein JA, Tucker CM, Steger CE, Nolin A, Reid R, Hopping KA, Yeh ET, Pradhan MS, Taber A, Molden D, Ghate R, Choudhury D, Alcántara-ayala I, Lavorel S, Müller B, Grêt-regamey A, Boone RB, Bourgeron P, Castellanos E, Chen X, Dong S, Keiler M, Seidl R, Thorn J, Yager K (2019) An integrated community and ecosystem-based approach to disaster risk reduction in mountain systems. Environ Sci Policy 94:143–152. https://doi.org/10.1016/j.envsci.2018.12.034

Lange W, Sandholz S, Viezzer J, Becher M (2019) Ecosystem-based approaches for disaster risk reduction and climate change adaptation in Rio de Janeiro State, pp 345–359

Mensah A, Deeb A, Grünwaldt AH (2011) Making the case for ecosystem-based adaptation: building resilence to climate change. United Nations Environment Programme. UNEP

Mishra B (2011) Analysis and forecasting of snow cover using ANN in Kaligandaki Basin, Nepal. A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Remote Sensing and Geographic Information Systems, Asian Institute of Technology School of Engineering and Technology, Thailand

Munang R, Thiaw I, Alverson K, Liu J, Han Z (2013) The role of ecosystem services in climate change adaptation and disaster risk reduction. Curr Opin Environ Sustain 5:47–52. https://doi.org/10.1016/j.cosust.2013.02.002

NARC (2010) NARC's strategic vision for agricultural research (2011–2030). Meeting Nepal's Food and Nutrition Security Goals through Agricultural Science and Technology

Nepal P, Khanal NR, Pangali Sharma BP (2018) Policies and institutions for disaster risk management in Nepal: a review. Geogr J Nepal 11:1–24. https://doi.org/10.3126/gjn.v11i0.19546

Pittock J (2011) National climate change policies and sustainable water management: conflicts and synergies. Ecol Soc 16

Poudel S, Shaw R (2015) Demographic changes, economic changes and livelihood changes in the HKH Region. In: Krishna Nibanupudi H, Shaw R (eds) Mountain Hazards and disaster risk reduction. Springer Japan, Japan, pp 125–137. https://doi.org/10.1007/978-4-431-55242-0

Poudel S, Shaw R (2016) The relationships between climate variability and crop yield in a Mountainous environment: a case study in Lamjung District, Nepal. Climate 4:13. https://doi.org/10.3390/cli4010013

Poudel S, Funakawa S, Shinjo H (2017) Household perceptions about the impacts of climate change on food security in the mountainous region of Nepal. Sustainability 9:641. https://doi.org/10.3390/su9040641

Poudel S, Funakawa S, Shinjo H, Mishra B (2020) Understanding households' livelihood vulnerability to climate change in the Lamjung district of Nepal. Environ Dev Sustain 1. https://doi.org/10.1007/s10668-019-00566-3

Pramova E, Locatelli B, Brockhaus M, Fohlmeister S (2010) Ecosystem-based adaptation in the national adaptation programmes of action (NAPAs). In: National climate change adaptation research facility (NCCARF) 2010 climate adaptation futures conference. Gold Coast, Australia.

Reid H, Alam M, Berger R, Cannon T, Milligan A (2009) Community-based adaptation to climate change, participatory learning and action. International Institute for Environment and Development, London, UK

Renaud FG, Murti R (2013) Ecosystems and disaster risk reduction in the context of the Great East Japan Earthquake and Tsunami: a scoping study Report to the Keidanren Nature Conservation Fund. UNU-EHS

Renaud FG, Sudmeier-Rieux K, Estrella M (2013) The role of ecosystems in disaster risk reduction. United Nations University Press

Renaud FG, Sudmeier-Rieux K, Estrella M, Nehren U (2016) Ecosystem-based disaster risk reduction and adaptation in practice. Springer

Spehn EM, Rudmann-Maurer K, Körner C, Maselli D (2010) Mountain biodiversity and global change. Global Mountain Biodiversity Assessment

Stucki V, Smith M (2011) Integrated approaches to natural resources management in practice: the catalyzing role of national adaptation programmes for action. Ambio 40:351–360

The Government of Nepal—Ministry of Home Affairs (MoHA) (2019) Nepal disaster report
UN (2015a) Sendai framework for disaster risk reduction 2015–2030
UN (2015b) Sustainable development goals (WWW document). https://www.un.org/sustainabledevelopment/news/communications-material/. Accessed 7 May 2020
UNDP (2015a) Making the case for ecosystem-based adaptation: the global mountain EbA programme in Nepal, Peru and Uganda
UNEP (2015b) Promoting ecosystems for disaster risk reduction and climate change adaptation: opportunities for integration
UNFCCC (2015) Adoption of the Paris agreement (WWW document). https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf. Accessed 7 Apr 2020
Van Bohemen H (2012) (Eco)system thinking: ecological principles for buildings, roads and industrial and Urban areas. In: Sustainable urban environments. Springer, pp 15–70