Chapter 2
Ecosystem-Based Adaptation (EbA) in the Hindu Kush Himalaya: Status, Progress and Challenges

Sunita Chaudhary, Basant Raj Adhikari, Pashupati Chaudhary, Tashi Dorji, and Renuka Poudel

Abstract Ecosystem-based Adaptation (EbA) has been gaining attention in science, policy and practice as an effective way to address climate change and contribute to sustainable development. In Hindu Kush Himalaya (HKH), EbAs are implemented to enhance resilience of mountain communities to the harsh realities of climate change. However, very little documentation exists on nature and progress of EbA in the region, which are often fragmented and scattered. We analyzed the status, progress, benefits and challenges in EbA implementation. EbAs are focused on restoration (17%), mainstreaming in policy and plans (17%), ecosystem conservation (14%), flood risk management (12%), livelihoods (10%), capacity building (10%) and ecological risks assessment (7%). Though EbA varies across the countries, ecosystem conservation and livelihoods diversification is the focus. Major drivers of changes considered are climate change, floods, drought and landslides. Improved resilience through restoration, capacity building, better networking and better wellbeing are some of the notable benefits. However, awareness and mainstreaming of EbA in policies and plans are limited. Limited cooperation among the countries and stakeholders and short-lived donor-driven agendas are also the challenges. An effective and impactful EbA requires an integrated approach encompassing different sectors with vertical and horizontal cooperation and collaboration at the regional scale.

Keywords Ecosystem services · Adaptation · Aichi targets · Challenges · Barriers · Hindu Kush Himalayas

S. Chaudhary (✉) · T. Dorji · R. Poudel
International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal
e-mail: sunita.chaudhary@icimod.org

B. R. Adhikari
Institute of Engineering, Tribhuvan University, Pulchowk Campus, Kathmandu, Nepal

P. Chaudhary
Agriculture and Forestry University, Rampur, Chitwan, Nepal

M. Mukherjee and R. Shaw (eds.), *Ecosystem-Based Disaster and Climate Resilience*,
Disaster and Risk Research: GADRI Book Series,
https://doi.org/10.1007/978-981-16-4815-1_2

2.1 Introduction

The global climate change is an established phenomenon today (IPCC 2014). With the rapidly changing climate, the number and frequency of natural hazards and disasters have been increasing across the globe destroying life and properties (Deo and Garner 2014; Timalsina and Songwathana 2020). Climate change is regarded as the major driver of biodiversity loss and degradation of ecosystem services with significant impacts on millions of people dependent on nature (MEA 2005). To deal with the increased disasters induced by climate change, the engineering structures such as dikes, flood gates, dams are constructed (Jones et al. 2012). This is especially the case in developed countries that can afford financial and technical resources. In developing countries, the physical structures requiring huge investments are not always feasible, as priorities are more on dealing with poverty and development (Reid and Adhikari 2018). There has been, therefore, a growing realization that the Ecosystem-based Adaptation (EbA) could be an ideal adaptation solution, especially for developing countries. EbA is a cost-efficient and effective approach to deal with climate change and a pathway towards sustainable development (Swiderska et al. 2017). EbA, as defined by Convention on Biological Diversity (CBD), is the *use of biodiversity and ecosystem services to help people adapt to the adverse effects of climate change as part of an overall adaptation strategy* (CBD 2009).

EbA has gained increased attention in science, policy and practice since the mid-2000s. In 2001, CBD recognized the role of biodiversity and ecosystems for adaptation and acknowledged that ecosystem approaches could be the foundation of mitigation and adaptation. CBD defined the term EbA in 2008 and further elaborated to focus on 'sustainable management, conservation and restoration of ecosystems, as part of an overall adaptation strategy that takes into account the multiple social, economic and cultural co-benefits for local communities (CBD 2010). These are well reflected in the Strategic Plan for Biodiversity 2011–2020 which was adopted in 2010 with 20 Aichi targets by the Conference of the Parties to the Convention on Biodiversity (CBD) (CBD 2010). Since then, EbA has been increasingly used in science and policy documents (Chong 2014) and projects are implemented across the globe (Monty et al. 2017). For example, UN Environment World Conservation Monitoring Centre (UNEP-WCMC) in collaboration with International Union for Conservation of Nature (IUCN) and International Institute for Environment and Development (IIED) implemented projects in 13 sites in 12 countries around the world between 2015 and 2018 to develop policy guidance for EbA implementation (Reid and Adhikari 2018). Similarly, countries are mainstreaming and implementing EbA adaptation to climate change (Seddon et al. 2016a, b). Some countries such as Germany have already integrated EbA in municipal climate change strategies (Zolch et al. 2018).

In the Hindu Kush Himalaya (HKH), EbAs are implemented to help the mountain communities adapt to the harsh realities of climate change and shape their wellbeing. The HKH covers 4.2 million square kilometres across eight countries: Afghanistan, Bangladesh, Bhutan, China, India, Nepal, Myanmar and Pakistan (see

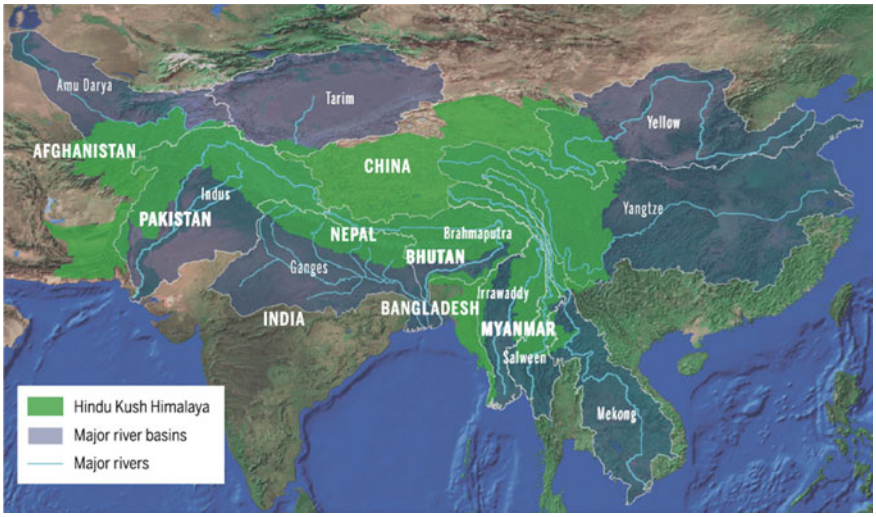

Fig. 2.1 The Hindu Kush Himalaya Region with major rivers and river basins. *Source* Sharma and Molden 2019). Map used with permission

Fig. 2.1) (Wester et al. 2019). The region, with hundred mountain peaks over 6000 m, is the source of ten major rivers of Asia. It hosts four global biodiversity hotspots (Mittermeier et al. 2004) and has diverse cultures, languages and traditional knowledge systems. This diversity provides ecosystem services that directly support the livelihoods of 240 million people in the region (Wester et al. 2019). However, the region is facing rapid changes such as climate change, land use, globalization, unplanned development and urbanization with implications on the environment and people living in and beyond the region (Wester et al. 2019). Actions are in place at local, national and regional scales to sustain the Himalayan ecosystems and improve livelihoods. EbA is one of those actions gradually emerging in the region.

A growing number of EbA are in operation to increase the resilience of the socio-ecological system in HKH region. For example, EbA in Bhutan and Myanmar focus on building resilience to the growing urban system, while the projects in Nepal are focused on enhancing capacity, knowledge and technology for resilient mountain ecosystems and their people. There are also a handful of EbA related projects in HKH countries such as China, India and Pakistan (IUCN 2020) with attempts to integrate the approach in their policy and strategies (Reid and Adhikari 2018). Nepal has briefly mentioned the term 'ecosystem services' in its National Adaptation Plan of Action (NAPA) (Chaudhary and McGregor 2018). In general, documentation of such approaches are very fragmented and scattered. The limited knowledge on the progress and effectiveness of EbA has been hindering the integration of the approach into policy and practice (Ojea 2015). In this context, this review aims to analyze the status of EbA, its types, types of disaster targeted and the progress made in HKH countries. In doing so, we aim to discuss the challenges and benefits related to EbA

and recommend actions for further socio-ecological resilience in the region. The chapter is guided by the following research questions:

1. What is the nature of EbA in the Hindu Kush Himalaya (HKH)?
   (a) What types of EbA are in practice?
   (b) What are the similarities and differences in EbA across the countries?
   (c) What types of drivers of change and hazards are considered for EbA?
2. How progressive has been EbA in the HKH countries?
3. What are the benefits and challenges of EbA in the region?
4. What are the recommendations for science, policy and practice of EbA in the region?

2.2 Materials and Methods

This review is based on a systematic review of literature based on an approach (Fig. 2.2) proposed by Brink et al. (2016) and Triyanti and Chu (2018) in the Hindu-Kush Himalaya. This review approach has been already applied for a systematic literature review on EbA for urban areas and Eco-DRR.

2.2.1 Data Collection: Literature Search, Screening and Categorization

The data collection consists of three stages: The first stage is collection of literature, followed by screening and cleaning in the second stage and categorisation of the cleaned data for analysis in the third stage.

Literature collection: Published literature of three different types: peer-reviewed articles, Sixth National Reports submitted to CBD and others (reports, book chapter, booklet and issue brief) were collected. Scopus and Google Scholar, both advanced academic search tools (Chaudhary et al. 2015), were used for academic literature. While the non-academic literature were searched through Google search engine. This included reports, websites, books, issue briefs and brochures. The literature search was guided by a set of criteria:

1. Keywords: EbA, HKH, ecosystem services, country name, DRR, Eco-DRR and early warning as follows:
   (a) Ecosystem-based adaptation (EbA), ecosystem services, Himalaya and/or mountain
   (b) EbA, Hindu Kush Himalaya (HKH) and/or country name (like Afghanistan, Bangladesh, Bhutan, China, India, Nepal, Myanmar and Pakistan)
   (c) EbA, DRR, country name

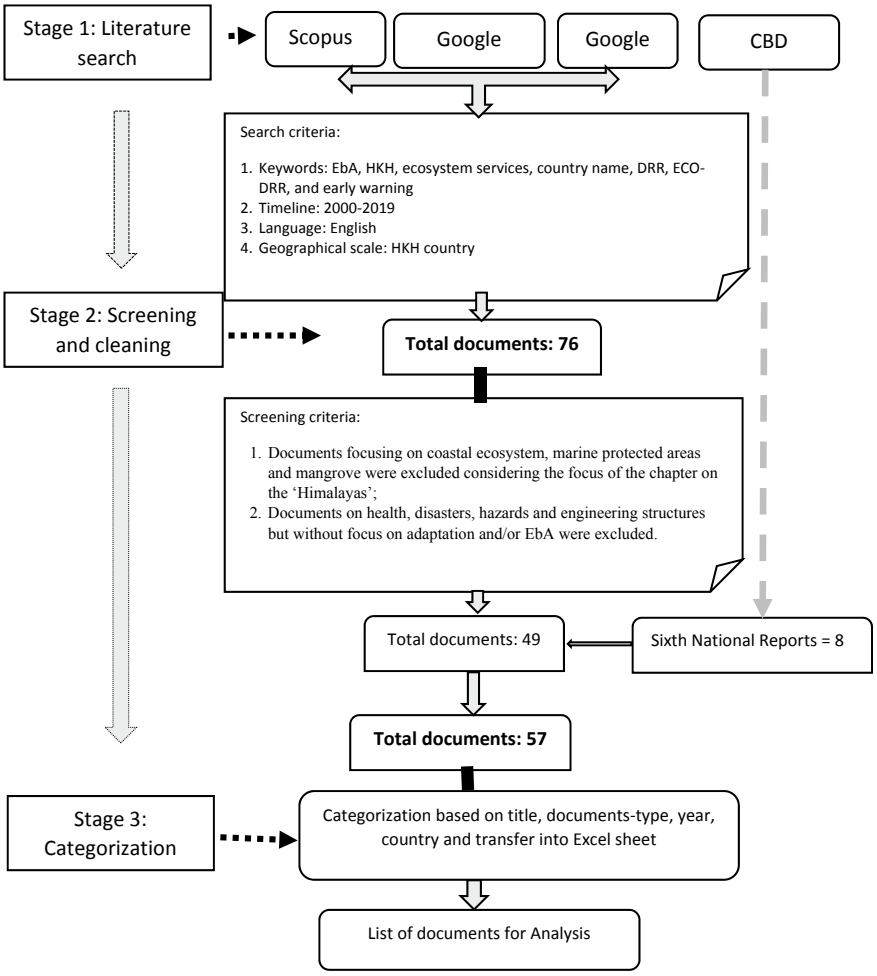

Fig. 2.2 Methodological framework of the review

(d) EbA, ECO-DRR, country name
(e) EbA, early warning system, country name.

2. Timeline: As the term EbA was coined in 2000 (Seddon et al. 2016a, b), a timeline from 2000–2019 was used.
3. English language.
4. Geographical scale: Hindu Kush Himalaya.

With this, altogether 76 documents were collected.

In the second stage, screening and cleaning of the literature were done by screening the title and abstract of 76 documents using the following pre-defined criteria:

Table 2.1 Composition of literature

Document	No.
Article	33
Book chapter	3
Booklet	3
Thesis	1
Report	8
Science Brief	1
Sixth National Reports to CBD	8
Total	57

Documents focusing on coastal ecosystem, marine protected areas and mangroves were excluded considering the focus of the chapter on the 'Himalayas';
Documents on health, disasters, hazards and engineering structures that did not focus on adaptation and/or EbA were excluded.

After screening, 27 documents were excluded. This gave us a total of 49 documents for further review and analysis.

Besides, the sixth national reports (6NRs) submitted to CBD by each HKH country were considered for review. The sixth national report provides a final review of progress in the implementation of the Strategic Plan for Biodiversity (2011–2020)[1] including the Aichi Targets to implement the Convention. The plan has five strategic goals with 20 Aichi Targets (CBD 2020). Altogether, including CBD reports, a total of 57 documents were used for a thorough review.

In the third stage, the literature were categorized based on title, country, published year, document type, abstract and project name with donors (if any) in an excel sheet for analysis. The documents included peer-reviewed articles, book chapters, booklets, theses, reports, science briefs and CBD reports. Table 2.1 shows the composition of literature.

2.2.2 Data Analysis

The literature review included a descriptive analysis and a qualitative content analysis (i.e. thematic analysis). Thematic analysis is a qualitative approach that focuses on identifying, analyzing and interpreting patterns of meaning (i.e. theme) in qualitative data (Castleberry and Nolen 2018).

Descriptive analysis: Each document was thoroughly reviewed and information on the country, year of publication, type of EbA and hazards were collected and

[1] The Strategic Plan for Biodiversity including 20 Aichi targets were adopted during the tenth meeting of the Conference of the Parties, held from 18 to 29 October 2010, in Nagoya, Aichi Prefecture, Japan for the 2011–2020 period. The plan is an overarching framework on biodiversity conservation and management (CBD 2010).

saved in an Excel sheet. Then, a detailed analysis guided by research questions was performed in excel. This gave us findings on the status of EbA (country-wise), type and trend of EbA publication over the years.

Thematic analysis: The contents of each document were analyzed through coding of themes. The themes were guided by the research questions: Benefits of EbA, Challenges and Barriers of EbA and recommendations. The coded themes were collected, analyzed and interpreted with reference to the research questions.

Sixth National Report (6NRs) to CBD: The eight 6NRs to CBD submitted by all HKH countries were analyzed to track the progress made by each country towards EbA. Lo (2016) thoroughly reviewed the linkages between the Aichi Targets and EbA and Eco-DRR and identified the Aichi Targets (5, 7, 10, 11, 13, 14 and 15) closely linked to EbA and Eco-DRR. A brief snapshot on the links is given in Annex 1. Following Lo (2016), we selected the Aichi Targets 5, 7, 10, 11, 13, 14 and 15 to analyze the country's progress towards EbA in the region. Countries report their progress on Aichi Targets qualitatively with different levels of progress (see Table 2.2). For each category, we assigned a term and value (very good = 3, good = 2, fair = 1 and low = 0).

Following the table, the progress reported by each country was analyzed descriptively in Excel and interpreted accordingly (see Sect. 3).

Table 2.2 Level of progress category with terms and values assigned

Level of category (as per CBD)	Terms used	Value assigned
 On track to exceed the target	Very good	3
 On track to achieve the target	Good	2
 Progress towards target but at an insufficient rate	Fair	1
 Moving away from the target	Low	0

2.3 Findings

2.3.1 Status of EbA in the Hindu Kush Himalaya

The status in the HKH is shown by the type of EbA, type of hazards considered and similarities and differences in EbA activities across the region.

What types of EbA are in the region?

EbAs in the Hindu Kush Himalaya (HKH) are mostly focused on 12 different activities, aiming to maximize the multiple benefits and increase the resilience of both nature and society to climate change and disasters (Fig. 2.3). Most of the EbAs are focused on restoration (17%) and mainstreaming in policy and plans (17%). This is followed by ecosystem conservation (14%), flood risk management (12%) and livelihoods (10%), capacity building (10%) and ecological risks assessment (7%). Sustainable fishery, traditional knowledge and invasive species management were also considered important for increasing resilience in the region. This shows that maintaining healthy ecosystems through conservation and management play an important role in adaptation. Similarly, the assessment and management of different

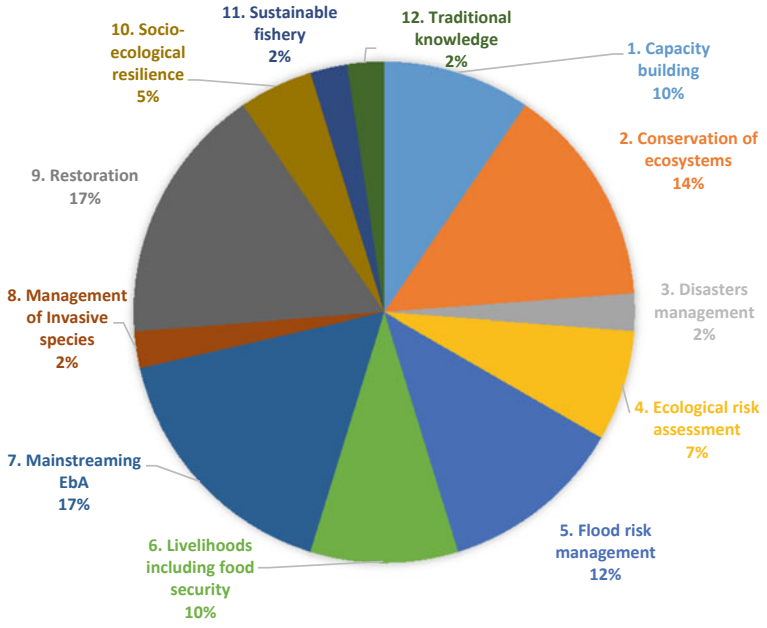

Fig. 2.3 Ecosystem-based Adaption (EbA) activity in the Hindu Kush Himalaya region, as a percentage of total number of activities, as reported in different literatures

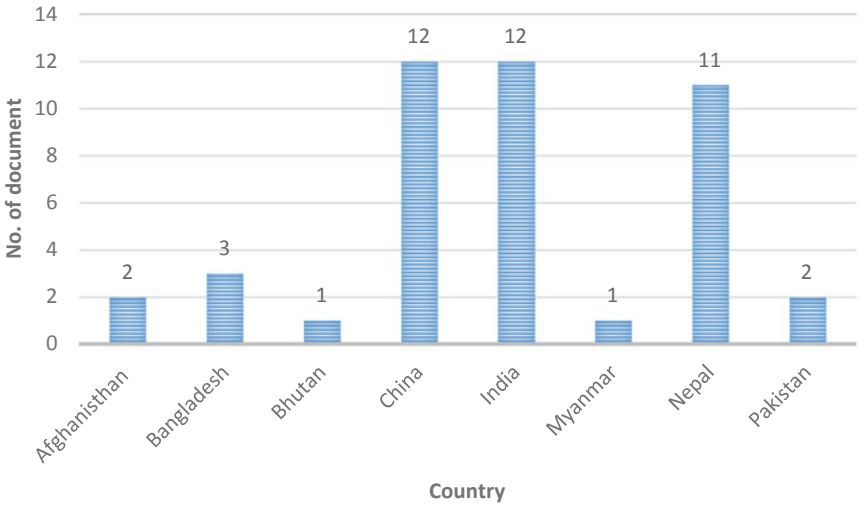

Fig. 2.4 No. of literature on EbAs across the HKH country

risks and threats across sectors were considered important. For instance, about one-fourth of the EbA activities are focused on assessing risks related to flood, disasters and ecology and their management (Fig. 2.3).

What are the similarities and differences in EbA across the HKH countries?: Country-wise EbA.

The literature are unevenly distributed across the region (Fig. 2.4). Altogether 44 literature are focused on EbA in the region. Among the countries, China (12) and India (12) have the highest focus on EbA, followed by Nepal (11). Pakistan, Bhutan and Myanmar have limited EbA literature. Across the countries, ecosystem conservation and livelihood diversification are the major focus for all EbAs. In China, other EbAs are focused on restoration of degraded lands, risks and vulnerability assessment, urban floods and agrobiodiversity with a particular focus on food security. While mainstreaming in policy and plans, Eco-DRR, traditional knowledge, smart city and groundwater recharge are focused in India. In Nepal, activities on capacity building, community-based disaster management, reforestation and crop diversification are other EbAs. Similarly, the socio-ecological resilience of agro-pastoral community in Afghanistan, sustainable fishery in Bangladesh, Eco-DRR in Myanmar and flood management in Pakistan are some of the additional activities. Considering the threats considered for EbA across the region, we also assessed the types of threats.

What types of hazard risks are considered in EbA in the region?

Altogether, ten different types of hazards have been reported for EbA in the Hindu Kush Himalaya (see Fig. 2.5). The analysis shows climate variability and change as the top hazard for EbA in the region, by about 38%. This is followed by floods

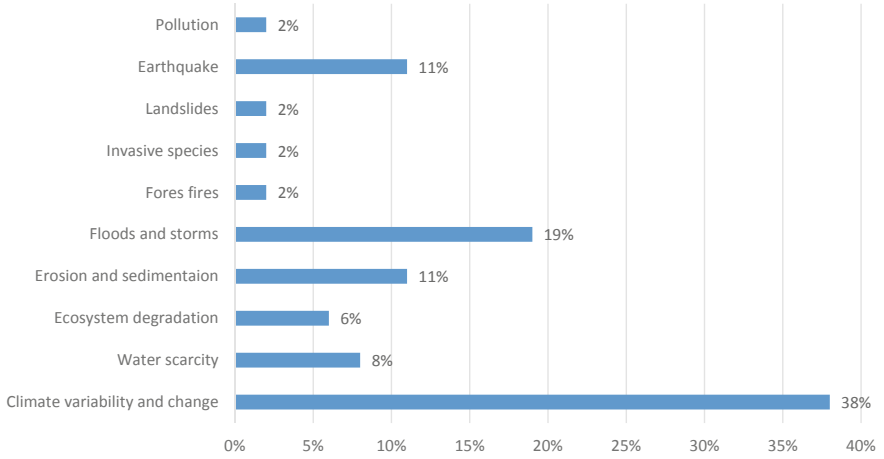

Fig. 2.5 List of hazards reported in EbA literatures, in percentage with regards to total number of reported hazards

and storms (19%), earthquakes (11%) and erosion and sedimentation (11%). Water scarcity (8%) and ecosystem degradation (6%), pollution, landslides, invasive species and forest fires are also threatening the region.

2.3.2 Progress of Countries Towards EbA in the Region

The review of sixth national reports to CBD of HKH countries is the basis of analyzing the progress made by each country towards EbA. The Aichi targets analyzed included the targets 5,7,10,11,13,14 and 15 as these targets are closely linked to EbA (as discussed in Sect. 2.2). For each target assessed, most of the HKH countries show good and fair progress to EbA (see Fig. 2.6). China in particular shows good progress towards all the targets related to EbA, followed by India, Bhutan and Nepal. Bhutan is 'very good' for target 11 as the country has exceeded the target of protected areas coverage. India has also been 'very good' for protected areas coverage and 'good' for all other EbA related targets. Similarly, Nepal exceeding its protected areas coverage shows very good progress in target 11 and report 'good' in other targets. Afghanistan and Myanmar show good to fair progress in all targets related to EbA. Pakistan shows low progress in targets 10 and 14 but reported 'good' for other EbA related targets. This indicates that the countries are trying their best in terms of increasing their resilience to varied hazards including climate change.

The progress is also 'good to fair' for most of the targets (see Fig. 2.7). Target 15, in particular, focusing on restoration for resilience to climate change is 'good' followed by target 11 on protected areas coverage. Except Pakistan, target 14 focusing on

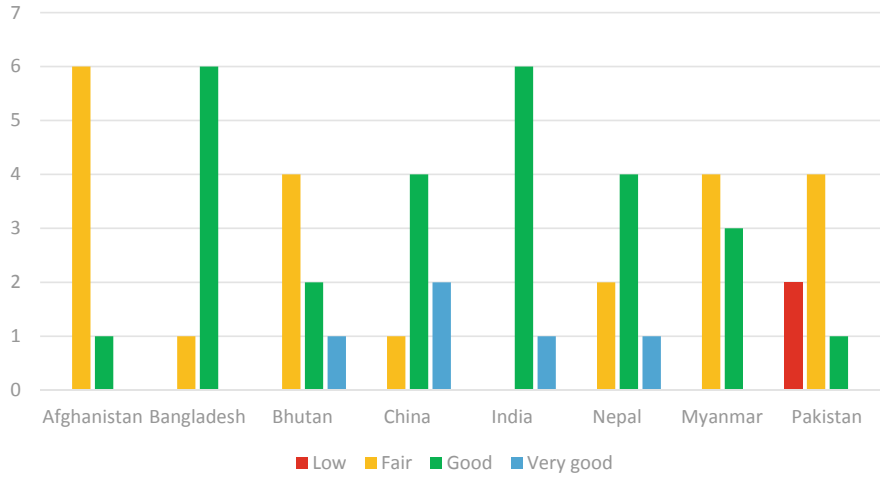

Fig. 2.6 Progress of countries towards Aichi targets related to EbA. Values are shown in percentage of reports identifying levels of progress for each target based on sixth National Reports to CBD

Fig. 2.7 Progress on Aichi targets linked to EbA in the Hindu Kush Himalaya

increasing the capacity of ecosystems to provide services for sustainable livelihoods is 'good' for all the countries.

2.3.3 *Benefits of EbA in the Region*

Besides the analysis of progress by HKH countries for Aichi targets related to EbA, we also analyzed the EbA benefits. The analysis shows significant benefits to both people and ecosystems arising from EbAs. Some of the notable benefits are thematically described below:

1. Human wellbeing: Livelihoods support and its diversification is the core element of EbA in the region. EbAs contribute to the overall wellbeing of people with increased economic benefits. The benefits are through selling of vegetables, honey, cardamom products, banana, bamboo and non-timber forest products of the communities. For instance, Increased water availability and equal access to water, increased tourism, improved agricultural productivity through agroforestry practices and better air and water quality through plantation in the abandoned areas and the river banks are reported to contribute to better health of people.
2. Capacity building and networking: Capacity building is also one of the most important components of EbA. Capacity building in terms of enhancing marketing skills, access to markets, networking with stakeholders and knowledge about value chains of products is important for enhancing economic benefits. Similarly, knowledge to manage natural resources sustainably and managing community-based institutions are the focus of the EbAs. Besides, the leadership skill of community people is important for many community-based adaptation initiatives. The activities are the reflection of the type of hazards in the countries. The capacity building of deprived communities has been prioritized to improve their livelihoods and hence build resilience.
3. Traditional knowledge: Recognition of indigenous communities and their traditional knowledge for ecosystem management and resilience building have been promoted in EbAs. Many EbAs have particular arrangements for marginalized communities, especially the poor and indigenous people. For instance, the Chepangs (an indigenous[2] community of Nepal) are being provided with support to promote their agriculture productivity. Similarly, the feminization of homestay businesses has been prioritized for women groups and female-headed households.
4. Improved resilience: Crop diversification, improved irrigation systems and promoting water recharging systems are some of the priorities for building resilience. Activities are also focused on promotion of strong and cost-effective means such as agroforestry practices, minimizing flood risks and agrobiodiversity to deal with the impacts of changing climate and improve sustainability against extreme weather events, pests, weeds and other hazards.
5. Ecosystem health and functions: The benefits to ecosystems, in terms of restoring, managing and enhancing the capacity of ecosystems to withstand

[2] The indigenous ethnic community is a tribe/community native to a particular area with its own mother tongue, traditional culture and egalitarian social structure. They do not fall under the conventional Hindu hierarchical caste structure (GoN 2009).

different stressors, as well as provide services for local communities are the benefits arising from EbAs. The analysis showed notable improvement of *ecosystem health and its functions* through EbA. For instance, the land rehabilitation interventions such as restoration of forest and river through green belt, gulley control in the Panchase Mountain area protected land from degradation and conserved more than 50 hectares of land (UNDP 2015).

6. Restoration: Ecosystems conservation and management have been the foundation of many EbAs in the region. Degraded ecosystems are managed through restoration and sustainable land management. For instance, UNEP's project planted 500,000 seedlings for forest enhancement in Nepal (IUCN 2020). The ecosystem restoration is reported to improve ecosystem health and its functions such as soil and nutrient management, biodiversity and genetic diversities, surface accretion, carbon sequestration, water quality improvement and reducing surface water run-off during storms. For instance, wetland protection and rehabilitation through EbA in India is reported to increase water storage potential, mitigate floods and wise use of water during droughts (Dhyani et al. 2018). Moreover, water quality improvement, groundwater recharge, reducing surface water run-off during storms are also important.
7. Disasters risk reduction: EbA has always been playing an important role in disaster risk reduction. Low-cost and low-tech approaches are especially feasible in the mountainous areas (see Box 1). The restored ecosystems are an integral part of protecting infrastructure and enhancing human security, acting as natural barriers and hence mitigating the impact of and aiding recovery from many extreme weather events and disasters. Biodiversity and genetic diversities were reported to be conserved through an EbA approach. This could help biodiversity especially engendered species to adjust to changing climatic conditions. The successful implementation of EbAs controls soil erosion and provides an alternative livelihood option. For example, an intervention by IUCN Nepal in western Nepal has implemented bio-engineering techniques for 'eco-safe roads' concept to control the landslide. This project also provided different plant species for the protection of slope land erosion and now communities are harvesting broom grass for use as fodder and for sale and are earning 20,000 NPR per year, per kilometre (Monty et al. 2017).

Box 1: Landslide Early Warning Systems for ECO-DRR in Nepal

Landslide occurrence in the Himalayas is a complex and common phenomenon causing many lives and properties. Landslide mitigation using hard engineering techniques such as retaining wall, drainage, rock bolting and iron netting are common examples in the region. However, these techniques are not always feasible due to high cost and topographic challenges, i.e. steep terrain, high altitude, strong monsoon, inaccessibility of areas. Therefore, Landslide Early Warning System (LEWS) is one of the best non-structural mitigative measures

in those terrains where the local population at risk will be benefitted by increasing their awareness and enhancing their preparedness. The history of LEWS in Nepal is not so long. Water Induced Disaster Prevention Technical Centre (DPTC), Government of Nepal installed rain gauge, Piezometer, moving pegs, Tiltmeter, extensometers in the Km 19 landslide along the Kathmandu-Trishuli road, central Nepal in 1993 for the landslide monitoring. Some regional LEWS based on rainfall threshold is installed in the Nepal Himalaya but these systems did not consider the threshold based on physical movement of the landslide (JICA 2009; Dahal and Hasegawa 2008). One of the successful examples can be taken from Thapa and Adhikari (2019) where they have explained how Government of Nepal has installed a community-based LEWS. Some of the major features and mechanisms are described below:

The community-based low-cost and low-tech has considered all three parameters: rainfall, displacement and soil moisture content. This system was set up in the Mehele landslide, Dolakha, Nepal (N 27° 43′ 22.54″; E 86° 03′ 49.11″; 1952 m) on 28th May 2018. The system consists of Arduino Mega controller, flash memory of 256 KB, SRAM 8 Kb, EEPROM 4 KB, Click Speed 16 MHz, Click Speed 19 MHz and an LCD 16 × 2 display with 50 W power supply. The system set up a threshold of 60 mm in 24 h or cracking increases equal or greater than 30 cam and moisture content in the soil exceed more than 60%. The LEWS worked perfectly when the landslide occurred at 11 pm on 23rd August 2018. The local community heard the siren and prepared for evacuation. Altogether 495 people from 117 households benefited from this system and most of them are from marginalized population. This LEWS has set up a landmark in the Nepal Himalaya to implement the ECO-DRR approaches for the rural-mountainous communities.

2.3.4 Challenges of EbA in the Hindu Kush Himalaya

The implementation of EbA in the region is challenged by varied issues across sectors and scales. One of the major challenges is the **limited coordination and cooperation** within the government and among different stakeholders. For instance, limited cooperation was reported between two state governments in India (Delhi government and Uttar Pradesh government) during the implementation phase (Singh et al. 2013). In this regard, the **multi-stakeholder engagement** including local communities and private sectors is quite important. Equally important is environmental governance in the region which has been regarded weak in terms of managing institutions and stakeholders. The limited capacity of nodal institutes is one of the challenges for better environmental governance. Similarly, limited regional cooperation among the countries to address hazards and disasters that often cross borders is important.

Climate and water-induced disasters can cross borders requiring collective action across countries and communities for disaster resilience (Molden et al. 2017). Effective cooperation and consultation with different sectors across the scales are of utmost importance. However, limited consultation with multi-stakeholders is challenging for EbA measures. Many EbA projects have failed to ensure participation of relevant stakeholders. For example, the top-down selection of beneficiaries for afforestation projects in Bangladesh has ignored the specific needs of local communities promoting equity and justice issues. As EbA is multi-dimensional in nature, the **integration of different disciplines and working with different sectors** is a challenge. Lack of coordination amongst DRR, climate change and natural resource management policies and interventions are some of the observed barriers for EbA effectiveness in the region.

EbA should involve integrated sectoral approaches, including all relevant sectors such as forestry, fisheries, agriculture and water resources that help the community adapt to climate change and other disasters. The ecological risks and societal vulnerabilities are often analyzed in isolation and without necessarily linking ecological, social and economic aspects that exacerbate vulnerabilities. EbA approaches are often narrowly focused, failing to integrate conservation and development goals. For example, the Tidal River Management project in Bangladesh aimed to trap sediment within polders and restricted fishing and farming for the local communities who are dependent on their subsistence livelihoods (Saroar et al. 2019).

The EbA measures are **donor-driven and often lack funds** for implementation, monitoring and management after project period. As such, major projects are focused on mainstreaming EbA in national policies and plans for sustainability. However, the limited awareness, funding and capacity to integrate EbA in policy and plans are the challenges for mainstreaming EbA. Most of the stakeholders are unaware of the EbA concept, its benefits and adequate understanding of the local conditions. For instance, the private sectors are not aware of the importance of floodplain and wetland ecosystems which has been challenging for EbA counterparts to initiate conservation efforts. Limited knowledge and capacities to apply environmental tools for DRR and mainstream into development planning are other challenges for EbA in the region.

2.4 Discussions

While EbA is gaining worldwide recognition in climate change adaptation and resilient community development (Nalau et al. 2018), the progress in its widespread use is still slow, particularly in the HKH (Bourne et al. 2016). The current EbA activities in the region cover a variety of topics related to process, goal, objective and outcomes. Several EbA projects have a focus on the integration of traditional knowledge, capacity building and mainstreaming of the EbA approach in government policies. Ali Shah et al. (2019) reported that EbA is part of the activities of a majority of

smallholder farmers in Pakistan and they suggest its wider application through non-government organization effort in fostering farmer-to-farmer information sharing and appropriate government policy support.

A community-based approach coupled with enhancing social capital and institutional building is crucial for the success and sustainability of EbA (ibid). Participatory plant breeding and community-supported agriculture project in China has applied EbA, which emphasizes four key issues: (i) effectiveness for human societies, (ii) effectiveness for the ecosystem, (iii) financial and economic effectiveness and (iv) policy and institutional issues (Song et al. 2015; Reid and Zhang 2018). The promotion of organic agriculture at national and community scale especially in Bhutan, India and Nepal is also EbA focused. These frameworks and approaches can be useful for other ongoing and future EbA projects across the region.

Climate-induced hazards qualifying EbA are manifold of which floods and storms rank the top. Part of HKH is the hotspots for natural disasters, floods and glaciers lake outburst in particular, with immense impacts on people's lives, livelihoods and economies at a transboundary level (Yusuf and Francisco 2009) since the region is home to several transboundary landscapes and rivers including Ganges, Bramhaputra and Meghna (Mirza 2011). In August 2017, floods and landslides caused by torrential monsoon rains affected almost 41 million people and killed over 900 in Bangladesh, India and Nepal combined (UNOCHA 2017). River basin approach with upstream and downstream linkages would help the countries and communities deal with such disasters. Similarly, the mountain ecosystems are extremely vulnerable to climate change with impacts on people and their livelihoods (Sharma et al. 2009). This calls for a transboundary, regional and inter-country coordinated and collaborative effort. To promote transboundary initiatives, cross-learning and joint undertakings of EbA activities are important. It will require fair and transparent dialogue, followed by cooperation and coordination among the countries at the policy level. Countries can also cooperate on the documentation and exchange of case studies and good practices from the region. This can be further enhanced by north–south and south-south cooperation on science, technology and innovation for better disaster resilience. For instance, regional cooperation among the upstream and downstream countries can be strengthened to maximize benefits such as irrigation and hydropower, while minimizing adverse risks of floods and landslides. It can integrate scientific, economic, social and ecological knowledge to support decision-making (Molden et al. 2017). While there are some similarities in approaches, goals and outcomes, there is differentiated progress in EbAs across countries. Therefore, cross-country learning, among other approaches, can play a pivotal role in building capacity and scaling up good practices. Capacity building, including cross-country learning, is necessary to address the following gaps: (i) inadequate technical knowledge and capacity regarding the designing and implementation of projects; (ii) lack of capacity to plan, (iii) limited technical capacities within DRR sector on implementing natural resource management strategies; and (iv) limited understanding, research and public awareness of the benefits of EbA. The Paris Agreement gives due emphasis on equity to ensure vulnerable groups, communities and ecosystems receive a priority in climate change

actions (UNFCCC 2015), so it is important to duly consider gender equality and social inclusion during capacity building and project implementation in future.

When looked through an Aichi Target lens, the majority of countries have made either fair or good progress in implementing EbA related targets. Moreover, all the targets linked with EbA are also moderately good in terms of achieving set goals. Since the Fifteenth Meeting to the Conference of the Parties of the Convention on Biological Diversity (CBD CoP15) is approaching, it would be good to raise the gaps in achieving targets for different countries so that the post-2020 biodiversity framework duly consider important issues that remained poorly attempted so far. The study highlighting the challenges and barriers aims to contribute to the post-2020 biodiversity framework.

Awareness about EbA among government officials and development partners is equally important to accelerate the integration of the approach into policies and strategies. The future of EbA planning, implementation and evaluation will require a combination of "top-down" and "bottom-up" approaches to ensure sustainable outcomes across various levels of implementation. Moreover, an integrated approach to social protection, DRR and climate change adaptation is necessary (Schipper and Pelling 2006; Mercer 2010; Guha-Sapir et al. 2013; Kundzewicz et al. 2014; Bakker and Duncan 2017) with its clear linkage with the nature-based solutions (Cohen-Shacham et al. 2016), which will require an inter-disciplinary and multi-institutional approach. Vertical and horizontal cooperation and collaboration are key to fostering inter-disciplinary and multi-intuitional approaches.

Research work is also limited in the region. So, it is important to take stock of research work conducted in the past and identify research gaps. Future studies are essential to examine how existing EbAs are contributing to relevant national and global initiatives and what further actions are needed to improve efficiency and effectiveness. This will give insights on the ways of integrating EbA activities in different strategies, goals and sectoral approaches. Future work is necessary to evaluate the benefits of EbA projects by assessing the contribution of EbA on adaptive capacity, resilience and reduced vulnerability of human beings in the face of climate change along. It is also essential to examine the co-benefits and impact of EbA on restoring, maintaining or enhancing the capacity of ecosystems in producing useful services and combating climate change impacts (Reid and Zhang 2018). Equally important is to appraise cost-effectiveness, economic viability along social, institutional and political issues pertaining to effective EbA implementation (Seddon et al. 2016a; Reid et al. 2017; Reid and Zhang 2018).

2.5 Conclusion

We systematically reviewed EbA literature in the Hindu Kush Himalaya. EbA practices in the HKH are focused on ecosystem conservation, integration of indigenous knowledge, capacity building and mainstreaming EbA and disaster management. This approach has been applied to address climate change, floods, drought and

landslides, however, the goal and outcomes of this approach differ from country to country. For example, China and India are comparatively advanced in capacity building and restoration of ecosystems, while Nepal is ahead in equity issues. Nevertheless, the majority of countries have made fairly good progress in implementing EbA related targets, to achieve their set goals. The benefits of EbA are multi-dimensional. They improve the resilience of ecosystems and communities by enhancing people's wellbeing and maintaining ecosystem's health. EbAs are particularly important in diversifying livelihoods of people and building their capacity to deal with disasters and hazards. However, limited cooperation among the countries, coordination across different sectors and short-lived donor-driven projects are some of the challenges. More efforts are required to improve the socio-ecological resilience of the countries by creating awareness, effective mainstreaming of EbA in national and regional plans and policies. As such, we argue to have an integrated approach encompassing different sectors and disciplines with clear linkages with the nature-based solution for effective and impactful EbA in the region. This would require vertical and horizontal cooperation and collaboration among different stakeholders. Regional cooperation among the countries to share knowledge, best practices and technology is required for disaster resilience. The future research could focus on analysis of contribution of existing EbAs and their effectiveness in improving the resilience of socio-ecological systems.

Acknowledgements ICIMOD gratefully acknowledges the support of its core donors: the Governments of Afghanistan, Australia, Austria, Bangladesh, Bhutan, China, India, Myanmar, Nepal, Norway, Pakistan, Sweden and Switzerland. **Disclaimer:** The views and interpretations in this publication are those of the authors. They are not necessarily attributable to ICIMOD and do not imply the expression of any opinion by ICIMOD concerning the legal status of any country, territory, city or area of its authority, or concerning the delimitation of its frontiers or boundaries, or the endorsement of any product.

Annex

Annex 1: Links between Aichi Targets and EbA and Eco-DRR

Strategic goal	Aichi target	Link to EbA and Eco-DRR
B. Reduce direct pressures biodiversity and promote sustainable use	Target 5: By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero and degradation and fragmentation is significantly reduced	Forests and coastal vegetation can serve as a protective buffer from extreme events

(continued)

(continued)

Strategic goal	Aichi target	Link to EbA and Eco-DRR
	Target 7: By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity	DRR is a core element of sustainability for forestry and agriculture; forests serve as a protective buffer from erosion and landslides
	Target 10: By 2015, the multiple anthropogenic pressures on coral reefs and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning	Coral reefs can be effective in protecting against coastal hazards, such as by reducing wave energy
C: Improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity	Target 11: By 2020, at least 17 per cent of terrestrial and inland water areas and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures and integrated into the wider landscapes and seascapes	Protection of ecosystems, which allows them to keep providing services that are important for adaptation and disaster risk reduction, even beyond the boundaries of the protected area
	Target 13: By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio economically as well as culturally valuable species, is maintained and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity	Reduces risks of climate change affecting food security and livelihoods

(continued)

(continued)

Strategic goal	Aichi target	Link to EbA and Eco-DRR
D: Enhance the benefits to all from biodiversity and ecosystem services	Target 14: By 2020, ecosystems that provide essential services, including services related to water and contribute to health, livelihoods and wellbeing, are restored and safeguarded, taking into account the needs of women, indigenous and local communities and the poor and vulnerable	Ensures provisioning of essential ecosystem services, including those underpinning DRR
	Target 15: By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15% of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification	Resilient ecosystems are a key component of DRR, e.g. restoration of coastal vegetated ecosystems contributes to mitigation, adaptation and disaster risk reduction through shoreline stabilization

Source Lo (2016)

References

Bakker MHN, Duncan JA (2017) Future bottlenecks in international river basins: where transboundary institutions, population growth and hydrological variability intersect. Water Int 42(4):400–424

Brink E, Aalders T, Ádám D, Feller R, Henselek Y, Hoffmann A, Ibe K, Matthey-Doret A, Meyer M, Negrut NL, Rau AL, Riewerts B, von Schuckmann L, Törnros S, von Wehrden H, Abson DJ, Wamsler C (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

Castleberry A, Nolen A (2018) Thematic analysis of qualitative research data: Is it an easy as it sounds? Curr Pharm Teach Learn 10(6):807–815. https://doi.org/10.1016/j.cptl.2018.03.019

CBD (2010) Strategic plan for biodiversity 2011–2020 and the aichi targets. CBD Secretariat, Montreal Canada. https://www.cbd.int/doc/strategic-plan/2011-2020/Aichi-Targets-EN.pdf

CBD (2020) Sixth national reports to convention on biological diversity. Secretariat of the Convention on Biological Diversity, Montreal, Canada

Chaudhary S, McGregor A (2018) A critical analysis of global ecosystem services (*paristhiki sewa*) in Nepal. Land Use Policy 75:364–374. https://doi.org/10.1016/j.landusepol.2018.03.024

Chaudhary S, McGregor A, Houston D, Chettri N (2015) The evolution of ecosystem services: a time-series and discourse-centred analysis. Environ Sci Policy 54:25–34. https://doi.org/10.1016/j.envsci.2015.04.025

Chong J (2014) Ecosystem-based approaches to climate change adaptation: progress and challenges. Int Environ Agreement 14(2014):391–405

Cohen-Shacham E, Walters G, Janzen C, Maginnis S (eds) (2016) Nature-based Solutions to address global societal challenges. Gland, Switzerland: IUCN. xiii + 97p

Dahal RK, Hasegawa S (2008) Representative rainfall thresholds for landslides in the Nepal Himalaya. Geomorphology 100(3–4):429–443. https://doi.org/10.1016/j.geomorph.2008.01.014

Deo A, Garner D (2014) Tropical cyclone activity over the Indian ocean in the warmer climate. In: Mohanty UC (ed) Monitoring and prediction of tropical cyclones in the Indian Ocean and climate change. Springer, New Delhi, pp 72–80

Dhyani S, Lahoti S, Khare S, Pujari P, Verma P (2018) Ecosystem based disaster risk reduction approaches (EbDRR) as a prerequisite for inclusive urban transformation of Nagpur City, India. Int J Disaster Risk Reduction 32:95–100. https://doi.org/10.1016/j.ijdrr.2018.01.018

GoN (2009) Guidelines for Community Forestry Development Programme Community Forest. Ministry of Forests and Environment, Government of Nepal, Kathmandu

Guha-Sapir D, Hoyois P, Below R (2013) Annual disaster statistical review 2012: the numbers and trends. CRED, Brussels

IPCC (2014) Climate change 2014: synthesis report. Contribution of Working Groups, I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, IPCC, Geneva, Switzerland. [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151p

IUCN (2020) Ecosystem-based approaches to climate change adaptation. International Union for Conservation of Nature (IUC), Gland, Switzerland. https://www.iucn.org/theme/ecosystem-management/our-work/ecosystem-based-approaches-climate-change-adaptation

JICA (2009) The study on disaster risk management for Narayangharh-Mugling highway. Final report, vol I, Summary. Japan International Cooperation Agency (JICA) and Nippon koei co., Ltd., pp 4–11. http://open_jicareport.jica.go.jp/pdf/11922242_01.pdf. Accessed on 02 Aug 2019

Jones HP, Hole DG, Zavaleta ES (2012) Harnessing nature to help people adapt to climate change. Nat Clim Chang 2(7):504–509

Kundzewicz ZW, Kanae S, Seneviratne SI, Handmer J, Nicholls N, Peduzzi P, Mechler R, Bouwer LM, Arnell N, Mach K, Muir-Wood R, Brakenridge RG, Kron W, Benito G, Honda Y, Takahashi K, Sherstyukov K (2014) Flood risk and climate change: global and regional perspectives. Hydrol Sci J 59(1):1–28. https://doi.org/10.1080/02626667.2013.857411

Lo V (2016) Synthesis report on experiences with ecosystem-based approaches to climate change adaptation and disaster risk reduction. In; Secretariat of the Convention on Biological Diversity. Retrieved from https://www.cbd.int/doc/publications/cbd-ts-85-en.pdf

MEA (2005) Linking ecosystem services and human wellbeing. In: 3, C. (ed)

Mercer J (2010) Disaster risk reduction or climate change adaptation: are we reinventing the wheel? J Int Dev 22(2):247–264

Mirza MMQ (2011) Climate change, flooding in South Asia and implications. Reg Environ Change 11:95–107

Mittermeier RA, Robles-Gil P, Hoffmann M, Pilgrim JD, Brooks TB, Mittermeier CG, Lamoreux JL, Fonseca GAB (2004) Hotspots revisited: earth's biologically richest and most endangered ecoregions. CEMEX, Mexico City, Mexico, p 390

Molden D, Sharma E, Shrestha AB, Chettri N, Pradhan NS, Kotru R (2017) Advancing regional and transboundary cooperation in the conflict-prone Hindu Kush Himalaya. Mountain Res Develop 37(4). https://doi.org/10.1659/MRD-JOURNAL-D-17-00108.1

Monty F, Murti R, Miththapala S, Buyck C (eds) (2017) Ecosystems protecting infrastructure and communities: lessons learned and guidelines for implementation. IUCN, Gland, Switzerland, x + 108p

Nalau J, Becken S, Mackey B (2018) Ecosystem-based adaptation: a review of the constraints. Environ Sci Policy 89:357–364. https://doi.org/10.1016/j.envsci.2018.08.014

Ojea E (2015) Challenges for mainstreaming ecosystem-based adaptation into the international climate agenda. Curr Opin Environ Sustain 14:41–48. https://doi.org/10.1016/j.cosust.2015.03.006

Reid H, Adhikari A (2018) Ecosystem-based adaptation: strengthening the evidence and informing policy. International Institute for Environment and Development, Inn Road, London

Reid H, Zhang Y (2018) Ecosystem-based approaches to adaptation: strengthening the evidence and informing policy. Research results from the Participatory Plant Breeding and Community Supported Agriculture project, China. IIED Project Report. IIED, London

Reid H, Seddon N, Barrow E, Hicks C, Hou-Jones X, Kapos V, Rizvi AR, Roe D, Wicander S (2017) Ecosystem-based adaptation: question-based guidance for assessing effectiveness. IIED, London

Saroar MM, Rahman MM, Bahauddin KM, Rahaman MA (2019) Ecosystem-based adaptation: opportunities and challenges in coastal Bangladesh. In: Huq et al. (eds) Confronting climate change in Bangladesh. The Anthropocene: Politik, Economics, Society and Science, vol 28. https://doi.org/10.1007/978-3-030-05237-9_5

Schipper L, Pelling M (2006) Disaster risk, climate change and international development: scope for, and challenges to, integration. Disasters 30(1):19–38. https://doi.org/10.1111/j.1467-9523.2006.00304.x

Seddon N, Reid H, Barrow E, Hicks C, Hou-Jones X, Kapos V, Rizvi AR, Roe D (2016a) Ecosystem-based approaches to adaptation: strengthening the evidence and informing policy: research overview and overarching questions. IIED, London. Available at http://pubs.iied.org/G04045/

Seddon N, Hou-Jones X, Pye T, Reid H, Roe D., Mountain D, Rizvi AR (2016b) Ecosystem-based adaptation: a win-win formula for sustainability in a warming world? IIED Briefing paper. IIED, London

Shah SIA, Zhou J, Shah AA (2019) Ecosystem-based adaptation (EbA) practices in smallholder agriculture; emerging evidence from rural Pakistan. J Cleaner Prod 218:673–684

Sharma E, Chettri N, Tse-ring K (2009) Climate change impacts and vulnerability in the Eastern Himalayas. ICIMOD, Kathmandu, p 27

Sharma E, Molden D et al (2019) Introduction to the Hindu Kush Himalaya Assessment. In: Wester P, Mishra A, Mukherji A, Shrestha A (eds) The Hindu Kush Himalaya Assessment. Springer, Cham

Singh S, Nair SS, Gupta AK (2013) Ecosystem services for disaster risk reduction: a case study of wetland in East Delhi Region, India. Global J Human Social Sci Geogr Geo-Sci Environ Disaster Manage 13(4):37–47. Retrieved from http://socialscienceresearch.org/index.php/GJHSS/article/view/646

Song Y, Zhang Y, Song X, Buckley L (2015) Emerging biocultural innovations for climate resilience in southwest China. SIFOR qualitative baseline study. IIED, London

Swiderska K, King-Okumu C, Monirul Islam M (2017) Ecosystem-based adaptation: a handbook for EbA in mountain, dryland and coastal ecosystems. IIED, London

Thapa PS, Adhikari BR (2019) Development of community-based landslide early warning system in the earthquake-affected areas of Nepal. J Mt Sci 16(12):2701–2713

Timalsina R, Songwathana P (2020) Factors enhancing resilience among older adults experiencing disaster: a systematic review. Australas Emergency Care 23(1):11–22. https://doi.org/10.1016/j.auec.2019.12.007

Triyanti A, Chu E (2018) A survey of governance approaches to ecosystem-based disaster risk reduction: Current gaps and future directions. Int J Disaster Risk Reduction 32:11–21

UNDP (2015) EbA annual progress report. United Nations Development Programme Nepal, Kathmandu, Nepal. Accessed at: https://www.np.undp.org/content/nepal/en/home/operations/projects/closed-projects/environment---energy/eba/home.html

UNFCCC (2015) Adoption of the Paris Agreement. Conference of the Parties twenty-first session, Paris, 30 Nov to 11 Dec 2015. http://bit.ly/2GGWXXa

UNOCHA August 21, 2017. https://reliefweb.int/sites/reliefweb.int/files/resources/Nepal%20Flood%20Sitrep%2021%20August%202017.pdf

Wester P, Mishra A, Mukherji A, Shrestha ABS (eds) (2019) The Hindu Kush Himalaya Assessment—mountains, climate change, sustainability and people. Springer Nature Switzerland AG, Cham. https://doi.org/10.1007/978-3-319-92288-1

Yusuf AA, Francisco HA (2009) Climate change vulnerability mapping for Southeast Asia. Economy and Environment Program for Southeast Asia (EEPSEA), *S*ingapore. Available at https://www.idrc.ca/sites/default/files/sp/Documents%20EN/climate-change-vulnerability-mapping-sa.pdf

Zolch T, Wamsler C, Pauleit S (2018) Integrating the ecosystem-based approach into municipal climate adaptation strategies: the case of Germany. J Cleaner Prod 170:966–977. https://doi.org/10.1016/j.jclepro.2017.09.146