Ecosystem-based approaches to adaptation: strengthening the evidence and informing policy

Research results from the Mountain EbA Project, Nepal

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Summary

Ecosystem-based adaptation (EbA) is the use of biodiversity and ecosystem services as part of an overall strategy to help people to adapt to the adverse effects of climate change. Under the 'Ecosystem-based approaches to adaptation: strengthening the evidence and informing policy' project, IIED, IUCN and the UN Environment World Conservation Monitoring Centre (UNEP-WCMC) are working at 13 sites in 12 countries to gather practical evidence and develop policy guidance for governments on how EbA can best be implemented. The project has developed a definition of effective EbA and a framework for assessing EbA effectiveness which has been applied at all 13 sites, and the results will be collated and compared to draw conclusions that are based on more than single case studies. This report presents the findings from a literature review, and interviews with a wide variety of stakeholders conducted by IUCN at the project site in the Panchase region of Nepal, where activities aimed at improving access to water resources, bioengineering practices and cultivation of useful plants, as well as livelihood improvement programmes, were implemented to help mountain communities adapt to the adverse impacts of climate change.

The report concludes that EbA can be an effective way to tackle climate change. The project activities helped people maintain or improve their adaptive capacity or resilience, and reduce their vulnerability to climate change, in a multitude of ways. While it was clear that some groups benefitted more from improvements than others, there was little evidence of this coming at a cost to others. Many social co-benefits also emerged from the project, and it was clear that the use of participatory processes had been key to improving community adaptive capacity. Also as a result of the project, ecosystem resilience in Panchase improved and ecosystem services were maintained or restored, primarily at the catchment level. Downstream improvements in ecosystem service provision were often larger than improvements at the project sites, however, and increases in crop raiding and water provision for conservation rather than agricultural needs were apparent. A number of cost-benefit analyses were conducted on various activities implemented under the project that suggest that EbA approaches were cost-effective and compared well with alternative adaptation approaches. Quantifying the monetary values of ecosystem services and environmental resources, however, was challenging.

Acronyms

AF	Adaptation Fund
ASK	Aapasi Sahyog Kendra
BMU	German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
CBA	Community-based adaptation
CBD	Convention on Biological Diversity
EbA	Ecosystem-based adaptation
EPIC	Ecosystem Protecting Infrastructure and Communities
GCF	Green Climate Fund
GGN	Green Governance Nepal
IIED	International Institute for Environment and Development
IKI	International Climate Initiative
ISET	Institute for Social and Environmental Transition, Nepal
IUCN	International Union for Conservation of Nature
LAPA	Local Adaptation Plan of Action
MDO	Machhapuchhre Development Organisation
NAPA	National Adaptation Programme of Action
NGO	Non-governmental Organisation
PES	Payments for ecosystem services
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNEP-WCMC	United Nations Environment Programme World Conservation Monitoring Centre
UNFCCC	United Nations Framework Convention on Climate Change
VDC	Village Development Committee

Introduction

The global climate is changing rapidly, and as nations and the international and bilateral organisations and processes that support them plan how best to adapt to climate change, they need evidence on where to focus efforts and direct financial resources accordingly. The main approach to climate change adaptation to date has tended to involve investment in engineered interventions, such as sea walls or irrigation infrastructure (Jones et al. 2012). There is growing realisation, however, that Ecosystem-based Adaptation (EbA) may sometimes provide the optimal adaptation solution, particularly for poorer countries where people are more dependent on natural resources for their lives and livelihoods. A growing number of organisations and countries are implementing EbA and integrating it into emerging climate change policy responses (Seddon et al. 2016a; 2016b).

EbA is defined by the United Nations Convention on Biological Diversity (CBD) as the "use of biodiversity and ecosystem services to help people to adapt to the adverse effects of climate change as part of an overall adaptation strategy" (CBD 2009). This definition was later elaborated by the CBD to include "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). Examples of EbA include: restoring coastal ecosystems to lower the energy of tropical storms and protect local communities against erosion and wave damage; wetland and floodplain management to prevent floods, and to maintain water flow and water quality in the face of changing rainfall patterns; conservation and restoration of forests and natural vegetation to stabilise slopes and prevent landslides, and to regulate water flows preventing flash flooding; and, the establishment of diverse agroforestry systems to help maintain crop yields under changing climates. Box 1 describes some of the key attributes of effective EbA, derived from a review of relevant literature (taken from Seddon et al. 2016b).

Box 1: Key attributes of effective ecosystem-based approaches to adaptation (EbA)

1. **Human-centric.** EbA emphasises human adaptive capacity or resilience in the face of climate change.
2. **Harnesses the capacity of nature to support long-term human adaptation.** It involves maintaining ecosystem services by conserving, restoring or managing ecosystem structure and function, and reducing non-climate stressors. This requires an understanding of ecological complexity and how climate change will impact ecosystems and key ecosystem services.
3. **Draws on and validates traditional and local knowledge**. Humans have been using nature to buffer the effects of adverse climatic conditions for millennia. Traditional knowledge about how best to do this should thus be drawn upon when implementing EbA.
4. **Based on best available science**. An EbA project must explicitly address an observed or projected change in climate parameters, and as such should be based on climatic projections and relevant ecological data at suitable spatial and temporal scales.
5. **Can benefit the world's poorest**, many of whom rely heavily on local natural resources for their livelihoods.
6. **Community-based and incorporates human rights-based principles.** Like community-based adaptation (CBA), EbA should use participatory processes for project design and implementation. People should have the right to influence adaptation plans, policies and practices at all levels, and should be involved with both framing both the problem and identifying solutions. EbA initiatives should be accountable to those they are meant to assist and not simply those providing support (ie donors or governments). EbA should consistently incorporate non-discrimination, equity, the special needs of the poor, vulnerable and marginalised groups, diversity, empowerment, accountability, transparency, and active, free and meaningful participation.

7. **Involves cross-sectoral and intergovernmental collaboration.** Ecosystem boundaries rarely coincide with those of local or national governance. Moreover, ecosystems deliver services to diverse sectors. As such, EbA requires collaboration and coordination between multiple sectors (eg agriculture, water, energy, transport) and stakeholders. EbA can complement engineered approaches, for example combining dam construction with floodplain restoration to lessen floods.
8. **Operates at multiple geographical, social, planning and ecological scales**. EbA can be mainstreamed into government processes (eg national adaptation planning) or management (eg at the watershed level), provided that communities remain central to planning and action.
9. **Integrates decentralised flexible management structures** that enable adaptive management.
10. **Minimises trade-offs and maximises benefits with development and conservation goals** to avoid unintended negative social and environmental impacts. This includes avoiding maladaptation, whereby adaptation 'solutions' unintentionally reduce adaptive capacity.
11. **Provides opportunities for scaling up and mainstreaming** to ensure the benefits of adaptation actions are felt more widely and for the longer term.
12. **Involves longer-term 'transformational' change** to address new and unfamiliar climate change-related risks and the root causes of vulnerability, rather than simply coping with existing climate variability and 'climate-proofing' business-as-usual development.

Sources: Travers et al. (2012); Jeans et al. (2014); Faulkner et al. (2015); Reid (2014a); Reid (2014b); Girot et al. (2012); Ayers et al. (2012); Anderson (2014); Andrade et al. (2011); GEF (2012); ARCAB (2012); Bertram et al. (2017); Reid et al. (2009).

If properly implemented, EbA can meet objectives under all three Rio Conventions (Seddon et al. 2016b). For example, its emphasis on restoring natural ecosystems and increasing habitat connectivity helps countries meet their commitments under the Convention on Biological Diversity (CBD). EbA often involves maintaining the ability of natural ecosystems to control water cycles or supports effective management regimes for dry areas, and thus aligns with the goals of the United Nations Convention to Combat Desertification. Many EbA activities sequester carbon and some prevent the greenhouse gas emissions that would be emitted from hard infrastructure-based approaches to adaptation thus helping meet mitigation targets under the United Nations Framework Convention on Climate Change (UNFCCC). EbA promotes sustainability across a range of sectors, including agriculture, forestry, energy and water, and as such could help countries meet their Sustainable Development Goals (Seddon et al. 2016b). Lastly, by increasing the resilience of vulnerable communities to extreme events such as flooding and landslides, EbA helps countries to meet the goals of the Sendai Framework for Disaster Risk Reduction (Renaud et al. 2013).

Despite its strong theoretical appeal, many positive anecdotes from around the world and the acknowledged multiplicity of co-benefits, EbA is not being widely or consistently implemented, or sufficiently mainstreamed into national and international policy processes. Relative to hard infrastructural options, EbA currently receives a small proportion of adaptation finance (Chong 2014) There are four major explanations for this (Biesbroek et al. 2013; Ojea 2015; Vignola et al. 2009; Vignola et al. 2013; Seddon et al. 2016b).

1. First, there is uncertainty around how best to finance EbA. International climate finance, through mechanisms such as the Green Climate Fund (GCF) or the Adaptation Fund (AF), is one possibility, but this will not provide enough to address adaptation challenges at the scale required to meet the needs of the world's poorest. Payments for ecosystem services (PES) is another possibility, and may provide an alternative source of funding, or large-scale government social protection, employment generation, or environmental management programmes. However, in the context of providing finance for adaptation, both are in their infancy.
2. Second, many climate change impacts will be long-term, but this does not sit well with what are usually short-term political decision-making processes often based on standard electoral cycles. Photogenic engineered adaptation solutions with immediate but inflexible benefits are thus often

favoured over the long-term flexible solutions offered by EbA under which benefits may only be apparent in the future.

3. Third, the evidence base for the effectiveness of EbA, especially its economic viability (Black et al. 2016), is currently weak. Much evidence is anecdotal and comes from single case studies, and often the costs, challenges and negative outcomes of EbA activities are under-reported. More robust quantitative evidence, or at least consistently collated qualitative evidence, on the ecological, social and economic effectiveness of EbA projects relative to alternative approaches is needed (Doswald et al. 2014; Travers et al. 2012; Reid 2011; Reid 2014a; UNEP 2012).
4. The final major challenge to EbA relates to issues around governance. EbA necessitates cooperation and communication across multiple sectors and varying administrative or geographical scales. This is challenging for most models of governance, where decision making is often strongly based on sectors, administrative boundaries, and opportunities for supporting participation and locally driven approaches are limited.

Ecosystem-based approaches to adaptation: strengthening the evidence and informing policy

The 'Ecosystem-based approaches to adaptation: strengthening the evidence and informing policy' project was conceived to address the third (and fourth) challenge in the above list. The project aims to show climate change policymakers when and why EbA is effective: the conditions under which it works, and the benefits, costs and limitations of natural systems compared to options such as hard infrastructural approaches. It also aims to promote and provide tools to support the better integration of EbA principles into policy and planning. The project is supported by the International Climate Initiative (IKI). The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) supports IKI on the basis of a decision adopted by the German Bundestag. The project is being implemented by the International Institute for Environment and Development (IIED), the International Union for Conservation of Nature (IUCN) and the United Nations Environment World Conservation Monitoring Centre (UNEP-WCMC) in collaboration with 13 in-country partner organisations in 12 countries across Asia, Africa and the Americas (see Table 1). The project runs from July 2015 to September 2019.

Table 1: 'Ecosystem-based approaches to adaptation: strengthening the evidence and informing policy' project countries, partners and case studies

Project partner country	In-country partner institution	Project case studies
China	Centre for Chinese Agricultural Policy, Chinese Academy of Science	Participatory plant breeding and community-supported agriculture in Southwest China
Nepal	IUCN	Ecosystem-based adaptation in mountain ecosystems programme (Nepal)
Bangladesh	Bangladesh Centre for Advanced Studies	Economic incentives to conserve hilsa fish in Bangladesh - a supportive research project to the Incentive-based hilsa fishery management programme of the Department of Fisheries
Kenya	Adaptation Consortium; Kenya Drought Management Authority	Adaptation Consortium - supporting counties in Kenya to mainstream climate change in development and access climate finance
South Africa	Conservation South Africa	Climate-resilient livestock production on communal lands: rehabilitation and improved management of dryland rangelands in the Succulent Karoo

Uganda	IUCN	Ecosystem-based adaptation in mountain ecosystems programme (Uganda)
Burkina Faso	IUCN	Helping local communities to prepare for and cope with climate change in Northern Burkina Faso
Senegal	IUCN	Ecosystems protecting infrastructure and communities (EPIC)
Peru	IUCN	Ecosystem-based adaptation in mountain ecosystems programme (Peru)
	ANDES	Indigenous people biocultural climate change assessment, Potato Park
Chile	IUCN	Ecosystems protecting infrastructure and communities, South America geographical component (EPIC Chile)
Costa Rica	IUCN	Livelihoods and adaptation to climate change of the Bri Bri indigenous communities in the transboundary basin of Sixaola, Costa Rica/Panama
El Salvador	IUCN	Mangrove ecosystem restoration and responsible fishing practices in the Paz River

In order to address the weak evidence base for EbA, the project has developed a definition of effective EbA and a framework for assessing EbA effectiveness. Effective EbA is defined as “an intervention that has restored, maintained or enhanced the capacity of ecosystems to produce services. These services in turn enhance the wellbeing, adaptive capacity or resilience of humans, and reduce their vulnerability. The intervention also helps the ecosystem to withstand climate change impacts and other pressures” (Reid et al. 2017, based on Seddon et al. 2016b). This definition generates two overarching questions that need to be addressed in order to determine whether a particular EbA initiative is effective:

1. Did the initiative allow human communities to maintain or improve their adaptive capacity or resilience, and reduce their vulnerability, in the face of climate change, while enhancing co-benefits that promote wellbeing?
2. Did the initiative restore, maintain or enhance the capacity of ecosystems to continue to produce services for local communities, and allow ecosystems to withstand climate change impacts and other stressors?

By definition, EbA should also be financially and/or economically viable, and for benefits to materialise it needs support from local, regional and national governments and to be embedded in an enabling policy, institutional and legislative environment (Seddon et al. 2016b; Reid et al. 2017). This leads to two further overarching questions:

1. Is EbA cost-effective and economically viable?
2. What social, institutional and political issues influence the implementation of effective EbA initiatives and how might challenges best be overcome?

These questions encompass much important detail regarding how to assess and compare effectiveness in ecological, social and economic terms. They lead to a further set of nine more specific questions (Table 2) that reflect the growing consensus around the key characteristics of effective EbA (Box 1).

This framework is being applied in 13 project sites in 12 countries, and results from all sites will be collated and compared during 2018 to draw conclusions that are based on more than single case studies and help answer the question of whether EbA is effective or not. Detailed guidance on the way that researchers and project managers can use the framework to draw conclusions about the effectiveness of an EbA project, or to shape project design or assess the progress of an ongoing EbA project or a project that has ended are provided in Reid et al. (2017).

Research conducted under the project will then be used to help climate change policymakers recognise when EbA is effective, and where appropriate integrate EbA principles into national and international climate adaptation policy and planning processes. An inventory of EbA tools and a 'tool navigator' are also being developed to support this process.

Table 2: Framework for assessing EbA effectiveness

1) Effectiveness for human societies

Did the initiative allow human communities to maintain or improve their adaptive capacity or resilience, and reduce their vulnerability, in the face of climate change, while enhancing co-benefits that promote long-term wellbeing?

1. Did the EbA initiative improve the resilience and adaptive capacity of local communities, and help the most vulnerable (eg women, children and indigenous groups)? If so, over what time frames were these benefits felt, and were there trade-offs (or synergies) between different social groups?
2. Did any social co-benefits arise from the EbA initiative, and if so, how are they distributed and what are the trade-offs between different sectors of society?
3. What role in the EbA initiative did stakeholder engagement through participatory processes and indigenous knowledge play? Did/does the use of participatory processes support the implementation of EbA and build adaptive capacity?

2) Effectiveness for the ecosystem

Did the initiative restore, maintain or enhance the capacity of ecosystems to continue to produce adaptation services for local communities, and allow ecosystems to withstand climate change impacts and other stressors?

4. What were/are the factors threatening the local ecosystem(s)? How did/do these pressures affect the resilience of the ecosystem(s) to climate change and other stressors and their capacity to deliver ecosystem services over the long term?
5. After the EbA initiative, which ecosystem services were restored, maintained or enhanced, and did the resilience of the ecosystem change? Over what geographic scale(s) and time frame(s) were these effects felt, and were there trade-offs (or synergies) between the delivery of different ecosystem services at these different scales?

3) Financial and economic effectiveness

Is EbA cost-effective and economically viable over the long term?

6. What are the general economic costs and benefits of the EbA initiative? How cost-effective is it, ideally in comparison to other types of interventions, and are any financial or economic benefits sustainable over the long term?

4) Policy and institutional issues

What social, institutional and political issues influence the implementation of effective EbA initiatives and how might challenges best be overcome?

7. What are the key policy, institutional and capacity barriers to, or opportunities for, implementing EbA at the local, regional and national levels over the long term?
8. What, if any, opportunities emerged for replication, scaling up or mainstreaming the EbA initiative or for influence over policy, and how?
9. What changes in local, regional and/or national government or in donor policies are required to implement more effective EbA initiatives?

The Mountain EbA project, Nepal

The Global Mountain EbA Programme, funded by the International Climate Initiative (IKI) with support from the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), was implemented from 2011 to 2016 by UNDP, UN Environment and IUCN, in partnership with the Governments of Nepal, Peru and Uganda. This case study focuses on programme activities in Nepal, which in this report are referred to as the Mountain EbA project.

The Mountain EbA project in Nepal was implemented in the districts of Kaski, Parbat and Syangja, in the Panchase region of Nepal. This region covers an area of 279 km² and has a population of roughly 62,000. The altitude of Panchase ranges from 800 to 2,517 metres above sea level, linking the lowlands to the Annapurna range of the high Himalayas. Natural mountain ecosystems in the area are mostly temperate broadleaf and mixed forests, and small lakes. Some 50% of the Panchase region is forested, 30% is used for agriculture, and 10% is grassland (IUCN undated). Of the 55,000 hectares of forested land, about 68% is protected. The region is famous for the diversity of its orchid species (Shah et al. 2012).

Box 2 lists the main project partners in Nepal. The project also worked with 17 Village Development Committees (VDCs) in the Panchase Protected Forest area. Nine of these are within the core part of the Panchase Protected Forest, a conservation area working to sustainably manage biodiversity, water resources and ecotourism through participatory management approaches with local communities. The remaining eight VDCs are on the margins of the Panchase Protected Forest (UNDP 2015). The economy of Panchase is largely subsistence agriculture based on crops and livestock (UNDP 2015).

Box 2: Main partners in the Mountain EbA project, Nepal

- Ministry of Forest and Soil Conservation, Department of Forest (implements the project at the national level)
- Ministry of Population and Environment, previously known as the Ministry of Science, Technology and Environment (overall coordination)
- Government Authorities of Kaski, Parbat and Syangja (District Forest Office, District Soil Conservation Office, Panchase Protected Forest Programme)
- Machhapuchhre Development Organization (MDO) Nepal and Aapasi Sahayog Kendra (ASK) Nepal
- Panchase Protected Forest Council

Source: UNDP (2015); IUCN (undated).

Project activities in Nepal aimed to enhance the ability of decision makers to plan and implement EbA strategies and measures at the national and ecosystem level. Stakeholders targeted by the project included vulnerable, marginalised and poor communities from the Panchase Protected Forest area and local and national-level policymakers and decision makers. EbA measures implemented under the project included (UNDP 2015; Rizvi et al. 2014):

- Maintaining and restoring ecosystems through agroforestry, forest resource conservation, and fodder species and broom grass plantations – known locally as Amriso (Thysanolaena maxima) – particularly alongside roads to reduce landslides.
- Restoring wetlands, springs and ponds to ensure year-long water supplies.
- Soil nutrient management by promoting the use of organic soil nutrients (compost dung and animal urine) to maintain and enhance soil health, increase crop productivity and increase soil moisture during dry periods. Specific activities included livestock-shed improvement, urine collection and use, compost making/farm yard manure improvement, biogas establishment, kitchen waste water use, vegetable seed distribution, a farmer's field school on Integrated Plant Nutrient Systems, and provision of training in organic farming (Adhikari et al. 2014a).
- Strengthening homestay businesses to diversify livelihoods and build local people's resilience to climate change. Specific activities included homestay operation skill enhancement, focusing on hospitality management; local cultural conservation and support for community museums; the establishment of an information centre; organic vegetable farming; promoting bee keeping; sanitation and hygiene improvement; and raising conservation awareness (Adhikari et al. 2014b).

The project also included a number of studies, such as vulnerability impact assessments, cost-benefit analysis and value chain studies. Not all EbA projects have the resources for this.

Methodology for assessing effectiveness

The methodology applied for assessing EbA effectiveness is detailed in Reid et al. (2017). Based around asking a detailed set of questions, this guidance describes a process that can be used to draw conclusions about the effectiveness of an EbA project that is ongoing or has ended. Table 3 shows how many Mountain EbA project stakeholders in Nepal were interviewed for this case study.

Table 4: Number of stakeholders interviewed under the Mountain EbA project

Level of interviewees	Number of respondents
National-level interviewees (to provide information on the context within which EbA project operates and bringing lessons to scale). These included stakeholders from the Ministry of Population and Environment, the Ministry of Forest and Soil Conservation, the Department of Forests, the national non-government organisations (NGOs) Green Governance Nepal (GGN) and the Institute for Social and Environmental Transition (ISET Nepal), and the deputy chair of the IUCN Commission on Ecosystem Management.	5
District-level authorities, including stakeholders from the District Forest Office, the District Soil Conservation Office, the District Agriculture Office and the Institute of Forests.	10
Project implementing partners, including stakeholders from the Panchase Protected Forest Council, the Machhapuchhre Development Organisation and Aapasi Sahayog Kendra.	13
Community beneficiaries, including the chairperson of the mothers' group, the VDC secretary, and male and female members of the Panchase Protected Forest Council. Focus group discussions were also held with a mothers group, a youth club, local leaders, a disadvantaged community (the Dalit community), teachers, a group of elders and a homestay group. Women were well represented amongst these interviewees.	12
Total number of respondents	**40**

Along with the interviews conducted, publications on the Mountain EbA project were also reviewed to assess the characteristics of project activities that contribute to EbA effectiveness. The results of this assessment are described in the following results section.

Research results

Effectiveness for human societies: did the initiative allow human communities to maintain or improve their adaptive capacity or resilience, and reduce their vulnerability in the face of climate change, while enhancing co-benefits that promote long-term wellbeing?

Did the EbA initiative improve the resilience and adaptive capacity of local communities, and help reduce vulnerability?

Changes in climatic patterns are quite noticeable in the area:

- Temperatures have increased (Shah et al. 2012; Adhikari et al. 2014a). Over a 30-year period (1981 to 2011), maximum and minimum average temperatures have increased by 0.8°C and 0.2°C, respectively (Khanal et al. 2014a; Adhikari et al. 2014a). These observed increases are in line with long-term predictions for a temperature increase of 1.2°C by 2030 for Nepal and 2°C to 5°C for the Panchase area by 2100 (Dixit et al. 2015).

- Changes in rainfall distribution and intensity have been observed (Shah et al. 2012). Between 1977 and 2009, the Panchase area experienced increases in annual rainfall but with significant inter-annual variability. Parbat and Syangja districts experienced some reductions in winter rainfall and increases in summer rainfall (Dixit et al. 2015). Between 1981 and 2011, winter rainfall decreased from 30mm to 17mm per day, and the total number of days with rainfall decreased from 135 to 120 (Khanal et al. 2014a; Adhikari et al. 2014a). By the 2030s, rainfall is expected to be intense and its seasonality more pronounced (Dixit et al. 2015).
- The frequency and intensity of extreme weather events has altered (Khanal et al. 2014a; Adhikari et al. 2014a). More droughts and landslides are being experienced, the latter of which can devastate remote mountain villages (UNDP 2015). Interestingly, in Chitre VDC, a decrease in flood frequency and strength has been noted (Shah et al. 2012). By the 2030s, the frequency of floods and landslides is likely to increase (Dixit et al. 2015).
- Communities have observed a reduction in snowfall with the snowline shifting upwards (Shah et al. 2012).

Local villagers expressed grave concerns about the changing weather patterns in the area. They felt that increasing temperature, erratic rains and diminishing snowfall were negatively affecting their lives and livelihoods, agriculture, forests and biodiversity (Poudyal and Huang 2012). They have observed a decline in water resources (especially for irrigation), and traditional farming patterns have been affected. Maize takes longer to mature these days, less rice and millet are grown, potatoes suffer higher infestation levels, and the quality of fruit and vegetables is declining. Pest attacks are increasing, as are mosquito numbers (Shah et al. 2012). Climate change-related vegetation changes and increased incidences of landslides have been experienced (IUCN undated).

If the above climatic trends continue, profound adverse effects can be expected, particularly for water resources as a result of drying of natural springs and wetlands and reduced groundwater recharge (Khanal et al. 2014a). Agriculture will also experience serious negative impacts, with decreasing crop productivity, changes to cropping calendars, pest and disease infestations, water shortages, drought and invasive plant infestations (Adhikari et al. 2014a). Too much or too little rainfall may increase water-induced disasters, especially soil erosion and landslides, and the risk of downstream sedimentation will increase (Khanal et al. 2014a).

All community-level interviewees felt the Mountain EbA project had reduced their vulnerability. Most felt that conservation of and access to water resources, bioengineering practices and cultivation of useful plants were key components of this, as were knowledge promotion on EbA and organic/ecological farming. Others felt that livelihood improvement programmes focusing on agriculture reduced vulnerabilities, as did improvements in vegetable harvests under the project. Some felt that awareness about climate change further helped people reduce their vulnerabilities. All community-level interviewees highlighted the importance of livelihood and sustainable water provision as key contributors to local resilience. Some also stressed the importance of food security, disaster risk reduction, market access and improved policies as factors that improve local resilience. Most community-level interviewees felt the project helped communities adapt to climate change. Most felt that livestock shed improvements and local-level water resources conservation helped them adapt. More than half felt new knowledge helped them adapt. Others said that project homestay programmes, the cultivation of broom grass, the knowledge gained on ecosystems and EbA, and plantation activities helped them adapt.

All implementing partners felt that the project improved the resilience and adaptive capacity of local communities, and reduced their vulnerability. Examples of adaptive capacity improvements included local involvement in activities ranging from resource conservation and water body conservation to knowledge sharing and documentation.

District-level interviewees provided a number of examples of how the project affected local adaptive capacity. More than half felt it helped to engage local communities in conservation and the management of natural resources and ecosystem services, and that it raised awareness amongst local communities about invasive species and their impacts on local cultivation practices as well as native species. Others said the initiative helped reduce forest fires and improve soil conservation through the construction of conservation ponds. Some said the project improved local economic conditions through the production and marketing of non-timber forest products.

The published literature provided many examples of how the project most likely directly reduced vulnerability and improved resilience and adaptive capacity:

- The restoration and conservation of more than 60 community ponds and 45 water sources/natural springs in Kaski, Syangja and Parbat Districts occurred. Community ponds buffer against water-related natural hazards such as flooding, drought and landslides, and reduce erosion. Pond water is stored and is thus more available for irrigation and for domestic cattle and buffalo to drink during the dry season. Conserved water sources also sustain water supplies during dry seasons. Groundwater recharge has improved. All these contribute to building resilience (Khanal et al. 2014a). For example, the Dandaghopte Pond protects agricultural land and downstream areas from disasters such as flooding and landslides. Restoration also provides sufficient continuous clean water for households and agriculture, even during increasing dry periods, and increases the resilience of vegetation during dry periods (UNDP 2015).
- Improved livestock sheds (that collect urine and improve farmyard manure) mean less water is needed in the farmyard, which is important during droughts (UNDP 2015).
- Project soil management interventions and climate smart farming practices built the resilience of agriculture ecosystems and built community capacity to cope with climate change. Practices included timely crop cultivation and reductions in alien plant invasions (Adhikari et al. 2014a). Integrated soil nutrient management (using organic soil nutrients from compost dung and animal urine) supports the cultivation of crops according to the cropping season due to the timely availability of production inputs (UNDP 2015). Resulting increases in farm income, high crop and labour productivity, and savings made from reducing external inputs, reduced vulnerability (Adhikari et al. 2014a).
- Crop selection considered climate change (Adhikari et al. 2014a). For example, drought-resistant seed varieties support food provision during droughts (UNDP 2015).
- Broom grass cultivation and timur (*Zanthoxylum armatum* or bamboo-leaved prickly ash, commonly known as Nepalese pepper) restores hillsides and prevents landslides. Broom grass's strong root system helps reduce top-soil and sub-soil loss caused by heavy rainfall, soil erosion and landslides, and combats invasive species (UNDP 2015). It can thrive on dry land, thereby helping rehabilitate degraded lands (Rossing et al. 2015).
- Gabion walls reduce landslides and flooding during periods of intense rain. Roadside stabilisation with plantations (including broom grass) ensures that communities have better access to markets and alternative sources of livelihood. Gulleys reduce the damage to roads and agricultural land during floods (UNDP 2015).
- Project forest management activities improved resilience because of livelihood diversification, reduced water-induced disasters and rural infrastructure protection (Baral et al. 2014).
- Commercialisation of plant products diversifies livelihoods, which are then better able to deal with climate shocks (UNDP 2015).
- Project awareness raising and capacity building activities – such as EbA learning groups, exchange visits, events and radio broadcasts – helped improve understanding of EbA and track learning from implementation (Rizvi et al. 2014). Forest management, soil management and homestay interventions also built capacity in conservation of natural resources and sustainable use (Baral et al. 2014; Adhikari et al. 2014a; 2014b).

Some initial 'no regrets'[1] project activities contributed to adaptive capacity through income supplementation and diversification of livelihoods, and thus risk spreading, but project vulnerability

[1] 'No regrets' measures under this project means measures that do not worsen vulnerabilities to climate change or which increase adaptive capacities, as well as measures that will always have positive impact on livelihoods and ecosystems regardless of how the climate changes (Rossing and Nyman 2015).

impact assessments showed that they were not directly linked to the climate change adaptation challenges faced by local communities. Similarly, ecotourism promotion had no discernible direct adaptation benefits (UNDP 2015).

Which particular social groups experienced changes in resilience, adaptive capacity or vulnerability as a result of the initiative?

The Global Mountain EbA Programme chose to focus on vulnerable mountain communities, in part because mountain communities tend to be among the world's poorest and most marginalised people and are particularly vulnerable to climate change (UNDP 2015; Reilly and Swiderska 2016). The disadvantages mountain communities face in terms of general rural poverty are often compounded by gender, ethnic and geographic discrimination (UNDP 2015). Their remoteness often means that communication and transport links are limited, which can result in marginalisation and vulnerability to environmental impacts. Limited access to other resources means they have a relatively low capacity to adapt to climate change (Bhatta et al. 2016).

Many community interviewees also said that the poorest and the most vulnerable, children and indigenous groups were better able to adapt as a result of the project. All implementing partners agreed with this. For example, target beneficiaries of water source restoration and conservation at Dandaghopte Pond, Parbat are among Nepal's most disadvantaged and marginalised groups, the Dalits (UNDP 2015). For the project's soil management activities and forest conservation activities, households with poor economic conditions belonging to socially and economically disadvantaged groups that are considered highly vulnerable to climate change impacts were prioritised (Adhikari et al. 2014a; Baral et al. 2014).

All community interviewees and implementing partners said that women experienced changes in resilience, adaptive capacity or vulnerability and were better able to adapt to climate change as a result of the project. The feminisation of homestay businesses means that women particularly benefit from these activities (Adhikari et al. 2014b). This was not a deliberate project goal, but rather a result of male migration, the fact that kitchen and home-related work falls primarily to women in Nepal, and the fact that membership of the homestay business group consisted mostly of women.

Trade-offs in terms of who experiences changes in resilience, adaptive capacity or vulnerability, where changes occur and when

The project adopted a 'no regrets' approach to implementation in its initial stages. This aimed to maximise the positive and minimise the negative aspects of EbA activities, and to avoid worsening climate change vulnerabilities (Rizvi et al. 2014; Adhikari et al. 2014a).

More than half of the community interviewees felt there were trade-offs in terms of *who* was more able to adapt to climate change as a result of the project. Examples of groups that may be better able to adapt than others included those involved in project homestay programmes (contradicting the UNDP assessment that ecotourism had no direct adaptation benefits), the Amriso/broom grass group, those promoting alternative energy like biogas, improved cook stoves and livelihood activities along with the conservation of water resources, and locals with knowledge about climate change adaptation. Some 40% of the community interviewees felt there were no trade-offs, however, and all implementing partners stressed that there was no evidence of exclusion of any particular social groups in the context of accruing adaptation benefits and changes in resilience. Adhikari et al. (2014b) explain, for example, that specific households engaged in homestay businesses benefitted more from these activities than others, but that a rotational system for hosting guests gave each participating household or homestay member household an equal opportunity to generate income.

Most community interviewees felt there were no trade-offs in terms of *where* changes in resilience, adaptive capacity or vulnerability occur. Some felt, however, that there were trade-offs but gave no details. Several district-level and implementing partner interviewees explained that whilst project activities involved more community contributions to forest management or water recharge activities in upstream areas, it was downstream areas that accrued many of the benefits – to agriculture or in terms of water provision – without contributing as much to the project. One implementing partner also described a trade-off between upstream and downstream areas in terms of the construction of a rural road connecting two streams that had constantly constrained the flow of water from upstream to downstream areas, resulting, for example, in a trade-off between upstream ecotourism activities requiring road access and downstream agricultural water needs.

Most community interviewees felt there were no trade-offs in terms of *when* changes in resilience, adaptive capacity or vulnerability occur. Some, however, felt that adaptation gains accrued at different times, for example in terms of when project farming and water resources activities occurred. The project was designed to ensure early adaptation gains that would persist through the medium to long term. An initial rapid participatory vulnerability and impact assessment helped identify and implement early EbA actions on the ground, which in turn helped make the case for EbA at the community level, ensuring buy-in, commitment and local relevance. This phased or integrated approach to planning EbA measures proved valuable (UNDP 2015).

Social co-benefits from the EbA initiative

Community and implementing partner interviewees and the published literature describe a number of social co-benefits from the project. Many of these also contributed indirectly to improved climate change adaptation (UNDP 2015), even though they were not explicitly described as such by interviewees or the published literature. Interviewees rated sustainable water provision, the provision of livelihoods and disaster risk reduction as the most important social co-benefits.

- ***Sustainable water provision***. Implementing 'grey-green' water infrastructure measures early on in the project yielded tangible and visible social benefits. Pond restoration reduced the time spent collecting water, leaving more time for other work (UNDP 2015). Restored community ponds increased water availability for livestock, wildlife and humans, and increased the availability of water for irrigation and other household activities, especially during the dry season (Khanal et al. 2014a).
- ***The provision of livelihoods***. Early project 'no regrets' activities focused on generating economic benefits, such as promoting alternative livelihoods or increasing agricultural or livestock production. This helped secure local commitment and ownership. Reconstruction of ponds in Panchase led to enhanced soil moisture levels and soil quality, and reduced soil erosion, which will benefit agricultural land. Gabion wall construction provided short-term employment in construction. Roadside stabilisation with plantations such as broom grass has enhanced scenic beauty and thus supported tourism (UNDP 2015). Broom grass can also provide an alternative source of income for sustainable livelihoods – there is large market for the sweeping brooms made from the plant, while its leaves can be used as livestock fodder and its stems as fuelwood (Rossing et al. 2015). Promoting homestay practices helped diversify livelihood opportunities (Adhikari et al. 2014b). Forest management activities also supported tourism and livelihood diversification, and reduced workloads and the time spent collecting forest products, especially firewood and grasses (Baral et al. 2014). The use of organic manure and urine helped to maintain and enhance soil productivity. It improved soil properties and microbial activities, reduced dependency on chemical fertilizers and pesticides and supported timely crop cultivation. Use of organic manure and urine has increased farm productivity and income from the sale of high value crops, especially vegetables. Improved farm manure has also reduced pest problems (Adhikari et al. 2014a).
- ***Disaster risk reduction and increased security***. Restored community ponds protect agricultural land and downstream areas from erosion, flooding and landslides (Khanal, Adhikari et al. 2014). For example, Dandaghopte Pond reconstruction has helped collect rainwater as well as silt and eroded soil, and reduced surface water runoff. This protects downstream areas from disasters such as flooding and landslides. Gabion walls also protect riverside households and infrastructure and have enhanced the local sense of security (UNDP 2015). Forest management activities also protect rural infrastructure, especially roads, from water induced disasters such as erosion and landslides (Baral et al. 2014).
- ***Market access***. Roadside bioengineering and broom grass plantations have helped to reduce landslide risk and stabilise the road infrastructure, thus supporting road transport. Gabion wall construction has also improved transport links due to reduced flooding on roads and bridges. Gulleys protect road and plantation sites (UNDP 2015).

- ***Health benefits***. Pond and natural spring restoration has led to a decrease in waterborne diseases for humans as well as a notable decrease in diseases afflicting livestock, particularly intestinal parasites. Human health has also improved from consuming healthier livestock products (milk and meat). Better livestock sheds have improved household nutrition and dietary diversity and improved animal health and hygiene. Integrated soil management (using soil nutrients from organic manure and animal urine) has improved household nutrition and dietary diversity through the cultivation of high value crops, and improved animal health and hygiene, reducing animal health expenditures (UNDP 2015; Adhikari et al. 2014a). Ecotourism opportunities have also led to improvements in household sanitation (UNDP 2015), and forest management activities have led to improvements in women's health, especially a reduction in acute respiratory infections (Baral et al. 2014).
- ***Food security***, for example from drought resistant seed varieties and improved soil management (UNDP 2015; Adhikari et al. 2014a).
- ***Governance improvements***. Commercialisation of plant products has strengthened local groups. Broom grass and timur cultivation helps break down caste-related social and cultural barriers, while gabion wall construction has enhanced links with government agencies. Roadside stabilisation with plantations has strengthened institutional capacity for community broom grass management (UNDP 2015). Interviewees also felt local plans and policies had improved as a result of project activities, as they incorporated EbA.
- ***Reduced conflict over resources***. Pond restoration has reduced conflict over water, for example, and roadside stabilisation with plantations such as broom grass has increased social cohesiveness (UNDP 2015).
- ***Climate change mitigation.*** The establishment of new biogas plants, maintenance of old biogas plants and introduction of improved cook stoves have helped reduce deforestation and the use of wood for fuel.
- ***Enhanced traditional cultural customs***. The promotion of ecotourism and homestay practices has helped nurture local cultures and traditions (Adhikari et al. 2014b; UNDP 2015). Restored community ponds provide religious and cultural benefits and also provide recreational opportunities (Khanal et al. 2014a).
- ***Knowledge generation***. The Central Department of Environmental Science at Tribhuvan University helped with knowledge generation under the project, producing a total of 50 reports (case studies and masters theses). The project also produced a comprehensive vulnerability impact assessment, including hazard mapping.

Distribution and trade-offs relating to social co-benefits

All community interviewees felt that some social groups – for example, groups of homestay mothers, the broom grass group, and Dalit and poor and marginalised people – had benefitted more from the above social co-benefits than others. Kanel (2015a) describes how cultivation of non-timber forest products such as timur and broom grass under the project generated the most income for poor families (as compared with middle- or higher-income families). UNDP (2015) also describes how women have benefitted more from some activities than other stakeholder groups. For example, the project worked with the Panchase Women's Network to cultivate broom grass and timur, thus empowering women and strengthening social bonds between them through capacity building and training. Broom grass grows quickly and requires minimal time and effort to plant and maintain, so cultivating this plant is a good fit for the women's demanding schedules and increasing workloads in an area with high male outmigration. Involving women from different castes also helped break down caste-determined social and cultural barriers (Rossing et al. 2015). Bee-keeping also empowered women by providing them with an alternative livelihood and income-generating opportunities. Ecotourism promotion empowered women and provided them with access to financial services in addition to enhancing their skills in the hospitality, sanitation and food services arena (UNDP 2015). All implementing partners, however, felt that no social groups had benefitted more from these co-benefits than others.

The role of participatory processes and local/indigenous knowledge

Most community and district-level interviewees and all implementing partner interviewees said that the project incorporated local/indigenous knowledge. This was explored through consultation with 'citizen scientists', interviews and key informant surveys. Efforts were made to involve those with indigenous technical knowledge in selecting and implementing EbA activities. Published literature also supports these perceptions, with one early project planning document stating it is "important to document traditional knowledge about biodiversity and resource use" (Poudyal and Huang 2012), and Adhikari et al. (2014a) emphasising that 'no regret' EbA measures that integrated local knowledge with good practices being implemented in Nepal and elsewhere were selected to secure local ownership. Examples of where indigenous knowledge was used given by interviewees included:

- Pond conservation activities, and hence the rehabilitation of degraded land and soil fertility restoration.
- Group/collective farming activities and systems, such as kitchen gardens, organic farming and water source protection. Traditional knowledge informed fodder plantation activities.
- Protection of local culture.
- Road slope stabilisation, landslide treatment, gully control and other low-cost bioengineering works.
- Informing the project planning process by incorporating knowledge into project programming.
- Forest protection systems such as those determining who can enter the forest area to collect resources, and the allocation of rotations for keeping watch in community forests.

Interviewees and the published literature described a range of types of participatory processes[2] that were used to engage the local community in the project. These are listed below in order of interviewee priority:

- Most community interviewees, more than half of the implementing partner interviewees and some district-level interviewees felt that communities participated through 'self-mobilisation'. Compared to other countries in the Global Mountain EbA Programme, communities in Nepal were relatively cohesive and levels of participation were already high, which may have facilitated this self-mobilisation.
- Most implementing partner and district-level interviewees, and some community interviewees, felt that communities participated in an 'interactive' manner. For example, locals were engaged in decision making through the committees they were represented on, and UNDP (2015) describes how the Panchase Protected Forest had already adopted participatory community management approaches prior to the project (although arrangements for forest co-management by government and communities in Nepal are still being developed). One early project document states that site selection was based on a number of criteria, one of which was that "EbA options are available and will be acceptable to local communities" (Poudyal and Huang 2012). Rizvi et al. (2014) reiterated that activities were planned based on community suggestions, priorities, interests and skills (as well as criteria relating to ecosystem resilience) and that the use of participatory processes ensured that important institutions and stakeholders contributed to the action plans and EbA strategising. Project implementation sites for soil health management activities were identified in consultations with local communities. Detailed activity planning for soil management, and tourism/homestay promotion considered the interests and skills of the community. The beneficiaries of soil management activities

[2] Participatory approaches can be characterised according to the following typology: (1) passive, where people are told what is going to happen or has already happened; (2) information giving, where people answer questions posed by extractive researchers (they cannot influence proceedings and research findings may not be shared with them); (3) consultation by external professionals who define both problems and solutions (decision-making is not shared, and professionals are under no obligation to take on board people's views); (4) for material incentives, where people provide resources, for example labour, in return for food, cash or other material incentives; (5) functional, where people form groups to meet predetermined objectives related to the project. Such involvement tends to be during later project cycle stages after major decisions have been made; (6) interactive, where people participate in joint analysis, which leads to action plans and the formation of new local institutions or the strengthening of existing ones (groups take control over local decisions so people have a stake in maintaining emerging structures or practices); and (7) self-mobilisation, where people take initiatives independent of external institutions, develop contacts with external institutions for the resources and technical advice they need, but retain control over how resources are used. Adapted from Adnan et al. (1992) and Dazé (2009).

were identified by considering willingness to participate or interest in participating (Adhikari et al. 2014a). Similarly, sites were selected for implementing forest conservation activities in part based on the interests and skills of the local communities (Baral et al. 2014), and site selection and species for restoration/plantation activities were developed in consultation with district-level stakeholders and community institutions (IUCN Nepal 2013a). These activities have not yet been implemented.

- More than half of the community-level interviewees and some district-level interviewees said that participation by providing material incentives occurred.
- More than half of the community-level interviewees and some implementing partner interviewees said that participation by consultation with external professionals occurred. For example, guided consultations and interactive discussions with the communities improved understanding of community perspectives on ecosystem services, and changes in the flow of services.
- More than half of the community-level interviewees said that participation by information giving occurred. Some implementing partners also described how training programmes helped sensitise community members to climate change impacts, adaptation and EbA.
- Some community, implementing partner and district-level interviewees also felt that 'functional' participation occurred. For example, community ponds were mapped in consultation with local communities (Khanal et al. 2014a).

All 40 community, implementing partner and district-level interviewees felt that adopting participatory processes improved the adaptive capacity of local communities. They provided the following examples:

- The local community replicated project activities themselves because participatory approaches brought about a feeling of ownership. UNDP (2015) also explains that "carrying out participatory assessments enabled a sense of ownership and buy-in for identified 'no regrets' measures".
- Active participation helped raise awareness about ecosystem services and climate change impacts, and the impacts of invasive alien species on local species and cultivation. A common understanding about EbA and its implementation was developed, learning on the benefits of EbA compared to other adaptation approaches was shared, and knowledge on EbA was internalised. This new knowledge served as a foundation for building resilience and adaptive capacity. Rizvi et al. (2014) reiterate that the participatory process helped to translate the EbA strategy into awareness raising and capacity building activities for local partners and the community. UNDP (2015) also describes how initial rapid participatory assessments conducted under the project increased understanding of the links between climate change, ecosystems and livelihoods and enabled the implementation of early 'no regrets' measures. These in turn helped make the case for EbA, ensuring local buy-in (especially at local the level), and informed the design of well-grounded EbA measures at an appropriate scale (UNDP 2015).
- Participatory approaches helped local people build infrastructure and provide the labour for conservation and adaptation activities.
- Local capacity to implement projects was built. Training and visits helped with this. Rizvi et al. (2014) add that exchange visits in turn helped modify and improve field activities where needed.
- Forest ecosystems and water resources were better conserved and managed due to community mobilisation. The watershed was managed better and natural resource use rights were better implemented.
- Alternative livelihoods and better transport infrastructure can serve as a foundation for building resilience and adaptive capacity. Incomes also increased from the production and marketing of valuable non-timber forest products.
- Greater use of indigenous knowledge helped to transfer indigenous knowledge to the younger generation. UNDP (2015) also describes how using local and traditional knowledge can further the achievement of benefits. For example, existing conservation ponds had been used for hundreds of years but had been degraded over time. These were restored to their full function and adapted to provide a climate change adaptation function.
- Community involvement ensured project sustainability, which in turn improved local adaptive capacity. Rizvi et al. (2014) add that participatory planning, implementation and monitoring of project

activities minimised misunderstanding amongst the different stakeholders and motivated implementation. It further guided project activities, aligning them with EbA principles, managing time efficiently during implementation and making activities more cost-effective (Rizvi et al. 2014).

Effectiveness for the ecosystem: did the initiative restore, maintain or enhance the capacity of ecosystems to continue to produce ecosystem services for local communities, and allow ecosystems to withstand climate change impacts and other stressors?

Factors threatening local ecosystem resilience and service provision

Mountain ecosystems are particularly vulnerable to climate change (Bhatta et al. 2016). Increasing temperatures melt glaciers and snowpacks, bringing flooding and then drought. Increasingly frequent landslides follow more intense rainfall (UNDP 2015). The Panchase area is highly vulnerable –habitats are being destroyed, biodiversity lost, invasive species are increasing and ecosystem functions are becoming degraded (IUCN Nepal 2013a). If current trends continue, climate change is likely to lead to shifts in tree line and forest species composition; the arrival of more new species; an increase in forest fires and alien plant invasions; depletion of wetlands, water and forest resources; and habitat fragmentation from natural disasters, especially floods and landslides (Baral et al. 2014; IUCN Nepal 2013a). All district, community and implementing partner interviewees agreed that climate change was a major factor threatening local ecosystems. They described the following ways that climate change affects ecosystems, their ability to adapt to climate change and other stresses, and their ability to provide ecosystem services:

- Increases in natural hazards such as forest fires, floods, landslides and erosion are being observed. Sudden and abrupt changes in the climate, such as heavy rainfall, storms and drought, adversely affect farming.
- Decreasing forest/vegetation cover and the availability of water resources have a direct and immediate impact on productivity and food security.
- The cumulative stress faced by ecosystems over the years because of gradual temperature rises and irregular rains has eroded the capacity of the ecosystem to recover from shocks and disrupted ecosystem services provision. The ecosystem is thus less able to adapt to climate change pressures when exposed for a prolonged period of time.
- Species are becoming extinct and food chains are being disturbed.
- A reduction forest aesthetic values are being reduced.

All community, most district and over half the implementing partner interviewees felt that invasive species were a major threat to local ecosystems. Interviewees described how they encroach on cultivated land, affecting crop cultivation (and hence food security). The invasive species threaten native grassland species and weaken forest conservation efforts. Outmigration – whereby young men leave to look for work in cities – is common in mountainous areas in Nepal (Reilly and Swiderska 2016), and Panchase is no exception. This has led to encroachment by invasive species on abandoned, unproductive grasslands (UNDP 2015; IUCN Nepal 2013a). Poudyal and Adhikari (2013a) counter, however, that outmigration has also had positive impacts on biodiversity. A 2013 survey found 52 invasive alien species in the area, 18 of which were highly invasive, with *Ageratum conyzoides* and *Ageratina adenophora* particularly problematic. Invasive species threaten local biodiversity and bring socioeconomic risks. For example, *Ageratum conyzoides* is poisonous for grazing cattle and outcompetes agricultural crops such as ginger, millet, rice and grasses (Poudyal and Adhikari 2013b).

More than half of the district, community and implementing partner interviewees felt that land conversion leading to habitat change, and often overexploitation, threatened local ecosystems. UNDP (2015) also explains how deforestation, road construction and mining accelerate erosion and enhance landslide and flood risk. Informal road network expansion done by communities has also promoted deforestation, in particular the overharvesting of commercial species (Baral et al. 2014). The VDC of Bhadaure Tamagi, in Kaski, has reported some cases of human-wildlife conflict such as crop raiding by monkeys and wild hares, and occasional instances of leopard attacks (Poudyal and Adhikari 2013a).

Most implementing partner interviewees felt that weak institutions or legal frameworks and weak governance threatened local ecosystems, in many instances exacerbating the challenges listed above. District and community interviewees agreed with this to a lesser extent. Examples given included weak governance facilitating the encroachment of invasive species, which have degraded the forest; poor soil, vegetation and water management; overexploitation of the ecosystem for agricultural purposes; unplanned infrastructure construction due to weak governance and the lack of appropriate institutional and legal frameworks; and land degradation and deforestation reducing local peoples' resources. Various publications also emphasise the damaging consequences of unplanned infrastructure construction and repair, especially rural roads, which have destroyed community ponds, degraded forests and accelerated soil erosion, river/wetland sedimentation, landslides and biodiversity loss (Khanal et al. 2014a; UNDP 2015; Baral et al. 2014; IUCN Nepal 2013a). Further examples of poor management include the decreased use of organic manure and biopesticides leading to soil nutrient imbalances, which have degraded soil quality and productivity (Adhikari et al. 2014a). Forests are also being degraded due to open livestock grazing and unsustainable management. The performance of plantations is poor, primarily because of inappropriate species selection and the limited attention given to plantation management (Baral et al. 2014; IUCN Nepal 2013a). Overgrazing and unsustainable resource use also occurs in Panchase (IUCN Nepal 2013a), along with poaching and illegal logging (Poudyal and Adhikari 2013a).

Additional threats listed less frequently by implementing partner and community-level interviewees included nutrient pollution and diseases. For example, new diseases are appearing, outbreaks of which may lead to livestock and harvest loss. Forest fires also occur in the Panchase region (IUCN Nepal 2013a).

Boundaries influencing ecosystem resilience

Most implementing partner interviewees felt there were boundaries influencing ecosystem resilience in Panchase, but some did not. More than half of the district-level interviewees felt that there were no boundaries.

A landscape-level approach can better address climate hazards such as floods (UNDP 2015), although one implementing partner interviewee noted how climate change impacts cross spatial (and temporal) ecosystem boundaries. Implementing partners also stressed the importance of size. They explained that the resilience of a system is linked to how large it is and that larger areas will be better able to contain the effects of disturbances to habitats or species. Ecosystem services will be more stable and reliable as size increases. Whilst the extent of anthropogenic pressure on ecosystem services is important, a larger area can help distribute stress better.

One district-level interviewee explained that local ecosystem services strongly align with local boundaries such as those of the watershed. If the watershed is managed properly, ecosystem services improve and the resilience of people in the watershed increases. This is also strongly linked to local governance, and the sub-watershed boundary in Panchase in fact falls within a number of VDC administrative boundaries, resulting in a misalignment of management levels. One implementing partner interviewee explained that emphasising the sub-watershed basin inside a larger basin can be a useful approach to sustainable ecosystem-based development and the regeneration of ecosystem services production. They too emphasised that administrative boundaries delineating forests or water bodies affect ecosystem resilience.

Thresholds influencing ecosystem service provision

Most implementing partner interviewees felt there were thresholds beyond which the ecosystems in Panchase could no longer provide key ecosystem services. However, the remaining implementing partners, along with more than half of the district-level interviewees, felt there were no thresholds, so there was no clear consensus on the issue. One interviewee explained that quantifying thresholds is difficult as it requires scientific validation, which is time-consuming and expensive. Thresholds may change according to climate change and other stressors that affect ecosystem structure and functioning, so measurement may only be relevant for a particular point in time. Interviewees described possible thresholds relating to the following factors:

- ***Temperatures that are too high*** will reduce soil water content and lead to plant death.

- ***Excessive rainfall*** induces landslides on the hillsides and sedimentation in the valleys, which in turn causes desertification.
- ***Climate change*** limits the ability of an ecosystem to deliver its services and leads to extinctions. Abrupt climate change may lead to agricultural losses.
- ***Nutrient pollution*** from cropland can pollute water bodies.
- ***Degradation, exploitation and land use change*** will alter species composition and lead to a deficit in nutrient supply and soil quality.

EbA initiative impacts on ecosystem resilience and services provision

Most implementing partner and district-level interviewees felt that ecosystem resilience in Panchase had improved after the project, and all agreed that ecosystem services had been maintained or restored. Some also mentioned that the duration of the project was too short and it was too soon after project completion to see if improvements in ecosystem resilience and service provision had emerged. All interviewees agreed that provisioning services had been maintained or restored as a result of the project. Many also felt that regulating, cultural and supporting services had been maintained or restored. The published literature was also clear that initial project 'no regrets' measures had improved ecosystem service provision (UNDP 2015). It provided the following examples:

Provisioning services

- Restored community ponds improve rainwater infiltration and contribute to groundwater recharge and to water sprouting from springs in downstream areas, especially during the dry season. For example, the Dandaghopte Pond has enhanced soil moisture levels. Water flow from upstream areas and water provision for domestic, livestock and agricultural use has increased. The increase in water availability has supported biodiversity conservation, especially through the provision of water for birds and other wild animals. It has protected and created habitats for aquatic organisms and water-dependent ecosystems. Restored wetlands, springs and ponds helped address climate change-induced reductions to year-long drinking water supplies, but water is still not always available throughout the year in all ponds (UNDP 2015; Khanal et al. 2014a).
- Bioengineering and broom grass plantations improved farming yields in areas adjacent to roads, as flooding was controlled, slopes and soils were stabilised and debris from upstream no longer collected on the farmland (UNDP 2015).
- Commercialisation of plant products supported sub-surface and groundwater recharge (UNDP 2015).
- Forest management activities conserved water sources (Baral et al. 2014).

Regulating services

- Broom grass cultivation and timur helped control invasive species, soil erosion and also overgrazing. Broom grass plantations on the sides of roads, barren/eroded areas, sloping land and farmland stabilised slopes and reduced erosion, thus preventing climate change-induced hazards such as landslides, soil erosion and flash floods. They also reduced sedimentation, again reducing the risk of climate change-induced landslides. Broom grass cultivation in forests and on barren land helped control invasive species (Kanel 2015a; UNDP 2015; Baral et al. 2014).
- Bioengineering helped with landslide management and protected irrigation canals, thus preventing flooding of adjacent farms. It protected agricultural land, preventing the topsoil from washing away (UNDP 2015).
- Gulley control protected and stabilised gulleys and reduced soil erosion (UNDP 2015).
- Restored community ponds increase water infiltration by reducing the rate and volume of run-off. This slows erosion and buffers against ecological damage from water-induced disasters such as floods and landslides (Khanal et al. 2014a). For example, in reducing water run-off, the Dandaghopte Pond will reduce downstream flooding and landslides. The risk of forest fires is also reduced due to enhanced soil moisture (UNDP 2015; Rossing and Nyman 2015).

- The use of organic manure and urine has reduced water body nutrient loads and thus eutrophication as a result of the influx of nutrients into downstream water bodies from chemical fertilizer use. It has also reduced soil erosion and alien invasive plant invasions (Adhikari et al. 2014a; UNDP 2015).
- Homestay promotion has helped improve ecosystem resilience in part because it is a more sustainable alternative to hotel construction, which is often associated with environmental damage (Adhikari et al. 2014b).
- Forest management activities, especially planting fast-growing species, mean the forest is now better protected against water-induced disasters such as landslides, erosion and waterbody sedimentation. This has improved forest resilience. Forest management activities have also reduced carbon emissions from deforestation and forest degradation (Baral et al. 2014).
- Household biogas promotion lowers carbon emissions (Baral et al. 2014).

Cultural services

- Ecotourism promotion has improved the availability of cultural goods and services, conserved natural heritage and increased conservation awareness (UNDP 2015; Adhikari et al. 2014b).
- Forest management activities raised conservation awareness and sensitised the community on the importance of controlling open grazing. Activities include celebrations of different days, conducted with households, schoolchildren and community members (Baral et al. 2014).

Supporting services

- Broom grass cultivation and timur grown for commercial purposes helped rapidly rehabilitate the ecosystem and degraded land and slopes, by regenerating soil and raising soil moisture levels (UNDP 2015).
- Restored community ponds such as the Dandaghopte Pond improve soil conditions, especially soil moisture content and fertility. Greenery and the growth of trees and other crop species has increased near water sources and in downstream areas (Khanal et al. 2014a; UNDP 2015).
- Bee-keeping increased species diversity by increasing pollination and productivity, including crop productivity (UNDP 2015).
- Soil management activities have maintained soil productivity and fertility, especially organic matter content, and enhanced soil moisture retention capacity, resulting in less need for irrigation water and tackling climate change induced soil moisture reductions during dry periods. Activities have increased soil microbial activity, reduced pressure on grasslands and reduced the incidences of agricultural land lying fallow. Grasslands now store more carbon (Adhikari et al. 2014a; UNDP 2015)
- Homestay promotion has helped improve ecosystem resilience in part because of the organic farming it involves (Adhikari et al. 2014b).
- Forest restoration with utis trees (*Alnus nepalensis*) facilitates soil conservation and nitrogen fixation (IUCN Nepal 2014).
- Forest management activities built forest ecosystem resilience by reducing direct dependency on forest resources (for example, by promoting biogas), controlling alien invasive plants in forests, and promoting in-situ conservation and regeneration of indigenous plant species, which have high conservation value and are at different threat levels. Activities improved habitats and included the establishment of biodiversity gardens on forest sites (Baral et al. 2014).

Geographic scale of ecosystem services provision and trade-offs or synergies between geographical scales

Most implementing partner and district-level interviewees agreed that ecosystem services were restored at the watershed level as a result of the project. During inception, the Global Mountain EbA Programme identified catchments or sub-watersheds as a particularly good scale for planning and implementing EbA measures, particularly in the context of ensuring comprehensive and sustainable landscape scale EbA benefits and ecosystem services provision, but also in the context of working with district level governments and protected area managers. In Nepal, project activities focused on the sub-watershed level (UNDP 2015). Panchase feeds the Harpan Khola, Andheri Khola and Phedi Khola watersheds (Shah et al. 2012), and project activities were initiated in the Kaski, Syangja and Parbat Districts, which represent three different sub-watersheds of the Panchase region (Baral et al. 2014).

Most initial 'no regrets' project activities related to soil and forest management at the UNDP sites were scattered and implemented at the community scale, in isolation from other ecosystems and without considering the entire farming or forest system. When later vulnerability impact assessments were conducted, landscape connectivity was considered, with interconnected EbA measures embedded in ecosystems and focusing on the provision of ecosystem services at a landscape scale. A strategic VDC level plan for EbA was developed and implemented (Adhikari et al. 2014a; Baral et al. 2014).

To a lesser extent, implementing partner and district-level interviewees said that ecosystem services were maintained or restored as a result of the project at the level of the forest, the local village or urban area, and the mountainous region.

Project activities at the sub-watershed level in Nepal also provided ecosystem service provision improvements to downstream areas. Areas downstream from the project area, such as Phewa Lake and Pokhara City, benefitted from improved water availability due to project interventions and the risk of hazards (floods, landslides and droughts) was reduced (UNDP 2015).

Some 70% of implementing partner and district-level interviewees felt there were trade-offs in ecosystem service provision. They explained that activities undertaken to improve ecosystem resilience and service provision upstream often saw these improvements accrue in downstream areas. One implementing partner explained that the trade-offs between upstream and downstream areas in terms of water use for conservation and ecotourism are likely to continue, but that the watershed management plan will help address them. A PES scheme is under consideration. More conservation-oriented forest management – facilitated by out-migration of local communities in search of better livelihood opportunities, which reduced direct dependency on forests resources – meant that crop raiding increased (Baral et al. 2014). Similarly, whilst restored community ponds increased water availability, water is still not available throughout the year, so whilst the conservation value of the ponds has improved, this has been poorly integrated with the needs of agriculture and other economic activities. Pond water holding capacity needs to increase further to provide sufficient water for irrigation (Khanal et al. 2014a).

Time frame over which ecosystem services are provided, and trade-offs or synergies between timescales

Implementing partner and district-level interviewees felt that ecosystem services were maintained or restored over a range of time frames, from two years to more than ten years. Several gave examples of how activities undertaken now are likely to lead to long-term improvements in ecosystem resilience and service provision. For example, protection of water sources such as springs will provide immediate improvements to water provision for users within the watershed, and these improvements are likely to be sustained. Similarly, adopting EbA options for road protection is likely to provide both immediate and long-term benefits. Community involvement in ecosystem maintenance will improve intergenerational equity, and natural resources are being conserved for future generations. UNDP (2015) also argues that the project adopted a long-term planning approach that provided early environmental benefits that are expected to be sustained for the medium to long term, beyond the lifetime of the project.

Some 70% of implementing partner and 40% of district-level interviewees felt there were trade-offs in terms of the delivery of ecosystem services at different timescales, but no examples were given.

Financial effectiveness: is EbA cost-effective and economically viable over the long term?

How cost-effective is the EbA initiative?

Various cost-benefit analyses were conducted under the project using simple economic analysis techniques or cost-benefit analysis tools that considered the value of different ecosystem services. The first three of the following interventions were implemented, whilst a cost-benefit analysis for the last one was conducted to assess its feasibility (UNDP 2015; Rossing et al. 2015). Results from this latter cost-benefit analysis are not detailed here because whilst siltation dams may be 'climate friendly' and provide development benefits, they cannot be classified as EbA (Kanel 2015b; Martin 2016).

1. Planting broom grass in degraded grasslands.
2. Planting timur on private land.
3. Constructing gabion walls with anchoring revegetation along the banks of the Harpan River.
4. Siltation dams along the streams of the Harpan River.

The cost-benefit analyses for the first two showed they were viable and profitable (Kanel 2015a; Rossing et al. 2015). Results from both are described in the next section.

The cost-benefit analysis for gabion wall construction and revegetation showed that this intervention has net benefits and is thus "a very beneficial investment and a cost-effective way of helping society adapt to anticipated climate change" (UNDP 2015). The analysis applied a 10% discount rate and showed that the total present value of the cost was 782,140 Nepalese rupees, and the present value of benefits was 1,288,737 rupees over a period of 20 years (the life of the structure is estimated to be 20 years, so the cost-benefit analysis was conducted over this period). Thus, the benefit-to-cost ratio is about 1.6. The internal rate of return is 19% (Kanel 2015b). Calculations included the costs of soil excavation, gabion wire fabrication, setting the gabion boxes, transportation of materials from Pokhara to the site, filling boxes with stones, and planting bamboo on top of the gabion wires. An estimated annual structural maintenance cost was also included. Most of the construction and maintenance labour costs are borne by the local landowners (about 40%), while the capital costs of gabion wire, skilled labour, and materials transportation are borne by the government or by the project (about 60%). Two types of benefits accrue: benefits to private landowners from protection of their land against erosion, and benefits to downstream water users and the tourism industry from reduced erosion-induced siltation in Phewa Lake. Analysis showed that without the gabions, the Harpan River would have ravaged 90m^2 of productive land annually, and that 92% of the benefits from the gabion walls accrue to landowners. They are therefore a very popular measure in the area (UNDP 2015; Kanel 2015b).

Project soil management activities (improving livestock sheds, collecting urine and improving farmyard manure) are also considered highly cost-effective, although no formal cost-benefit analysis has been conducted. Costs are low overall, in part due to the use of local resources, and include the labour costs of farming. Benefits include reduced investment in repair, maintenance and external inputs such as chemical fertilizers, and higher economic returns from vegetable cultivation and high value crops (such as organic produce) compared with cereal crops. Crop and livestock production levels have increased and farmer attitudes related to leaving land fallow are changing as a result (Adhikari et al. 2014a; UNDP 2015).

Project homestay promotion and the 'green jobs' this provides is also considered highly cost-effective, although no formal cost-benefit analysis has been conducted. Homestay operators, however, need to develop a stronger business culture to run homestays more like a business than a socially responsible tourism initiative. Costs are low as existing homestay businesses are strengthened and no new infrastructure is needed. Each homestay operator household gets employment for at least 50 days a year and generates an annual additional net profit of 40,000 rupees[3] from room and other service charges, cultural programmes, and the sale of local food and products such as honey and vegetables. Homestay promotion also provided business opportunities in allied sectors, like grocery shops, tea stalls and butchers shops, and hence contributed on the local economy (Adhikari et al. 2014b).

Restoration of conservation ponds and natural springs was considered cost-effective although no formal cost-benefit analysis has been conducted. This is because of the low costs of the technology used, the use of locally available construction materials and the focus on rehabilitating existing ponds (Khanal et al. 2014a). Sufficient clean water means livestock are healthier, which in turn increases income from milk and meat production. Greater availability of water for irrigation during the dry season increases crop yields and income (UNDP 2015).

[3] 100 Nepalese rupees is equivalent to one US dollar.

Forest management activities were also deemed cost-effective although no formal cost-benefit analysis has been conducted. Adopting bioengineering techniques for on-going road construction kept costs low and benefits included income from planting fast growing multipurpose species with high market demand, income from planting short duration crops, the ability to leverage resources from other agencies such as biogas investors, and the ability to use time saved from collecting firewood and fodder in other economically productive ways (Baral et al. 2014). Forest restoration brings additional income and employment opportunities. For example, thinning utis trees after five years and then clear felling after ten years can supply raw materials to plywood factories and firewood to brick industries (IUCN Nepal 2014)

Despite these studies, some 80% of national-level interviewees said that there was no evidence on the cost-effectiveness of EbA approaches more generally in Nepal. The remaining 20% said that they did not know if there was evidence or not. The concept is relatively new so more evidence from cost-benefit analyses related to EbA approaches is needed.

The project found that undertaking cost-benefit analysis was challenging for a number of reasons. Estimating or quantifying the monetary values of ecosystem services and environmental resources is particularly difficult, and confidence in the methodologies applied and the emerging results is low. For example, calculating the economic value of the livelihood benefits of broom grass cultivation was easier than calculating the economic benefits from ecosystem service improvements that can help people adapt to climate change, such as the value of broom grass roots binding the soil and improving soil water retention capacity (Rossing et al. 2015; UNDP 2015).

How did the EbA approach compare to other types of intervention?

All national-level interviewees said that the project EbA interventions were more cost-effective than other approaches. Various published studies support this view.

A cost-benefit analysis comparing broom grass cultivation to 'business as usual' grassland management in Panchase showed that planting broom grass as an EbA intervention is more profitable and viable in terms of benefit-to-cost ratios than the business as usual scenario (see Table 4). This latter scenario involved cultivating a shorter grass on degraded grassland and harvesting it only for fodder. Costs included an annual rental fee for the land, the costs of harvesting and transporting grass to households, and costs from soil erosion and clearing the resulting sediment collecting downstream in Phewa Lake. Benefits included the value of the grass for household use. Given that this grass does not have strong root systems which bind the soil, no additional benefits would be provided for soil conservation in the face of changing rainfall patterns. The costs of the EbA intervention using broom grass included project financial disbursements and other costs borne by the stakeholders and beneficiaries in the project area. These included the initial cost of preparing the land and weeding, rhizomes as planting material, training for the women's network, and wages for maintaining the broom grass plantation. Benefits included those from the sale of brooms and bundles of broom grass, household use of leaves for feeding livestock and use of stems for fuel, reduced soil erosion and reduced sedimentation downstream (Kanel 2015a; UNDP 2015; Rossing et al. 2015).

A cost-benefit analysis comparing planting timur as an EbA intervention in Parbat with planting maize showed that planting timur provided significantly higher financial returns per hectare. The net present value from maize cultivation was calculated as 457,076 rupees per hectare over a 20-year period, but the equivalent net present value from the timur plantation was 769,434 rupees. Timur thus provides additional benefits of 312,358 rupees, or 68% more financial benefits per hectare, over a 20-year period (Kanel 2015a).

Table 4: Economic analysis of broom grass plantation versus business as usual grassland management

Profitability indices	Grassland (business as usual scenario)	Broom grass (EbA scenario)
Discounted annual net benefit (rupees per hectare)	-3,528	
Net present value (rupees per hectare). This is the difference between the discounted benefits and discounted costs of an intervention. An intervention is desirable if the sum of discounted benefits is greater than the sum of the discounted costs.	-29,816	277,392
Benefit-to-cost ratio. This is the ratio of the discounted stream of benefits and the discounted stream of costs. A ratio of one implies that the benefits are equal to the costs.	0.9	1.3
Internal rate of return (%). This is the discount rate that makes the stream of benefits equal to the stream of costs. The internal rate of return is compared to the discount rate to decide if the intervention is beneficial or not. An intervention with an internal rate of return that is higher than the discount rate is considered a good one. Technically, this implies that the return from the intervention is higher than the costs that go into it.		21

Note: Calculated with a discount rate of 10% and a lifespan of 15 years. Source: Rossing et al. (2015); Kanel (2015a).

Results from a cost-benefit analysis modelling and comparing two forest restoration approaches that address climate and non-climate-related threats showed that over a ten-year period, both approaches were viable and profitable but the net present value, benefit-to-cost ratio and internal rate of return are all significantly more favourable under the payments for restoration approach (see Table 5). In Table 5, opportunity costs are calculated as the net profit generated from crop cultivation in a similar area, which equates to the restoration payment. A sensitivity analysis showed that the benefit-to-cost ratio for the payments for restoration approach remained favourable even if utis market prices decreased by 20%, utis yields were 20% less than expected, or restoration costs were 25% more than expected. The payments for restoration approach is thus economically worthwhile in all modelled scenarios (IUCN Nepal 2014).

IUCN developed this approach involving payments for performance-based restoration to address the challenges experienced by traditional plantation approaches in Nepal. These have a history of poor performance due to poor management, long gestation periods, inadequate market links, inadequate direct cash incentives and poor monitoring. The IUCN approach addressed these challenges in two ways. First, direct economic incentives (grants) would be provided to community institutions for tree-planting and management improvements (IUCN Nepal 2014). These would be equivalent to the net profits communities would have otherwise made from planting more labour-intensive cereal crops such as rice, wheat or maize, and they would last for at least three years or until plantations provided economic returns (IUCN Nepal 2014; IUCN Nepal 2013a). This would incentivise restoration work (Baral et al. 2014) like a type of 'payment for ecosystem services,' of which there are many (or similar) schemes in Nepal (IUCN Nepal 2013b). Second, independent monitoring would occur, particularly of seedling survival rates. This would inform grant-making, which would be partly performance-based (IUCN Nepal 2014). Although the model suggests the payments for restoration approach is economically worthwhile, it was not implemented by the Mountain EbA project due to a lack of time.

Table 5: Respective costs and benefits from two forest restoration approaches

	Traditional plantation		Payments for restoration	
	Without opportunity costs	With opportunity costs	Without opportunity costs	With opportunity costs
Costs at 10% discounting rate (rupees per hectare). Includes the costs of operation and maintenance	874,277	968,182	476,463	605,157
Benefits at 10% discounting rate (rupees per hectare). Includes material benefits from fodder, firewood and timber sale	1,230,925	1,230,925	1,538,050	1,538,050
Net present value	356,648	262,743	1,061,587	932.892
Benefit cost ratio at 10% discounting rate	1.41	1.27	3.23	2.54
Internal rate of return (%)	16.2	14.3	36.8	30.2

Source: IUCN Nepal (2014).

Broader economic costs and benefits from the EbA initiative

All national-level interviewees said there were broader economic costs and benefits from the EbA initiative. All specified that the land or service value had increased. More than half specified that losses from disaster risks decreased despite the increased chances of disaster striking. Some said that there were opportunity costs when other land uses were not taken up, and that costs were avoided from the use of ecosystem services instead of man-made systems. Several said, however, that it was difficult to source evidence regarding these broader costs and benefits. And UNDP (2015) stresses the importance of conducting appropriate assessments of market opportunities for goods harvested or produced through EbA interventions. This was a key lesson from the Global Mountain EbA Programme (UNDP 2015).

Published literature provided the following examples of broader economic costs and benefits from the various project interventions that were not included in the formal analyses and perceptions of cost-effectiveness described above:

- Economic benefits from broom grass cultivation that were not included in the cost benefit analysis described above include those from a net reduction of 5.08 tonnes per hectare per year of soil erosion (Kanel 2015a).
- Additional income and employment opportunities were secured from bee-keeping (UNDP 2015; Baral et al. 2014; Rossing and Nyman 2015).
- Drought resistant seed varieties will lead to additional income from increased productivity (UNDP 2015).
- Roadside stabilisation with plantations (including broom grass) improves road access for communities, thus providing better market access. Plantations are fast growing, multipurpose and have high market demand. Activities have increased income and employment opportunities. Gulley control increases the productivity of agricultural land and reduces topsoil loss.
- Short-term employment was provided constructing grey-green infrastructure during riverbank stabilisation (Rossing and Nyman 2015).

Financial and economic trade-offs at different geographical scales

More than half of the national-level interviewees said that there were financial or economic trade-offs between management at different geographical scales, but no clear examples were given. One felt this was a matter for further study. Early project interventions were designed and implemented as ‘no regrets’ actions (Adhikari et al. 2014a), however, and some, such as timur cultivation, may have generated finance that could be used elsewhere (UNDP 2015).

Changing financial and economic benefits and costs over time

Some 80% of national-level interviewees said that the financial and economic benefits and costs from the project had changed over time. Comments included the feeling that financial/economic benefits are long-term, but that the supply of goods and services to outsiders might be curtailed in the short term as ecosystem services and biodiversity restoration and protection activities proceed.

UNDP (2015) reports that project EbA interventions are beginning to demonstrate economic benefits, and that additional benefits are expected in the medium to long term, beyond the project lifetime. An important lesson from the Global Mountain EbA Programme, however, is that EbA interventions must generate short-term economic benefits to increase local support and secure long-term commitment to implementing ecosystem conservation, restoration and management measures. Communities were more interested in the economic and social benefits of EbA than the environmental benefits (UNDP 2015). For example, even though the economic benefits from the timur plantation far exceed those of maize cultivation, farmers had not extensively planted this crop because it takes five years for a medium-sized tree to yield seeds and they thought that 20 years was too long to wait for the total benefits (Kanel 2015a). This is why the modelling exercise described above comparing the costs and benefits of two forest restoration approaches promoted incentive-based payments to communities to offset the relatively high early costs and negative cash flow for the first five years of the utis plantations – until they are established and able to generate income (IUCN Nepal 2014).

Policy and institutional issues: what social, institutional and political issues influence the implementation of effective EbA initiatives and how might challenges best be overcome?

Local-level barriers to implementing EbA

All implementing partner interviewees said the unavailability of knowledge was a barrier to implementing EbA at the local level, and over half said that the unavailability of technical resources was a barrier. One stressed the need for a common understanding of EbA at the local level. Over half of the national-level interviewees also said that the unavailability of knowledge and technical resources was a barrier, and most said that the unavailability of financial resources was a barrier. Adhikari et al. (2014b) report that challenges to the homestay business interventions include the limited knowledge of and skills on handling homestay businesses and also high youth migration, poor tourism facilities (roads, trekking routes, water provision, and toiletry and food hygiene facilities), inadequate local community investment capacity and poor destination marketing. Additionally, whilst local communities were highly aware of the economic and livelihood benefits from the EbA interventions, they were less aware of ecosystem benefits and need sensitising on the importance of these for maintaining and enhancing the productivity of agricultural ecosystems (Adhikari et al. 2014a).

More than half of the national-level interviewees and some implementing partner interviewees stated that insufficient implementation capacity was a barrier to implementing EbA. UNDP (2015) also identifies the need for capacity development of protected area managers and planning officers in order to mainstream EbA into protected area plans and programmes (UNDP 2015). A strong need for long-term, local-level stakeholder capacity development to cope with environmental challenges was also identified in the Dolakha district of Nepal (Bhatta et al. 2016).

Most national-level interviewees and some implementing partner interviewees said that weak institutions were a major barrier to implementing EbA. Some national-level interviewees said that unclear mandates were a barrier, and some implementing partner interviewees stated that a lack of stakeholder authority to take the actions needed was a key barrier.

More than half of the national-level interviewees said that insufficient cross-sectoral institutional collaboration was a barrier to implementing EbA. Whilst Nepal's National Adaptation Programme of Action emphasises the need for an integrated approach linking the various actors and sectors involved in Plan implementation, the reality is that both vertical and horizontal coordination is often problematic at the local level (Bhatta et al. 2016). The need for further synergy and collaboration among various institutions working locally to address adaptation has also been identified elsewhere in Nepal – in the Dolakha district. Here, actions by different district line agencies, such as those relating to soil conservation, are undertaken in isolation rather than forming part of a coherent and collective plan. There is a strong need for integrated planning at the local level to cope with environmental challenges (Bhatta et al. 2016).

One implementing partner interviewee said that EbA should be incorporated into the operational plans of Community Forest User Groups and also municipalities, but that the EbA concept should be simplified for technical staff to do this.

Regional-level barriers to implementing EbA

All implementing partner and many district-level interviewees said that the unavailability of knowledge, including technical knowledge, was a barrier to implementing EbA at this level. One added that a common understanding of EbA at the regional level is needed.

Most district-level and many implementing partner interviewees said weak institutions were a barrier to implementing EbA. Many district-level interviewees also said that the lack of stakeholder authority to take the actions needed or planned was a barrier.

Most district-level interviewees said the unavailability of financial resources was a barrier to implementing EbA and many said that insufficient implementation capacity was a barrier.

More than half of implementing partner and district-level interviewees said that insufficient cross-sectoral institutional collaboration was a barrier to implementing EbA.

More than half of the implementing partner and some district-level interviewees said that unsupportive donor or government policies were a barrier to implementing EbA. One said EbA needs to be better integrated into sub-national planning processes. More than half of the district-level interviewees and several implementing partner interviewees said that unclear mandates were a barrier.

National-level barriers to implementing EbA

All implementing partner and many national-level interviewees said the unavailability of knowledge and understanding on EbA was a key barrier to implementation at the national level. A common understanding of EbA at the national level is needed along with long-term monitoring and more empirical data to generate evidence on EbA effectiveness. More clarity is needed on the difference between EbA and community-based adaptation. Research is needed and EbA learning centres, for example to better understand the climate vulnerability of different ecosystems. UNDP (2015) also emphasises that the lack of data needed to demonstrate and quantify the multiple benefits of EbA can mean EbA benefits are undervalued in cost-benefit analyses and make monitoring project EbA benefits challenging. More quantitative evidence is needed to make the case for EbA, but the development of EbA indicators is still in its initial stages.

Most national-level interviewees felt that the unavailability of financial and technical resources was a key barrier to implementing EbA at the national level. One said EbA needed to be integrated better into government budget planning processes and prioritised for financial support. More than half of the implementing partner interviewees agreed that limited financial resources was a barrier. Many national-level interviewees commented that insufficient implementation capacity was a barrier. Whilst many national policies provide for EbA, implementation and monitoring of these policies remains a major challenge. UNDP (2015) also emphasises that a key challenge for implementing EbA-relevant plans and policies in Nepal is the lack of financial and human resources for implementation, and weak technical capacity.

All national-level and some implementing partner interviewees said that a key barrier was insufficient cross-sectoral institutional collaboration. One identified the need for multi-sectoral or ecosystem-based conservation and development policies.

More than half of national-level and implementing partner interviewees said that weak institutions were a key barrier to EbA implementation.

Some national-level and implementing partner interviewees felt that inadequate or unsupportive policies and guidelines, and unclear mandates, were a key barrier to EbA implementation. One said EbA needs to be better integrated into national planning processes and another said that better implementation, monitoring and evaluation policies and guidelines are needed. For example, policies addressing disaster risk reduction in Nepal do not mention EbA or the role of ecosystems in reducing risk. Similarly, Nepal has no specific policy or legislation that supports or facilitates the institutionalisation of 'payments for ecosystem services' schemes. Whilst some policies recognise the value of such services, and some mechanisms for securing finance have been initiated, legislation is contradictory and confusing, mechanisms are not fully operational and government does not prioritise the issue (IUCN Nepal 2013b).

Local-level opportunities for implementing EbA

All implementing partner and nearly all national-level interviewees said strong – often legally-constituted – institutions provided a key opportunity for implementing EbA at the local level. UNDP (2015) explains how project activities worked with existing structures such as VDCs, Community Forest User Groups, water user groups, agriculture groups, livestock groups, savings and credit groups and women's groups. Implementing EbA interventions through these governance structures strengthened them, built on their existing expertise, built capacities to manage natural resources under climate change and helped embed EbA into existing plans and priorities (UNDP 2015). Community Forest User Groups were particularly important as they have the mandate and responsibility to manage local forest resources. VDCs are important for managing ecosystem services and supporting local adaptation strategies (Bhatta et al. 2016). Working with government technical and extension services has also provided an avenue for strengthening linkages between communities and local government, for example securing technical expertise from local government experts on issues such as forestry and soil and water conservation (UNDP 2015).

All national-level and more than half of the implementing partner interviewees said strong local governance and bylaws provided an opportunity for implementing EbA at the local level. Nyman and Rossing (2015) highlight the importance of opportunities to integrate EbA into Community Forest Management Plans. UNDP (2015) comment on the relative ease of implementing EbA measures on larger areas of communal land in Nepal compared with many small, privately owned parcels of land elsewhere.

More than half of the implementing partner and several national-level interviewees said appropriate incentives in place to motivate actions were important for implementing EbA. UNDP reiterate this view, arguing that "[i]t was essential for the programme to show some early benefits of 'no regrets' measures, in particular with regards to socio-economic benefits that can enhance livelihoods, to make the case for the project itself and eventually for EbA more broadly" (UNDP 2015). The use of participatory methods helped foster a sense of ownership as well as prioritising immediate economic benefits. Once these materialise, the case can then more easily be made for implementing broader, scaled-up EbA measures, such as reforesting water catchments, which provide a range of long-term benefits that can enhance adaptive capacity (UNDP 2015).

More than half of the implementing partner and some national-level interviewees said that EbA 'champions' were important for implementing EbA. UNDP (2015) stress that local committees and champions are important given that EbA interventions tend to require long-term implementation, beyond the project lifetime and through political government changes.

Regional-level opportunities for implementing EbA

Most district-level interviewees felt that having appropriate incentives in place to motivate action was key for implementing EbA at the regional level. Strong regional institutions were also important for more than half of the district-level interviewees, and some also mentioned the opportunities provided by strong regional policy or legislation and EbA 'champions'. Nyman and Rossing (2015) highlight the opportunity provided by working with the Panchase Protected Forest, which has a management plan and governance structure, and thus provided a good entry point for implementing EbA.

National-level opportunities for implementing EbA

Nepal has a range of national policies that directly or indirectly support EbA and its implementation (see Box 3).

Box 3: Policies that support EbA in Nepal

- The ***National Climate Change Policy*** (2011) specifically aims to enhance the resilience and capacity of local communities through natural resource management. It puts forward a set of policies for "climate-friendly natural resources management", which include a range of EbA measures such as sustainable management of forests, agro-forestry, pasture and rangeland, and water and soil conservation to address climate change impacts and provide for livelihoods. It puts forward the establishment of a national ***Climate Change Fund*** for implementing climate change programmes, but this fund is still to be operationalised.
- The ***National Adaptation Programme of Action*** (NAPA) (2010) prioritises different ecosystem-based management projects to combat climate change.
- The ***National Framework for Local Adaptation Plans for Action*** (2011) provides for the delivery of adaptation services to the most climate vulnerable areas and people of Nepal as part of the NAPA. The main LAPA entry points are agriculture, forestry, health, water and sanitation, watersheds, microfinance, education, infrastructure and disasters.
- The ***National Adaptation Plan*** (2015) identifies nine priorities, six of which relate to EbA: (1) community-based adaptation through the integrated management of agriculture, water, forest and biodiversity sectors, (2) building and enhancing the adaptive capacity of vulnerable communities through improved systems and access to services related to agricultural development, (3) community-based disaster management for facilitating climate adaptation, (4) forest and ecosystem management for supporting climate-led adaptation innovations, (5) ecosystem management for climate adaptation, and (6) empowering vulnerable communities through sustainable management of water resources and energy supplies.
- The Intended Nationally Determined Contribution (2016) explicitly mentions EbA.
- ***Nepal´s 13th Plan*** (2014-2016) is the country´s overarching development plan. Development programmes which support adaptation are one of seven key national priorities. Many of the adaptation measures relating to agriculture, irrigation, food security, forests and soil conservation, water and sanitation, local development and environment, for delivering the 13th Plan are directly relevant to EbA.
- The ***Nature Conservation National Strategic Framework for Sustainable Development*** (2015-2030) includes EbA approaches and prioritises the economic valuation of ecosystem goods and services in the country.
- The ***National Biodiversity Strategy and Action Plan*** (2014-2020) provides for nature-based adaptation solutions to climate change impacts. It prioritises the design and implementation of EbA programmes in the mountains, with a goal of restoring at least 10,000 hectares of degraded mountain ecosystems using participatory approaches by 2020.
- The ***Environment Friendly Local Governance Framework*** (2013) mainstreams environment, climate change adaptation and disaster management into local planning processes. It complements the LAPA framework.
- The ***Agro-biodiversity Policy 2063*** (First Amendment) recognises climate change and puts forward conservation of agrobiodiversity as an adaptation strategy.
- The ***Forest Policy*** (2015) includes EbA as an adaptation approach.
- The ***Forest Act*** (1993) recognises Forest User Groups as autonomous institutions with delegated forest management responsibility, including for sustainable use.
- The ***Forest sector strategy*** (2016-2025) mentions EbA and ecosystem services.

Sources: UNDP (2015); IUCN Nepal (undated); Khanal et al. (2014b); Nyman and Rossing (2015); Ministry of Environment (2010).

The Government of Nepal has also been gradually increasing financial resources allocated to tackling climate change. It has a strong policy framework supporting local level adaptation measures, including through Local Adaptation Plans for Action (LAPAs), and has determined that 80% of adaptation funding must be allocated to the local level (Government of Nepal 2011; UNDP 2015). Payments for ecosystem services has also proved to be a relevant model for securing finance for EbA in Nepal (Nyman and Rossing 2015).

The Climate Change Division in the Ministry of Science, Technology and Environment plays an overall coordination role for climate change in Nepal, and has implemented a number of climate-change-related projects to help address critical issues on the ground and at the policy level. The ministry is supported by a 25-member Climate Change Council operating within parliament and headed by the prime minister. This provides coordination and guidance for implementing climate related policies and legislation in Nepal. The NAPA framework established a consultative body for climate change related matters called the Multi-stakeholder Climate Change Initiatives Coordination Committee. This forum supports the Climate Change Council and includes representatives from national ministries, national and international non-governmental organisations, academia, the private sectors and donors. The Ministry of Forest and Soil Conservation and the Ministry of Agricultural Development are responsible for addressing climate change within their sector, and the National Planning Commission is tasked with ensuring coherence and avoiding conflicting policies and regulations. There is also a High Level Technical Committee on EbA, whose main role is to coordinate and mainstream EbA into sectoral plans and programmes in Nepal through technical guidance, facilitating discussions on investment opportunities and identification of capacity development needs. The Committee includes representatives from the National Planning Commission; Ministry of Forest and Soil Conservation; Ministry of Science, Technology and Environment; Ministry of Agricultural Development; and Ministry of Federal Affairs and Local Development (Nyman and Rossing 2015).

Is the EbA initiative sustainable?

All national-level interviewees felt that the policy, institutional and capacity support present at the local level was sufficient to ensure the project was sustainable over the long term. Most – but not all – felt the same about support at the national level.

At the local level, integration of project activities into institutions and policies was central to securing sustainability. For example, ‘no regrets’ measures were developed with district line agencies for the eight VDCs outside the Panchase Protected Forest. The project signed Memorandums of Understanding with district line agencies for delivering project activities, thereby instilling in them a sense of ownership and accountability for implemented measures, as well as aligning measures with ongoing government activities. District-level extension staff worked directly with Community Forest User Groups to implement EbA interventions, which strengthened local ownership and ensured sustainability. The Panchase Protected Forest Management Plan has been revised, and now includes project vulnerability impact assessment results and EbA interventions. Showing the multiple benefits of EbA to government planners and policymakers can secure their interest and hence incorporate EbA into relevant governance structures, plans and policies, as well as securing local to national level sectoral budgetary allocations for implementation (UNDP 2015). This can be seen in the forest sector strategy.

Further institutionalisation of project activities with associated budgetary allocations from line agencies, VDCs and District Development Councils is needed to improve sustainability. Mainstreaming into the national development agenda and enhancing institutional capacities for implementation would further enhance sustainability (Adhikari 2016). Payments for ecosystem services schemes have generated local-level conservation awareness in Nepal, but they have not generated enough finances to sustain services and nor have they been able to influence policy processes, so the sustainability of such schemes has been poor. The government should develop policy and procedures for addressing this challenge (IUCN Nepal 2013b).

Opportunities for replication, scaling up or mainstreaming the EbA initiative or for influencing policy

Most implementing partner and many national-level interviewees felt there were opportunities to replicate, scale up or mainstream EbA project activities or influence policy. Some 20% of implementing partner and national-level interviewees, however, felt no opportunities arose. They provided the following examples of opportunities that did or could arise:

- EbA approaches have been mainstreamed into national planning processes. For example, the National Forest Policy, and regulations to protect and manage forests and watersheds have been improved to make them more climate responsive using EbA approaches. UNDP (2015) explains how the project helped develop a five-year action plan for addressing climate change when implementing the Forest Policy in all 75 districts of Nepal. The project helped the Protected Forest Council produce guidelines on managing protected forests (there are 13 in Nepal), which incorporate EbA. These guidelines have been approved by the government. One interviewee also said that EbA can be a vehicle for realising sustainable development policies and programmes.
- Payments for ecosystem services schemes have legal support from various acts, plans and policies.
- EbA approaches have been mainstreamed into local planning processes. For example, forest conservation and management approaches have been incorporated into LAPAs in six districts in Nepal. UNDP (2015) also explains how the project is helping review the five-year Panchase Protected Forest Management Plan. This involves identifying climate change and adaptation gaps and highlighting opportunities for EbA. The project has also promoted the integration of EbA into existing local-level management plans such as those of Community Forest User Groups (UNDP 2015).
- Some project components have already been replicated. For example, the project vulnerability impact assessment tool has been used elsewhere in a similar mountain ecosystem, and methods for assessing climate vulnerabilities and choosing adaptation options have been applied in various national parks.
- EbA projects are occurring elsewhere in Nepal. For example, there is one in a mountain watershed of Lamjung, and ecosystem-based activities have been implemented under landscape conservation programmes including the Kailash Landscape Programme, the Himalayan Scared Landscape Programme, and programmes in the Kanchenjungha Landscape and the Chitwan Annapurna Landscape.
- EbA approaches have been mainstreamed into university and school curricula. Collaborations with universities have been established and there is a growing interest in EbA.
- There is a willingness amongst national and local institutions to integrate EbA approaches into their plans and programmes.
- Project experiences have fed into the UNFCCC Nairobi Work Programme process. This has enhanced buy-in for EbA from a range of stakeholders, including other governments (UNDP 2015).

Summary and conclusions

The Mountain EbA project in Nepal shows how EbA can be an effective approach to tackling climate change.

Effectiveness for human societies

Project activities in Nepal helped people maintain or improve their adaptive capacity or resilience, and reduce their vulnerability to climate change, in a multitude of ways. Those who experienced these changes included the vulnerable mountain communities targeted by the project, and also poor, vulnerable, young and indigenous groups, and women.

Although some interviewees felt there were trade-offs in terms of *who* accrued improvements in resilience, adaptive capacity or vulnerability, and it was clear that some groups did benefit more from these improvements than others, no examples of how improvements for some people came at a cost for others were apparent. Similarly, there were no apparent trade-offs in terms of *when* changes in resilience, adaptive capacity or vulnerability occurred, although it did take time for some of these gains to materialise. There may, however, have been trade-offs in terms of *where* gains in adaptive capacity, resilience or vulnerability occurred – notably in between upstream and downstream areas.

Many social co-benefits emerged from the project, including the provision of sustainable water and livelihoods, disaster risk reduction and increased security, market access, health improvements for livestock and people, food security, reduced conflict over resources, climate change mitigation, enhanced traditional and cultural customs, and knowledge generation.

As with adaptation benefits, some social groups (notably women and other vulnerable groups) may have accrued more of these social co-benefits than others, but not at the cost of others.

Project activities incorporated local and indigenous knowledge, and many of the participatory approaches adopted by the project were characterised by community agency and leadership. It was very clear that using such participatory processes improved the adaptive capacity of local communities.

Effectiveness for the ecosystem

Mountain ecosystems are particularly vulnerable to climate change, and Panchase is no exception. Other threats to local ecosystems include invasive alien species, and land conversion and overexploitation. Weak institutions, legal frameworks and governance exacerbate these challenges. It was unclear if there were thresholds, for example in temperature or rainfall, beyond which the ecosystems in Panchase could no longer provide key ecosystem services.

Project activities purposefully targeted the landscape and sub-watershed level to improve ecosystem resilience. Alignment with administrative boundaries and local governance structures is also important, and working at the landscape or sub-watershed level facilitated this.

As a result of the project, ecosystem resilience in Panchase improved and ecosystem services (provisioning, regulating, cultural and supporting) were maintained or restored, primarily at the sub-watershed or catchment level, but also in downstream areas. Ecosystem services were maintained or restored over a range of time frames, from two to more than ten years. There were, however, trade-offs in terms of where improvements in ecosystem resilience and service provision accrued. For example, downstream improvements were often larger than improvements noted at the Project implementation sites, crop raiding increased, and improvements in water provision for conservation purposes has occurred at times without meeting agricultural water needs.

Financial effectiveness

A number of formal cost-benefit analyses were conducted on various activities implemented under the project. These suggest that EbA approaches were cost-effective and compared well with alternatives. Planting broom grass in degraded grasslands and planting timur on private land were shown to be cost-effective and more profitable than a ‘business as usual’ scenario and an alternative intervention respectively. Constructing gabion walls with anchoring revegetation along the banks of the Harpan River was also cost-effective. Project soil management activities, homestay promotion, restoration of conservation ponds and natural springs, and forest management activities were also considered cost-effective, although no formal assessments were conducted. Results from a modelling exercise comparing two forest restoration approaches that address climate and non-climate related threats showed that both were viable and profitable, but that the net present value, benefit-to-cost ratio and internal rate of return were all significantly more favourable under the payments for restoration approach as opposed to the traditional plantation.

Conducting cost-benefit analysis was challenging for a number of reasons, particularly the difficulties of estimating or quantifying the monetary values of ecosystem services and environmental resources. A number of broader economic costs and benefits emerged from the various project interventions that were not included in the formal analyses and perceptions of cost-effectiveness described above. These were also difficult to source evidence on and quantify.

Project financial and economic benefits were viewed as long-term but had changed over time. Some took time to accrue, and short-term economic benefits/incentives were needed to overcome the relatively costly immediate transition period to secure long-term gains.

Policy and institutional issues

Key barriers to implementing EbA at the local, regional and national levels included the unavailability of knowledge, financial and technical resources, insufficient implementation capacity, weak institutions, insufficient cross-sectoral institutional collaboration and unsupportive policies.

Key opportunities to implementing EbA at the local level included strong – often legally constituted – institutions such as VDCs and Community Forest User Groups, strong local governance and bylaws, appropriate incentives and EbA 'champions.' At the regional level, appropriate incentives to motivate action and strong regional institutions were key for implementing EbA. At the national level, a range of national policies directly or indirectly support EbA and its implementation, and the Government of Nepal has been gradually increasing financial resources allocated to tackling climate change, notably at the local level. Nepal has a strong policy framework supporting local level adaptation measures, including through LAPAs. The Ministry of Population and Environment coordinates climate change responses in Nepal, and a number of committees and councils help coordinate responses and guide implementation.

At the local level, integrating project activities into institutions and policies was central to ensuring sustainability. Further institutionalisation with associated budgetary allocations, mainstreaming into the national development agenda and enhancing institutional capacities for implementation is needed to improve sustainability further.

A number of opportunities to replicate, scale up or mainstream EbA project activities or influence policy were apparent, most notably mainstreaming into local and national planning processes such as the Panchase Protected Forest Management Plan, LAPAs or the National Forest Policy. Project tools and methodologies have also been applied in other settings.

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Ecosystem-based adaptation (EbA) is the use of biodiversity and ecosystem services as part of an overall strategy to help people to adapt to the adverse effects of climate change and promote sustainable development. This report presents the results of using our Framework for Assessing EbA Effectiveness at the Mountain EbA Project, Nepal. The findings will be combined with those from 12 other sites in 11 other countries to help show climate change policymakers when and why EbA is effective.

Project Report

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