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

Research results from the Ecosystems Protecting Infrastructure and Communities project, Chile

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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 and focus groups discussions with a wide variety of stakeholders conducted by IUCN at the project site in Chile, where communities in a biosphere reserve were shown how healthy forest ecosystems can play a crucial role in protecting infrastructure and the communities themselves from avalanche and landslide hazards.

It concludes that, although the project did not implement specific EbA measures on the ground, it has provided communities with a base for reducing their vulnerability to disaster and potentially also climate change risks in the area, along with other welfare-enhancing co-benefits. However, there may be trade-offs in the future in terms of who benefits from reforestation or forest protection. Related studies suggest that the protective role played by healthy forests in mountain ecosystems can lead to economic savings, but here again there may be trade-offs in terms of reductions in ski areas and income from tourism. Chile benefits from strong government institutions and a supportive national policy environment for disaster risk reduction (DRR) and adaptation initiatives, meaning that benefits from the project are likely to be sustainable over the long term. Key barriers to implementing further Eco-DRR and EbA initiatives, however, relate to the availability of relevant knowledge, capacity and technical skills, and the challenges of cross-sectoral institutional collaboration and accessing funds.

Acronyms

BMUB	German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
CBD	Convention on Biological Diversity
CCA	Climate change adaptation
CNAG	Comité Nacional Asesor sobre Cambio Global (National Advisory Committee for Global Change)
CONAF	Corporación Nacional Forestal (National Forestry Corporation)
CREATE	Climate Resilience Evaluation for Adaptation through Empowerment
DRR	Disaster risk reduction
EbA	Ecosystem-based adaptation
Eco-DDR	Ecosystem-based Disaster Risk Reduction
EPIC	'Ecosystems protecting infrastructure and communities' project
GORE	Gobierno Regional (Regional Government)
IIED	International Institute for Environment and Development
IKI	International Climate Initiative
IUCN	International Union for Conservation of Nature
MMA	Ministerio del Medio Ambiente (Ministry of Environment), Chile
NGO	Non-governmental organisation
OCC	Oficina de Cambio Climático (Climate Change Office)
ONEMI	Oficina Nacional de Emergencia del Ministerio del Interior y Seguridad Pública (National Office of Emergency of the Interior Ministry)
PES	Payments for ecosystem services
PLI	Promoting local innovations
PROT	Plan Regional de Ordenamiento Territorial (Regional Land-Use Plan)
SEREMI	Secretaría Regional Ministerial del Medio Ambiente (Regional Environmental Secretariat of the Ministry of Environment)
SDGs	Sustainable Development Goals
SLF	Swiss Institute for Snow and Avalanche Research
UNEP	United Nations Environment Programme
UNEP-IEMP	UNEP International Ecosystem Management Partnership
UNEP-WCMC	United Nations Environment Programme World Conservation Monitoring Centre
UNFCCC	United Nations Framework Convention on Climate Change

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 adaptation 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 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 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 (UNCCD). 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 (SDGs) (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 or the Adaptation Fund, 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) 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 and 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, Building and Nuclear Safety (BMUB) 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

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. It defines effective EbA 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 to draw conclusions that are based on more than single case studies and help answer the question of whether EbA is effective or not. Reid et al. (2017) provide 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.

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?*
1. 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? 2. 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?*
1. 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?*
1. 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? 2. What, if any, opportunities emerged for replication, scaling up or mainstreaming the EbA initiative or for influence over policy, and how? 3. What changes in local, regional and/or national government or in donor policies are required to implement more effective EbA initiatives?

The 'Ecosystems protecting infrastructure and communities' (EPIC) project in Chile

The 'Ecosystems protecting infrastructure and communities' (EPIC) project aimed to build community resilience by implementing nature-based solutions to disaster risk reduction (DRR) and climate change adaptation (CCA). Using pilot projects in six countries (Burkina Faso, Chile, China, Nepal, Senegal and Thailand), EPIC has strengthened the evidence base on the effectiveness of nature as a solution to disasters and climate change. Working with multiple stakeholders, EPIC has informed policy and built capacities for better integration of ecosystems into disaster and climate change management strategies (Buyck 2017; Cortés-Donoso et al. 2017; Monty et al. 2017). EPIC was implemented by IUCN and funded by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, Germany, through IKI.

The Chilean component of EPIC was implemented in the 'Corredor Biológico Nevados del Chillán – Laguna del Laja' Biosphere Reserve. This is located in the northern part of Patagonia in central Chile, in the Biobío Region. The Reserve has an area of 565,807 hectares and is divided into three main areas: core, buffer and transition. It seeks to reconcile the conservation of biological and cultural diversity with economic and social development. Ecosystems in the Reserve consist primarily of tropical and subtropical dry broadleaf forests and coniferous forests, and montane grasslands and shrublands. The Reserve has a population of around 7,728 inhabitants, and around 70% of it is privately owned (Monty et al. 2017).

EPIC project work in Chile was led by IUCN in collaboration with the Ministry of Environment (MMA) and the Institute for Snow and Avalanche Research based in Switzerland (SLF). It also had the support of the Regional Government (GORE) of Biobío. EPIC did not work with specific communities within the Biosphere Reserve and it hasn't implemented specific Eco-DRR and EbA measures on the ground, but it did work with a range of stakeholders in the Biosphere Reserve. The project was implemented between September 2012 and August 2017. Its goal was to promote the conservation of forest ecosystem services as an integral part of policies, strategies and programmes for DRR and CCA. Specific project goals for activities in Chile were (Monty et al. 2017):

1. Demonstrate the importance of sustainable ecosystem management as an alternative to DRR and CCA
2. Strengthen capacities, and sensitise and communicate about the potential of sustainable ecosystem management for DRR and CCA
3. Disseminate through multi-stakeholder platforms, lessons learned and practical solutions which can be replicated or used as inputs for programmes and public policies.

Genuine ecosystem-based adaptation initiatives must meet the following four criteria (Martin 2016; CBD 2009; CBD 2010): they must use biodiversity and ecosystem services; they must help people; they must support human adaptation to the adverse effects of climate change; and they must form part of an overall strategy. EPIC was initially conceived of as an ecosystem-based disaster risk reduction (Eco-DDR)[1] initiative, but in practice, EbA and Eco-DRR initiatives are highly complementary and many initiatives can be categorised as both. Given that EPIC aimed to address climate change-related disasters, we can assess it using an EbA lens. Indeed, a review of EPIC argued that it was accurate to label EPIC "more as a hybrid Eco-DRR/CCA project than just Eco-DRR" (Monty et al. 2017).

Methodology for assessing effectiveness

Reid et al. (2017) provide a methodology for assessing EbA effectiveness. This includes a framework (Table 2) which details a set of questions to be used as part of a process to draw conclusions about the effectiveness of an EbA project that is ongoing or has ended. Table 3 describes the EPIC project

[1] Ecosystem-based disaster risk reduction (Eco-DRR) can be defined as the sustainable management, conservation and restoration of ecosystems to reduce disaster risk, with the aim of achieving sustainable and resilient development (Estrella and Salismaa 2013). While aiming to primarily address disaster risk reduction, it is recognised that Eco-DRR can contribute to climate change adaptation (CCA) (Monty et al. 2017).

stakeholders interviewed individually or as part of focus group discussions using this methodology. No initiative beneficiaries were interviewed, because EPIC has not implemented specific Eco-DRR and EbA measures on the ground.

Table 3: EPIC stakeholders interviewed

Level of interviewees	Those interviewed
National	National stakeholders were close collaborators throughout the EPIC implementation process (unlike in other EbA initiatives assessed, where national-level stakeholders sometimes had limited knowledge of the initiative). From the Ministry of Environment, the EPIC political partner at the national level, which accompanied and supported EPIC implementation, Daniel Álvarez was interviewed.
Local authority	From the Regional Environmental Secretariat of the Ministry of Environment, the political counterpart for EPIC at national level, which accompanied and supported EPIC implementation, María Cecilia Jiménez (Region Biobío) was interviewed.
Project implementers	IUCN and SLF, including staff from headquarters, the regional office in South America and in-country support: Radhika Murti, Senior Programme Coordinator – Disaster Risk Reduction (IUCN); Erika Cortés, IUCN consultant for EPIC in Chile; Alejandro Casteller, SLF researcher; Karen Podvin, Climate Change Adaptation Officer (IUCN).

Along with the interviews conducted, reports and publications on the EPIC project were also reviewed to assess the characteristics of project activities that contribute to effective implementation of the EbA approach. The results of this assessment are described in the following results section.

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?

Snow avalanches threaten towns, people and transport systems in many mountainous regions throughout the world (Dudley et al. 2015). Avalanches, landslides and falling rocks destroy forests, leaving downstream communities and infrastructure – such as roads – exposed and more vulnerable to hazards (Casteller et al. 2017). A growing body of scientific evidence shows that in some instances forests can prevent an avalanche from starting, which immediately makes them a valuable protective measure. In Chile, avalanche risk features amongst people's concerns, and as such, EPIC aimed to reduce the risks associated with snow avalanches and other natural disturbances, such as falling of rocks and debris flow, at the intervention site (Las Trancas Valley, within the Biosphere Reserve). The risk of snow avalanche in this area is largely unknown, and besides temporary road closures, no other passive or active measures to address these risks are in place. By understanding the risks and people's vulnerability to snow avalanches better, EPIC aimed to promote nature-based solutions that strengthen community resilience. EPIC demonstrated the role that healthy forest ecosystems can play in protecting infrastructure and communities from avalanche and landslide hazards (Monty et al. 2017). Avalanche modelling by Casteller et al. (2017) shows that broadleaved forests in Las Trancas help reduce the runout distances of avalanches as well as the impact pressure they put of infrastructure. They argue that the forests are therefore a valuable Eco-DRR measure.

Interviewees explained how the increasing temperatures and variations in rainfall patterns associated with climate change are melting glaciers and increasing avalanche and landslide risks at the project

site. Interviewees were in agreement that project activities improved community resilience and adaptive capacity, and provided the basis for reducing the vulnerability of local communities to disaster and climate change risks. They gave the following reasons why:

- EPIC ***brought together diverse stakeholders*** involved in Reserve management, including people from public services, civil society, non-government organisations (NGOs) and academia, enhancing links between the various Reserve stakeholders involved in EPIC Eco-DRR activities. For example, many attended a workshop in September 2013.
- Current and future drivers of risk and local vulnerabilities and adaptive capacities in the Biosphere Reserve were identified at the September 2013 workshop.
- The project ***strengthened the capacities of local stakeholders to cope with risk,*** especially among those that participated in project activities. For example, concrete measures for DRR and climate change adaptation were selected for implementation by local stakeholders attending the September 2013 workshop. These are grouped under four 'innovations' (IUCN 2013; Monty et al. 2017):
    1. Creating a water committee to regulate the sustainable use of water, including water use in the tourism sector
    2. Promoting the sustainable management and conservation of native forests
    3. Establishing an agency to promote ecotourism and conservation in the Biosphere Reserve
    4. Promoting sustainable energy consumption through innovative architectural design, new lighting solutions and the encouragement of sustainable firewood use.
- ***Reducing disaster risk*** was a primary project aim. Research on the protection provided by forests against avalanches, falling rocks and the flow of debris in the Las Trancas Valley was central to this, along with enhancing the knowledge and capacities of diverse stakeholders on Eco-DRR and EbA.
- ***Sustainable water provision*** was one of the innovations identified to address local vulnerabilities and adaptive capacities at the September 2013 EPIC workshop. EPIC raised awareness on sustainable water use and the need for regulation, and helped with the assessment, prioritisation and identification of actions under the regional government's drinking water project and the associated resources assigned to this, as well as the assessment and prioritisation of actions for the sustainable management of water under the Clean Production Agreement, including using grey water, consuming less water and ensuring sustainable provision of water. Outside of EPIC project activities, but partly as a result of them, a water committee was created to regulate water resources.
- The project facilitated ***collective learning and improved stakeholder knowledge*** levels on disaster risk and climate change vulnerabilities. Interviewees explained how hazard mapping taught people about risk, and how knowledge on the role of forests and forest ecosystem services had been enhanced amongst local authorities and other stakeholders through research, collection of local perceptions and workshops. Better knowledge amongst various Biosphere Reserve stakeholders provided the foundations for future improvements to management, for example by infusing EbA and DRR approaches into Reserve management. María Cecilia Jiménez, Environmental Secretariat of the Ministry of Environment, Biobío Region, explained: "Although no specific actions were implemented on the ground, there has been more knowledge among stakeholders, being the first phase to increase resilience." Cortés-Donoso et al. (2017) also argue that the increase in knowledge on DRR, CCA, climate change, natural hazards and forest ecosystems amongst project stakeholders was a key project outcome. This increase in knowledge contributes to adaptive capacity. Knowledge levels amongst those involved with, or affected by, the project increased because of evidence generated through scientific studies, for example on the role of forests in reducing avalanche risk. Communities living in the Las Trancas Valley are now more aware of the risks from avalanches, falling rocks and debris flow, and this improvement in knowledge has in turn improved people's ability to address these risks. The Ministry of Public Works is also interested in the outcomes of the study with a view to exploring possible green-grey solutions to protecting a specific part of the road and hence reducing local vulnerability.
- ***Improved policies***, for example the expected forthcoming integration of ecosystem-based approaches into the Biosphere Reserve management plan. The process for developing this

management began in early 2018. EPIC is also mentioned in Chile's National Action Plan on Climate Change, 2017-2022.

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

As a result of EPIC, improvements in adaptive capacity and resilience and reductions in vulnerability were experienced mostly by those participating in EPIC activities and those in the Las Trancas Valley, where the study site was located, and secondarily by communities living in the Biosphere Reserve. The project did not work directly with Reserve communities, however, but rather with a range of stakeholders, including government officials engaged in Reserve management, along with civil society, academia and NGOs. The Reserve is divided into districts, but communities are not very cohesive (they have different ways of working and a very different culture from rural Andean communities elsewhere, with stronger similarities to urban areas in some respects, and few opportunities for collaboration). The Las Trancas Valley is the most urbanised area within the Reserve and falls within the municipality of Pinto. This has a population of around 11,000 people, made up primarily of settlers from other parts of Chile who have established small- to medium-scale tourism and eco-tourism businesses. Previously, the area was primarily used for agriculture and cattle farming, but people now depend more on the ski station for employment and as a place to sell their products.

Trade-offs in terms of who *experienced changes in resilience, adaptive capacity or vulnerability,* where *changes occurred and* when

EPIC was a small project with no physical actions implemented in the field and no current trade-offs. Nevertheless, there are potential trade-offs if EPIC activities, together with other EbA and Eco-DRR measures, change the way the Biosphere Reserve is managed.

In terms of *who* benefited, a better understanding of avalanche and landslide risks could alter where tourism activities such as skiing occur in the future, which could affect people relying on these activities for their livelihoods. Although the project made efforts in the initial stages to include the private sector, this sector didn't participate, perhaps due to concerns about how this additional knowledge on avalanches could disrupt tourism and local economy. Likewise, more careful water use and management in the upper part of the Las Trancas Valley could lead to potential trade-offs between upper and lower watershed users or between larger private sector players and smaller businesses. Trade-offs between those relying on cattle farming, agriculture and tourism are currently not applicable because these activities are located in different parts of the Reserve.

In terms of *where* benefits accrue, the EPIC scientific study was not conducted close to the skiing areas, but a better understanding of risks in the area could inform the tourism sector and other stakeholders taking measures to address avalanches, and alter where tourism activities occur in the future.

Benefits from sustainable landscape management as a result of EPIC, and the adoption of other EbA and Eco-DRR measures, are likely to accrue in the mid to long term, with no expected trade-offs in terms of *when* they accrue. Buyck (2017) also states that investments in Eco-DRR solutions initiated under EPIC will provide long-term climate change adaptation benefits.

Social co-benefits from the EbA initiative

A number of social co-benefits emerged as a result of the EPIC project.

- ***Social cohesiveness*** amongst public services staff and stakeholders working in the Biosphere Reserve and the municipality of Pinto improved as a result of EPIC project activities. Reserve stakeholders are now more coordinated and know what other sectors and stakeholders are doing. More channels of communication are available.
- ***Improved governance*** of the Reserve and region as a result of EPIC work with the Biosphere Reserve committee and other stakeholders. The Regional Environmental Secretariat of the Ministry of Environment (Secretaría Regional Ministerial del Medio Ambiente, or SEREMI Ambiente) sent EPIC project results to, and recommended presenting directly to, those developing the Regional

Land-Use Plan (PROT). EPIC also aims to integrate recommendations into the Reserve management plan. Both of these processes will move forward in 2018.

Distribution and trade-offs relating to social co-benefits

No social groups benefitted from these co-benefits more than others. Rather, the diverse range of stakeholders involved in EPIC project activities meant benefits were spread widely.

The role of participatory processes and local/indigenous knowledge

EPIC worked more at the Reserve management level rather than directly with communities. Despite this, the project involved a range of participatory processes.[2] Information giving and consultation occurred when participants provided inputs to EPIC project research, for example when local perceptions on climate change and forest ecosystem services were collected. Functional participation occurred when people participated in EPIC workshops and implemented project activities. Interactive participation occurred where Reserve management stakeholders met and determined how to address the challenges they had identified. With support from EPIC, they also reactivated the 'cámara de turismo' (tourism committee) in the Las Trancas Valley. Self-mobilisation occurred when these stakeholders established a water committee and an agency to promote ecotourism and conservation in the Biosphere Reserve in parallel with EPIC project activities. EPIC catalysed the formation of these committees, but local stakeholders took actions to implement and sustain them independently from the project.

The workshop in the Las Trancas Valley held in September 2013 was central to EPIC initiation (IUCN 2013). This brought together representatives from local and regional governments, research centres and universities, local business owners, national and local NGOs and local community representatives to conduct a community-based analysis of vulnerability and adaptive capacities in relation to climate change. The Promoting Local Innovations (PLI) toolkit and elements of Climate Resilience Evaluation for Adaptation through Empowerment (CREATE) methodology were used to analyse risks and establish local capacities in the form of innovations. This helped improve understanding of vulnerability to climate change in the Reserve based on local-level perceptions.

In the initial project phase, workshop participants expressed a strong commitment to follow up on these four innovations, and different stakeholders offered to organise themselves to lead on innovation implementation. This did not, however, progress as expected (Monty et al. 2017). The EPIC project was small, so did not have resources to implement or monitor these innovations. EPIC rather focused on the second innovation, by promoting multi-stakeholder dialogue and capacity-building processes on this subject, with an Eco-DRR and EbA emphasis. Participants felt the workshop had been instrumental in promoting a sense of community and collective action. They felt they had been able to make valuable contributions to the PLI process and had brought their knowledge and expertise into learning and decision-making processes (Rizvi et al. 2014; IUCN 2013).

Interviewees felt that participation helped build adaptive capacity. In particular, engaging diverse stakeholders provided opportunities to integrate EbA and Eco-DRR approaches into other sectors. For example, liaison with the Ministry of Public Works could result in the use of green-grey measures to protect a Las Trancas Valley road, as an alternative to conventional grey infrastructure.

Lessons from other EPIC country case study sites also suggest that strong levels of participation were central to improving adaptive capacity and resilience (Monty et al. 2017). In other EPIC countries,

[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).

project partners worked more closely with communities, and participatory mapping and analysis of vulnerabilities proved important in ensuring that the nature-based solutions to be implemented were aligned with the needs of the local community. Lessons from these EPIC sites "showed that involving communities in defining priorities for action (solutions) and not just defining their vulnerabilities (problems) has ensured a strong commitment for implementation from all stakeholders involved in the project. Using traditional knowledge also helps to reach higher level for making the case for ecosystem-based solutions for climate change" (Buyck 2017).

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

Climate change threatens local ecosystems and ecosystem service provision in a number of ways. Droughts affect tourism and energy infrastructure, and forest fires affect forest biodiversity (IUCN 2013). Interviewees detailed how changing rainfall patterns and rising temperatures are increasing the risks of avalanches and landslides.

Avalanches, landslides and falling rocks and debris can destroy forests, and hence the protective roles and functions they provide (Casteller et al. 2017). Cortés-Donoso et al. (2017) argue that a key EPIC lesson is the need for zoning and the recovery of native vegetation on degraded slopes that have suffered from fires or extensive logging in order to reduce the risk of landslides or avalanches.

Weak governance and management, as well as a lack of collaboration amongst the multiple local stakeholders within the Biosphere Reserve (the public sector, private operators in the tourism industry, civil society, academia, public services, NGOs), inhibit sustainable Reserve management and aggravate the risks from disasters and climate change. Whilst there are regulations/guidelines to manage the Reserve area, these are not always enforced. This leads to overexploitation of natural resources such as water and firewood. Poor land-use planning and the disorganised building of ski resort infrastructure limit the capacity of ecosystems to provide services such as water provision, climate regulation, carbon storage, and cultural (recreational and aesthetic) services. In the municipality of Pinto, the lack of land-use plans and regulations has led to the uncontrolled establishment of new buildings in the area, thus increasing the population and local demand for water and wood (Casteller et al. 2017).

Related to this is the issue of land conversion leading to habitat change and fragmentation. Some areas have been re-forested with exotic species, which increases the risks from disasters and alters the local flora and fauna. For example, the south Andean deer, or huemul (*Hippocamelus bisulcus*), is categorised as endangered and its subpopulation in the Nevados de Chillán area is very isolated.[3]

Increases in tourism have put pressure on the ecosystem, for example by cutting down native forests to make way for ski resort infrastructure. Expansion in tourism has also increased the number of invasive species found locally. Cortés-Donoso et al. (2017: viii) explain how "urbanization has been accelerated during the last decade to address the demand of tourists visiting the valley during the winter season, mainly for skiing, trekking and also to visit the local water springs."

Boundaries influencing ecosystem resilience

The Biosphere Reserve is vast and many stakeholders are involved in its management and complex governance structures. This makes management challenging.

Management at the water basin level needs to be considered for overall ecosystem resilience. Upstream activities will have downstream impacts, and water provision is already limited both inside and outside the Reserve. Climate change is likely to lead to increased levels of snowmelt, which will

[3] http://www.iucnredlist.org/details/10054/0

change water availability and affect tourism. Glacial retreat will also affect water availability and precipitate the need for more intensive adaptation and DRR activities.

Thresholds influencing ecosystem service provision

A number of thresholds could be relevant for sustainable Biosphere Reserve management, namely, thresholds in natural resource exploitation, temperature and water availability. However, little is known about whether thresholds exist, at what levels and how important they are.

Interviewees explained that if native forests are overexploited, at some point they will cease to be able to provide the ecosystem services necessary to face climate change impacts or risks from disasters, for example by providing a protective barrier against avalanches or landslides.

Interviewees also explained how temperatures are increasing in the Reserve, leading to more droughts and fires in lower reserve areas. Evidence on the changing dynamics of water availability is sparse, and whilst prolonged drought may affect or even stop forest ecosystem service provision, evidence on this is also minimal. There are some examples from outside the Reserve of drought restricting certain species' survival, but none from within the Reserve.

EbA initiative impacts on ecosystem resilience and services provision

EPIC in Chile did not involve any implementation of activities on the ground, so ecosystem resilience was not directly affected as a direct result of the project. It did, however, highlight the factors threatening local ecosystems and possible thresholds for ecosystem service provision, and a number of future activities, all of which were initiated under the project, could lead to increased resilience and service provision, namely, research, capacity building, governance improvements and knowledge sharing. Ecosystem services potentially maintained, restored or enhanced in the future are likely to be regulating (eg forests stabilise slopes and regulate the climate), cultural (eg aesthetic, recreational (skiing), educational) and provisioning (food, water, wood, fibre).

Improvements in forest management, following the diverse recommendations and capacity-building activities which occurred, could lead to improved forest resilience and ecosystem service provision. Whilst sound forest management is crucial for reducing avalanche risk (Dudley et al. 2015), this depends on the type and structure of the forest – the age of trees, the extent of their root development and the species – as well as other climatic and geological factors. Good information on local forest/avalanche interactions is needed to choose the best strategy, and avalanche dynamics models need to be integrated into forest management practices. EPIC worked to address this and to promote the recognition and use of vegetation in reducing disaster risks from avalanches, primarily through proposals for sustainable management and conservation of native forests agreed at the September 2013 workshop.

A second recommendation emerging from the September 2013 workshop related to the establishment of an agency to promote ecotourism and conservation in the Biosphere Reserve. If this materialises, it will also likely affect Reserve ecosystem resilience and services provision. Efforts to infuse ecosystem-based approaches to DRR and adaptation into the Reserve management plan could also improve resilience.

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

Benefits relating to ecosystem service provision as a result of the project are likely to be at the scale of the Biosphere Reserve, with particular emphasis on certain areas within the Reserve, for example where the avalanche study was conducted. Benefits may extend to the level of the watershed if sustainable watershed management is implemented.

Trade-offs may emerge, but evidence on this is scarce. For example, if tree-planting or conservation activities occur as a result of future activities, this could have a negative impact on recreation/tourism. And *vice versa* as Casteller et al. (2017) note, private sector ski operators are "authorized to cut patches of native forests to clear the land for new ski tracks". This "potentially results in trade-offs with the forests' provision of protection against snow avalanches".

Synergies are also possible. For example, tree planting could perhaps improve downstream water provision in addition to protecting people and infrastructure from risk, but no studies on this have been done. Tools for selecting areas for forest restoration and the associated cost-benefit analysis of various options are available. Benefits from local carbon sequestration would also be spread globally.

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

The timescales over which benefits relating to ecosystem service provision as a result of the project could be felt vary according to what specific activities could emerge. Most interviewees felt they ranged from two years to long-term. For example, if green-grey measures to protect the road in Las Trancas Valley emerge, benefits could materialise soon and be long-lasting. Incorporating sustainable forest management practices into the Biosphere Reserve management plan could also have long-term impacts.

No trade-offs (or synergies) between the delivery of different ecosystem services at different timescales were mentioned by any interviewees. And no evidence on this has emerged from project activities.

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

How cost-effective is the EbA initiative?

There is no evidence on the cost-effectiveness of the EbA initiative conducted under EPIC to date. The project has, however, conducted a study aiming to quantify and optimise the value of mountain ecosystems in the reduction of risk associated with snow avalanches and other natural disturbances, such as falling rocks and debris flow. SLF led this work. The study has three main objectives: (1) to improve understanding of the effect of vegetation in avalanche simulation models; (2) to analyse the risk of avalanches under different climate change and soil use scenarios; and (3) to promote best mountain ecosystem management practices. Results suggest that appropriate afforestation could reduce the risks related to snow avalanches in Las Trancas (Casteller et al. 2017).

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

There is no evidence on the cost-effectiveness of EbA approaches to DRR compared to the use of infrastructural approaches, or the costs of inaction (for example, the costs of clearing debris and snow from roads, and road maintenance after an avalanche, falling rocks or debris flow) in the project area. Monty et al. (2017) acknowledge the critical need for economic valuation of Eco-DRR versus hard engineering solutions.

Indications are, however, that the protective role played by healthy forests in mountain ecosystems can lead to significant economic savings, as expensive alternatives in the form of snow retaining structures may no longer have to be considered. These benefits are additional to the many ecological benefits which healthy forests provide (IUCN 2017). Whilst Casteller et al. (2017) did not conduct a financial comparison with other approaches, results of their modelling suggest that reforestation would have fewer detrimental effects on the provision of other ecosystem services compared to grey measures such as sheds. In his *Disaster Risk Reduction for Practitioners Handbook*, Dudley et al. (2015) argues that silviculture in mountain regions more generally plays an important role in developing cost-effective defence measures against natural hazards and that if a forest has a protective function against avalanches, then expensive alternatives (snow supporting structures) do not have to be considered.

Broader economic costs and benefits from the EbA initiative

Interviewees listed two economic co-benefits from the EPIC project:

- Avoided losses from disasters emerging from potential improvements to forest management practices.

- Income from tourism enhanced. This would be indirect, but the private sector (primarily ski resort service providers) could benefit from new information emerging under the avalanche study, which could inform planning and risk reduction measures.

Financial and economic trade-offs at different geographical scales

Whilst financial and economic trade-offs under the EPIC project were not assessed, interviewees said there could be broader economic trade-offs as a result of EbA or Eco-DRR-related activities. Whilst re-forestation or improved native forest management might reduce economic losses from avalanches, it could also limit areas available for skiing and ski resort infrastructure, and the associated economic benefits this could provide to both the resorts and the whole municipality. Conversely, with more areas made available for skiing and the associated improvements in economic returns from this, the deforestation needed to clear the slopes could increase risks of economic losses from avalanches. Re-forestation in other areas by the National Forestry Corporation (Corporación Nacional Forestal, or CONAF), which is overseen and funded by the Ministry of Agriculture, could compensate for some of these forest losses.

Changing financial and economic benefits and costs over time

Benefits from improvements in DRR as a result of better information availability due to EPIC are likely to be immediate. Medium- and longer-term benefits (five years and beyond) are likely to materialise if the research and other components of EPIC are subsequently incorporated into the Reserve management plan and other strategies.

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

In general in Chile, there is local-level knowledge and technical capacity to implement EbA or Eco-DRR work. However, interviewees identified some areas for improvement, namely, in knowledge availability, implementation capacity, technical skills availability, and cross-sectoral institutional collaboration. EPIC worked to address all of these challenges.

Knowledge availability on vulnerabilities, climate change and disaster risk could improve in the Las Trancas Valley and in general in the Biosphere Reserve. Although EPIC has improved knowledge levels on avalanche and landslide risk, more data are needed from monitoring avalanches, and also on tourism levels. A better understanding of risks and the benefits, costs, opportunities and limitations of EbA and Eco-DRR approaches would support their implementation in the Reserve. This is also true beyond the EPIC project site. Casteller et al. (2017) note that snow avalanches and landslides have not been thoroughly documented or modelled in Chile.

Capacity and technical skills to address vulnerabilities, climate change impacts and reduce disaster risk could also improve in the Las Trancas Valley and in general in the Biosphere Reserve. Technical capacity to understand and implement EbA and Eco-DRR could improve, particularly amongst civil society, private sector actors such as the ski resorts, NGOs, and local staff from public services. In general, Chile would benefit from the presence of more qualified personnel at the local government and municipality level to enable the effective implementation of climate change adaptation plans.

Cross-sectoral institutional collaboration is insufficient, primarily between public sector actors working in the Reserve, but also between private sector actors and between public and private sector actors. For example, CONAF was also only marginally involved with Reserve management at the start of EPIC, although this has since changed. Most land within the Reserve is owned privately, and it can be difficult to engage with landowners on Reserve management.

Lastly, the municipality of Pinto, in which the Las Trancas Valley is located, lacks official land-use plans and regulations, and also local hazard maps (Casteller et al. 2017).

Provincial-level barriers to implementing EbA

Interviewees identified the following barriers to EbA implementation at the Biobío Region level, where the Biosphere Reserve is located.

- Limited understanding of risks and the benefits, costs, opportunities and limitations of EbA and Eco-DRR approaches. Better understanding of these issues would support their implementation in regional policies and planning such as the PROT.
- A shortage of technical skills. In general in Chile, more qualified personnel are needed at the regional level to enable the effective implementation of climate change adaptation plans.
- Insufficient cross-sectoral institutional or inter-ministerial collaboration amongst the diverse public services operating in the Biobío Region, with a view to ensuring sustainable Reserve management.
- Challenges with prioritisation and allocation of funds. Prioritising needs and allocating funds according to these priorities at the regional level is not easy. For this to happen, goals and actions have to be in the regional development/management strategies. Navigating regional bureaucracy is also complex.

National-level barriers to implementing EbA

A number of issues inhibit more effective EbA implementation at the national level within Chile.

Knowledge gaps are a challenge. More EbA and Eco-DRR initiatives need to be implemented and mapped in Chile. There are several initiatives addressing climate change adaptation or DRR in Chile, but EPIC is the only initiative using ecosystem-based approaches to address both so far, so experience and knowledge in this field is lacking. Current adaptation and DRR initiatives need to be built on. Efforts to adopt ecosystem-based approaches that might not be part of formal projects need to be mapped. Examples of such projects include work to prevent landslides through slope vegetation restoration conducted by the Ministry of Public Works. This would help raise awareness in Chile on the crucial role of ecosystems in ongoing adaptation and DRR efforts. More knowledge relating to the economic costs and benefits of EbA options is needed. Knowledge gaps relating to marine ecosystems and country-level indicators for preserving genetic resources also make EbA implementation in Chile a challenge.

Government policies do not always support Eco-DRR in Chile. For example, whilst DRR and adaptation policies, strategies and plans exist, ecosystem-based approaches to both have not been explicitly infused into them yet. Perverse incentives/subsidies also exist for deforestation in the farming and industrial sector, and for importing diesel. Cortés-Donoso et al. (2017) argue that the main challenge to protecting Chilean communities from climate change risks such as landslides, droughts, fires and flooding is the need to adopt new land planning systems that acknowledge the value of ecosystems in the context of livelihood provision and resilience.

Likewise, whilst government has strong institutions dealing with DRR and adaptation, these can also be inflexible at times, making it difficult to support new ecosystem-based approaches. Relevant government bodies do not always prioritise EbA. For example, securing greater CONAF involvement in Biosphere Reserve management was challenging. Monty et al. (2017) also stress the importance of ensuring Eco-DRR and EbA are further institutionalised for their benefits to endure.

Chile needs more qualified personnel at the national level to enable the effective implementation of adaptation plans. Monty et al. (2017) also emphasise the need to continue strengthening Eco-DRR and EbA capacity amongst a range of stakeholders in Chile.

Funding is also a barrier to addressing climate change in Chile. The Climate Change Office (Oficina de Cambio Climático, or OCC) has adaptation as a permanent item on its agenda, but ongoing funding from the Ministry of Environment and other ministries for adaptation priorities must be available to ensure implementation and continuity. International financial support is also needed to implement the measures envisioned, but the public sector is currently unable to receive and include international support it its annual budget. Some public service providers struggle to allocate funding to adaptation-related matters in their annual budgets if climate change has not been explicitly identified in their laws.

Coordination poses a challenge in several contexts. Various public service providers and other stakeholders work in the field of ecosystem management, climate change and DRR, but approaches to

addressing these issues are often segregated. For example, the Oficina Nacional de Emergencia del Ministerio del Interior y Seguridad Pública (ONEMI), the national office for managing emergencies and disasters in Chile, is responsible for DRR in Chile but is quite focused on disaster response rather than prevention (ONEMI 2014). Deeper collaboration between sectors and institutions and more joined-up policies are needed to further embed nature-based solutions in policies and practices. Although regional and municipal entities are increasingly working on adaptation, coordination and interaction between the central government and these subnational entities also need to improve (Climate Change Office 2014). Lastly, coordination between scientists and decision makers needs to be enhanced.

Local-level opportunities for implementing EbA

In the Biosphere Reserve and Chile in general, local knowledge and technical capacity levels for implementing EbA are quite good. EPIC helped enhance this knowledge and capacity (Monty et al. 2017; Cortés-Donoso et al. 2017).

SEREMI Ambiente prioritised EPIC as one of its key projects and championed its work within the Biosphere Reserve.

Social capital is strong and levels of community cohesiveness have improved, as those involved in managing the Biosphere Reserve have come together to work on improving Reserve management, a process which has facilitated discussion between a diversity of stakeholders (public sector officials, civil society, NGOs and academia).

Provincial-level opportunities for implementing EbA

EPIC work with Biobío regional bodies helped ensure government prioritisation and championing of Eco-DRR activities and helped institutionalise emerging knowledge and capacities from EPIC. The Biobío regional government (Gobierno Regional, or GORE) was the project's political partner at the sub-national level. SEREMI Ambiente has regional committees on climate change throughout Chile, and in the Biobío Region it is the political partner in the Biosphere Reserve management. EPIC worked with both GORE and SEREMI Ambiente to promote innovations in Biosphere Reserve management. It also provided information to the regional land-use plan (Plan Regional de Ordenamiento Territorial, or PROT), but follow-up is required to ensure uptake of EPIC lessons in the plan.

EPIC also engaged civil society organisations throughout its implementation, including some IUCN members and the University of Chile. This helped engage different actors in opportunities to follow-up on the integration and implementation of EbA and Eco-DRR approaches.

National-level opportunities for implementing EbA

Although EbA is not yet explicitly included in any existing climate change strategies, the current institutional and strategic/policy support for both climate change adaptation and DRR in Chile is strong. This provides a supportive policy and institutional environment for EbA and Eco-DRR, and hence opportunities for further implementation. Relevant national laws, policies and plans are as follows (Podvin et al. 2016):

- In 2006 the National Advisory Committee for Global Change (Comité Nacional Asesor sobre Cambio Global, or CNAG) launched the ***National Climate Change Strategy***, which was operationalised two years later through the ***National Climate Change Action Plan: 2008-2012*** (National Environmental Commission 2010).
- This will be replaced by the ***National Action Plan on Climate Change 2017-2022***, the latest draft of which is currently subject to public consultation. This will fulfil a government goal to establish a public policy instrument that guides actions to tackle climate change. It will provide guidance on national adaptation and vulnerability reduction, and an operational structure for its coordination and implementation. It will also consider cross-sectoral approaches at different levels.
- The ***Second National Climate Change Adaptation Plan*** (2016-2021) was approved by the Council of Ministers for Sustainability and Climate Change in December 2014. This raises the need to strengthen climate change institutional arrangements and proposes an operational structure for implementing the plan, using a cross-sectoral and territorial approach, led by the Council and

involving the inter-ministerial Technical Team on Climate Change, and the Regional Committees on Climate Change.

- Nine ***sector-specific plans*** addressing climate change adaptation in Chile have been proposed, and four of these have been developed and approved to date: 1) a forestry and agriculture plan, 2) a biodiversity plan, 3) a fishing and aquaculture plan and 4) a health plan. These already have national and international funds for their implementation. The other seven plans relate to water resources, energy, infrastructure, cities and tourism (Gobierno de Chile 2014; 2015).
- The government is currently working on a '***Proposal for a legal and institutional framework to address climate change in Chile***', which will assess the need for, and feasibility of, national climate change laws, as well identifying their minimum content (CR2 2016).
- ***Law 19,300*** is the most relevant piece of environmental legislation in Chile. It establishes a legal framework for activities that can modify or alter the environment, and it addresses climate change (CR2 2016).
- The third ***National Communication*** to the United Nations Framework Convention on Climate Change (UNFCCC) was published in 2016 (Ministerio del Medio Ambiente 2016). This included an EPIC project summary.
- Chile's ***Intended Nationally Determined Contribution*** (Gobierno de Chile 2015) is structured around three key areas: resilience to climate change, control of greenhouse gas emissions and cross-support for climate action.
- Chile includes EbA in its ***National Biodiversity Strategy and Action Plan*** (2003), which has a dual focus on both people and nature.
- Regarding DRR, Chile signed the Hyogo Framework for Action 2005-2015 and it has a ***National Policy for Disaster Risk Management*** that states the need for disaster risk management according to planning and territorial units such as watersheds and ecosystems.

Chile's institutional structures and capacities have advanced substantially in recent years, and institutions for addressing climate change and DRR are strong. Some government institutions prioritise EbA and the MMA is championing the issue. This supports and provides further opportunities for implementation. Key institutions are as follows (Podvin et al. 2016):

- The ***Ministry of Environment (MMA)*** has an Undersecretary of Environment in charge of six different departments, one of which addresses climate change.
- The ***Climate Change Office (OCC)*** was created within the Ministry of Environment in 2010. It sits within the MMA department addressing climate change.
- In 1996 the Government of Chile established ***CNAG*** in response to Chile's ratification of the UNFCCC in 1994. This committee plays a role in formulating positions for international negotiations, as well as formulating policy instruments for climate change. CNAG serves as a coordinating body for all organisations within the Chilean government whose work is linked to climate change.
- The ***Council of Ministers for Sustainability and Climate Change*** was created in 2014. Previously named the Council of Ministers for Sustainability, it is responsible for preparing the National Climate Change Strategy, which includes adaptation and mitigation measures. Ministries represented on the Council have focal points in charge of climate change within their institutions.
- Chile has a national multisectoral DRR platform called ***Mesa Temática para la Gestión del Riesgo y Reducción de Riesgos de Desastres***. Platform participants belong to the public sector, United Nations agencies, financial institutions, regional bodies, civil society, the private sector and representatives from the academic and scientific community.
- The ***National Office of Emergencies (ONEMI)*** is part of the Ministry of Interior and Public Security. It must plan, coordinate and implement activities relating to disaster prevention, mitigation, warning, response and rehabilitation. Its mandate is to protect people, property and the environment at national, regional, provincial and communal levels. To better link DRR and emergency response, ONEMI envisages incorporating various types of territorial planning units relating to ecosystems or water basins into its work in the future.

Cross-sectoral coordination is challenging, but inter-institutional committees and arrangements for cross-sectoral coordination have also been established. These support efforts to align and integrate different land use planning and development instruments, and ensure inter-sectoral dialogue. Projects such as EPIC provide opportunities to strengthen these platforms and galvanise cross-sectoral planning, as well as helping to meet multiple national commitments under global processes such as the Sustainable Development Goals, Aichi biodiversity targets, the Sendai Framework for DRR and global climate change mitigation and adaptation objectives under the UNFCCC (Buyck 2017).

Is the EbA initiative sustainable?

Despite some constraints, interviewees felt that local- and national-level institutional, policy and capacity support was available for ensuring long-term sustainability of EPIC project activities.

At the local level, capacity building has ensured that project activities will continue even after the project has ended. EPIC has worked with a variety of local stakeholders, such as municipalities and technical staff from the regional government and SEREMI Ambiente, to ensure that the foundations to support future Eco-DRR work are in place and to increase the likelihood that project benefits will be sustained. Institutionalising Eco-DRR and EbA approaches into Biosphere Reserve management and planning and into the Pinto municipality regulatory plan also means that benefits are likely to last (IUCN 2013).

At the national level, the MMA is increasingly predisposed to promoting Eco-DRR and EbA in its policies and strategies. The approaches are aligned with the ministry's objectives and it is committed to supporting them.

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

EPIC took steps to ensure project lessons reached beyond the Biosphere Reserve boundaries. Efforts continue to be made in this respect, and various opportunities have arisen through improvements in knowledge sharing and associated changes in attitudes, and altered policies at the regional and national level.

EPIC increased knowledge levels on climate change vulnerability and DRR beyond the boundary of the Biosphere Reserve by working with many stakeholders and supporting multi-stakeholder spaces to link various stakeholders, and support cross-sectoral government planning. EPIC brought together scientists, civil society, public sector service providers, planners, policymakers and decision makers from MMA, ONEMI and CONAF, and forest management authorities to share its research on forest management to protect against avalanche risks. The project arranged discussion forums on DRR and adaptation, and produced publications targeting various actors at local, regional and national levels. It held five technical and policy workshops from 2013 onwards to promote EbA and Eco-DRR. In one 2017 project meeting, EPIC catalysed new approaches linking ONEMI and the MMA regarding adopting EbA to address climate change adaptation and mitigate climate-related risks. Cortés-Donoso et al. (2017) describe how EPIC successfully introduced the concept of ecosystem services into the work of other public services such as the Ministry of Public Infrastructure and the Ministry of Housing and Urbanization.

The simulation programme used for the forest avalanche study could potentially be used in the same area and also in other areas with related risks. Study methods and results have been shared with the Ministry of Public Works with a view to promoting eco-engineering and green-grey infrastructure options. Opportunities are also emerging for integrating the approaches adopted under the project into other sectors. For example, the National Service of Geology and Mining is interested in the simulation programme to assess risks elsewhere Chile. Lessons learned from EPIC work in the Biosphere Reserve could also be relevant for other protected areas.

Links with the MMA have been strengthened and a memorandum of understanding aiming to promote joint activities beyond the EPIC project was signed by the MMA in December 2013. This provides an opportunity to develop further work on adaptation and DRR in Chile. MMA is now promoting the inclusion of Eco-DRR and EbA in policies relating to adaptation and climate change, and is exploring international funding to continue this work (Cortés-Donoso et al. 2017).

Changes in knowledge and attitudes have led to opportunities to alter various regional and national policies in Chile which, along with the existing institutional and policy framework, could provide further opportunities for scaling up EbA in Chile:

- EPIC is included in the sector-specific biodiversity plan addressing climate change adaptation in Chile (part of the National Adaptation Plan). The plan, prepared by the MMA, considers EPIC an exemplary measure of adaptation to climate change that also strengthens the national system of protected areas (Buyck 2017).
- Results from the study on native forests and avalanches/landslides could be integrated into recommendations in the PROT.
- The project could contribute to a broader revision of the national Rural Development Policy. This is a mature policy that recognises and values the quality and the potential of natural assets and ecosystems, and promotes their protection and management, but which could now be updated to improve the protection and restoration of ecosystems of public interest in rural territories, especially those reducing risk from natural and anthropogenic threats.
- The National Territorial Planning Policy is also under construction, and is likely to be finalised in the first quarter of 2018. It is crucial to incorporate EbA and Eco-DRR into this.

Globally, there have been major policy advances in recent years relating to the integration of ecosystems into DRR work. The Sendai Framework for Disaster Risk Reduction 2015-203 was a key milestone in this respect. This will support greater implementation of Eco-DRR in the future (Monty et al. 2017). Opportunities for scaling up through securing further funding are also possible. There is potential to secure funding from the Green Climate Fund for a larger project integrating biodiversity into DRR work.

Conclusions

The EPIC project aimed to build community resilience by promoting nature-based solutions to DRR and CCA in the 'Corredor Biológico Nevados del Chillán – Laguna del Laja' Biosphere Reserve. Results from applying the research methodology to assess EbA effectiveness suggest that EPIC helped communities improve their adaptive capacity or resilience, and provided them with a base for reducing their vulnerability to disaster and potentially also climate change risks in the area. It showed that healthy forest ecosystems in the Las Trancas Valley can play a crucial role in protecting infrastructure and communities from avalanche and landslide hazards (Monty et al. 2017). EPIC also built a stronger foundation for local resilience by bringing together diverse stakeholders involved in Reserve management, helping identify current and future drivers of risk and local vulnerabilities and adaptive capacities in the Reserve, strengthening the capacities of local stakeholders to cope with risk, facilitating sustainable water provision and collective learning, and improving stakeholder knowledge and relevant policies. If Reserve management includes the results from EPIC research, capacity building processes and policy recommendations, opportunities for increasing resilience and reducing vulnerability further can increase. EPIC has also enhanced co-benefits that promote wellbeing, such as social cohesiveness and improved governance. There may, however, be trade-offs in the future in terms of who benefits from reforestation or forest protection actions. Adoption of a variety of participatory processes throughout the project helped enhance adaptive capacities among local stakeholders.

A number of future Eco-DRR and EbA activities discussed under the project could lead to increased ecosystem resilience and service provision, especially improvements in forest management. It is also possible, however, that factors outside the reach of the project or Reserve management practices could affect ecosystem resilience, such as changes to water availability, glacial retreat and snowmelt due to global warming. Again, there may be trade-offs between the various ecosystem services provided, such as recreational services from tourism, and DRR services when forest management improvements reduce avalanche risk. Most anticipated ecosystem benefits would be immediate to long-term.

Project-level studies on the costs and benefits of DRR from improved forest management versus infrastructural approaches have not been conducted, but other studies indicate that the protective role played by healthy forests in mountain ecosystems can lead to economic savings. There may be trade-

offs, however, if reforestation or native forest protection reduces ski areas and thus income from tourism.

The key barriers to implementing further Eco-DRR and EbA initiatives in Chile relate to the availability of relevant knowledge (for example, on vulnerabilities, climate change and disaster risk, the economic costs and benefits of EbA, and strategies, opportunities and limitations to implementing EbA and Eco-DRR together), capacity and technical skills (for example, on addressing vulnerabilities and climate change impacts, CCA and reducing disaster risk), and the challenges of cross-sectoral institutional collaboration and accessing funds. Chile does, however, benefit from strong and committed government institutions at all levels, and a supportive national policy environment for DRR and adaptation initiatives. This, together with investments made in enhancing knowledge and capacity building by the project itself, means that benefits from EPIC are likely to be sustainable over the long term, and there are multiple opportunities for broader upscaling, replication and mainstreaming in Chile.

Finally, it is important to note that whilst EPIC in Chile was designed primarily as an Eco- DRR initiative, it also promoted EbA approaches. It is therefore reasonable to assume that other DRR initiatives globally, especially Eco-DRR initiatives, could have relevant learning for EbA as the discipline moves forward.

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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 Ecosystems Protecting Infrastructure and Communities project, Chile. 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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